Story By Steve D'Antonio

KEEPING YOUR ENGINE ROOM COOL WITH

DELTA "T" SYSTEMS

Delta "T" Systems

When it comes to efficient operation of an internal combustion engine, whether it's a propulsion engine or a generator, few elements are as important as the air that feeds the engine and cools the engine compartment.

Air that's laden with moisture and salt wreaks havoc on engine room equipment and generator windings (which are typically forced-air cooled), not to mention piston rings and valves. Add to this the effects of heat or an insufficient supply of combustion air for the engine to burn with fuel, and the results can spell poor performance, reduced fuel economy, and diminished engine life.

Hot air is thinner than cool air, and as such it makes for a less efficient "burn" in the combustion chamber. If there isn't enough air in the engine room, a vacuum or depression is created, which has a similar deleterious effect: inefficient burning of fuel in the combustion chambers. Hot air—and not enough of it—is simply the kiss of death for an engine compartment and the engines that reside within.

Advocating proper engine room ventilation is a passion of mine. Perhaps that's because in the work I do as a marine consultant, I encounter so many violations of what I call the "fresh air principle": the need to provide enough fresh air to engines, generators, and other machinery in the engine room for proper cooling and efficient combustion. Regrettably, these violations are not limited to older vessels. They are commonly found aboard factory-fresh models, as well.

The insidiousness of this problem is, I believe, what makes it so pervasive. Many of the faults and violations I encounter are not readily apparent. Most commonly these include overly hot engine rooms where the desert-like air temperature is simply stifling and engine room ventilation openings that are too small for the volume of air being drawn through them by engines and generators. Many boat owners and even professionals in the industry simply accept the former as normal. After all, engine rooms are supposed to be hot, right? Except in gross examples, the latter—an insufficient supply of combustion air—is simply impossible to identify without the use of special tools (special, perhaps, but also very simple and inexpensive, such as a water tube manometer). If the supply of combustion air is remarkably insufficient, a manometer isn't needed to diagnose the problem. Because of the vacuum that's created, it will be difficult to open the engine compartment door or hatch while the engine is running. And I'm not exaggerating.

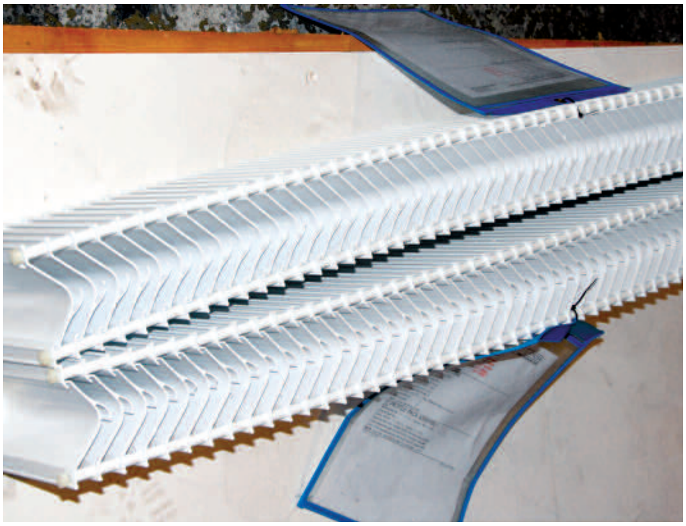
In the two decades I've worked in the marine industry, I've learned a great deal about engine room ventilation and its importance in proper, efficient engine and generator operation. On the pages that follow, I'll share some of this hard-won knowledge, along with a briefing on my visit with one of the premier manufacturers of engineering space ventilation equipment, Delta "T" Systems.

AIR FOR COMBUSTION AND COOLING, TOO

Beyond fuel and coolant, the one component that every internal combustion engine requires is air. Regardless of whether it's a 6hp outboard or a 600hp diesel, without air, the engine won't work. With enough air, it will run efficiently. However, there is an "in between" state that is more common than most people realize: having enough air to run, but not enough to run efficiently. (Low pressure, or a lack of air, in the engine room is referred to as "depression.") When an engine's supply of air is limited, the combustion process doesn't stop; it simply suffers, often unbeknownst to the operator. With an insufficient air supply, the engine may run in what's referred to as a "rich" state. It has enough fuel but not enough air to completely burn that fuel. This leads to poor performance, poor fuel economy, and, oftentimes, smoky operation.

It is possible to supply an engine with enough air for combustion while providing *insufficient* air for cooling of the engine compartment and the gear that's located in this space. I know what you're thinking: if an engine is cooled by sea water, why does it need air for cooling, too? True, the heat generated by the engine's combustion process, as well as by friction in moving components, is removed as quickly as it's created by coolant and then sea water. However, as we all know, the engine, and especially the exhaust system, becomes hot (extremely hot, in some cases). That heat is radiated into the engine compartment and is absorbed by surrounding structures, a process called "heat soaking." It can take many hours of engine running, often between 12 and 24, for the surrounding surfaces and air in the engine room to reach their maximum temperature. In most cases, a true measure of engine compartment temperature cannot be ascertained until heat soaking has reached equilibrium.

Not only does this hot air make the boat and its accommodations spaces warmer, but it also forces the engines to breathe hot air, and that's less than ideal. Hot air is less dense than cool air, and as a result, it diminishes the efficiency of the combustion process; the cooler and drier the air, the better. (More on moisture removal will follow.) Because turbocharged engines compress air before it's drawn into the combustion chambers, for these engines, the temperature of the surrounding air often is of greater importance than engine room pressure, although low pressure is always to be avoided in engine rooms. Naturally aspirated engines (those without turbochargers), on the other hand, are especially sensitive to engine room depression. Remember: even if your engine is turbocharged, it's likely that your generator is not, and it has to breathe, too. Therefore, my preference is for an engine compartment that, if not cool, is as cool as possible and whose pressure is slightly positive, meaning there's always enough air for the engines to consume.



Photos by Steve D'Antonio

Left: Lynn Oien, president of Delta "T" Systems, displays a partially assembled air-intake component at the company's Florida plant. Right: Delta "T" moisture eliminators use a process known as air impingement. Air is forced to make a sharp turn as it enters the engine room; in the process, water molecules are "slung" out of the air stream. The water collects and drains outboard.

FORCED VENTILATION

In most cases, it's possible to supply an engine with sufficient combustion air simply by providing the engine compartment with vents that are large enough for air to be drawn through. A variety of formulas exist for determining the size of the vent area. The one I've used for years calls for dividing the collective horsepower of all engines (both propulsion engines and generators) by 3.3, which yields the required vent area in square inches. (I didn't invent this formula; it was created by naval architect and author Dave Gerr.) Therefore, if your vessel is equipped with twin 450hp engines and has two 12kW gensets (which you can calculate as having a combined horsepower of about 36hp, since multiplying 1.5 by the rated genset kilowatt output yields the approximate generator engine horsepower), the total horsepower is 936. By dividing by 3.3, you'll find that the vent area should be a minimum of 284 square inches, or two

Photos courtesy of Delta "T" Systems

The PT4 system maintains target engine room temperature and ensures that the engine receives ample combustion air.

vents each measuring 10 by 14-1/2 inches. I'm surprised by how often I encounter vessels with an air intake that is a fraction of what it should be, based on this or any other air-intake formula. Check yours to see if your engines and generator are having trouble breathing.

Keeping an engine compartment cool is often an active, rather than a passive, affair; that is, fans or blowers are needed to move enough air through the compartment for cooling purposes. Unfortunately, this task is not as simple as running an exhaust blower full time. Doing so can create a depression in the engine room, thereby robbing the engines of sufficient combustion air. If this approach is taken, a manometer should be used to check engine compartment pressure while the engines and generators are running at full rated rpm to ensure that enough air is available for both cooling and combustion. The more sophisticated electronically controlled ventilation systems monitor both temperature and pressure, and they adjust the speed of both intake and exhaust fans to maintain a slightly positive engine room pressure.

In the event of a fire, dampers are used to close off the engine room, to prevent fresh air from entering and feeding the fire, and to contain the fire extinguishing agent.

DELTA T

As far as many engine manufacturers are concerned, the important measurement when it comes to temperature is the difference between ambient temperature (the temperature outside the vessel in the shade) and the temperature at the engine's air-intake manifold, which typically is measured at the air filter. This temperature difference is referred to by its scientific designation of ΔT ("delta T"). Engine manufacturers realize that the temperature inside an engine room will be affected by the temperature outside the vessel. If the vessel is operating in the tropics and the air temperature is 86°F (and the water temperature is the same or higher), this will have a large impact on engine room temperature. Therefore, establishing the ambient temperature as a baseline and then specifying how much above this figure the engine room's temperature may be is the accepted approach.

Depending on the engine manufacturer, the mandatory or preferred ΔT may be anywhere from 18°F to 25°F. This means that when operating in our above-mentioned tropical paradise, our theoretical vessel's engine room should be no hotter than 104–111°F. In some cases, a ΔT is specified along with a maximum absolute engine room temperature, a temperature above which the engine is not designed to operate efficiently or for prolonged periods. This absolute maximum temperature may be 120°F or 130°F. Check the specifications provided by your engine and generator manufacturers to determine these values, and then carry out measurements yourself, preferably after the vessel has been under way at cruising rpm for at least six hours, with ancillary equipment such as generators, air conditioning compressors, and the water heater operating.

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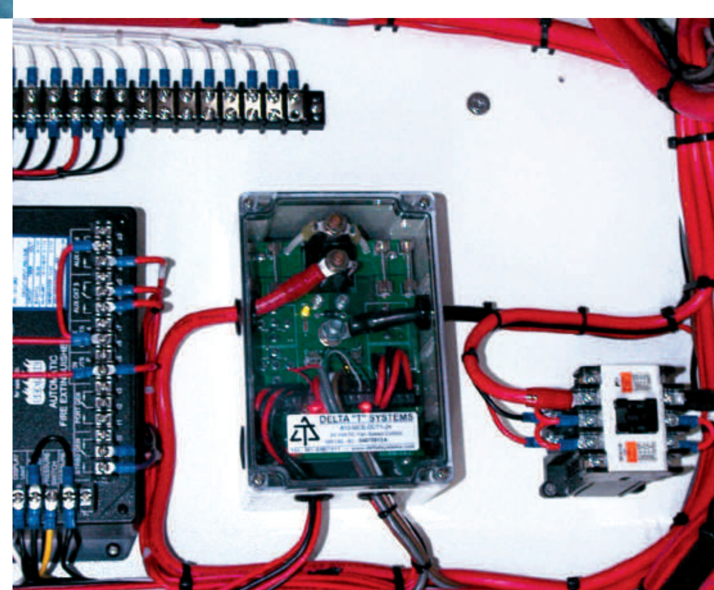
if the installation guidelines were violated. If this occurs, you could find yourself in the unenviable position of arbitrating intense finger-pointing between the boatbuilder and the engine manufacturer. Most production boatbuilders agree to install engines supplied by manufacturers in accordance with installation guidelines in order to guarantee that the warranty will remain valid.

Smaller custom and semi-custom shops often go to the trouble of paying the dealer from whom they've purchased the engine to "certify" the engine installation and ensure that all protocols were met, thereby absolving themselves of any installation wrongdoing should a failure occur. Part of the testing and certification procedure nearly always involves measuring engine room or inlet air temperature and calculating ΔT.

Production builders often obtain "type certification" for engine installations, which means they submit a representative example of a vessel (usually the first of a model) for inspection by the engine manufacturer or dealer, who carries out the typical battery of certification testing. The builder then agrees to build all subsequent vessels of that model in the same fashion. If a change is introduced—if a larger or different engine or generator is offered or ventilation intake vents are altered, for instance—then the type certification should be carried out once again to ensure that engine room temperature, ΔT, and other elements are still in compliance.



Delta "T" Systems

Above left: A technician tests a ventilation system control module. Above: This is the DCT1 model control enclosure for a Delta "T" engine room ventilation system. This control automatically monitors the temperature of the engine room and then runs the intake and exhaust fans accordingly.

Generators housed in enclosures tend to retain heat and, as such, are often temperature challenged. Ideally, their temperature should be taken with the enclosure in place, which calls for the use of a remote temperature probe. Many digital multimeters have such probes available as attachments. Fluke (fluke.com) offers the 80TK Thermocouple Module, which will work on most Fluke multimeters and many others.

In addition to poor efficiency, what other consequences may arise from overly hot engine compartments? It's possible for excessive and prolonged heat to weaken fiberglass and wood structures. The lives of rubber and other flexible components, such as hoses, belts, and acoustic insulation, are shortened when they dwell in Hades-like environments.

Of greater consequence is the view an engine manufacturer may take of engine room temperatures that exceed the recommendations, particularly when a warranty claim is involved. I've never heard of an engine manufacturer denying a warranty claim because the engine room lacked sufficient ventilation, but it is possible

Photos by Steve D'Antonio

Left: Many of Delta "T" Systems' components are manufactured using high-density plastics. This provides several advantages: the components require no paint or corrosion inhibitors, and they are light and easy to assemble. Here, an employee "welds" a plastic air-intake assembly. Right: Water eliminators are assembled by a Delta "T" employee. These nonmetallic assemblies are currently available in black or white; however, plans are in the works to offer other colors.

If you're purchasing a production vessel, you can assume this procedure has been followed, but it never hurts to ask. If you are buying a custom-built vessel or are having one built, it's worth insisting that the engine installation be inspected and approved by the engine manufacturer's dealer. It's never too late to have this procedure carried out, even if the vessel is not new. You may have to pay for this regardless of when it's done, but it's well worth the cost. (Be sure to ask for a copy of the report.)

DELTA "T" SYSTEMS INC.

When it comes to engine room ventilation and moisture removal, few would argue that there's anyone more knowledgeable or experienced than the folks at Delta "T" Systems in Riviera Beach, Florida. As a longtime admirer and user of their products, I have a special appreciation for their know-how and success in this niche market of the marine industry. Therefore, when I was asked to visit the company's facilities and speak with the founder, Lynn Oien, I wasted no time in making arrangements to do so.

Delta "T" Systems has been building precision ventilation and moisture-removal systems for recreational, commercial, government, and military vessels since the early 1990s. I met with Lynn at his manufacturing facility on a typically steamy Florida morning. As I entered the building, I had the distinct feeling that I'd been there before. I hadn't, but there was a sense of familiarity from having visited many similar facilities, most recently Sea-Fire, a Baltimore-based manufacturer of fire extinguishing systems (see *PMM* Sept. '08). One of the most enjoyable aspects of my job as a marine consultant and journalist is meeting highly innovative, passionate, and successful entrepreneurs who have changed the face of the marine industry. These individuals, people like Lynn and many others in the trade, are well known for their ability to see the need for

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Completed ventilation/moisture elimination assemblies await shipment at the Delta "T" plant. Another advantage of using high-density plastics: painted metallic assemblies could never be stacked in this manner, for fear of damaging their delicate coatings.

a product, conceive it, design it, and then bring together the necessary resources for manufacturing, marketing, distribution, and support.

When I mentioned the similarity I noticed between Delta "T" Systems and Sea-Fire, not only in the facilities but also in the approach toward the products and their creation and marketing, Lynn smiled and said, "We've recently formed an alliance with them as a result of our common interests." I should have known.

Delta "T" Systems began life as Rolo International in Lynn's garage in Boca Raton, Florida. His desire was to design and build products that would help eliminate water and salt intrusion in marine engineering spaces. Initially, he focused on refits and upgrades to existing vessels. Soon, that changed, and the company began manufacturing and marketing products geared for production boatbuilders as well.

In 1993 Lynn relocated the company offices, setting up shop in a small commercial building, the first of three moves he would make to successively larger premises. (Currently, Delta "T" occupies 30,000 sq. ft. in two buildings located across the street from each other in Riviera Beach.) In 1995, Lynn changed the company name to Delta "T" Systems, an obvious reference to the comparison between engine compartment temperature and outside temperature. It was a change that made perfect sense.

He also took on two partners by merging with a consulting engineering firm and a marine electrical design outfit. Lynn had worked in the aftermarket engine components business for 25 years and had little experience with marine systems, but he thoroughly understood things mechanical and electrical and recognized a need for the product he was developing. Selling gas turbine engines for several years—specifically, the gas turbines used on Navy and Marine Corps amphibious hovercraft, which typically operate in a cloud of salt spray—gave him a special appreciation for the importance of eliminating moisture from an engine's operating environment. Beginning with fans and ventilation products, Lynn and his partners went from concept to production of a complete ventilation and moisture elimination system in 120 days. In 1997, the company moved to digital control in its product line. Lynn purchased his partners' interest in Delta "T" Systems in 2006 and is now the sole proprietor.

From the very beginning, Lynn says, he was dedicated to providing boat owners and builders with a low-cost solution to machinery space ventilation. As a satisfied customer, I believe it's safe to say that Delta "T" Systems has succeeded. The company offers complete, end-to-end coverage of its product, from mechanical and electrical engineering to full naval architectural support for the design of any machinery space ventilation system on vessels ranging from 36-foot recreational cruisers to 200-plus-foot ferries and military, research, and commercial craft. The only job Delta "T" doesn't do is the installation.

It all starts with a worksheet that the customer accesses on the company's website (deltatsystems.com) and fills out. This provides Delta "T" with the information needed to begin designing a system. Drawing on one of the world's largest engine and generator databases, Delta "T" engineers are able to accurately calculate the necessary air movement, fan size, and moisture eliminators for virtually any vessel in the aforementioned size range. The system they assemble for the customer is complete and includes fans, louvers, and dampers, as well as sophisticated electronic control and monitoring systems that are capable of sensing temperature and depression in an engine room and adjusting ventilation accordingly to provide maximum cooling, moisture elimination, and combustion air. Customers are not charged for engineering and system design services; these are part of the package that remains so integral to the Delta "T" concept of full product support.

The devil, as they say, is in the details, and Delta "T" Systems has those covered, too. For example, the fan fixture openings must be large enough to admit sufficient combustion air, even if a fan fails (not that that happens often with Delta "T" equipment). The moisture eliminator, referred to as an impingement separator, works by using an ingenious, velocity-induced slingshot effect. Air is blown at high velocity through a louver that induces a sharp bend in the direction of flow. Because water molecules are denser than air molecules, they are inertially slung out of the air, forming a film in an area of low pressure. Ultimately, they coalesce into droplets that drain out of the separator. The unique design of the impingement "dryer" allows for maximum airflow with the least amount of resistance possible. The components used in the louver mechanism, referred to by Delta "T" as a "profile," are made of PVC, while the housings are constructed from PVC or aluminum, depending on the customer's preferences and needs. They are custom-made for each customer's specific application and can even be painted to match the vessel.

The systems designed by Delta "T" typically rely on cross-ventilation for compartment cooling. This usually involves the use of two intake fans located forward and two exhaust fans located aft. Their speed and operation are dictated by the aforementioned temperature- and pressure-sensing control mechanism. All of the products Delta "T" uses, from moisture eliminators, axial fans, and centrifugal blowers to smoke/fire dampers and ventilation control systems, are designed in house, and 95 percent are manufactured at the Delta "T" facility. All products are designed by Delta "T" Systems specifically for marine applications; they do not simply adopt industrial equipment for their needs. During my tour of the manufacturing facility, I watched as a variety of complex components were designed and assembled, from huge, steel-cased axial fans to delicate electronic control systems. Indeed, they do it all under one roof (or, technically, two roofs).

Delta "T" Systems can boast of having designed more than 1,000 ventilation systems that use moisture elimination technology. Lynn stressed that the firm's repeat customers drive improved engineering. Their feedback and requests continually push Delta "T" to improve its products. An accommodations space dehumidifier that employs the Peltier effect, also known as thermoelectric cooling, has recently been added to the company's stable of ventilation and moisture elimination products. I've seen this product, and its compact design is both effective and impressive.

It's a telling statement that one of the earliest Delta "T" systems, installed aboard an Alaska State fisheries patrol vessel that operates nearly 365 days a year in the most severe weather, has been working effectively and efficiently without failure since 1995. Similar systems have been installed in a variety of vessels that run under the most demanding temperature and moisture conditions imaginable: recreational cruisers, Coast Guard craft, U.S. and foreign naval ships, oil rig supply vessels, and others. If you're searching for the ultimate in engineering space ventilation and moisture elimination, it's worth having a look at Delta "T" Systems.

FOR MORE INFORMATION

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Steve owns and operates Steve D'Antonio Marine Consulting (stevedmarineconsulting.com), providing consulting services to boat buyers, owners, and the marine industry.