Every marine exhaust system should do three things well: 1) Dispose of exhaust gases; 2) Reduce engine-room heat; and, 3) Make the engines as quiet as possible.

Marine diesel engines develop an enormous amount of excess heat. A little less than \( \frac{1}{2} \) of every gallon of diesel fuel burned by a marine propulsion engine goes to turn the crankshaft and eventually the propeller—over \( \frac{1}{2} \) of the fuel turns into heat that must be disposed of as quickly as possible.

To get the proper perspective on the amount of heat generated by a marine diesel engine onboard a fishing boat, consider the size of the heating unit in your home: A 100,000-British Thermal Unit (BTU) home heating system will heat a small home during cold weather; 1 gal. of No. 2 diesel fuel contains more than 130,000 BTUs of heat. Consider also a 42-ft salmon seiner with a 400-hp engine burns 20 gal. fuel/hr running at full power. More than \( \frac{1}{2} \) the fuel—almost 2 million BTUs of heat/hr—is wasted as heat.

The hottest parts of the system are the exhaust manifold and turbocharger. Dry-wrapping manifolds and turbos helps control surface temperature with insulation that coasts the exterior of the manifold and keeps heat from escaping into the engine room. Since it takes power to pump exhaust gases through the boat’s exhaust system, an engine with a dry-wrapped exhaust manifold can be slightly more efficient because the exhaust gas temperatures are higher, making them easier to pump.

**Water-jacketed exhaust manifolds**—heavier & more expensive than dry-wrapped manifolds—absorb heat from the exhaust & transfer it to the engine cooling system. Exhaust gases cool a bit & make it harder for the engine to pump, reducing turbocharger efficiency & putting added load on the engine cooling system.

**Silencers and Mufflers**

On-board fishing vessels, a dry-exhaust silencer is called a silencer, & a plastic or fiberglass muffler used in a wet-exhaust system is called a **muffler**.

Exhaust silencers work by trapping & absorbing sound waves, turning them back into heat while restricting the flow of exhaust gases as little as possible. Steel or stainless-steel exhaust silencers come in several grades, the more corrosion-resistant steel & Quiets the grades costing more.

- Sizing a silencer is a science, involving:
  - Cubic feet per minute (CFM) of exhaust gas coming out of the engine at its full-rated power & speed;
  - Maximum exhaust gas temperature;
  - Inside diameter & length of exhaust pipe;
  - Number of bends in exhaust pipes & whether 45º or 90º, long radius or short;
  - Level of silencing desired; and, finally, Available space for installation.

**Inside the Pipe—Wet or Dry?**

Although there are variations on marine-exhaust system design, the choices come down to only 2—either a wet or dry exhaust. But now we’re talking about wet or dry **inside** the exhaust pipe.

When Stewart Everest of Everest Marine & Ian Jeffers of Penn Cove Shellfish designed their 4th shellfish-harvesting vessel, the 63-ft *Mytilus*, they again specified JOHN DEERE engines from MER Equipment. The original plans called for a wet-exhaust system to exit the stern, but Stew was very concerned about reducing exhaust noise for the sake of the crew as well as those on shore, often operating near populated shorelines. MER President Bob Allen persuaded Stewart instead to go with a specially configured dry-exhaust system exiting through a vertical stack. Bob’s plan called for wrapped Cowi silencers in the engine room with 5-in.-diameter openings in & out, adding two 5-in., 90º elbows 3 feet downstream of the Cowi silencer to further absorb sound. Finally, near the far extremity of the 20-ft system just 6 feet from the end, they installed EM critical-grade inline silencers with 5-in.-openings, exiting with 6-in. pipe.

It’s worth mentioning that Cowi & EM both make air-intake silencers for installing on an engine’s air-intake side, which can really make a difference in the engine-room noise level.

Stew says he always lines enclosures housing the exhaust components with Barrier 104—his favorite sound-attenuation product—in either \( \frac{1}{2}” \), or \( \frac{1}{4}” \) thicknesses.

“Another reason I was reluctant to try the vertical stacks. ”

“However, after the marine architect ran the numbers & we knew that stability was very good, we took Bob’s advice & went for the vertical stacks.”

When starting the engines Stew found the silence was … deafening!

“**Sound of Silence**

Exhausts, Mufflers, Silencers—Cowl, EM, JD, & MER

“We had to turn off the radios in the wheelhouse to hear if the engines were running.”

Penn Cove Shellfish owner Ian Jeffers, running DEEREs with MER’s exhaust system: “The sound level far exceeded our expectations.”

**PHOTOS COURTESY EVEREST MARINE**

**F/V Mytilus**

**MER’S Cowi-EM silencers on the latest mussel harvester in the Penn Cove Shellfish fleet. All 4 powered by MER JOHN DEERE engines.**

**MER’s last scientific name for mussels**

**With the mussel-processing deck directly above the engine room. Stew wanted to keep the work area very quiet.**

**Water-jacketed exhaust manifolds—heavier & more expensive than dry-wrapped manifolds—absorb heat**

**Going with the vertical exhaust rather than the original wet exhaust meant two stacks with outlets above the top house.**

**The black EM-silencer house out of the weather. Stewart put sound-deading material in these cavities where the EM silencers were fitted.**

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The third & final installment in this generator-troubleshooting series will help you positively identify components of the MAC generator to check the system’s various parts with a multimeter.

**What Makes It Tick?**

How then does the MAC generator control voltage without a voltage regulator or a rheostat? An electrical engineer might say, “The MAC generator is a transformer-controlled machine.”

What this means to the rest of us is that a very carefully calibrated, partial amount of the current to the load is wired to run through the exciter stator windings.

When operating with no load the unit’s residual magnetism creates the basic system voltage. When the load increases, however, the added current flowing to the load increases the strength of the stator’s magnetic field—it is this feature of the MAC that increases or decreases the excitation voltage to the generator’s revolving field, depending on the load.

The MAC excels in applications where large electric motor-starting is a higher priority than weight or ultra-precise voltage control. Per unit of electrical power, these machines are heavier & more costly than more closely regulated sets. For instance, commercial fishing boats use MACs for motor starting refrigeration systems, large electrohydraulics, & pump loads.

**MAC Generator Troubleshooting**

For slightly low or high frequency just reset the engine speed until cycles are at 60-61 HZ for engines with electronic governors, 61.5-62.5 HZ for mechanical governors.

Likewise, if slightly low voltage is the problem check the engine speed carefully. Also check for possible problems that limit engine speed under heavier loads. This would include a partially plugged air or fuel filter, air entering the fuel, or even a poorly adjusted shutdown solenoid linkage.

As with all generator engines, track down the source of air in the fuel by installing a transparent sight glass downstream of the engine’s fuel-transfer pump. After you get the engine fuel system bled of air & warmed up, put a load on the engine and watch for steady air bubbles in the sight glass—the fewest bubbles means you have at least 5% air in the fuel, which will cause brownouts and low power.

Beginning with the engine, proceed to check and reseal every connection between the engine and the fuel supply.

Brownouts & engine-speed variations can also be a result of starting very high loads, & you may need to manually start the largest loads first before adding the smaller loads.

**Important Safety Note:** When checking a generator before starting it, perform a voltage check of the generator leads (L1, L2, L3, & Neutral) to verify they are indeed electrically dead & the unit is safe to touch. This protects you from shorepower current or the possibility that another generator is running.

**The Visual Check**

Now do a visual check of the generator looking for burned wires or components. Notice how the unit smells—a burnt plastic smell most likely indicates burned wiring or insulation. Run your fingers along the wiring, prodding and pulling gently to find anything loose or disconnected.

**Note:** Of course no water must ever enter the air intake of a generator. But smaller MACs are constructed so that any water that enters the generator’s air intake can become trapped—resulting in severe corrosion of the conductors connecting to the exciter stator!

**Beginning The Electrical Testing**

This shows us 1 of 3 conditions: Correct voltage, Low voltage, or No voltage.

First verify the unit’s voltage. **Guesswork at this point is not to your advantage!** Start the generator & check voltage line-to-line; in most fishing boats it’s 208 V but your system could also be 240 or 480.

**Low Voltage:** If voltage is normal with no load but low under load, proceed to check the diodes by disconnecting them and doing a continuity check on each one. A good diode will allow continuity in only one direction.

**Note:** The MAC has 6 diodes on the rectifier assembly—1 classified as forward (also called normal), and 3 classified as reverse. The difference is that they allow flow in opposite directions to each other.

For a generator configured at 208 V, if the actual generator voltage is only 50-60 V line-to-line or 25-30 V line-to-neutral, you are seeing residual voltage and the exciter is not working, probably due to faulty wiring or diodes. By checking voltage line-to-line and line-to-neutral, your voltages will be equal if the stator assembly and its individual coils (L1, L2, & L3) are O.K.

**No Voltage:** A generator’s residual magnetism creates residual voltage when the generator rotor spins. If there’s no voltage at all the unit may have lost its residual magnetism over time, either from proximity to another source of magnetism or even from dropping during shipment.

When there is no voltage, flash the unit to see if this restores residual magnetism (and residual voltage). Flashing uses outside current to restore residual magnetism so make sure the generator’s off or at rest. Prepare two 14-gauge wires, one with an in-line 30-amp fuse to protect the circuit. Voltage used to flash the circuit may be 20 V either AC or DC. Flash any two generator leads using a quick glancing movement to temporarily touch the leads, then run and check the unit.

If flashing the unit does not restore the voltage it usually means severe damage such as stator wires burned open. Check the stator windings by disconnecting the 12 leads, 2 for each of the 6 coils around the barrel of the generator housing. Check continuity of the 12 leads for the 6 generator stator coils & that there is no continuity between the coils & the frame of the machine (ground). If one leg has low voltage suspect a ground in that leg.

Finally, monitor the temperature of the generator’s rear housing that contains the bearing. If the rear plate seems to warm up before the rest of the generator housing, follow up by replacing the bearing.

More troubleshooting resources at MER’s new blog & www.marathonelectric.com/generators/index

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**Sarah Elizabeth Banks:**

One hundred years ago and an ocean away, Malcolm Harker’s 60-ft Motor Yacht (MY) Sarah Elizabeth Banks was built as a steam-powered, firefighting “river-watch” boat in Sunderland, England. First named the Steam Ship (SS) Fire King—and now named for Malcolm’s wife, Sarah—the 1906 riveted-hull vessel was assigned to combined fire watch and police duty patrolling rivers that flowed through cities.

In England back in 1878, Malcolm’s grandfather F. T. Harker founded the family business for designing and producing steam engines. His three sons joined him, then continued building their steam engines up until 1950, in later years building heavy machinery under contract.

However, in the early 1900s steam-engine builders specified the hulls into which their steam engines went. The company commissioned the Fire King, built both to fill the contract for the fire-watch boat and to power it with a pair of their own engines.

The vessel originally carried eight tons of water and two tons of coal. Rough estimates show the coal was topped-off regularly to keep the boat maneuverable and able to pump water for a 48-hour period should a large fire occur.

It’s interesting to note that historical records show the price of coal in Seattle at that time was $5–$6/ton, also recording that the average open-pit miner could mine and load 2.67 tons of coal in a day (2000 pounds of coal is roughly equivalent to 150 pounds of coal)...
We began blogging as a new customer service to help you quickly get the answers you need and create an avenue for interactive comments and questions. Packed with a wealth of info both technical & topical, we continually post original resources about the trades.

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**REPOWER—steam engines to twin MER DEERES**

The original pair of Harker steam engines turned twin 4-ft bronze propellers & probably pushed the boat at 5-7 knots. Malcolm says horsepower was calculated & probably pushed the boat at 5-7 knots.

In 2008 MER Equipment supplied two new JOHN DEERE 4045 Marine Diesels, installed by Townsend Bay Marine of Port Townsend, Wash., along with other extensive upgrades.

The JOHN DEERE 4045TFM 4-cyl. turbocharged diesels couple to ZF45-1 Deep Case 3:1 marine transmissions turning 2" stainless-steel propeller shafts with 30" diameter x 24" pitch x 4-blade propellers. The boat reaches 7.5 kts at 1800 rpm & a top speed of 9.8 kts.

Malcolm also inherited a Harker steam engine built by the family business, similar to but slightly smaller than the original. He kept it onboard for historical display, bolted forward in the lower level.

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**OIL STARVATION:**

When the valve is open & the engine’s shut off, oil will be trapped under pressure in the tube. Then next time you start the engine just open the valve first so oil flows into the engine (pre-lubing), then hit the starter switch and off you go!

Just remember to close the valve before shutting the engine down.

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**A WORD OF WARNING:** When fabricating & installing a system like this be doubly sure there are no abrasives inside the unit, valve, fittings—even the hose when you install it. Don’t let even one speck of dust enter the pressure side of the tube system—engines have zero-tolerance for specks!!!
Part 2: The morning of the Mayday everyone was in shock. Crowley Tug had their plane at the cannery in Ugakik, a Widgeon, piloted by Skip Olsen, one of the top bush pilots in Alaska. Skip offered to go in search of the Deep Sea. The weather was SE 25-30 kts, ceiling 300’, visibility 1 1/2 mi. with drifting fog. We first landed at Packers Spit in the North Arm, to see if any of the beach seiners had boarded the Deep Sea. As I had feared, 5 visiting family members had boarded for a ride to Kodiak as the season was winding down. Skip & I flew out of Ugakik for Whale Pass, the weather was terrible. We were on the radio with the Coast Guard en route, they had sent a rescue chopper to the area after they received the Mayday—it had to have been around 6 a.m. They reported at that time there was a NE wind, gusting to 85 mph. The Deep Sea had entered Whale Pass with a huge following tide of probably 9 kts & met in the dark head-on with an 85-kt wind coming from the port side at the other end of the pass. The Coast Guard reported large whirlpools & standing waves where the tide & wind intercepted. In their view, no vessel could have survived. As Skip & I went through the pass I sighted a life raft drifting. It was still in its white container. We reported it to the Coast Guard & they later picked it up. The shock & horror of the incident is hard to describe. The Ugakik Bay beach seiners were a colorful group. They came North every year, built a driftwood lean-to cabin or pitched a tent on the beach where they spent about 3 1/2 months on a gravel spit near the mouth of the Ugakik River, beach-seining for salmon. Nearest thing had to have been the early settlers in the Western U.S. Each of these beach locations survived by sharing food, fuel for the outboards, & fishing gear amongst the group. They hauled water in 5-gal buckets from a nearby creek, cut up driftwood for heat. They worked with the tides in small wooden dories to pull their nets off the beach in front of the migrating salmon, then haul them back up the beach by hand, hoping to drag a few salmon in with the heavy nets. I’ll never forget the state of shock on Mick McCrea’s face when I told him the Deep Sea had disappeared with his wife, his daughter, & his two sisters on that terrible night. I guess the final chapter of this tragedy was a hearing in Kodiak at the Coast Guard Base. At the center of the meeting was the Deep Sea life raft which they were going to check to see if it was operational. The cord on the raft was pulled & the raft opened as designed. Whatever happened that dark night, the crew didn’t have time to launch the raft. The Coast Guard believed the house on the Deep Sea was torn off the vessel, she probably rolled over & sank. There was a total loss of 8 souls—3 crew & 5 passengers, all of which were women & children.