Chapter 6 Electrical Systems

Overview

There are two electrical systems on the boat:

- 120V (volt) alternating current (AC) from the shore power, generator, or inverter.
- 12V direct current (DC) from the batteries.

The only place they are interconnected is in the battery charger or inverter.

Sorry if the following is too basic and wordy. You know the expression – "ask an engineer the time, and he'll tell you how a watch works"...

The batteries are kind of like those large raised water towers that every small town has (or used to have):

- The amount of water in the tank is like the available energy in the battery.
- The water pressure is like the voltage (V).
- The amount of water flowing at an instant in gallons is like the current in Amps (A). The capacity is more useful when related to time, and thought of as gallons-per-hour. For the same reason Amp-hours (Ah) is the measure of capacity of a battery over time.

As more water is drained from the tank, the pressure falls. As more Ah are drained from a battery, the voltage falls (though the change is subtle, as a fully-charged battery is 12.8V, and a discharged one is around 12.0V).

The water pipes are like the wires in a circuit. The larger they are, the more gallons (or amps) can flow through them.

Unfortunately this comparison is not exact. There are a few crucial differences:

- A water tank can be completely drained, but when a battery gets below about 50% of capacity the voltage tends to fall so there is not enough 'pressure' to move electricity around the circuit. You risk damaging the battery and shortening its life drastically if you go below this level.
- There is not a linear relationship between Amps and time, because the more Amps you take from a battery, the lower its capacity. As an example:
    - A 200Ah battery will probably provide 1Amp for about 300 hours, but if you tried to try to draw 200A it might only last 30 minutes.
    - Batteries are usually rated at the '20 hour' level, so a 200Ah battery is actually rated to provide 10A for 20 hours.
- When recharging a battery, it's similar to pumping water up through the bottom of the tank. The last 10-15% of recharge takes a much longer time, because the charging current tapers down as the voltage of the battery rises.
- Lastly, electrical circuits need a return path (the negative circuit), where water doesn't….

Each stock 4D battery has a capacity of about 200 Ampere-hours (Ah). This means that there is a total of 400 or 600 Ah in the house bank (depending on whether you have 2 or 3

batteries), and 200Ah in the engine start battery. However, only around 50% of that capacity is usable. Effectively we can get around 200Ah from the standard house bank of two 4D batteries.

Manufacturer
Most of the electrical switches, panels and fuses are from Blue Seas Systems
425 Sequoia Dr
Bellingham WA 98226
360-738-8230
www.bluesea.com

Battery Power / DC

Batteries

American Tug use only AGM (Absorbed Glass Mat) batteries. These are closed cell batteries. You do not need to add water to the cells as you would for a lead acid battery. A good thing too, as there is limited clearance above the batteries.

Each battery is installed in an individual 'Blue Seas' plastic battery box, under the tank room floor. The following batteries are installed on an AT34:

- One 4D AGM deep-cycle battery that supplies engine starter, and also the bow thruster and windlass. Located on the starboard side of the tank room.
- Two 4D AGM deep-cycle batteries that supply the 'house' circuits (basically everything else). Located on port side of tank room.
- One smaller Group 24 AGM battery that is connected to the generator *only*. Located on the starboard side of the tank room (with the exception noted below).
- If the factory inverter option was installed, a additional 3rd 4D AGM house battery is on starboard side of the tank room. To make room for this, the generator battery is moved into the engine room, and installed next to the generator.

There is a voltmeter on the DC side of the electrical panel, with a switch to select a battery. On my boat, and every other American Tug I've worked on:

- Battery #1 is the house bank
- Battery #2 is the engine start battery
- Battery #3 is the generator battery

My house batteries lasted 4 years, and the experience of another owner at the East Coast Rendezvous was about the same. The symptoms were a failure to hold a charge, and the voltage collapsed (to less than 11.5V) very quickly under discharge.

We replaced ours with Discover 4D AGMs which are rated at 240 Ah, versus the 200 Ah which was the rating on the batteries that were on our boat. The website for Discover batteries is www.discover-energy.com. We also added a third battery to our house bank and switched out our 40Amp battery charger for a 130Amp charger/inverter.

The engine start battery is very over-sized for the purpose, and is only lightly discharged and charged. I'm still using the original one, and it should last a long time with this light usage – I hope.

The generator battery is also lightly loaded, and should last a long time.

Selector switches

These are under the pilot house seat. They are Blue Seas switches. The exact model has changed on later boats, but the functions are:

- Rotary switch for the Engine Start Battery. Should be left **ON** to start the engine, or operate the windless or thruster. This is the forward-most rotary switch on our boat.
- DC Main 100AMP Circuit Breaker for all the House power– feeds electrical panel and all breakers on DC side. Should be left **ON** to operate any 12V circuit. I think this has been replaced with a rotary switch on later boats.
- Emergency Parallel rotary emergency combiner switch. Manually connects the engine and house batteries together. Should be left **OFF**.
- 'Always-on' circuits – a 30A circuit breaker that feeds bilge pumps, propane detector, CO detector and tank level guages. This connects directly to the house battery, bypassing the other circuit breakers. Should always be left **ON** at all times.

We added a toggle cover to the DC main breaker after I accidentally brushed against it, and all power to the panel was turned off….

It's a Blue Seas toggle switch cover – the same as on the shower sump pump switch.

Combiner

An automatic battery combiner is installed on the forward bulkhead of the tank room, protected by 150A circuit breakers. This device is basically an 'electronic relay' which connects the engine start and house batteries together when the voltage is greater than 13.3V, and disconnects them when the voltage is less than 13.3V.

Why, you may ask?? Read on ……

Battery Management

Battery Charging

Any long-time boaters remember those Battery Selector switches with OFF-1-BOTH-2 positions?? The idea was that you switched to BOTH when the engine was running to charge both batteries, then switched to 1 or 2 overnight to save a full battery for starting the engine.

Well, forget 'em, because they were trouble. People would leave them on BOTH and discharge all the batteries overnight, or your dumb Brother-in-Law would switch them when the engine was running and fry the alternator…..

Tomco has designed a much better system:

- The alternator is connected directly to the engine start battery. When the engine is running, the alternator is producing over 13.3V, which is enough to close the Combiner. This means that both batteries are connected together, and they're both charged.
- When the engine is stopped, the battery voltage slowly declines. It will drop below 13.3V, and the Combiner will open. (You can sometimes hear it 'click'). Now the batteries are separate, and all the drain comes from the house batteries only, reserving the start battery to get the engine started again.
- The battery charger is wired directly to each battery, and charges them separately.

The Battery Combiner is protected by two 150A surface mount circuit breakers: one on each side of the combiner. If either of these trips it will prevent the house battery from being charged by the engine alternator. This has been known to happen, and the first sign is usually very low house battery voltage.

These breakers are located on the tank room bulkhead, one is on the right in front of the engine battery, the other is on the left in front of the house batteries The breaker is not the typical panel type - it is a square block with a large wire terminated on each side.

There will be a red button on the unit, push that button, as you push a small black lever will move on the side, which actually connects/disconnects the power.

Richard Gray (AT34-087 "Gray Dawn" had a low-voltage problem:

> "I was reading 13.1 volts at the Cummins smart panel and about 11.5 at the meter. Turns out that the combiner breakers were working but the sensitivity was set for 13.5 for the combiner to feed into the house batteries. Testing the alternator showed only 13.1 volts produced, within the Cummins specs, but not good enough. We replaced the alternator and everything works!"

Emergency Power

What if there isn't enough power in the engine battery to get the engine started??

This is the bit in 'Star Trek' when the little red-shirted Scottish engineer says "Cap'n, a canna give yer any more power." However, Kurt is smarter than Scottie, and has provided two emergency solutions:

1. Manually connect the engine and house batteries together by turning the Emergency Parallel rotary switch under the pilothouse seat to ON.
2. Start the generator and use the battery charger to charge the batteries.

Generator Battery

The generator has its own dedicated battery, that is used to start the generator only, and *nothing else*. It is deliberately isolated from all the other circuits – see the 'Emergency Power' section for the reason.

It is recharged by its own 12V charging circuit in the generator.

If you don't run the generator for a while (over the winter for example) there is another way to charge this battery. There is a switch (or circuit breaker on later boats) in the tank room fwd bulkhead that connects the generator battery to the battery charger.

This should normally be left off, because if you ran the generator *and* the battery charger at the same time, the generator battery would have 2 competing charging sources - and that would not be good. It would probably not get charged by either.

Fuses and Circuit Breakers

Now this is how a boat should be wired !

There are seven basic types of fuse or circuit breaker used:

1. Circuit breaker switches in the electrical panel. Re-settable, and various ratings from 5A to 30A, mostly 10A and 15A. The same type of breakers are used for DC and AC. Made by Blue Seas or Cole-Hersee.
2. Small 2 inch square surface-mount circuit breakers mounted to the bulkhead. Made by Blue Seas, and only a few of these, and various ratings around 150A.
3. AGC fuses – those 1/4in round glass fuses with a metal contact at each end and a wire running between them.
4. ATO/ATC fuses - colored plastic blade fuses with 2 downward-facing blade contacts. Different ratings have different colors.
5. Maxifuse – looks like the ATO/ATC fuse, but larger. Not many of these.
6. Large Class T fuse. About 3 in long and expensive. Only one of these, for the bow thruster (and maybe one for an inverter, if fitted).
7. GFCI circuit breakers. There are GFCI (ground fault circuit interrupter) breakers on the first outlet in every circuit of 120V outlets. These are the little red and black buttons on the outlet. These GFCI breakers protects all outlets that are downstream of that outlet. If an outlet stops working, you may need to reset the GFCI breaker on that outlet or the one upstream of it with the breaker.

Every individual electrical circuit has its own breaker or fuse:

- Each switch on the electrical panel is a circuit breaker for that circuit.

- Switches on the dash have AGC fuses, under the little gray circular plug next to each switch. These seem to be 2Amp, 5A 10A.
- There is a distribution box inside the electrical panel for the push-button multiplexed light circuits (boats up to around hull#50 only). It has many ATO/ATC fuses of 5A and 10A
- There is a small distribution box under the console (fed through the 'always on' breaker) with ATO/ATC fuses for the bilge pumps and CO detector. You have to pull out some of the gauges on the console to get at it. On newer boats, the console is hinged for better access.
- There is another small distribution box under the console with ATO/ATC fuses for the navigation electronics.
- A few circuits have in-line fuses
    - The stereo has a 2A AGC fuses on the tank room fwd bulkhead wired directly to the power busbar
    - The voltmeter has a 2A AGC fuses at each battery positive terminals, inside the battery box
    - The davits (if fitted) have 30A Maxifuse on the forward tank room bulkhead.
- There's a honkin'-great 400A Class T fuse in the engine room on the starboard side of the engine on the stringer for the bow thruster and windless.
- There are two 150A surface-mount circuit breakers on the tank room bulkhead for the battery combiner, and probably another there for the generator battery disconnect. There is another 150A surface-mount breaker is on the starboard side of the bed for the anchor windless.

If there is a short circuit, it should just blow the fuse for that circuit. If one item stops working, then check the circuit breaker or fuse for that item.

In addition, there are 'high-level' fuses for multiples of these circuits, just in case. For example, the 100A DC main breaker under the pilothouse seat protects all the house circuits in addition to the individual fuses.

Battery Charger

The standard battery charger is a Xantrex Truecharge 40 charger, which is nominally capable of producing 40 amps. It is wired to each of the 3 battery banks.

http://www.xantrex.com/

I never saw more than 25A from mine. This proved to be inadequate for longer term cruising and anchoring-out, as it took too much generator time to recharge the batteries. However, it is an excellent long-term shore-power charger, because it has an advanced 3-stage regulator that resets every 21-days to keep batteries fully-charged.

I replaced it with a Xantrex Freedom 2500 Inverter/Charger, which has a 130A charger. I get in excess of 100A from this charger, slowly tapering-down as the batteries get charged. It has reduced our generator run-time to about 1 to 2 hours a day.

Engine Alternator

The 105A Delco alternator on the Cummins engine only really delivers 40-50A at most, and that rapidly tapers down to 10-20A as the battery voltage rises. The standard regulator built-in to it is not really optimized for deep-cycle battery charging – it is designed for trucks, and to prevent over-charging the batteries.

Don't depend on the alternator to keep your batteries charged, unless you replace the internal regulator with an external 3-step regulator (like a Xantrex or Balmar). The alternator must be modified to include an external Field wire for this regulator.

Randy Guzar (AT34-95 “heart Tug”) reports good experiences with this modification, which has reduced genset usage considerably.

On the Cummins engine, it’s a good idea every year to take the Beltguard off the front of the engine and check that serpentine belt closely. Note how it’s routed, remove it, and spin all the pulleys checking for rough bearings. I just did mine after hearing a *tiny* squeal at start-up. The old belt had done 2131 hrs in 3 1/2 years, and had a couple of tiny loose chunks.The engine manual has instructions for belt removal/replacement, and pictures of good and bad belts.

AT41 (actually Volvo engine only AT41s)

There are issues with the dual-alternator installation on the Volvo engine in the AT41. The mounting bolts break, and the disable the entire engine…..

From Shawn Severn (Ocean Mistress AT41-xxx): The reason that the bolts keep breaking is probably due to damage on the plate that is on the engine leg and holds the second alternator. When the forward bolt comes loose, the motion of the alternator against the plate causes the plate to become worn and grooved. It is very evident on mine. No amount of muscle power will be able to put the bolt on tight enough so that it won't come loose and break. The perpendicular force on the bolt must be very large and with the vibration it is doomed, especially once the plate is damaged. You may also find that you are starting to chew up belts. That is because the #2 alternator is no longer aligned quite properly.

To use the single alternator will need about a 1/2 inch spacer on the engine sprocket to use the shorter belt, otherwise it will not fit. I had a part machined while I was in Campbell River. It isn't pretty but has worked well so far. You might consider going to the single alternator until you back south. It does not sound like you will be able to solve your problem up north.

I can also tell you that switching to the single high output and regulated Balmar has worked spectacularly well for me. It comes with a regulator and it seems to detect the generator because it drops the output to the house side. It also detects battery condition

and adjusts the voltage accordingly. I think in the long run it will keep the batteries in better shape.

Shore Power / AC

East Coast and West Coast boats

When my boat was built there were 2 basic options for American Tugs

- 'East Coast' boats were built with air conditioning, electric stove, and two 30A shore power connections.
- 'West Coast' boats were built with a diesel heater, propane stove, and one 30A shore power connection.

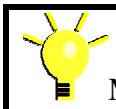
Of course, hybrids were ordered: In fact "Tardis" has air conditioning, a propane stove, and two 30A shore power connections. We love this combination!

Shore Power Connections

These are located in the port side of cockpit.

Shore power one is on top, shore power two (if fitted) is second and the bottom connector is for cable TV and phone.

Make sure the plug fits securely in the socket, and is turned 1/8 clockwise to lock, before the screw ring is tightened.



Mark the top of the plug with a permanent marker, so you can easily align the plug in the socket: the 30A three-prong plugs only fit one way.
This avoids experimenting, or bending down to look at the socket.

The primary 30A circuit breakers are behind the settee back, towards the stern. There are one or two breakers, depending on how many shore power connectors are fitted.

From these primary circuit breakers the wires go through a conduit down the port side of the boat, exiting in engine room. They are routed up along the engine room overhead along the port side to the forward engine room bulkhead. From there they go up to an access hole to the electric panel which is located in middle of the pilot house.

Kurt has suggested that owners with boats configured with air conditioning should check their power cord connections and plugs frequently, as air conditioning puts a heavy electrical load on the connections.

A few years ago I chartered a sailboat, and during the check-out they insisted on a procedure for connecting and disconnecting the shore power. I thought it was a little too

anal-retentive at the time, but it makes a lot of sense – and it's the process we follow on our boat:

Connecting

1. Plug in the cord to the boat
2. Plug in the cord on the dock
3. Turn-on the power on the dock
4. Turn on the Main breaker on the boat, and check the Reverse Polarity light
5. Turn on the individual breakers required

Disconnecting

1. Turn off the individual breakers one-by-one
2. Turn off the Main breaker on the boat
3. Turn-off the power on the dock
4. Unplug the cord from the dock
5. Unplug the cord from the boat

The idea is to minimize the electrical load switched by any circuit-breaker and (more importantly) reduce the risk of electrocution. I've seen people plug-in a power cord on the dock, then step onto the boat holding the live cord. If they fell in the water……

Shore Power 1

Shore power one always feeds main set of AC breakers in the electric panel. There is a source selector switch with a sliding lockout that allows you to select either Shore 1 or Generator – but not both. There is also a reverse polarity light and a Voltmeter and an Ammeter. Shore power 1 feeds:

- Battery charger
- Water heater
- Outlets 1 – this includes all outlets forward of the electrical panel. (e.g. Outlets in pilot house are on this breaker). It also feeds the baseboard heater in the stateroom.
- Outlets 2 – this includes all outlets aft of the electric panel. (e.g. Outlets in engine room are on this breaker). It also feeds the baseboard heater by the salon door.
- Microwave
- Electric Stove (if fitted)
- Inverter (if fitted)
- Ice maker (if fitted)
- Washer/Dryer (if fitted)

Shore Power 2

On boats with air conditioning, shore power two feeds a separate shore power panel. There is a source selector switch with a sliding lockout that allows you to select either Shore 2 input or Transfer (from Shore 1) – but not both.

There is no reverse polarity light or meters on Shore Power 2.

The panel has 3 breakers, for the two air conditioning units and the shared air conditioner water pump.

If you are using only one 30 amp supply and the Transfer Switch, you need to be careful with power consumption as the small air conditioner uses 14 amps and the large air conditioner uses 18. We can usually run one air conditioner, but not both, with only one shore power cord, as we're also usually running the battery charger, and maybe appliances.

As we plug-in to many different marina power circuits, I use a Marinco electrical tester to check the power before I bring it onto the boat… It looks like a 30A plug, but has test lights built-in to warn of bad connections.

In 4 years of using this, I've never found a problem…

Power Management

It is *very easy* to overload the shore power circuits, and draw more than 30A.

We find that the circuit breaker(s) behind the settee trip tend to first, well before any on the dock power outlet.

The small air conditioner uses 14 amps and the large one uses 18 amps. The microwave uses 10 amps, and a coffeemaker around 8amps. An electric stove uses 8.3A per element and 11A for the oven. Adding these up, you can see that it's easy to exceed 30 A on one shore power circuit. Even plugging-in the second 30A cord (on air-conditioned boats) won't help much, as this power is dedicated to the air-conditioners only.

To help manage power, we try to:

- Watch the Ammeter closely! If it gets near 30A (when on shore-power) or 40A (when on generator) reduce the load by turning something off.
- Start-up the biggest appliances first, as some (like air conditioners) have a high initial startup surge.
- Try to stagger appliance usage, eg. turn-off the air-conditioner when using the coffee-maker.

The Onan 5kW generator produces about 42 amps. (Amps = Watts/Volts, 5000/120 is approximately 42).

The Northern Lights 6kW generator produces around 50 amps, and the 8kW around 67 amps.

Galvanic Isolators

All boats have one or two galvanic isolators inside the electrical panel (one per shore power cable). Newer boats have a 'self-test' status display next to the battery switches under the pilothouse seat.

Older boats don't have this self-test function, and the isolator should be periodically tested/checked by a marine electrician.

You can also check it yourself, as follows:

1. You need a multimeter with a 'Diode Test' function. Work carefully and slowly here - shore power is a deadly thing….
2. TURN OFF ALL AC POWER. That means at the panel AND unplug the Shore Power cord. If you have an Inverter turn that off AND disable its battery connection if possible.
3. Remove the 2 screws and hinge the Electrical Panel open. Isolator(s) are on the port side.
4. Boats with air conditioning have two isolators (one per shore power cord). Boats without air conditioning only have one.
5. Connect the meter to each isolator and measure the voltage drop using the diode test function. It doesn't matter which way you connect the leads - you have to do it BOTH ways anyway.
6. There is an internal capacitor, so the voltage reading rises slowly. It should stabilize in the range 0.7-1.4 Volts(approx). My Guest Isolator manual says 0.7-0.8 Volts DC, but its very meter-dependant. Consistency is more important, and it should not be zero or > 1.5V (or so): both of mine were 1.04V each way.

Inverter

If a factory inverter option was installed, then an additional three position inverter-supplied shore power panel is installed. The microwave, outlet 1, and outlet 2 breakers are moved to this panel, and can be fed from the shore power, the generator, *or* the inverter. The electrical strip heater circuits are split off from the outlets, and have their own circuit breakers so they cannot be powered from the inverter.

In addition, the factory installs an additional 4D AGM house battery, and a Link10 meter to monitor the power consumption.

Some dealer-installed and aftermarket inverter setups are not as well engineered. They take short-cuts and install the inverter in-line with the shore power circuit.

The problem is that unless you carefully monitor which circuits are used, the inverter can be used to run the high-demand devices like the water heater and air conditioning! That will drain and damage the house batteries very quickly, and probably overload, overheat and damage the inverter.

The Tomco factory installation is engineered so that *only* the microwave and outlets circuits can possibly be run from the inverter.

Interior Lights

Bulbs

The interior dome and reading lights use small 12 volt type T halogen bulbs, with a 2-pin G4 base. The maximum recommended rating is 10W, due to the heat produced.

These are readily available at Wal-Mart, Home Depot etc.

After the refrigerator, the interior lights are the largest users of electrical power.

Relay controlled system

AT34s up to around hull 50 were fitted with a low-voltage relay controlled light system by Advanced Digital Systems (now Carling Technologies). It's recognizable by the black light switch panels with small push buttons and lighted red labels.

The system has a bank of small ATO/ATC fuses and a central control unit behind the electrical panel. The little push-buttons send low-power signals to the controller, which then switches power to the light circuits. Check these fuses, as well as the bulb(s) if any individual circuits fail. The system is also voltage-sensitive: if the house batteries fall too low, all the red lights start flashing. One fix is to 'reset' the system by turning the main power circuit breaker (under the pilothouse seat) off and back on.

They're trouble-prone - at the east coast rendezvous Kurt quoted a 2 to3 year life expectancy, and they are no longer supported by the manufacturer. Kurt has designed a Tomco-built replacement, and will sell it to us at cost-price if necessary. It includes new switch pods, wiring and control panel, and installation may be time-consuming. Contact him for details.

Later boats have a more conventional system, recognizable by banks of rocker switches. The only reported problem with these is accidental switching when someone leans against the switch panel.

Navigation Lights

Anchor light

As an AT34 is less than 12 meters in length, the same all-round white light can be used for both anchoring and under power.

AT41 AT41s are more than 12 meters (39ft) in length, so must have separate white masthead and stern lights.

My boat came with a Perko 2-bulb light, that had two 10 watt bulbs in it (one facing forward, one facing aft). The bulbs kept blowing, and used 2A altogether, which is quite a lot for an overnight anchor light.

Newer boats have an LED light which uses a lot less power. I replaced mine with a Perko 1340DP1WHT LED version. It uses 0.1A total (which is nice) but cost around $140 (which is not). The same unit is available with a black housing as 1340DP1BLK.

It bolts right on to the radar mast fitting, but Tomco run 2 positive wires up there (1 for each bulb), and a negative. You need join both positive wires to the LED unit when you install it.

The only downside to these LED lights (apart from the price, of course) is that they are about 2-3" taller than the original, so they do raise the bridge clearance requirements a little.

Running Lights

I bought replacement 'bulbs' (actually LEDs + electronics encapsulated in a bulb-sized unit) from superbrightleds.com.

http://www.superbrightleds.com/

I ordered both white and Red/Green versions of the bulbs (4211 LED Festoon bulbs), for about $2.00 each. The red and green ones (in the appropriate sides of course !!) are brighter, and draw less power. Only thing to watch is the polarity - the 'bulb' only works one way.

Tank Level Gauges

Manufacturer

Tomco installs a customized ‘Tankwatch 8’ system from Snake River Systems up to 2008 (approximately). It is a 7 X 3 in black panel marked 'Tank Systems Monitor', with an on/off switch, and Up/Down and C(alibrate) buttons.

This was then replaced with a similar system from New Providence Marine Systems. This company was actually started by former employees from Snake River, and the systems work the same way, are probably somewhat compatible with each other.

http://www.snake-river.org/

New Providence Marine

The systems are capable of monitoring up to 8 separate tanks, but only used for 4 on our boats:

- Port and Starboard Fuel Tanks
- Fresh Water Tank
- Waste (Holding) Tank

They are pretty unreliable: most Tugs have at least one tank level (usually the holding tank) not functioning.

The problem is usually in the sender unit. This is a tube (metal in the metal tanks, PVC in the plastic holding tank), that is inserted thru a small hole in the top of the tank, ending just above the bottom of the tank. The tube is totally sealed from the surrounding liquid.

The control unit sends pulses of low voltage alternating current thru the sensor and then measures the change in capacitance caused by immersion in a liquid. This electrical signal is then translated into a display of a number of 'bars'. It depends on the gauge being properly calibrated 'Empty' and 'Full' to infer the liquid level between these two points.

(I think some of the later systems use a foil stuck to the outside of the tank, but I have no experience with them).

The sensor tube is easily coated with 'stuff' (especially in the holding tank!) which then gives misleading results. There is minimal clearance to remove the fuel and water sensors from those tanks for cleaning, but the good news is that the more problematic holding tank sensor is easy to remove.

Calibration

To calibrate the sensors, scroll up/down to the appropriate tank, then press the 'C' button.

You get a calibration display, and press 'UP' for 'Full', 'DOWN' for 'Empty' or 'C' to quit. Then a Microsoft-like 'Are you sure?' display, and press 'UP' for 'Yes.'

That is it, at least for the Snake River gauge. The New Providence Marine Systems are harder to calibrate – at least for the fuel tanks. John (AT34-115 "Breezy Spirit") reports:

> Last summer, we recalibrated all of the tanks, four tanks. Water and holding tanks went fine, but the two fuel tanks were never the same again. They were always off.
>
> We were in LaConner for some service work, and I happened to mention this issue to Kurt. He said that the two fuel tanks can't be recalibrated by the owners easily, and I shouldn't have done it. He sent a tech down to the boat and he went through a lot of key sequences and got it put back the way it should.
>
> Kurt said the fuel tanks should not need calibration. The sensors are different than the water and holding tanks. If I ever need to change it, I should get the tech on the phone, and he/she will walk me through it. Water and holding tanks are no problems, and I can recalibrate it as often as I like.

It is more accurate if you can calibrate both empty AND full, but that is hard to do for the fuel tanks, easy for the water tank, and kinda-easy for the holding tank – see the following text.

Diagnostics

First though, before calibrating anything, there are some preliminary diagnostics you can do. This information applies to the Snake River gauges – I'm not sure how the later New Providence gauges work.:

- Press and hold the Up and Down buttons, and turn the panel ON. It should do a system memory check and report 'Flash Memory Good'. Turn it off - don't press any buttons or you might lose calibration. If you get any other display, it is time to call Snake River.

- Press and hold the 'C' button and turn the panel ON. It should display the raw sensor data in the format of 'Channel x Live Diag' and a 3-digit number. Later versions also display the ‘Full’ and ‘Empty’ values of this number.

This is the raw sensor data, and the value should be:
0-50 for an empty tank and 150-200 for a full tank.
Depends on the fluid level, and what kind of fluid it is....
This value is then translated into 'bars' by the control panel. Scroll thru the channels (goes up to 8) - they are in the same order as normally displayed (mine go Port fuel / Stbd fuel / fresh water / Waste tank).

If the raw number is out of the range, or seems unrealistic for the known tank level, the sensor is bad or the wiring may be bad.

- Turn the gauge ‘Off’ then ‘On’ again to return to normal mode.

Cleaning the Holding Tank Sensor

Now for the nitty-gritty. On the AT34 the sensor is easy to access under the drawers at the foot of the bed.

AT41 On the AT41 it is under a access panel in the floor.

Remove the two port drawers under the bed, and there is a 12in round access port. remove that (2 screws) and the sensor and wiring is right there.

Isn't that nice of the Kurt-man to engineer that ? - makes a nasty job a little nicer. Actually, *all* the ports and sensors on *all* the tanks on our boats have access hatches over them. He da Man.
Removing the drawers is the hardest part of the whole process. As for all the AT drawers, remove the contents, then pull it all the way out, then find the little black lever on the end of the slides. Push one up, and the other down, and pull the drawer out. On these drawers, however, there is not enough room to pull them out, so you have to push the slide back instead...

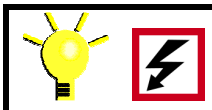
Disconnect the 3-wire electric plug (it only goes back one-way), and unscrew the sensor (a big 1 1/2in plastic nut). Wriggle it out of the tank (it’s a tight fit) and drop in a HazMat bag (or a plastic baggie....). Its probably pretty nasty, and coated with ‘stuff’….

Clean it up, then test the system by reconnecting the wire and putting it in a disposable container (I used a milk jug). Er - don't use anything you'll be eating out of later.....

Calibrate it empty, then fill the container (with water!) and calibrate it full, then test it with the container partially full. I had to calibrate empty, then full, a couple of times, before it 'took'.

Re-assembly is the reverse, as they say. You'll need a little thread-seal or plumbers teflon-tape on the threads to seal the sensor.

I find that pulling one slide out an inch or two enable you to line-up the drawer better. That’s it. Have a shower and a beer, in that order.



Jim Minozzi (AT41 'Peregrine') has successfully replaced his senders with SSI fluid-trac, ultrasonic senders (also used by SeaRay), which work with the Cummins smart craft panel, and graphically display fuel tank levels.

Wipers

Several different wiper arm and dashboard switch systems have been used on AT34s, but all seem to be from Imtra.

www.imtra.com

My boat has three control separate knobs in the pilot house navigation station, one for each wiper. I've seen integrated electronic units on newer boats.

An interval-control option is important, especially in salt water surf where you really must wipe every few minutes. Individual controls for each window are also important, because a side wind will make it necessary to wipe one window constantly where the one on the other side might stay dry. You don't want to constantly run a wiper blade over a dry window.

The widow washer system is fed from the boats fresh water system (i.e. there is no separate tank as on a car), via a fitting on the starboard side of the engine room forward bulkhead.

Fred Werner (AT34 #044 "Tug 44") reports:

> "My control unit failed because I was changing the wiper arms, and used the circuit breaker to stop them from moving in mid-stroke, so that I could adjust the swing. Apparently the older version sustained damage from this. Surely they have fixed this little problem by now, but still ... don't switch the breaker when the wipers are running, just in case!"

New wiper blades are available from auto supply stores, or Imtra.

If the wipers seem to smear, the blade may be lifting-off the window. Unlike cars, we don't go fast enough to generate air pressure! Take a look at the wiper arms: earlier boats had pressure springs in *one arm only*. Additional springs are available from Imtra, and improve wiper performance immensely.

These are, however, a bear to install since the spring is heavy duty and it snaps into a very narrow spot on the wiper mechanism. We discovered that if we tied a string to the bottom of the spring and pulled down hard while pushing it into position we could get them installed without loosing a finger.

Wiring Schematic

The wiring diagram (or circuit schematic) is different for each vessel, depending on the options installed. Tomco supply a customized schematic for each vessel when it is shipped. They should be able to supply one if it is lost.

This diagram will not, however, reflect any non-factory added equipment or navigation electronics. It's a good idea to update this schematic whenever new equipment is added. Future owners will thank you. More importantly, you will thank you when you need to track down a problem in the future and you can't quite remember how the wiring was run.

American Tugs are wired in accordance with ABYC practices, which means that:

- 12V DC positive wiring is *red*,
- 12V DC negative wiring is *yellow* (some equipment uses *black*),
- 120V AC live (or hot) wires are *black*,
- 120V AC neutral wires are *white,*
- 120V AC ground wires are *green*.

ABYC Shore Power Wiring Codes

(courtesy of Pete Balkus AT34-#021 "Braveheart")

Wire Color	**US 115V AC**	**US 230V AC AT41 (AT41 50A)**	**European 230V (European boats ONLY)**
Ground	Green	Green	Green and Yellow
Neutral	White	White	Light Blue
Hot	Black	Black	Brown
Hot	-	Red	

In most cases on my boat, the circuit name/function was written on the wire insulation with a ballpoint pen.

My boat had wires run for options that were not installed at the factory. These ran from the electrical panel to the location where that option would be installed. For example, there was a coil of wire behind the electrical panel that ran to the port aft hanging locker marked 'Washer/Dryer'.

There was also a TV coaxial cable run from the pilothouse overhead to that locker.

Wiring Circuit Conduits

Most of the wiring on our boat is run through plastic PVC conduits that run the length of the boat from the engine room aft to the lazarette.

The conduits are 4-inch PVC pipes and are accessible on the starboard side through three access panels in the galley cabinets (one forward of the stove, one just aft of the stove, and one under the sink). The pipe on the port side is accessible by pulling out the settee and looking down through the two oval openings that you can see once the settee has been pulled out. There is another access panel in the cabinet by the door on the port side of the boat.

The conduit has openings cut along the way where needed for cords to enter and exit. The hot and cold water pipes also use this conduit on the starboard side of the boat – as do the hydraulic steering lines.

There is a raceway of wires that runs between the electric panel and the helm. Wiring for the radio and any other instruments in the overhead area in the helm is run up the plenum between the forward pilot house windows. Wiring for the radar, navigation lights, anchor light and horn are also run up this raceway – as well as wiring for ceiling cabin lights and the stereo speakers.