

APCT-3 Operations Manual

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1.0 Purpose/Scope

1.1 Overview

Introduction

This manual describes the third generation of IODP temperature hardware and software to be used to determine sub seafloor temperatures within sediments during piston coring operations.

The APCT-3 tool is a data logger that captures time-dependent temperature data in a deep-sea borehole.

For additional information on interpreting the data, log in to Cumulus and download the *User Manual for the Third-Generation, Advanced Piston Corer Temperature Tool (APCT-3)* by Fisher, Villinger, and Heeseman (Cumulus web version at [http:// web.iodp.tamu.edu:8080/CumulusE/ng/index.jspx](http://web.iodp.tamu.edu:8080/CumulusE/ng/index.jspx) or Cumulus Client on your computer).

2.0 Introduction

2.1 Overview

Introduction

The APCT-3 tool is deployed on the APC inner core barrel, which is run on the coring wireline to the bottom of the borehole. The APCT-3 temperature logger electronics are mounted inside the annular cavity of a Heat Flow Coring Shoe (OP4375).

The combined APCT-3 tool and coring shoe is attached to the APC tool during coring operations to obtain borehole temperature at the same time a hydraulic piston core is retrieved, eliminating the costly delay of entering the borehole twice with two separate investigation tools. APCT-3 data are downloaded from the data logger onto a computer on the ship.

In situ temperature measurement adds ~10 min to each APC core barrel run. Mudline measurements can add 5 min more.

2.2 APCT-3 Operational Overview

Deployment

The tool is deployed in soft sediments to determine:

- Formation temperature
- Heat flow gradient
- Hydrocarbon maturity

Typically, the tool is run starting at 30 meters below seafloor (mbsf) and then run with every other core until four good readings are obtained. The shoe is hydraulically stroked 9.5 m into the sediment and remains stationary for ~10 min.

The APC Inner Core Barrel is then retrieved, the instrumented shoe is removed, and data are downloaded to a computer.

APC pullout and partial penetration

The crew normally switches to extended core barrel (XCB) coring after an APC pullout of 60,000–100,000 lb (this decision is left to the rig crew, Tool Pusher, and IODP Operations Superintendent). Leaving the APC barrel in the mud for the extra minutes required by APCT operation allows the formation to settle in around the tool and may increase the pull required to remove the tool from the mud. In the past during some APCT runs, when the sediment firmed up at shallow depths, researchers agreed to pull out after 6–8 min.

If the tool is left in the sediment for any time period less than this, it may be difficult to get enough of an equilibration curve to extrapolate a meaningful in situ temperature (see Fisher et al.), but much depends on drilling conditions, water depth, sea state, lithology, and other factors.

You can experiment with the length of measurement with the *TP-Fit* software (see *APCT-3 Data Processing (TP-FIT)*).

During later ODP and early IODP operations, drilling crews continued to core using the APC to great depths (300 m or more) using a “drilllover” technique. The APC drill bit was advanced the length of recovery following incomplete stroke, and another APC barrel was launched. This approach requires more time, since the depth increment of each core might be only a few meters, but it allows collection of high-quality APC samples, and APCT-3 data, to much greater depths than have been attained previously. Discuss this option early in the expedition (or during pre-expedition planning) if deep APC (and APCT-3) penetration is important to the scientific objectives.

Data storage

Temperature data are time stamped and stored in external erasable programmable read-only memory (EEPROM) within the tool.

Temperature range

The APCT-3 tool has a temperature range -5°C to $+50^{\circ}\text{C}$ with an accuracy of $\pm 0.02^{\circ}\text{C}$ (see Chapter 6, Specifications) and a resolution of <2.5 mK at -5° to $+50^{\circ}\text{C}$ range and <1.0 mK at $<25^{\circ}\text{C}$.

Dual deployment option

As part of the APCT-3 development, an option was created to deploy two sets of APCT-3 electronics, with a sensor-to-sensor spacing of ~ 57.2 cm (22.5 in) during a single Advanced Piston Corer (APC) deployment (see *Dual deployment (OM0700)* or Fisher et al., 2007 in Cumulus [full citation is listed in the *Bibliography*]), but IODP has not operated the tool in this configuration as of 2010.

2.3 APCT-3 Components

Overview

The tool system comprises three main components:

- Coring hardware
- Electronics components
- Operating software

Coring hardware

Primary coring hardware components (*Fig. 2-1*) of the APCT-3 tool include:

- Heat Flow Shoe with annular cavity (OP4375)
- Heat Flow Catcher Sub Body (OP4377)



Figure 2-1. APCT-3 Components.

Heat Flow Shoe (OP4375)

APCT-3 electronics are deployed inside a coring shoe. The APCT-3 shoe differs from the shoe used with second-generation tools only in the depth extent of the O-ring surfaces (they are slightly longer) and in labeling instructions for the vendor.

The coring shoe tapers near the cutting end, placing the APCT-3 thermistor probe within ~1-2 mm of the outer surface of the shoe. In addition, the taper of the cutting shoe helps to assure that it makes good thermal contact with the surrounding formation.

Heat Flow Catcher Sub

The Heat Flow Catcher Sub is cylindrical in cross-section and forms the seal at the top of the annular cavity. The top of the sub screws onto the bottom of the Inner Core Barrel.

Electronics

APCT-3 tool electronic components (*Fig. 2-2, Fig. 6-1*) have an operating temperature range of approximately -5° to $+55^{\circ}\text{C}$ (except the batteries which have a maximum temperature range of $+70^{\circ}\text{C}$ (see **Measurement temperature range**) and include:

- Electronics Support Frame(OM0720)
 - Battery Circuit Board
 - Temperature Logger Circuit Board
 - O-Rings
 - Prongs
 - Locating pins and screw holes
 - Banana Plugs
- Top Ring (OM0705)
- Frame Insertion-Extraction tool (OM0830)
- Communication Cable (OM0722) (not shown in *Fig. 2-2*; see *Fig. 2-6*)

Electronics Support Frame

The Electronics Support Frame (*Fig. 2-2*) houses two circuit boards, which are built into the aluminum cylindrical support frame. Three flat surfaces are machined onto the older generation support frames and four on the new APCT-3 frames. On both frames, two of the flat surfaces are currently used to hold circuit boards, and one (APCT)/two (APCT-3) remain empty for potential future use.

Battery Circuit Board

One circuit board (*Fig. 2-2*) holds two 1.3 V lithium coin cells (manufacturer's part number is CR2430-P2-2) in parallel, providing a 3 V power supply to the tool. One set of batteries should allow for ~600,000 readings; at a sampling rate of one per second, the tool should operate ~1 week on a set of batteries.

Temperature Logger Circuit Board

The other circuit board (*Fig. 2-2*) holds electronics for the following:

- Thermistor probe (YSI 55032)
 - Temperature coefficient = ~4% per $^{\circ}\text{C}$
 - Temperature range = -80°C to $+100^{\circ}\text{C}$
 - Temperature maximum = 200°C (thermistors tend to drift greatly when subjected to temperatures above 100°C ; thermistors would probably require calibration and may be damaged)
- Microprocessor
- Analog-to-digital (A/D) converter, 16-bit
- Memory, nonvolatile (can hold 65,000 readings)
- Real-time clock

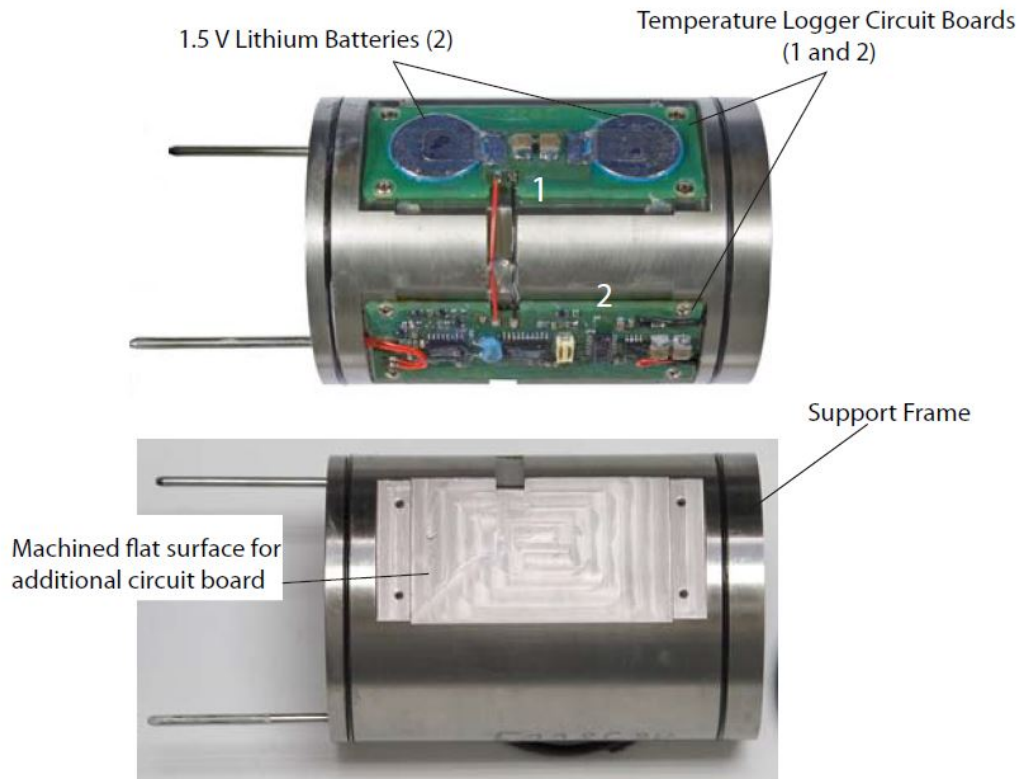


Figure 2-2. Electronics Support Frame

Electronics Support Frame O-Rings

The Electronics Support Frame has one O-ring located near the top and one near the base (*Fig. 2-2*). The O-rings stabilize the electronics only, they **do not** seal out moisture. The part number for the O-rings is OD2041.

Prongs

On the bottom of the support frame are two prongs (*Fig. 2-2*); one is empty and the other contains the thermistor probe (nominal 30 kW at 25°C).

Currently, the empty prong acts as a locating pin. A second thermistor or other sensor could be placed in the empty prong in the future as a tool modification.

Locating Pins and Screw Holes

On the top of the electronics support frame (*Fig. 2-3*) are four threaded screw holes and four locating pin holes for use with the frame insertion-extraction tool.

Banana Plug Contacts

Two female mini-banana plug contacts (readout ports) are also located on the top of the Electronics Support Frame and provide access for the Communications Cable to communicate with the deck box and computer (*Fig. 2-3*).

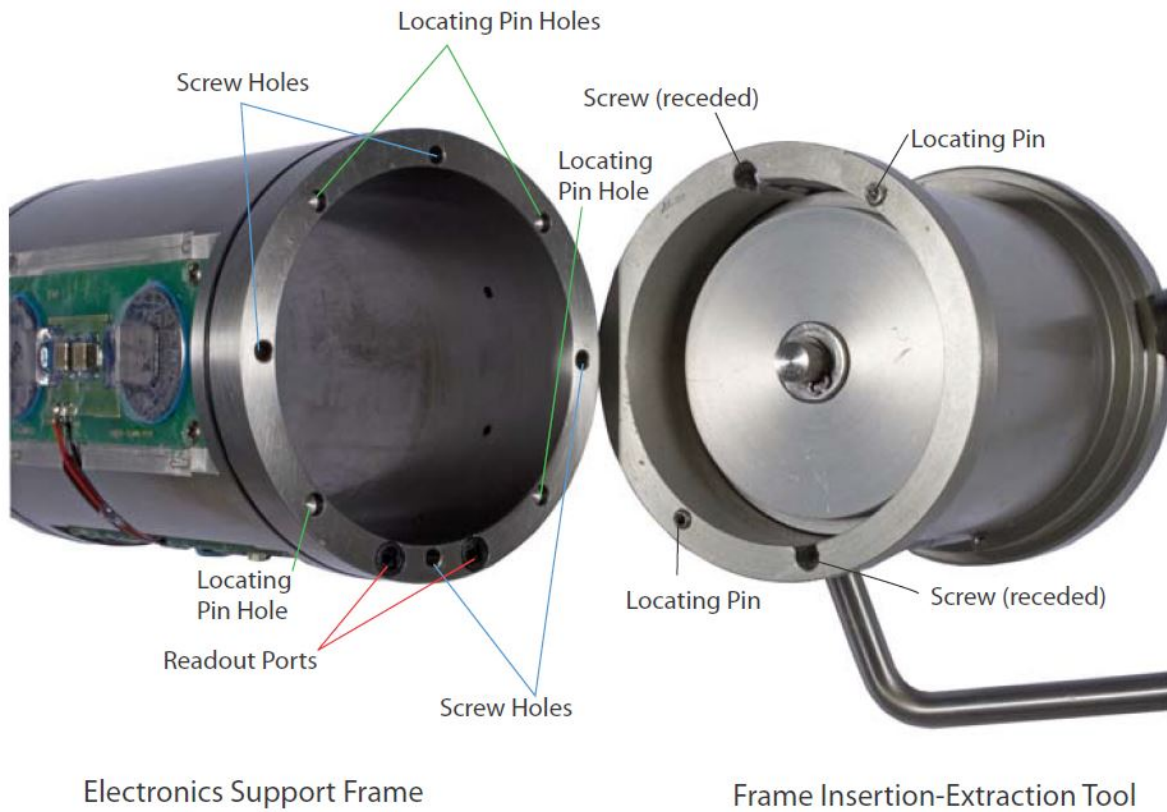


Figure 2-3. Top of Electronics Support Frame and Bottom of Frame Insertion- Extraction Tool.

Top Ring

A Top Ring (machined steel with inner [OD2039] and outer [OD2041] O- rings) fits above the Electronics Support Frame after it is inserted in the coring shoe.

The Top Ring (Fig. 2-4) protects the electrical contacts from water, grease, and mud, which are otherwise exposed on the top surface of the support frame.



Figure 2-4. APCT-3 Top Ring.

Frame Insertion- Extraction tool

The Frame Insertion-Extraction tool (OM0830) (*Fig. 2-5*) was designed and manufactured by Antares. It is used when:

- Placing or removing the Electronics Support Frame into and out of the Heat Flow Shoe
- Inserting and removing the Top Ring

Ideally, an Electronics Support Frame might be placed in a Heat Flow Coring Shoe near the start of an expedition and not be removed until the end of the expedition, minimizing opportunities for damaging the electronics.

The Top Ring **must be** removed after every temperature run to download data.



Figure 2-5. Frame Insertion-Extraction Tool.

Communication cable

Communication is accomplished using serial communication, either through a DB-9 serial port on the computer or a USB port and a serial adapter. The Communication Cable (OM0722) attaches to a deck box, from which a second cable connects to the APCT-3 electronics.

A special connector at the end of this cable (*Fig. 2-6*), with male mini- banana plugs attached to a curved form, is shaped to slide into the top of the annular cavity and fit into the Electronics Support Frame to download data while the frame is in the APC coring shoe.

This allows the APCT-3 electronics to be programmed and deployed, and data to be recovered, without removing the electronics frame from the APC coring shoe.

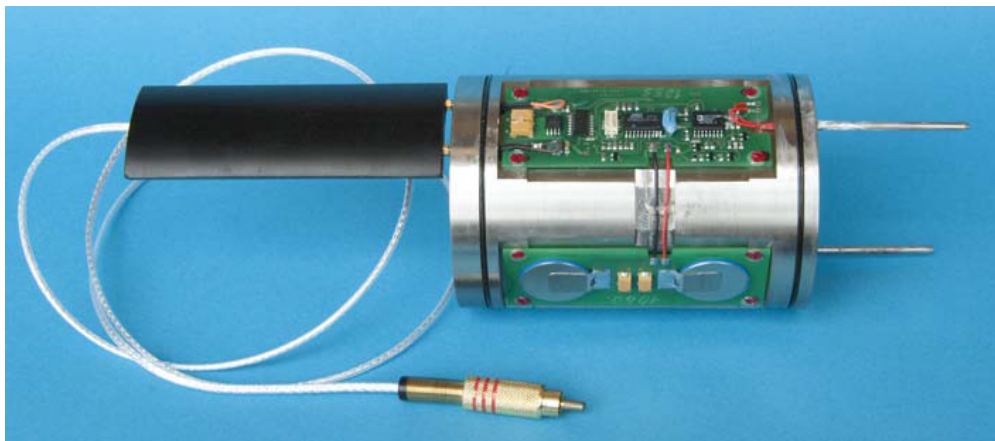


Figure 2-6. Electrical Connector (white arrow) and Support Frame (right).

Operating systems

The electronics are programmed using a desktop or notebook computer running Windows XP. At the time of this writing (2009), no tests had been run using Vista. Limited testing has been performed using Windows 98, but vendor specifications do not include support for this operating system.

3.0 APCT-3 Tool Assembly

3.1 Overview

Introduction

The APCT-3 Electronics Support Frame is stored in a plastic cylinder when not in use to prevent damage to the electronics.

The physical assembly of the APCT-3 has been simplified from that of the APCT tool. The batteries are built into the Electronics Support Frame and do not need changed as often.

3.2 Attach Frame Insertion-Extraction Tool

Introduction

Attach the Frame Insertion-Extraction tool to the APCT-3 to load it into the APCT Coring Shoe. Once the APCT-3 tool is assembled, the electronics support frame should not need to be removed from the coring shoe during the remainder of the expedition.

Parts required

- Electronics Support Frame in storage cylinder
- APC Coring Shoe
- Frame Insertion-Extraction tool
- Stand to hold Coring Shoe and Electronics Support Frame storage cylinder

To attach the Frame Insertion-Extraction tool to the Support Frame, perform these steps:

STEP 1: Place an APC coring shoe with annular cavity on the lab bench on a stand to prevent the shoe from falling over.

STEP 2: Unscrew the top of the plastic electronics storage cylinder containing the APCT-3 Electronics Support Frame.



Note: The APCT-3 electronics should not be left exposed on the counter; keep the electronics inside the plastic cylinder or in an APC coring shoe.

STEP 3: Place the Frame Insertion-Extraction tool on top of the Electronics Support Frame and turn the thumb knobs to tighten the tool against the frame. Carefully remove the Support Frame from the storage cylinder.

Note: There are two sets of threaded holes in the top of the frame that are compatible with the insertion tool: one set of threaded holes is blocked (protected) with set screws, and the other set includes holes that will align the insertion-extraction tool with the electrical contacts on the top of the tool frame. When installed properly, a small vertical groove near the top of the insertion tool aligns with the thermistor probe, making it easier to insert the frame in the coring shoe.

STEP 4: Back out the large wing-nut in the center of the insertion-extraction tool to expose ~3 cm of thread. This raises a piston in the insertion-extraction tool to allow the electronics support frame to land in the base of the annular cavity in the coring shoe.



STEP 5: Proceed to [Clean, Grease, and Install the Support Frame](#) in section 3.3

3.3 Clean, Grease, and Install the Support Frame

Overview

Before the electronics support frame is installed in the APC coring shoe, clean and grease the O-ring grooves and coat the thermistor probe with heat sink compound to ensure good contact with the coring shoe. Although the heat sink compound will not damage the electronics, try to keep it only on the probe because it makes the tool, and possibly the user, messy.

To inspect or clean the electronics, the user may extract the frame from the plastic case by pushing your hand inside the frame and lifting the Electronics Support Frame up. To insert the frame into the APC shoe, use the Frame Insertion-Extraction tool.

Parts required

- Electronics Support Frame
- Old APCT Stand or other stand to support the shoe
- Frame Insertion-Extraction tool
- Dow 4 silicone grease
- Nonsilicone heat transfer compound (PN 52050-1J0)
- Top Ring
- O-Rings (OD2041)
- Small applicator (e.g., a cotton tipped applicator)

To clean and grease the Electronics Support Frame, perform these steps:

STEP 1: Inspect O-rings.

If O-rings:

- Need replaced or the tool is being run for the first time, go to Step 2.
- Are in good shape, go to Step 5.

STEP 2: Remove Insertion-Extraction tool and place the Electronics Support Frame on the APCT stand (two are located on the ship and one is in the onshore lab).

STEP 3: Remove O-rings (OD2041), if present, and clean the O-ring grooves on the Electronics Support Frame.

STEP 4: Insert new O-rings into the grooves on the Electronics Support Frame.

STEP 5: Use Dow 4 or similar O-ring grease to grease the O-rings on the Support Frame and inside and outside of the Top Ring. Lay Top Ring aside for installation after programming of the tool is complete.

STEP 6: Hold the Electronics Support Frame in one hand with the handle of the Frame Insertion-Extraction tool and with the other hand use a small applicator to apply a thin (1–2 mm) coating of heat sink compound around the thermistor probe, which can be identified by the wires extending from the main circuit board into the probe.

Note: Use AOS nonsilicone HTC with a thermal conductivity of 2.6 W/ (m-K), and apply heat sink compound **only** to the thermistor probe and **not** the empty prong.

STEP 7: Proceed to Install the Electronics Support Frame on page 3-6.

Install the Electronics Support Frame into the APC coring shoe as follows:

STEP 1: Place an APC coring shoe with annular cavity on a stand to prevent it from falling over.

STEP 2: Hold the Frame Insertion-Extraction tool (which is connected to the support frame) by the handle and position the Electronics Support Frame so the two prong tips align with the holes in the annular cavity of the shoe.

Note: It may help to have someone hold a flashlight or to use a head lamp to view the base of the annular cavity.

STEP 3: Lower the Electronics Support Frame into the cavity in the coring shoe. The alignment mark near the top of the frame insertion-extraction tool should align with the wrench flat on the coring shoe.

Note: The O-rings on the electronics frame may cause some friction as the tool is set into the cavity of the coring shoe. If there is too much resistance, extract the support frame and check the O-rings and coring shoe cavity for obstructions.

STEP 4: If the thermistor probe lands on the bottom of the annular cavity but misses the hole, gently raise, turn, and lower the support frame until the probe lands in the hole, then lower the support frame until it lands on the bottom of the cavity in the coring shoe.

Note: Over time, the coring shoe or electronics support frame may deform, requiring that smaller O-rings (or possibly no O-rings) be used on the support frame.

STEP 5: Remove the Frame Insertion-Extraction tool from the Support Frame.

STEP 6: Clean and dress the O-rings in the Top Ring, if you are preparing for an actual deployment (as opposed to running a bench test).

STEP 7: Fill out the top of a Data Sheet (see *APCT-3 Tool Data Sheet on page 3-7*). Pertinent information (i.e., penetration, time, mud line temp, unusual activity, etc.) from the data sheets should be added to the comment box in the TP-FIT data when the data is processed.

Note: Data Sheets for the current expedition are kept on a clip board next to the DHML PC. Scientists are welcome to make copies of the sheets. The data sheets may be disposed of once the expedition is completed.

3.4 APCT-3 Tool Data Sheet

IODP Downhole Temperature Run Sheet

Expedition: _____ Site/Hole: _____ Observer(s): _____
 Date: _____ Water Depth (mbrf): _____ Tool ID: _____
 Core Number: _____ Top Depth of Core (mbsf): _____
 Clock Synchronized? Measured Interval: _____ Battery Voltage: _____

Choose Measurement Type

APC *In Situ*

Top Depth + APC Stroke Length*: _____ = Measured Depth (mbsf): _____

Partial Stroke? Or Full Stroke?

Full APC = 9.5m Half APC = 4.5m

Probe *In Situ*

Top Depth + 1m = Measured Depth (mbsf): _____

All Systems, Open Borehole

Depth (mbsf): _____

Comment regarding depth value: _____

Water Sample? Volume Recovered (ml): _____

Pressure Measured?

Local	GMT	Activity
		Time when recording was started
		Start Down Pipe, Rate: (m/min):
		Stop At Mudline – pumps off, 5min
		Lower Into Hole – pump slowly
		Fire APC / Insert Probe – compensate (at sampling depth)
		Pulled From Sediment
		Time when recording was stopped

DATA: Successfully downloaded from tool Uploaded to LIIMS Backed up DATA1

Filename (*.dat): _____

Comments: _____

3.5 Tool Programming

Introduction

If you are not familiar with operation of the APCT-3 tool, take time in port or during transit to review these instructions and run bench tests.

Operating system

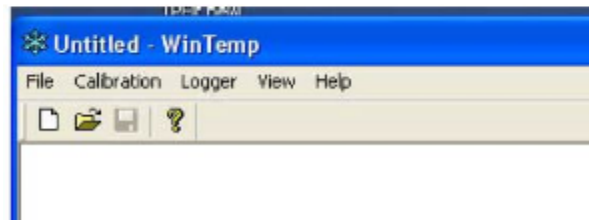
The data logger is programmed using a desktop or notebook computer running *Windows XP*. No tests have been run using *Windows Vista*; limited testing has been performed using *Windows 98*, but vendor specifications do not include support for this operating system.

Procedure: activate logger and check battery

To activate the tool and check the battery for the APCT-3 tool, follow these steps:

STEP 1: Connect the serial cable to the computer and to the deck box, then connect the deck box to the tool cable, which terminates with the curved connector.

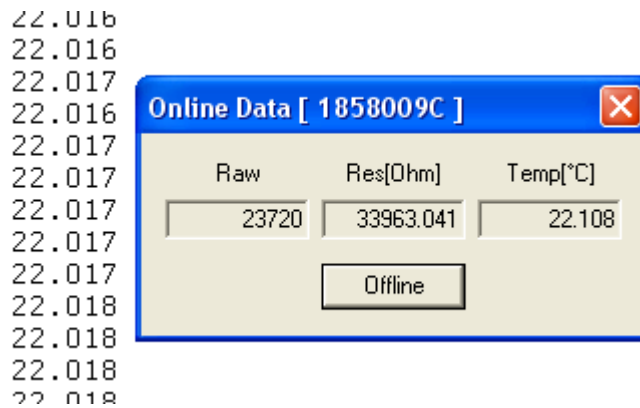
STEP 2: Double click on the *WinTemp* icon on the computer to open the starting menu (arrow).



STEP 3: Insert the mini-banana plugs on the curved connector into the contacts on the top of the electronics support frame.

STEP 4: Click **Yes** in the logger window (*Fig. 3-1*) to see a real-time summary (*Fig. 3-2*) of digital counts, resistance, and temperature, updated once /second.

STEP 5: Click the **Offline** button in the Online Data window to return to the main screen.



STEP 6: Select **Logger > Battery**.

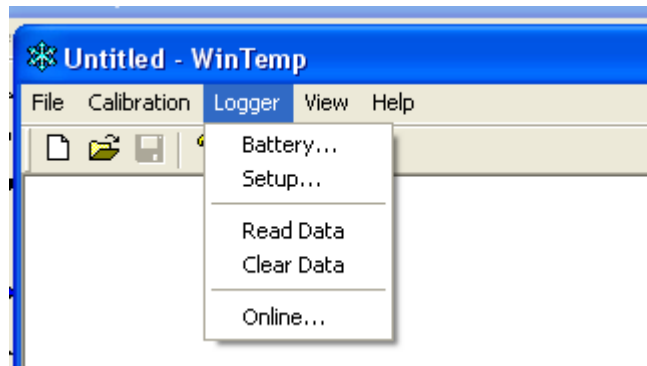


Figure: logger online window

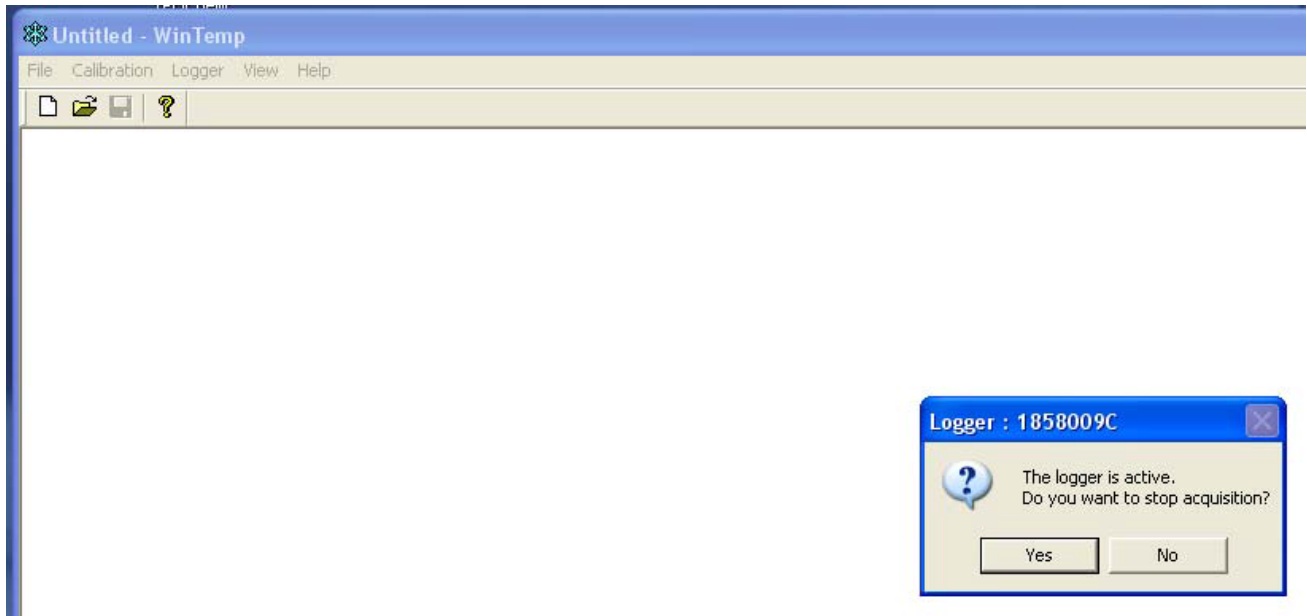


Figure 3-1. Logger > Online Logger Window.

Figure: logging data summary

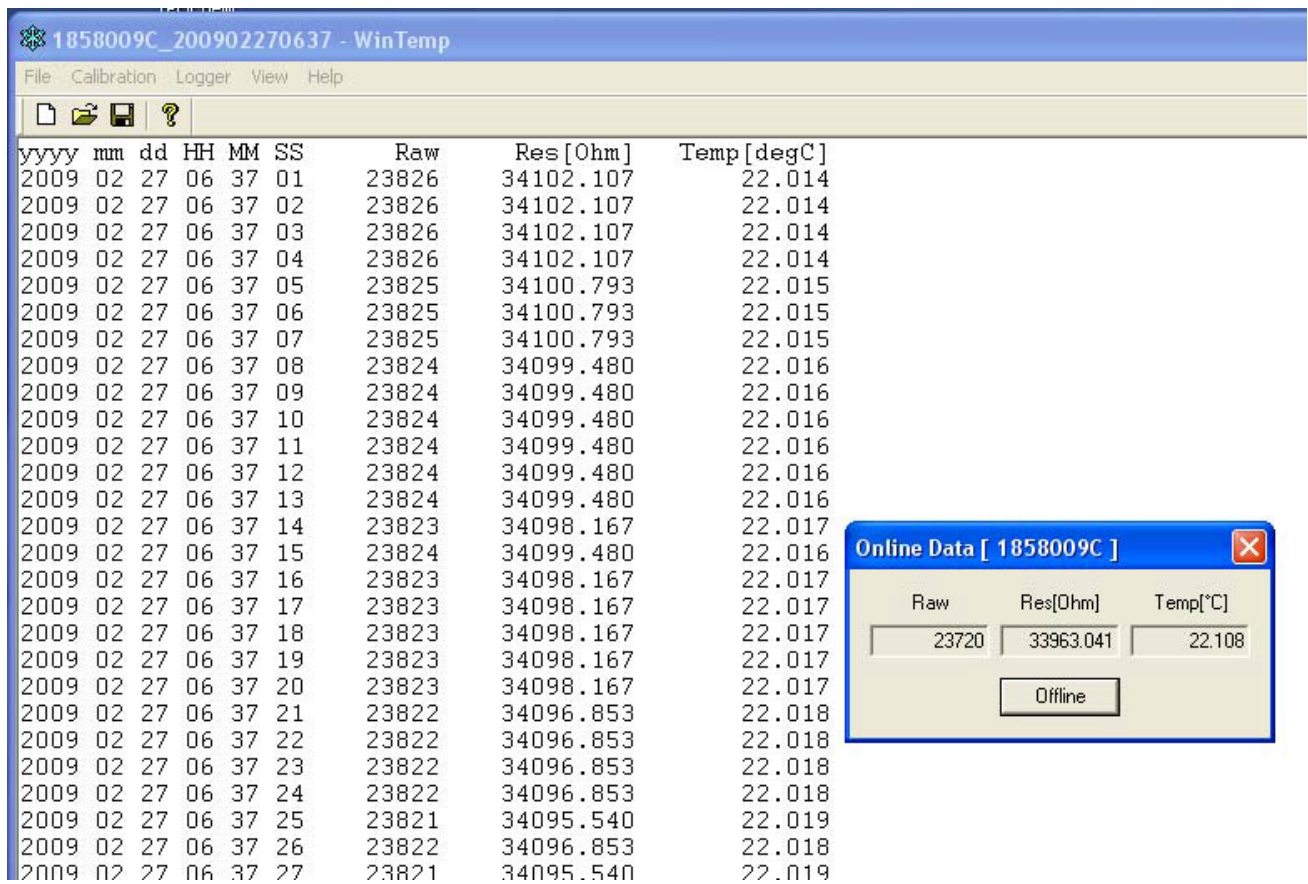
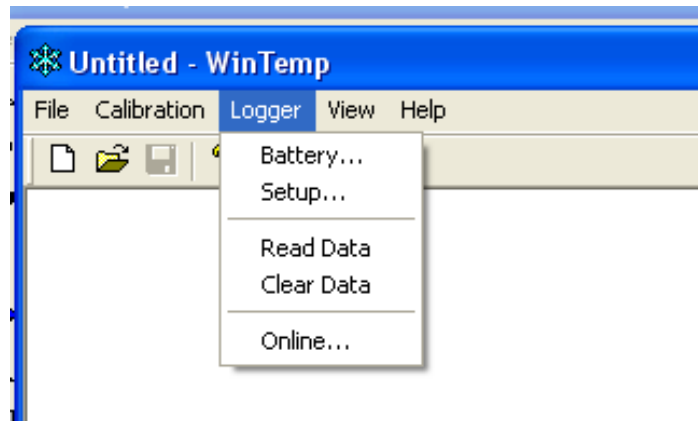


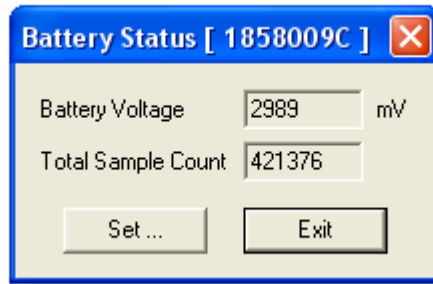
Figure 3-2. Real-Time Logging Summary of Online Data.

STEP 7: In the WinTemp tool bar menu, select **Logger > Online** to verify communication has been established.



STEP 8: Click **Yes** in the Logger window that opens to open the Battery status window.

22.016
22.017
22.016
22.017
22.017
22.017
22.017
22.017
22.017
22.018
22.018
?? 018



Note: Collection of this data will be helpful in evaluating tool performance.

STEP 9: Record *Battery Voltage* and *Total Sample Count* on the Data Sheet.

Note: If the battery volts are less than 2850mV, replace the battery.

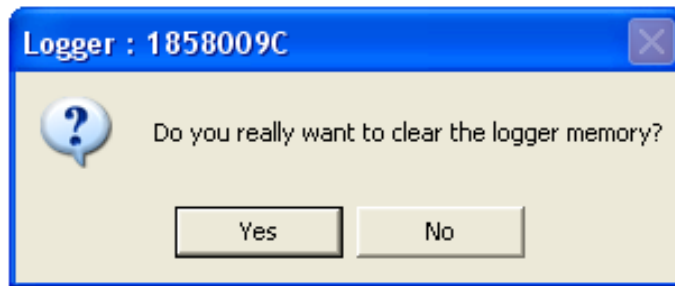
STEP 10: Click **Exit** in the Battery Status window to return to the main screen.

STEP 11: Go to **Clear logger data**.

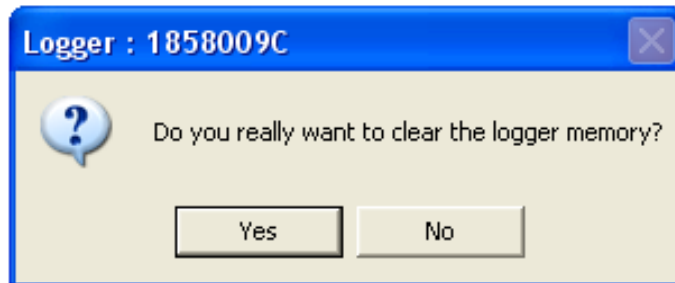
Clear logger data

After activating the tool and checking the battery, select **Logger > Clear data** to collect new data. There are four possible responses:

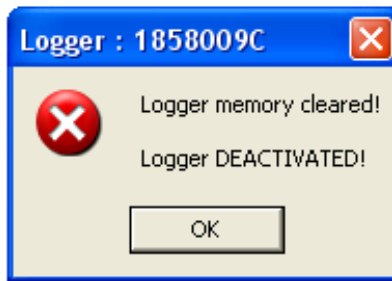
- Logger has not been run and no data are present in the window but the program requests user to clear the logger memory. Click **Yes** or **No**.



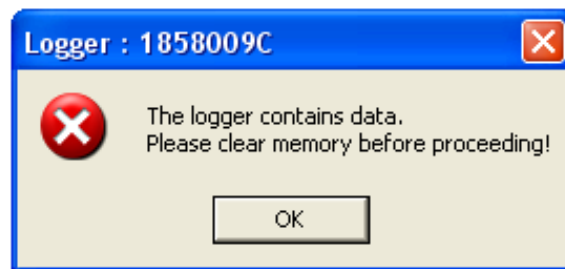
- Logger has been run, acquisition was stopped, and the program asks if you want to clear the data in the window. Click **Yes** or **No**.



- Logger was deactivated and memory cleared. Click **OK**.



- Logger contains data, program requests user to clear memory before proceeding. Click **OK** to clear data.



Procedure: data logger setup

To prepare the data logger for a new deployment, perform these steps:

STEP 1: In the WinTemp tool bar menu, select **Logger > Setup** to open the setup screen (*Fig. 3-3*).

STEP 2: Set time to *GMT* to avoid problems with data interpretation.

Note: If the *GMT* is not correct, contact the Marine Computer Specialist.

STEP 3: Select the **Synchronize Logger to PC Time** check box to synchronize the tool real-time clock to the computer clock.

STEP 4: Mark the Data Sheet for GMT (UTC).

Note: Use of GMT (UTM) is standard in marine science observations.

STEP 5: Select 'Sync Logger to PC time.'

STEP 6: Select max duration.

STEP 7: Select 1 s interval.

STEP 8: Select 'Start Now.'

STEP 9: A *Verification* window shows selected parameters, giving the operator a chance to revise the logging plan (*Fig. 3-4*). The time until logging will begin is displayed above the **OK** button.

- If *WinTemp* finds no problem, the **OK** button will be colored green.
- If the **OK** button is grayed out, there is a problem with the selected program. Click **Back to Setup** to return to *Setup* if needed to revise the sampling plan.

STEP 10: Proceed to **Final Tool Assembly for Deployment**.

Figure: logger setup screen

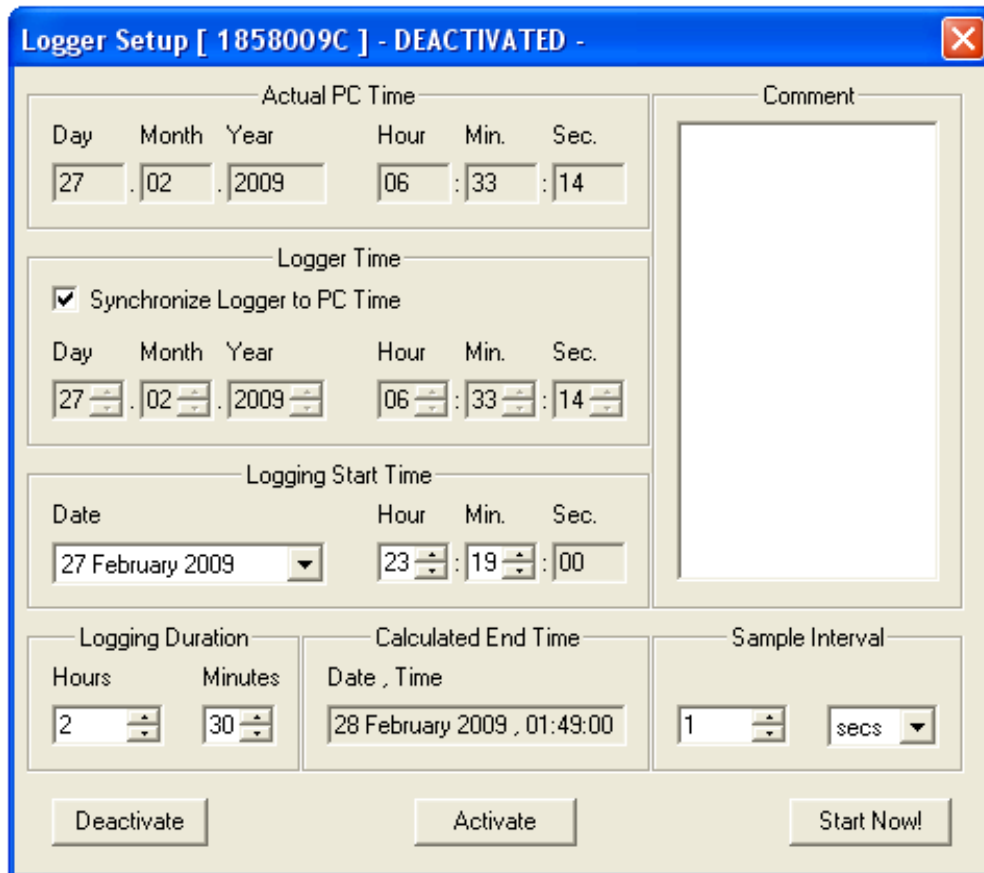


Figure 3-3. Logger Setup Screen.

Figure: logger setup verification

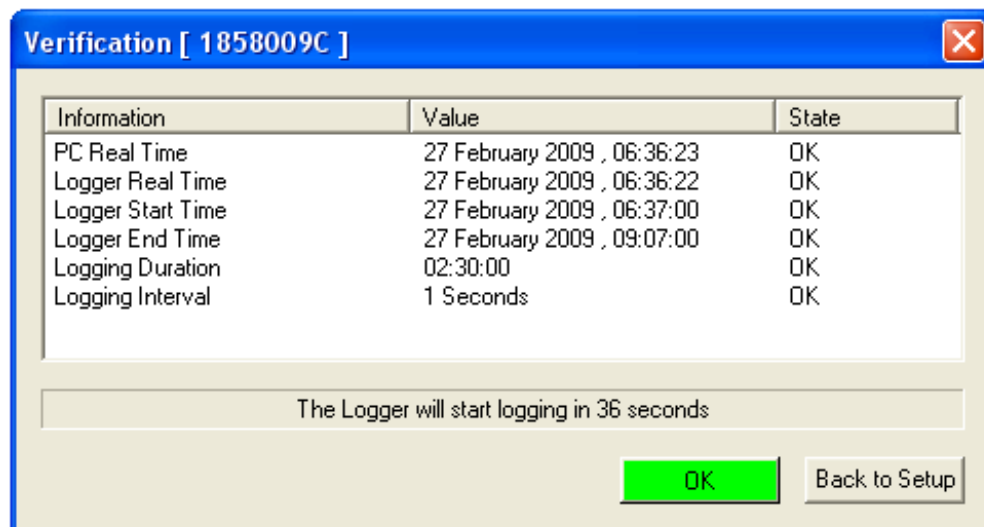


Figure 3-4. Logger Setup Verification.

4.0 Tool Deployment

4.1 Overview

Introduction

The APCT-3 tools have been carefully calibrated on shore at the Metrology Lab, but it is good practice to verify bottom water temperature at each site at least once for each APCT-3 tool used during an expedition. More frequent bottom water measurements may be desirable, particularly when working in shallow water or in other environments where bottom water temperature variations are expected.

See *APC pullout and partial penetration* for additional information on deployment.

4.2 Final Tool Assembly for Deployment

Procedure: final tool assembly

Finish assembling the tool, coring shoe, and core catcher sub before deploying the tool:

STEP 1: Remove the connector from the top of the support frame after programming the tool.

STEP 2: Insert the Top Ring (with clean, dressed O-rings) above the Electronics Support Frame using the Frame Insertion-Extraction tool.

Note: Always use the Frame Insertion-Extraction tool with the Top Ring, otherwise it may go into the shoe skewed and become jammed or damage the O-rings.

STEP 3: Clean and dress the Core Catcher sub O-rings (Core Tech provides Core Catcher).

STEP 4: Insert the Core Catcher sub into the top of the coring shoe and make it up by hand so that only a few threads remain exposed to limit opportunities for water, dirt, or grease to foul the APCT-3 electronics.

STEP 5: Proceed to **Procedure: running a temperature station**.

4.3 Running a Temperature Station

Introduction

The drill pipe is an efficient heat exchanger, so water in the pipe is generally close to bottom water temperature by the time the water reaches the bottom of the pipe, provided the water is sufficiently deep and the surface water is not anomalously warm.

However, depending on the pumping rate and the ambient hydrography, water in the pipe may not equilibrate with bottom water if the pumps are running quickly.

In addition, the complete APCT-3 system is thermally massive, and the best bottom water temperature measurement will be made by holding the tool stationary, a few meters above mudline, for 10-15 min with the **pumps off**.

When positioning the tool at the mudline, be sure to take into account the length of the core barrel. If the tool is inadvertently held below the mudline, a spurious bottom water temperature will be determined.

Procedure: running a temperature station

To run a temperature station with the APCT-3 tool, perform these steps:

STEP 1: Pass the untightened tool assembly to the Core Tech or a member of the rig crew 20 to 40 minutes before they send the core barrel down the pipe so it will be ready.

Note: The Core Tech or rig crew will tighten the core catcher using a special wrench made for the coring shoe.

STEP 2: The rig crew will make up the coring shoe/Core Catcher Sub to an Inner Core Barrel, then lower the barrel into the pipe on the sand line.

STEP 3: Go to the drillers shack with the Data Sheet wearing the appropriate safety gear after the core barrel has been launched and let the driller know how you would like to run the station.

Note: Tell the driller in advance if you would like to stop at the mudline to record a bottom water temperature.

STEP 4: The driller performs the following tasks, after measuring the bottom water temperature:

- Lowers the tool into the bit
- Pressurizes the drill string
- Fires the core barrel into the formation
- Waits 8–10 min for the tool to partly equilibrate with the formation

STEP 5: The driller pulls the tool out and returns it to the rig floor.

Note: Some researchers like to pause again at the mudline during tool recovery, but the tool equilibrates more slowly at this time because it is thermally more massive than during deployment (because it contains sediment). The best bottom water temperature measurement is made prior to collection of a core.

STEP 6: Mark the Data Sheet to indicate the time of penetration and whether pressure “bled off” normally following APC deployment.

Note: Complete pressure bleed-off generally indicates a normal deployment, with the expectation that the APC coring shoe penetrates ~9.5 m ahead of the bit; actual penetration depth is calculated on the basis of recovery. However, abnormal pressure bleed-off generally indicates an incomplete stroke of the APC, and the driller releases the pressure manually.

STEP 7: Proceed to **Procedure: retrieving the tool and core.**

4.4 Removing the Core

Introduction

After the core is retrieved, the APCT-3 tool must be cleaned, data downloaded, tool reprogrammed for the next run, and tool redeployed.

Special wrench

When the APCT-3 tool comes back on deck the rig crew breaks the coring shoe and core catcher sub connection with a special wrench. **Stand and watch every time the rig crew breaks the connection.**

Failure to use the special wrench to break the connection between the coring shoe and the core catcher sub could result in a deformed coring shoe or damaged electronic components inside the shoe.

Procedure: retrieving the tool and core

To retrieve the APCT-3 tool, perform these steps:

STEP 1: When the tool is retrieved, ensure the rig crew uses the **special wrench** to break the connection.

STEP 2: Unscrew the crossover by **one thread only** so the Heat Flow Catcher Sub/Heat Flow Shoe remain watertight.

Note: Unscrewing by only one thread is vital because if the core technicians need to hammer the sediment from the coring shoe they could drive mud and grease into the cavity above the Top Ring and damage the electronics.

STEP 3: An IODP technician or Downhole Measurement Technician on the catwalk removes soupy or firm core from the watertight Heat Flow Catcher Sub/Heat Flow shoe using a plunger.

STEP 4: The technician labels the core as core catcher sample, and passes the Heat Flow Catcher Sub/Heat flow Shoe unit to the Downhole Measurement Lab (DHML) Technician if an IODP Core Technician removes the core.

STEP 5: The DHML Technician then

- Cleans the tool (**Procedure: cleaning the tool**)
- Downloads the data (**Procedure: data download**)
- Redresses the tool for the next deployment (**Procedure: redressing the tool**)

Procedure: removing stiff sediment

To safely remove stiff sediment, follow these steps:

STEP 1: Wash any mud off of Heat Flow Shoe. Water will not reach the connector inside, as it is protected by the inner and outer wall of the tip housing and sits face up.

STEP 2: Place the APCT Heat Flow Shoe (or tip) in a vise with the shoe pointing upward or hold the shoe and Heat flow Catcher Sub on the workbench.

STEP 3: Swab off any remaining water from the cleaning process.

STEP 4: Unscrew and separate the cutting shoe containing the Electronics Support Frame from the Heat Flow Flow Catcher Sub. With stiff sediment, there should be little or no flowing water. If necessary, the outer part can be sprayed with hot water to remove excess clay.

STEP 5: Once this is completed, it is safe to use the plunger and hammer to recover the core inside the Heat Flow Catcher Sub, as below.

STEP 6: Remove any sediment inside the cutting shoe (or tip) by cutting the clay with a long flat spatula around the inner wall and pushing out.

Caution: Use caution when hammering sediment out of the cutting shoe while the electronics are in the Heat Flow Shoe.

STEP 7: Clean the tool before downloading data as per **Procedure: cleaning the tool.**

4.5 Cleaning the Tool

Introduction

After the core is retrieved, clean the tool before downloading data to the PC.

Procedure: cleaning the tool

Clean off the tool and download the data by following these steps:

STEP 1: Place the shoe and crossover sub (still connected) upside-down (with the cutting edge facing up) on the catwalk.

STEP 2: Hose off the inside and outside of the APCT-3 assembly.

Note: Do this outside where there is water and it will not matter if it is messy. If the mud dries it will be tougher to clean off later.

STEP 3: Run a brush or rags through the inside of the coring shoe to remove all mud off after removing the core catcher sub from the coring shoe.

STEP 4: After cleaning, take the shoe and crossover sub to the Downhole Measurement Lab (DML) and set on the counter upside down (cutting edge facing up).

STEP 5: Wipe off the exterior of the coring shoe and sub with a dry rag.

Note: If the sub has water on it when you open the coring shoe cavity, the water could drip down inside and onto the APCT-3 electronics.

STEP 6: Unscrew the coring shoe after drying. Either have someone hold the sub or put it in the vise until you get it unscrewed past the O-rings.

STEP 7: When the coring shoe is free, turn it over and place it on the stand on the counter. The Top Ring should be visible at the top of the coring shoe.

STEP 8: Wipe off grease and mud from around the Top Ring using Kimwipes, Q-tips, and lint-free rags.

STEP 9: Use the Frame Insertion-Extraction tool to remove the Top Ring, then gently wipe any water drops off the top of the Electronics Support Frame before attaching the electrical connector to recover the data.

Note: Do not remove the Electronics Support Frame from the coring shoe unless it requires servicing or inspection. You should be able to collect data from dozens of deployments without removing the support frame from the coring shoe.

STEP 10: While data are downloading (**Procedure: data download**), (this takes several minutes) wash the Heat Flow Catcher Sub (hot water spray gun or hold it above a wash basin) with clean with hot water.

Note: A strong solution of dish soap can be used if needed.

STEP 11: Ensure the cavity of the Heat Flow Catcher Sub is completely dry.

STEP 12: Redress APCT-3 Tool for next deployment (**Procedure: redressing the tool**).

4.6 Downloading Data

Introduction

Download the data to the PC before redressing and redeploying the APCT-3. For more information on modeling see Fisher et al., 2007(see **Bibliography** or find document in Cumulus).

Procedure: data download

To download the APCT-3 data, perform these steps:

STEP 1: Insert the electrical connector into the top of the support frame to allow the APCT-3 electronics to communicate with the computer.

STEP 2: Start *WinTemp*, if it is not already running on the computer.

STEP 3: Select **Logger > Read data** from the main menu.



STEP 4: A window opens (*Fig. 4-2*) containing a statement that the logger is active and ask: *Do you want to stop acquisition?* Click **Yes**. *Figure 4-2* shows the open data file.

Note: The program uses a default calibration file to process the data after clicking **Yes**. If you want to load a specific calibration file, ask the Downhole Measurements Lab Technician for assistance. For additional assistance, contact the Metrology Lab Lead, Dean [Ferrell via ferrell@iodp.tamu.edu](mailto:ferrell@iodp.tamu.edu).

STEP 5: The file is saved in *WinTemp* (.wtf) and ASCII (.dat) formats to the **Antares** directory (*Fig. 4-3* and *Fig. 4-4*).

Note: The file is automatically named with the:

- Tool ID
- Date and time at which the tool started

STEP 6: Complete the Data Sheet, recording any anomalous events or tool behavior.

Note: Data Sheets for the current expedition are kept on a clip board next to the DHML PC.

STEP 7: Pertinent information (i.e., penetration, time, mud line temp, pull out time, unusual activity, etc.) from the data sheets should be added to the comment box in the TP-FIT data when the data is processed. The datasheets may be discarded at the end of the expedition once this is done.

STEP 8: Run another temperature station (see **Running a Temperature Station**) or store the APCT-3 tool (see **Tool Redress**).



Figure 4-1. Logger is Active Window.

1858009C_200902270637 - WinTemp

File Calibration Logger View Help

yyyy	mm	dd	HH	MM	SS	Raw	Res[Ohm]	Temp[degC]
2009	02	27	06	37	01	23826	34102.107	22.014
2009	02	27	06	37	02	23826	34102.107	22.014
2009	02	27	06	37	03	23826	34102.107	22.014
2009	02	27	06	37	04	23826	34102.107	22.014
2009	02	27	06	37	05	23825	34100.793	22.015
2009	02	27	06	37	06	23825	34100.793	22.015
2009	02	27	06	37	07	23825	34100.793	22.015
2009	02	27	06	37	08	23824	34099.480	22.016
2009	02	27	06	37	09	23824	34099.480	22.016
2009	02	27	06	37	10	23824	34099.480	22.016
2009	02	27	06	37	11	23824	34099.480	22.016
2009	02	27	06	37	12	23824	34099.480	22.016
2009	02	27	06	37	13	23824	34099.480	22.016
2009	02	27	06	37	14	23823	34098.167	22.017
2009	02	27	06	37	15	23824	34099.480	22.016
2009	02	27	06	37	16	23823	34098.167	22.017
2009	02	27	06	37	17	23823	34098.167	22.017
2009	02	27	06	37	18	23823	34098.167	22.017
2009	02	27	06	37	19	23823	34098.167	22.017
2009	02	27	06	37	20	23823	34098.167	22.017
2009	02	27	06	37	21	23822	34096.853	22.018
2009	02	27	06	37	22	23822	34096.853	22.018
2009	02	27	06	37	23	23822	34096.853	22.018
2009	02	27	06	37	24	23822	34096.853	22.018
2009	02	27	06	37	25	23821	34095.540	22.019
2009	02	27	06	37	26	23822	34096.853	22.018
2009	02	27	06	37	27	23821	34095.540	22.019
2009	02	27	06	37	28	23821	34095.540	22.019
2009	02	27	06	37	29	23821	34095.540	22.019
2009	02	27	06	37	30	23820	34094.227	22.020
2009	02	27	06	37	31	23820	34094.227	22.020
2009	02	27	06	37	32	23821	34095.540	22.019
2009	02	27	06	37	33	23821	34095.540	22.019
2009	02	27	06	37	34	23820	34094.227	22.020
2009	02	27	06	37	35	23820	34094.227	22.020
2009	02	27	06	37	36	23820	34094.227	22.020
2009	02	27	06	37	37	23820	34094.227	22.020
2009	02	27	06	37	38	23820	34094.227	22.020
2009	02	27	06	37	39	23820	34094.227	22.020

Ready

Figure 4-2. Data File.

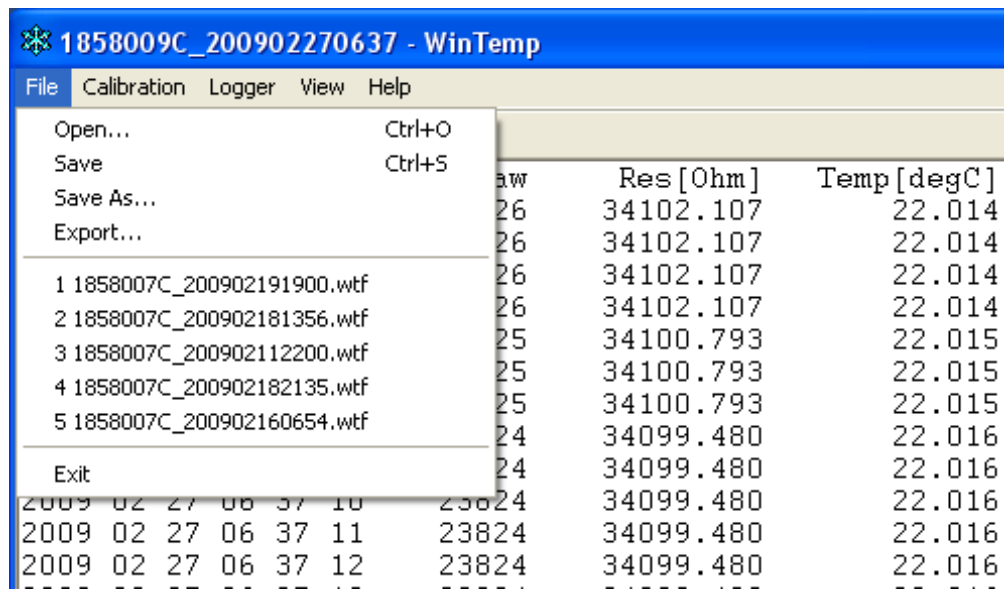


Figure 4-3. Save Data as *.wtf File.

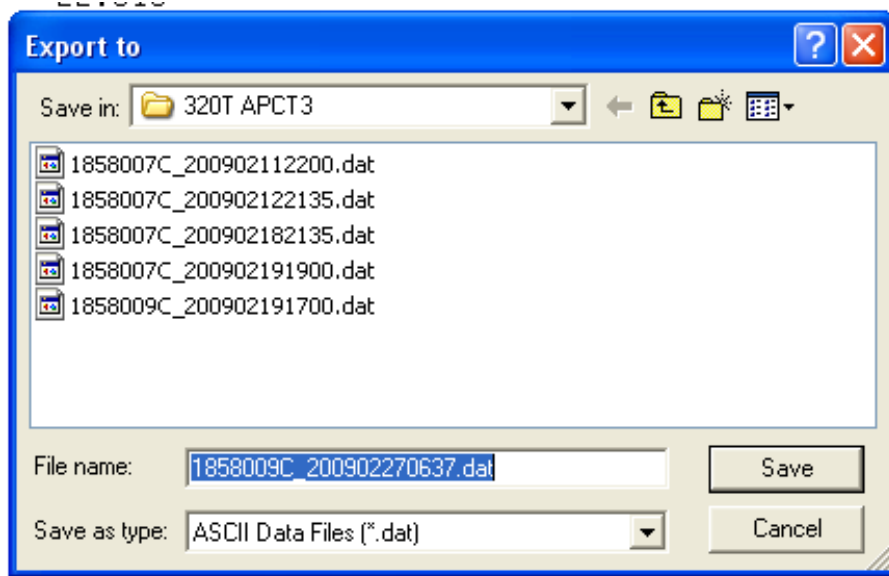


Figure 4-4. Export data as *.dat File.

4.7 TPFIT Quick Start

Introduction

TPFIT software is designed to work with APCT-3, SET, and SETP tool data. TPFIT is a Matlab™ program created for processing APCT-3 data.

This Quick Start guide will provide the novice user steps to do simple data processing. Section 4.8 **APCT-3 Data Processing (TP-FIT)** provides more detailed information on using TP-FIT.

Additional resources

For advanced users, see the *Formation Temperature Analysis User Guide* (Heesemann, 2007).

Definitions

The following symbols are defined as:

- k = sediment thermal conductivity
- ρc = heat capacity

Procedure: process data

To process data, perform these steps:

STEP 1: Place APCT-3 data in a working directory with the *TPFit.m* code (and subdirectories) then

1. Start Matlab.
2. Run *TPFit*.

STEP 2: Select **Load Data** to load a data file.

STEP 3: Select **Edit Meta-Data** and enter appropriate values for k and ρc only if you are familiar with using TPFIT software and know the values are incorrect.

Note: If you are not a very knowledgeable user of TPFIT, then do not change the k and ρc values.

STEP 4: Select **Pick** and choose the following:

- Tool penetration time (t_0)
- Initial data point to fit to the model (*Data Start*)
- Final data point to fit to the model (*Data Stop*)

STEP 5: Select **Show Fit** and examine the *Results* plot window.

STEP 6: Select **Make Report** to generate text output for later plotting.

4.8 APCT-3 Data Processing (TP-FIT)

Overview

This section provides an overview of using the TP-FIT software. TP-FIT is a MatLab program created for processing APCT-3, SET, and SETP data.

Launching

To launch TP-FIT (tpfit3.exe), perform these steps.

STEP 1: If Matlab is installed on your computer, start Matlab and open the working directory. This directory should contain the main *TPFit.m* script and subdirectories called *RefModels* and *TP-Fit*. It's best to have a single working directory for an expedition.

Bring data files into this directory for processing and then move the files out of the directory when work is completed.

STEP 2: Launch the GUI: double click the *TPFIT3.exe* icon on the desktop or the *TPFit.m* script in the TP-Fit\MatLab directory within Matlab.

STEP 3: The Opening screen is a narrow window with 10 buttons that represent the general TP-Fit workflow process from top to bottom (see *Fig. 4-5*). This screen remains open throughout the process.

The button commands are:

- Load Data
- Edit Metadata
- Pick
- Show Fit
- Compute Contours
- Explore
- Save Session
- Make Report
- Extras
- Quit

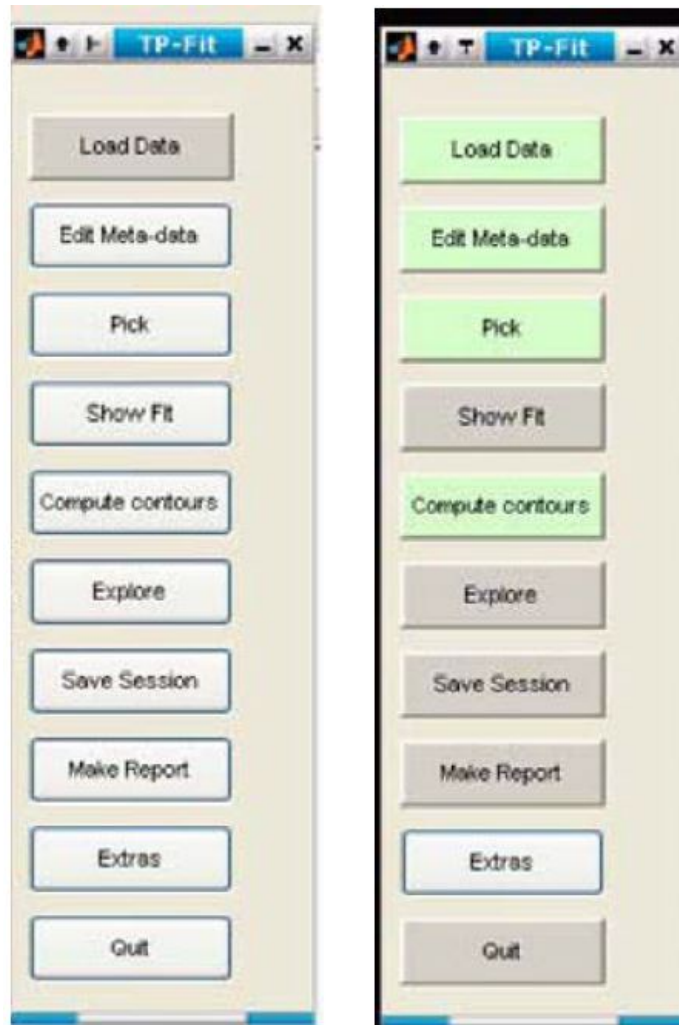


Figure 4-5. TP-Fit Opening Screen before and after loading a data file.

Load Data

The **Load Data** button imports a data file for processing (e.g., the APCT-3 file 1329C09H.dat from the test data directory). Once a data file is loaded, the **Pick**, **Compute contours**, **Load Data**, and **Edit Metadata** buttons turn green (Fig. 4-5).

Edit Metadata

When a data file is loaded, TP-Fit creates basic metadata. Select the **Edit Metadata** button to open the Edit Metadata screen (Fig. 4-10).

The information displayed on the Edit Metadata screen becomes the header information for the data record. Initial values are filled in from the data file. Fill in any fields on this screen that are missing information.

File metadata includes the following:

- Expedition, Site, Hole, Core, and Core Type
- Depth (m)
- Tool ID (tool serial number)
- Tool Type (APCT, APCT-3, DVTP, SET)
- Operator
- Initial k (see **Initial k and Initial rC Fields (Heat Mass)**)
- Initial rc (see **Initial k and Initial rC Fields (Heat Mass)**)
- Comments

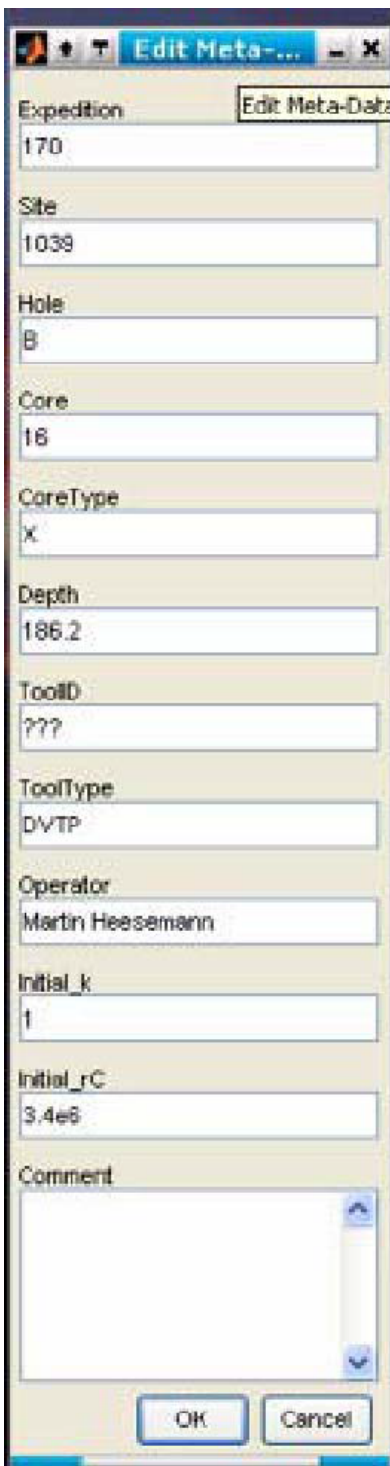


Figure 4-6. Edit Meta Data Screen

Enter and review the information on the Edit Metadata screen and then click **OK** to close the Edit Metadata window.

Initial_k and Initial rC Fields (Heat Mass)

Initial k and Initial r_c values are supplied by the program and are standard physical property values used in calculations. Do not change these values unless you know the values for the area.

Part of data processing is evaluating the uncertainty in final temperatures caused by the uncertainty in k and r_c values, but it is best to enter a reasonable initial value.

In the last generation of APCT processing software, the user was asked to enter only a value for k , and thermal diffusivity ($K = k/r_c$) was calculated from the empirical relation of Von Herzen and Maxwell [1959]:

$$K = 3.657 \times (k - 0.70)^{10-7}$$

where

k is in W/(m-k) and

K is in m²/s.

Other studies have explored relations between k and K , and the advanced user is advised to choose a favored relation initially but to explore the significance of this relation as part of APCT-3 processing (see section *Computer Contours and Explore* in Heeseman, 2007, available in Cumulus [use TP-FIT in the quick search]).

Pick

The next step in processing TP-Fit data is to select the data segments to process. Three data points must be selected:

1. Tool penetration time (t_0)
2. Data start (initial data point to fit to the model)
3. Data stop (final data point to fit to the model)

Click the **Pick** button on the opening screen to open a plot of the data record (*Fig. 4-7*). As the data are shown in a standard Matlab plotting window, you can zoom in and out and adjust axes.

TP-Fit defaults to a data processing window of 9 min (from 60 s to 600 s after penetration; see boxed area in *Fig. 4-7* and expanded area in *Fig. 4-8*). These times can be adjusted by choosing the appropriate **Pick** button in the upper right hand side of the screen (t_0 , Data Start, and Data End; see *Fig. 4-7*).

Figure: initial data plot screen

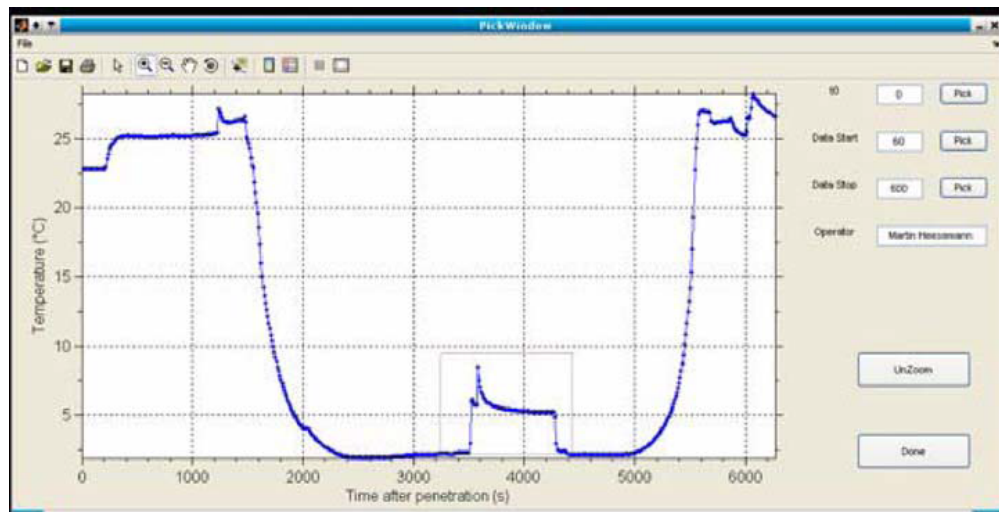


Figure 4-7. Initial Data Plot Screen.

Zoom in on the plot (*Fig. 4-9*) to define the data interval to process. Include data points before penetration and after penetration, including several minutes of data prior to tool penetration.

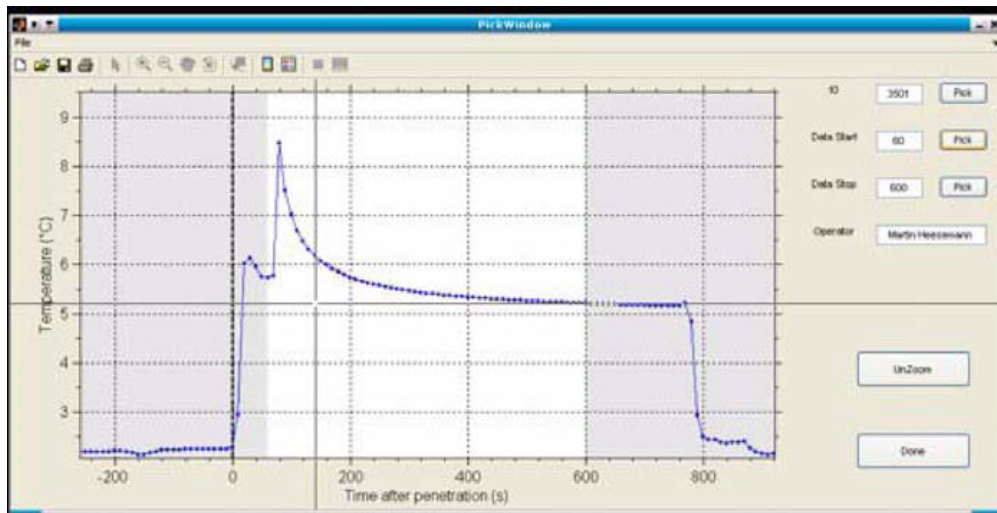


Figure 4-8. Data Plot with t_0 (dark vertical dotted line) and Data Start Pick (crosshair cursor).

Select Data Start

Select the data start point following these steps:

STEP 1: Click the **Pick** button next to Data Start in the *Data Plot* window (Fig. 4-8).

STEP 2: Move the cursor to the point at which you would like to start processing the data (i.e., a sharp rise in temperature).

STEP 3: *Left-click* with the mouse to change the cursor to a crosshair to select and move the crosshair to the start time on the *Data Plot* window (this region is reused in the result plots later).

STEP 4: Refine the pick by selecting an interval in the unshaded region (see Fig. 4-9) of the plot. Pick an area with the most consistent data, but the pick should not be too close to t_0 .

STEP 5: Select the Data Stop point (**Select Data Stop**).

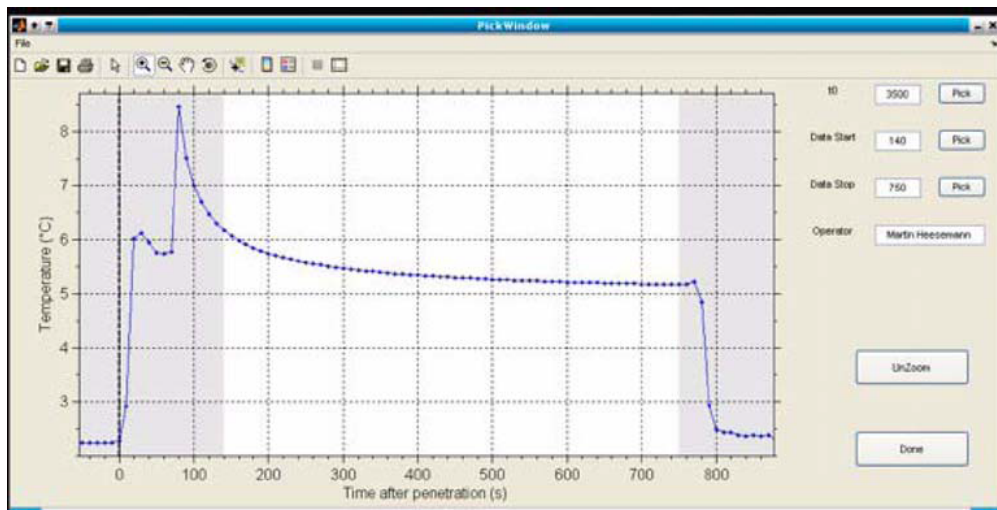


Figure 4-9. Zoom View of Best Data Area.

Select Data Stop

The next step is to pick the end time (which is 600 in Fig. 4-7):

STEP 1: Click the **Pick** button next to Data Stop in the *Data Plot* window (Fig. 4-8).

STEP 2: Move the cursor to the point at which you would like to stop processing the data.

STEP 3: *Left-click* with the mouse to change the cursor to a crosshair to and move the crosshair to the stop time on the *Data Plot* window (this region is reused in the result plots later).

To ensure a good pick it is best to pick the value a little left of the point where the temperature rapidly changes (rapid changes indicate the tool is moving)

STEP 4: Once tool penetration data start and data stop points are selected, click

Done on the Data Plot screen to return to the opening screen.

Show Fit

The **Show Fit** button on the opening screen opens the *Results* screen, which contains four plots (see *Fig. 4-10*). Plots A and B show actual and extrapolated data points and parts C and D show how equilibrium formation temperature was estimated.

Plot A

- Blue dots = tool measurement stations
- Unshaded region = data selected for processing
- Diamond = last third of the selected data
- Bold red line = reference model corresponding to the physical properties (shown in lower right plot)
- Dashed/dotted lines: extrapolated temperatures

Plot B

This plot shows the difference between data and model and reveals systematic deviations that cannot be recognized in the first plot. The deviations are plotted on a log-scale, as absolute values

- Open symbols = overestimates
- Solid symbols = underestimates

Figure: results screen

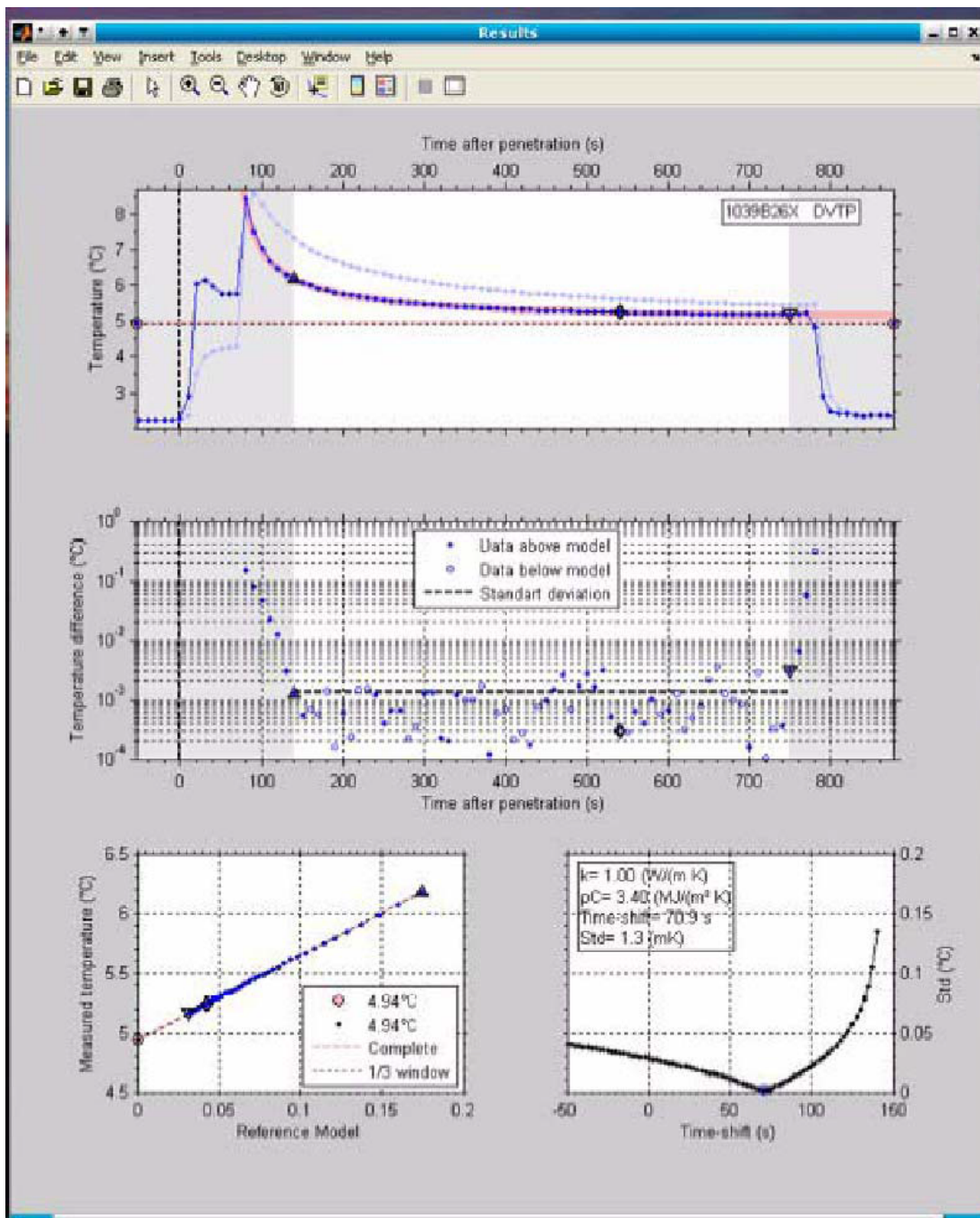


Figure 4-10. Results Screen. (MH draft has a better figure)

Plot C

This plot shows a crossplot of measured and modeled temperatures. Early data appear on the upper right corner of the plot and later data appear toward the lower left corner. Extrapolation of the (hopefully) linear trend shown in this plot back to the $x = 0$ value indicates the interpreted formation temperature at equilibrium (i.e., what the tool would have recorded eventually, if it were left in place long enough).

Two values are indicated:

- Dashed pink line = use of the full data window
- Dotted black line = use of the last third of the data window (see part A)

Plot D

- Black dotted line = standard deviation of the misfit between the model and observations
- Blue open circle (at ~ 70 s on the x-axis) = optimal time-shift used in the previous plots.

- Click on the axes to see dashed and dotted lines that show the sensitivity of estimated undisturbed formation temperatures to time-shift changes [**Author: blue dot, dashed line, dotted line don't show up well in this jpeg-MG suggested a different data set.**]
- Click the *time-shift* axis to inspect the effect of different time-shifts on all graphs.
- Click the *parameter box* in the top left corner of part D to open a new window where model parameters k and r_c can be changed by moving the crosshair on the displayed graph

Make Report

The final step in these instructions is to make a report. You can send the results of the fit analysis to a text file for plotting with different software by clicking **Make Report** in the opening screen.

Make Report creates .eps files of the current result and contour plots in the data directory and generates a simple ASCII report.

4.9 Tool Redress

Introduction

Notify the electronics technician, lab tech, or lab officer if supplies are needed.

Procedure: redressing the tool

To prepare the tool for redeployment, follow these steps:

STEP 1: Complete **Procedure: programming the tool**

STEP 2: Remove the electrical connector from the top of the support frame.

STEP 3: Clean and dress the Top Ring O-rings.

STEP 4: Place the Top Ring above the Electronics Support Frame, with threaded holes facing up, using the Extraction -Insertion tool to prevent damage to the APCT-3 tool.

STEP 5: Clean and dress the Core Catcher sub O-rings.

STEP 6: Insert the Core Catcher sub into the top of the Coring Shoe and make it up by hand so that only a few threads remain exposed.

STEP 7: Proceed to **Procedure: running a temperature station** if more temperature stations are wanted. If the tool will not be used again, see **Procedure: cleaning the tool**.

4.10 Quickstart Deployment Guide

Overview

This quickstart guide section assumes the electronics frame is in the shoe, ready for deployment.

Procedure: deploy tool

To deploy the APCT-3 tool, perform these steps:

STEP 1: Turn on computer, launch *WinTemp*.

STEP 2: Attach curved connector to top of electronics support frame.

STEP 3: Fill out top of Data Sheet.

STEP 4: Select **Logger > Battery**; record *Voltage* and *Total Sample Count* on Data Sheet.

STEP 5: Select **Logger > Clear data**.

STEP 6: Select **Logger > Setup**. Select **Synchronize Logger from PC Time** check box.

STEP 7: Set:

- Start time
- Logging duration
- Logging interval

STEP 8: Click **Activate** and confirm plan, click **OK**.

STEP 9: Disconnect connector from top of support frame.

STEP 10: Insert Top Ring using Insertion-Extraction tool.

STEP 11: Make up Core Catcher sub and hand to rig crew.

Procedure: data recovery

This procedure assumes the coring shoe is clean and open, and the electronics frame is accessible.

STEP 1: Launch *WinTemp*.

STEP 2: Attach curved connector to top of electronics support frame.

STEP 3: Enter time on Data Sheet.

STEP 4: Select **Logger > Read Data**. Confirm you wish to stop logging, if necessary.

Note: The file is automatically saved as *WinTemp* (.wtf) and ASCII (.dat) formats to the **Antares** directory.

STEP 5: Copy and/or backup data to archive and working directories.

5.0 Tool Disassembly

5.1 Overview

Introduction

To preserve the life of the APCT-3 tool, it needs to be cleaned thoroughly after all tests are completed for a hole or site and stored in the cylindrical plastic holder with a screw-on top.

Disassembly and maintenance procedures for the APCT tool include:

- Disassembling and cleaning the tool components.
- Inspecting the Heat Flow Shoe for deformation

5.2 Tool Disassembly

Introduction

The Downhole Measurement Lab houses heavy, dirty, wet equipment from expedition to expedition. To keep the APCT-3 tools in good condition so they will last many years, clean up the tools and work area when all temperature measurements for a hole or site are completed.

Procedure: disassembling the tool

When all temperature measurements are completed, perform these steps:

STEP 1: Use the Frame Insertion-Extraction tool to remove the Electronics Support Frame from the Coring Shoe.

STEP 2: Make sure that the central piston and shaft in the extraction tool is backed out ~3 cm by turning the large wing-nut counter-clockwise.

STEP 3: Lower the insertion-extraction tool onto the top of the Electronics Support Frame and turn the thumb-knobs to engage the threaded holes in the top of the frame.

STEP 4: Make up the screws snug, but not too tight, so that you don't strip the threads in the frame.

STEP 5: If the insertion-extraction tool will not fit completely down on top of the frame, back out the central piston and shaft by turning the wing-nut.

STEP 6: When the extraction tool is fully secured to the frame, turn the wing-nut clockwise. This moves the central piston downward and pushes against the inner wall of the coring shoe.

STEP 7: Continue turning the wing-nut until the support frame becomes loose, then raise the handle on the insertion-extraction tool and gently lift the support frame vertically out of the coring shoe.

STEP 8: If there is difficulty in removing the Electronics Support Frame from the Heat Flow Shoe, inspect the shoe by rolling it on a flat surface to see if any wavelike deformations are on the surface. See **Heat Flow Shoe Deformation**.

Procedure: cleaning the Electronics Support Frame

When the tool has been disassembled, perform these steps to clean and store the Electronics Support Frame:

STEP 1: Clean the surface of the electronics gently with a dry cloth.

STEP 2: Wipe off excess grease or heat sink compound (especially the prong).

STEP 3: Lower the clean electronics frame into the plastic cylindrical storage holder and screw on the cap.

STEP 4: Put the storage cylinder in a drawer or on the shelf.

STEP 5: Clean off the Heat Flow Shoe and Heat Flow Catcher Sub per **Procedure: cleaning the Heat Flow Shoe** and **Procedure: cleaning the Heat Flow Catcher Sub**.

STEP 6: Put the deck box, cables, batteries and parts in Ziploc bags and place these in their boxes and/or on the shelf.

STEP 7: Tell the ET, lab tech, or Lab Officer if supplies are needed.

Procedure: cleaning the Heat Flow Shoe

Once the Heat Flow Shoe and electronic components are removed, follow these steps for cleaning the shoe:

STEP 1: Place the Heat Flow Shoe in a wash basin with hot water.

Note: A strong solution of dish soap may be used.

STEP 2: Use a big bottle brush and a stiff straight brush to scrub the Heat Flow Shoe thoroughly inside and out to remove all grease and grit from the grooves and surface.

STEP 3: Rinse in clean warm flowing water.

STEP 4: Blow dry with high air pressure available in the laboratory.

STEP 5: Use a clean dry cloth to finish drying the unit.

STEP 6: Place the Heat Flow Shoe in storage in the Downhole Measurement Laboratory.

Procedure: cleaning the Heat Flow Catcher Sub

To clean the Heat Flow Catcher Sub, perform these steps:

STEP 1: Wash the Heat Flow Catcher Sub with a hot-water spray gun or hold the unit above a wash basin and clean with hot water.

Note: A strong solution of dish soap can be used if desired.

STEP 2: Use a clean dry cloth to dry the sub.

STEP 3: Place the Heat Flow Catcher Sub in storage in the Downhole Measurement Laboratory.

5.3 Heat Flow Shoe Deformation

Introduction

The Heat Flow Shoe can become deformed or damaged during deployment. Inspect the Heat Flow Shoe after use, particularly if the Electronics Support Frame is difficult to remove from the shoe. Heat Flow Shoe deformation can damage the electronics.

Downward force applied to a damaged Heat Flow Shoe can cause seal failure and leaks, drowning the electronics.

Heat Flow Shoe deformation

There are two main types of Heat Flow Shoe deformation:

Deformation	Description/Symptoms	Action
Wavelike deformation	Detected by rolling the Heat Flow Shoe on a flat surface. If it does not roll evenly, observe the shoe against a light-reflecting wall.	Replace Heat Flow Shoe
Hump/valley	Deformation in Heat Flow Shoe caused by over pressure or damage during deployment.	Replace Heat Flow Shoe

6.0 Key Documents, Tools, References

6.1 Overview

Introduction

Information related to the tool but not part of the assembly/disassembly instructions (e.g., specifications) is included in this chapter.

Missing drawings

If an assembly drawing is missing from this manual, print out a new one from Cumulus or from the ship server.

6.2 Parts Lists

Overview

The APCT-3 parts lists are grouped by the following assemblies.

Name	Assembly Drawing
<i>APCT (overall) tool assembly</i>	<i>OM0800</i>
<i>Electronics Support Frame (incomplete)</i>	<i>OM0720</i>

Note: The Electronics Sub assembly drawing number OM0720 was assigned but currently no drawings have been provided by Antares.

OM0800

The APCT-3 tool assembly consists of the following parts:

Part Number	Description	Quantity
OP4375	Heat Flow Shoe	1
OM0720	Electronics Support Frame	1
OM0705	Top Ring	1
OP4377	Heat Flow Catcher Sub, body	1
OD2041	O-Ring, 2-041 (Top Ring & Support Frame)	3
OD2151	O-Ring, 2-151 (Heat Flow Catcher Sub)	2
OD2147	O-Ring, 2-147 (Heat Flow Catcher Sub)	2
OD2039	O-Ring, 2-039 (Top Ring)	1
OM0722	Communications Cable	1
OM0830	Frame Extraction-Insertion tool	1

OM0720

The Electronics sub assembly has these two parts, which are the same parts in the APCT (see OM0801 in the ODP APCT Operations Manual). OM0720 is incomplete as Antares has not provided drawings. :

Part Number	Description	Quantity
OM0809	Temperature Probe, RTD	1
OM0810	Alignment Pin	1

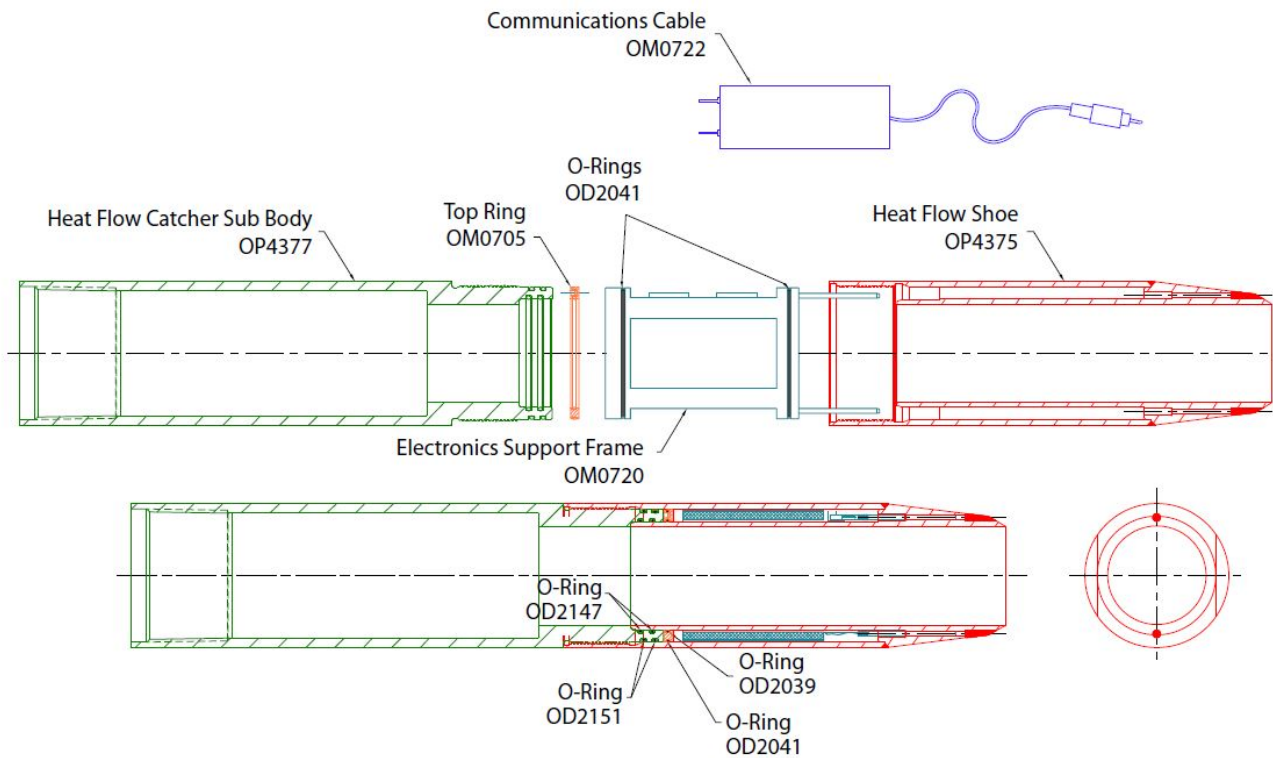


Figure 6-1. APCT-3 Components with Part Numbers

6.3 Specifications

Measurement temperature range

The APCT-3 tool's typical temperature measurement range is about -5°C to $+50^{\circ}\text{C}$ (nominal temperature resolution of the complete instrument is ≤ 2.5 mK over a range from -6° to $+55^{\circ}\text{C}$, and 1.0 mK at temperatures $\leq 25^{\circ}\text{C}$).

The components of the tool have different temperature ranges:

- Two coin cell lithium batteries in the APCT-3 tool are rated to an absolute maximum of 50°C .
- Thermistor has a high temperature coefficient ($\sim 4\%$ per degree change in temperature) from -80° to 100°C .
- Electronics can safely be operated at ambient temperatures from -10° to 60°C .

APCT-3 specifications

APCT-3 tool specifications are as follows:

- ATMEL 8 bit Microcontroller (AT90S2313)
 - 2 Bytes of In-System Programmable Flash
 - 128 Bytes of SRAM
 - 128 Bytes of In-System Programmable EEPROM
 - Programming Lock fo Flash Program and EEPROM Data Security
- Lithium batteries provide 600,000 readings (i.e., continuous operation for ~ 1 week at a sampling rate of 1 s)
- Nonvolatile memory for as many as 65,000 readings, which preserves the recorded data even if there is a total loss of battery voltage
- Real-Time Clock
- 16-bit A/D converter (AD7705BR)
- Aged, glass-encapsulated thermistor (Model YSI 55032)

Limitations

The APCT tool has these limitations:

- Can only be used in soft sediments appropriate for piston coring.
- Can only be used in relatively stable sediments where danger of hole collapse is minimal.
- The upper temperature limit of the tool is 50° C.
- The tool is limited to depths at which the force required on pullout is within safe limits, usually the upper 120 m. This depth limit is somewhat less than the limit for regular APC coring because the sediments will "grip" the corer more tightly during a 10-15 minute temperature measurement than during the much shorter time required to collect a core.
- Cannot be used when high overpulls indicate a risk of losing the tool if the shoe remains in the sediment for a prolonged time.

6.4 Calibration Summary

Overview

All temperature calibrations performed in the IODP-USIO Metrology Lab are comparison calibrations. This means that a very stable and uniform temperature source is applied to both the unit under test (UUT) as well as a temperature standard which has been calibrated and is traceable to an NIST (National Institute for Standards and Testing) temperature standard. The output of the UUT is compared to the output of the standard at several different set temperature points throughout the UUT operational or limited range. These data are collected and archived as the primary calibration data, which may be used to calculate coefficients for various curve fitting equations such as the Steinhart and Hart equation.

Temperature standard

For the APCT-3 tool, the temperature standard is the standard thermistor read with a BlackStack thermometer readout and the temperature source is the 7012 High Precision Bath.

Process

- The APCT-3 is installed in the APC Heat Flow Shoe with an adapter that seals the electronics chamber but allows data communication with the APCT-3 tool
- This assembly is then submersed completely in an oil bath.
- The standard thermistor is submersed in the bath in close proximity to the APCT-3 Probe.
- Ten temperature point data sets are logged and compared between the APCT-3 resistance measurements and the standard across the range of tool operation (0°C to 60°C at near 5°C intervals) but no attempt is made to hold these intervals exactly (i.e. the 5°C point may actually be 4.895°C)
- These data are curve fitted to the Steinhart and Hart resistance to temperature equation and coefficients are calculated.

Additional information

For more information about Calibration contact Dean Ferrell at ferrell@iodp.tamu.edu.

6.5 Development History

Overview

The APCT-3 tool is a third generation temperature tool. Measurements of in situ temperature have been made in oceanic sediments during scientific drilling since before the Deep Sea Drilling Project (DSDP) began (Von Herzen and Maxwell, 1964).

New tools were developed and modified during DSDP (Horai, 1985; Uyeda and Horai, 1980) and during the Ocean Drilling Program (ODP) (Davis et al., 1997; Fisher and Becker, 1993; Shipboard Scientific Party, 1992a), the successor to DSDP.

In some cases, temperature tools were run during drilling programs to resolve specific geothermal, hydrogeologic, or paleoceanographic questions, but in other cases, data were collected during routine operations even though they were not central to primary expedition goals (see summaries of DSDP and ODP thermal studies: Erikson et al., 1975; Hyndman et al., 1987; Pribnow et al., 2000).

Advanced Piston Corer Temperature Tool

Temperature measurement tools in scientific ocean drilling comprise a subset of third-party tool developments (designed, built, and tested independent of the primary scientific operator or its subcontractors) that have contributed to both the success and the enduring legacies of these programs.

One of the most innovative downhole tool developments in the latest years of DSDP was a piston coring shoe with temperature- measurement capability (Horai, 1985; Horai and Von Herzen, 1985; Koehler and Von Herzen, 1986).

This tool allowed DSDP (and later, ODP) personnel to determine in situ temperatures within the undisturbed formation well ahead of the drilling bit without making a dedicated tool run.

These tools have been used successfully in many geological environments to evaluate thermal conditions within seafloor sediments and in open boreholes. Although the piston coring system in DSDP was initially referred to as the HPC, subsequent improvements created an advanced piston coring (APC) capability. A temperature tool run with this system is herein referred to as an "APCT tool." For more information on the APCT, go to the ODP Legacy manual Advanced Piston Corer Temperature (APCT) Tool Operations Manual.

Eight APCT tools based on the design introduced during DSDP were purchased by the ODP science operator (Texas A & M University [TAMU]) in 1984 and were used extensively during the early years of the new program.

All of these tools were eventually lost or damaged over time, and by ODP Leg 117, it was necessary to begin building a new set of instruments. Second-generation APCT tool development was completed

in 1991. This tool system was designed and built on contract by a commercial engineering company, under the supervision of ODP personnel. The new tools were placed on the R/V *JOIDES Resolution* for use during Leg 139 and operated for more than 15 years. The second-generation APCT tools differed from first-generation tools in several important ways.

First-generation APCT tools

The first-generation tools were based on custom-designed and custom-constructed electronics, bonded with epoxy into a form about the size of a small package of chewing gum (*Fig. 6-2*; first-generation tool developed for use during DSDP and used in the first several years of ODP [Horai, 1985; Horai and Von Herzen, 1985; Koehler and Von Herzen, 1986]). A metal probe containing a thermistor extended from the base of the tool, and a separate battery pack was attached with a small connector. Both the tool and battery pack fit into slots milled into the wall of a conventional APC coring shoe.

These first-generation APCT tools were a marvel of technology, especially considering that they were created in the early 1980s, but they were fragile instruments (particularly the connectors) and had to be removed from the coring shoe after each deployment in order to recover data.



Figure 6-2. First Generation Temperature Tool. The logger electronics are on the outside and the battery pack is on the inside of each photograph..

Second-generation APCT tools

The second-generation tools were first deployed during ODP Leg 139 (Shipboard Scientific Party, 1992a) and were designed around a cylindrical tool frame that fit into an annular cavity in the base of a redesigned APC coring shoe (*Fig. 6-3*).

Two prongs extended from the base of the tool frame, one of which contained a platinum resistance-temperature device (RTD); the other prong helped to “register” the tool frame as it was lowered into the annular cavity.

Batteries were contained in two separate packs that fit into the tool frame, and the tool could be programmed, deployed, and downloaded without removing the tool from the coring shoe.

As of winter 2003, many of these second-generation tools had been lost or damaged, and the company (Adara) that had built and serviced these tools had gone out of business. These tools were called the Adara Temperature tool on the ship and by ODP staff. When the company went out of business, ODP changed the name to the APC Temperature (APCT) tool.

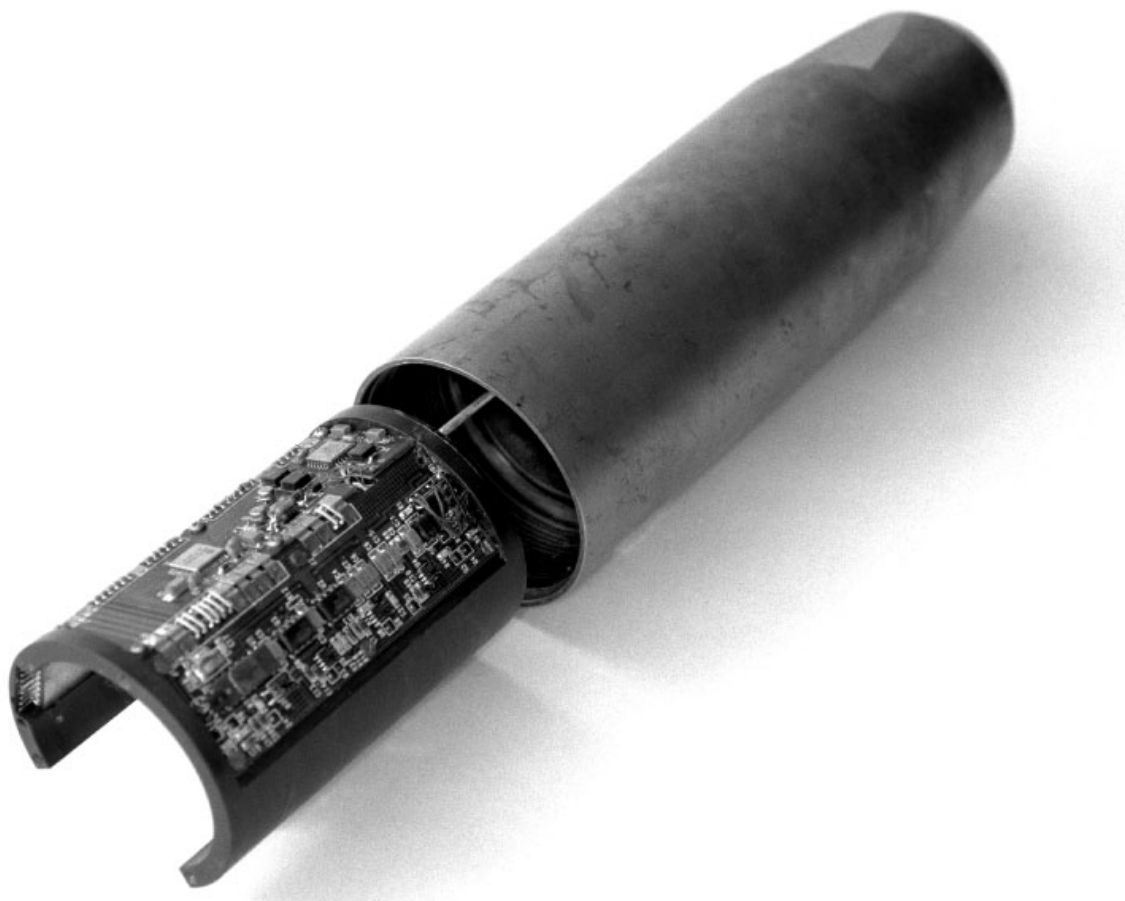


Figure 6-3. Second-generation APCT tool.

Third- generation APCT tools

Development of a new generation of APCT tools began simultaneously at ODP and by scientists interested in obtaining downhole temperatures.

The ODP version was not finished, but the version that began in 2003, with support provided by the German Science Foundation (to H. Villinger, University of Bremen) and the U.S. National Science Foundation (to A. Fisher, University of California, Santa Cruz) was completed in close collaboration with Fa. Antares (Stuhr, Germany) and was called the APCT- 3.

Fa. Antares had previously collaborated with H. Villinger and colleagues on development of a Miniaturized Temperature Logger (MTL) project for use with collection of thermal data during conventional gravity- and piston- coring operations (Pfender and Villinger, 2002; Jannasch et al., 2003).

In an attempt to differentiate between the discontinued ODP design and the Antares-Villinger-Fisher versions, the ODP version was called the APCT-2.

Hardware designs

Hardware designs were discussed through 2003 and into 2004, and it was decided to retain as much as possible of the form and function of the second-generation tools, which had proven to be robust and easy to operate. Designs for coring components were prepared by engineers working with the U.S. Implementing Organization (USIO) to IODP, and new coring components were built by an established vendor.

Antares personnel created a series of prototype tool frames so that the fit into the coring components could be confirmed and produced a working prototype tool in advance of IODP Expedition 311 (Cascadia margin gas hydrates). APCT-3 tool project co-primary investigators and colleagues worked closely with Expedition 311 researchers, who calibrated and field- tested the prototype tool, which worked extremely well and generated useful thermal data (Heesemann et al., 2007).

Post Expedition 311 design changes

On the basis of this experience, project researchers requested several important design and functional changes to the APCT-3 electronics, and Antares personnel responded by producing redesigned tools in Spring 2006. These instruments were taken to the Hydraulics Laboratory at the Scripps Institution of Oceanography in summer 2006 and calibrated across a working range of 0°–45°C (see Metrology Lab Operations Manual-in process) for a discussion of calibration procedures and examples of results from the 2006 calibration effort).

Dual deployment (OM0700)

The APCT-3 tool was originally designed to deploy two sets of electronics, with a sensor-to-sensor spacing of approximately 57.2 cm (22.5 in). The upper Electronics Support Frame is housed in the the Upper Thermistor Housing (OM0702), which Fisher et al. (2007) calls the Upper Tool Sub.

Although the annular cavities of the Upper Thermistor Housing (OM0702) and Heat Flow Coring Shoe are identical (allowing the same Electronics Support Frames to be deployed in either location), other geometries of these components are significantly different (see Fisher et al., 2007). IODP has not used the tool with this configuration as of Nov. 2010; drawing OM0700 shows the dual deployment configuration (see **Drawings in Cumulus**).

6.6 Failure Reports

Overview

This chapter provides a list of APCT-3 failures during IODP.

Expedition 315

NanTroSEIZE Stage 1 on the Chikyu, Nov. to Dec. 2007.

APCT Problem	Solution/Theory	Source
Tool stopped working	Chikyu 1 failures on the chikyu capacitor came off and was replaced. Tool worked after that.	D. Ferrell
Tool lost	Operational failure:core barrel was stuck and broke off while trying to get the pipe unstuck.	D. Ferrell

6.7 Vendors

Ancillary parts, seals, fasteners, and supplies (OD)

Vendors and contact information for tools with ODP category OD are:

Vendor Name	Address	Contact	Phone/Fax
Acetylene Oxygen Company (AOC)	812 S. Bryan, Bryan TX 77803	Charles Sanders	P: 979-779-7154 F: 979-822-5316
Capitol Bearing Service	1136 Finfeather Rd, Bryan TX 77803	Juan Gutierrez	P: 979-822-2425 F: 979-779-9318
McMaster Carr Supply Co.	6100 Fulton Industrial Blvd. Atlanta GA 30336	—	P: 404-346-7000 F: 404-349-9091

Core bits (OC)

Vendor contact information for core bits (ODP category OC) is:

Vendor Name	Address	Contact	Phone/Fax
Ultrerra Drilling Technologies.	7601 Will Rogers Blvd. Ft. Worth TX 76140	Brian Hilburn	P: 817-293-7555 F: 817-551-0823

Core liner (OP3400)

Vendor information for core liners (ODP category OP3400) is:

Vendor Name	Address	Contact	Phone/Fax
Anaheim Custom Extruders	4640 East Lapalma Anaheim CA 92807	Angie Rivas	P: 714-693-8508 F: 714-693-9531

Springs

Vendor information for springs (variable ODP categories) is:

Vendor Name	Address	Contact	Phone/Fax
Coiling Technologies, Inc.	7777 Wright Rd. Houston TX 77041	Talon Turner	P: 800-969-2645 F: 713-849-2645

Machine shop tools (OP/OJ)

Vendors and contact information for tools with ODP categories OP and OJ are:

Vendor Name	Address	Contact	Phone/Fax
Accurate Machine Technologies, LTD	4400 Pate Road Coll. Station TX 77845	Andy Ngai, Ralph Wren	P: 979-774-0062 F: 979-774-7412
C & M Machining, LTD	5898 FM 3455 Navasota TX 77845	Charlie and Mike Pasket	P: 936-825-8139 F: 936-825-6690
Langham Creek Machine Works	4408 D. Joyce Blvd. Houston TX 44084	Ricke Boyle Sr.	P: 281-550-9587 F: 281-550-9412

Welding and fabrication (OH/ OJ)

Vendors and contact information for tools in ODP categories OH and OJ (funnels and reentry cones) are:

Vendor Name	Address	Contact	Phone/Fax
Brazos Industries, Inc.	1640 Shiloh Ave. Bryan TX 77803	Kenneth Kleckley	P: 979-775-9433 F: 979-823-1439
Rick-Mar Fabricators, Inc.	400 Stone City Dr. Bryan TX 77801	Vince Neal	P: 979-779-1616 F: 979-822-0540

APCT-3

Vendor Information for the APCT-3 system is:

Vendor Name	Address	Contact	Phone/Fax
ANTARES Datensysteme GmbH	Rudof-Diesel StraBe, 28816 Stuhr, Germany (NOTE: GERMAN B) 6-8		P: +49-(0)421-871940 F: +49-(0)421-8719425
Hart Scientific	799 E. Utah Valley Drive, American Fork, UT 84003-9775		P: 800-438-4278 F: 801-763-1010
Machine Works (shoes)	1590 B Harvey Mitchell, Parkway	Dave Weber/James Dworacz	P: 979-775-5841 F: 979-823-4238

Hammer drill

Vendor information for the Hard Rock Reentry System Hammer Drill is:

Vendor Name	Address	Contact	Phone/Fax
SDS Digger Tools	49 Vulcan Rd., Canning Vale 6155 Western Australia	IODP: Michelle Strickland	979-845-9320

6.8 References

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6.9 APCT-3 Assembly Drawings

Overview

The following assembly drawings are available in Cumulus (TechDoc > Engineering > IODP Operations Manuals > APCT-3 >APCT-3 Drawings):

- OM0800 APCT-3 assembly
- OM0830 Frame Extraction-Insertion tool
- OM0720 Electronics Support Frame
- OM0700 Dual Deployment Configuration (title is Assy-Heat Flow Catcher Sub-APCT-3)

Note: Antares has not released the Electronics Support Frame assembly.

7.0 APCT-3 Revision Log

Revision data

Revisions to the manual are recorded in this table. Please include the page, section, or Chapter number(s) in the Revision Details:

Revision Date	Authority	Page	Revision Details
Nov. 2011	Ferrell	2-3	Changed reference to Chapter 9 to Chapter 6.
Nov. 2011	Graber	Ch 7	Added Revision Log to manual.
Dec. 2013	Graber	1-1	Fixed Intro page number and added revision chapter to chapter list.
Apr. 2015	Graber	2-5	Made correction from 1.5 V lithium to 1.3 V lithium and changed series to parallel in same paragraph

Credits

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