Cooling System Principles

All the best aftermarket parts used the wrong way can be less effective than the factory system. In the search for cooling knowledge, it is found that the topic of cooling systems is left out of most books on automotive high-performance. The next few paragraphs will give you a better understanding of how to properly design a cooling system for your vehicle. The following information comes from well known engine builders and our personal experience.

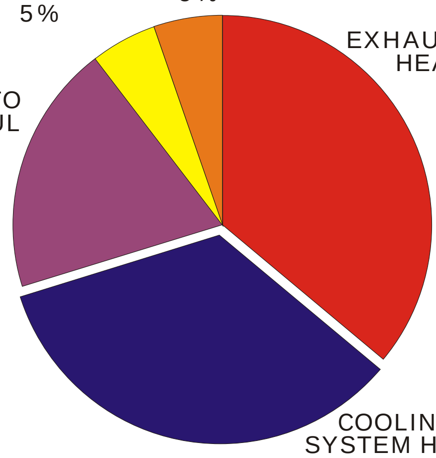
Engine Tune

Engine tune can be one of the greatest factors in water and oil temperature. A lean mixture (air/fuel) and or retarded timing situation will make heat quickly. Lean mixtures burn hot causing detonation and pre-ignition. Retarded timing makes the engine labor to compress the air/fuel mixture. The engine fires well after TDC at a reduced compression ratio. Exhaust valve timing or exhaust restriction will hold heat in the engine raising water temperature. These conditions also affect oil temperature through the cylinder heads and pistons.

The Big Five

With the engine tune problems eliminated it comes down to five major factors. They are:

1. Heat production (BTUs / HP)
2. Radiator Capacity (heat dissipation)
3. Air Flow
4. Water Flow
5. Pump & System Pressure



BTUs

Using a little science and math you can convert your horsepower to BTUs (heat). A horsepower/min. is equal to 42.44 BTU. One third of that heat goes into the water and must be dissipated by the radiator. When calculating radiator capacity you only need to consider the horsepower you're using continuously, not the amount your engine is capable of producing. For example a 500 hp stockcar will need much more cooling capacity than a 850 hp dragster. The stockcar's engine RPM will cycle above and below peak horsepower twice a lap, heat soaking the cooling system with 180,000 BTU in a ten-minute event. The dragster, in one round, might idle less than ten minutes and make an 8 second run at a 750 horsepower average. Running 10 seconds at full throttle the dragster would release about 6,000 BTU. In the case of the dragster, the system must be adequate enough to prevent detonation under power and maintain temperature at idle.

Heat Dissipation

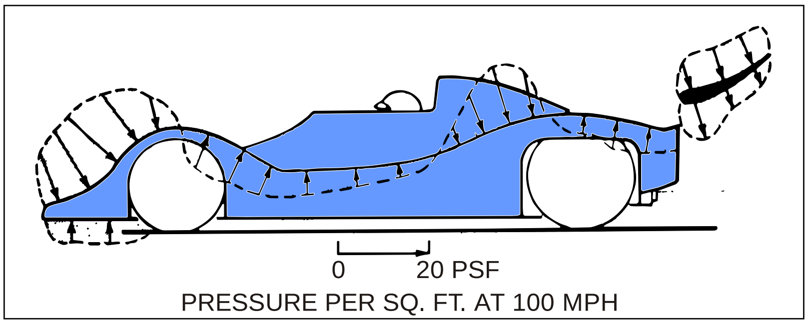
Radiator capacity, in this case, refers to the amount of heat it can dissipate; not the amount of coolant it holds. Due to the various designs and materials used in radiators today, you cannot judge them on size alone. In the past, all radiators were made from copper and brass. Copper was the obvious choice for the cooling fins because of its superior heat dissipation. The problem was that the solder used to join the two materials reduced the amount of heat that could be transferred to the copper. In the last ten or fifteen years aluminum has become the material of choice for racing and original equipment radiators. The major design changes have been the switch from ½ - ¾ inch wide tubes to 1 - 1 ½ wide tubes and the use of double pass tanks. The wider tubes have more surface area and therefore more heat dissipation. Dual pass designs force the water to travel the length of the radiator twice, increasing the amount of temperature drop capable for a given size, unfortunately the restriction is much more than doubled. Surface area is king when it comes to radiators. Doubling the square inch of your radiator will double the heat dissipation, whereas doubling the thickness is less effective and restricts air flow.

Heat Dissipation (cont.)
Other factors that play a role in radiator design are fin count per inch and configuration such as down flow (top tank) or cross flow (side tanks). Inlet and outlet size also play a major role.

Coolants will vary in heat transfer characteristics. Straight water is accepted as the most efficient coolant. A trade-off is usually made with glycol-based products to increase the boiling point, lubricate the pump seal, reduce corrosion, and prevent freezing. Some sanctioning bodies do not allow glycol-based coolants because of obvious track clean up problems. In these cases, use an anti-corrosion / seal conditioner additive available from any auto parts store. Many new coolants and additives are available. We suggest you do some research because many have merit, but some are more marketing than science.

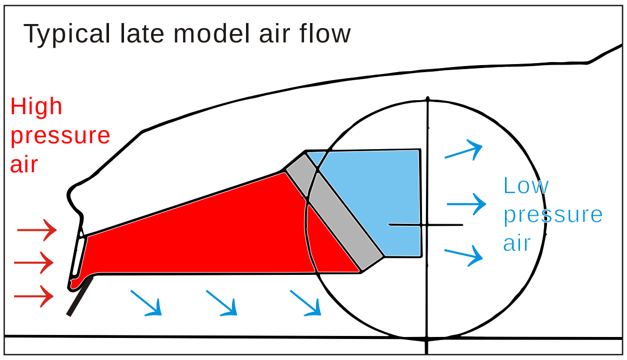
Air Flow

Air flow is the most critical factor in water to air radiated systems. Nothing affects a radiator's efficiency more than air flow. The speed of a vehicle is normally considered when choosing a radiator. Winston Cup teams use different radiators for different situations (full size radiators for short tracks and smaller radiators for super speedways). Maintaining adequate air flow at various speeds is critical and more complex than you might think. First, the radiator must be supplied with fresh air. **The grill opening or air inlet can make all the difference.** Ideally it should be facing squarely into the wind. Looking at the illustration you can see the closer to perpendicular to the ground a surface is, the higher the pressure or down-force. Due to the reduced frontal area of late model vehicles, the valance area becomes the only surface with enough air pressure to provide adequate air flow. Scoops, bills, deflectors and recessed screens can be used to improve less than ideal surfaces.



The size of an opening should be proportional to the vehicle speed. A Winston Cup car running laps at 180 MPH will run cool with less than a 6" x 6" opening. A short track late model with half the HP, the same body and an average speed of 90 MPH will require about a 6" x 24" opening.

Continuous duty race cars (stockcar, sports cars, rally, etc.) should have a well-designed air box to feed the radiator. The air box needs to be tightly sealed to force all the inducted air through the radiator, this also keeps the incoming air from mixing with air already heated by the engine. To maintain velocity, the air box should slowly graduate from the inlet to the size of the radiator, avoiding bottle necks and the floor should be level or slope up to the radiator.



The fan is the next consideration. **At speeds under 30 MPH, electric fans are most effective** because they operate independent of engine RPM supplying maximum air flow at low vehicle speed when you need it the most. **Above 35 MPH** (with a good grill opening and/or air box) **fans are not necessary** and in most cases more air will pass through an electric fan when turned off. Most electric fans have an integral shroud to maximize efficiency, but without being incorporated into a shroud covering the entire radiator core, they will only pull air through the area directly in front of the blade circle. A minimum 1" gap between the core and the shroud is necessary for proper air flow. **In some cases trap doors must be used to relieve back pressure** (see next paragraph). Engine driven fans also must be properly shrouded to be effective. This means tightly sealed to the radiator with half the fan blade into the opening of the shroud. The fan should have no more than 1" clearance to the shroud (15" fan /17" opening). Some stock type engine driven fans can reach blade stall at high RPM. This means it becomes like a wall stopping air from passing through it.

Air Flow (Cont.)

The radiator core must have a pressure drop across it. Air pressure builds up in the fan shroud or the engine compartment, the pressure will equalize and air flow across the radiator can stall. In the case of electric fan shrouds that cover the entire radiator core, rubber or mechanical trap doors can be used to bypass the fan opening as air flow increases at higher speeds. The engine compartment must be able to maintain a pressure differential as the vehicle speed increases. Auto makers will use an air dam to increase the air pressure at the radiator inlet and block air from passing under the car creating a low pressure or ground effect. Many owners of lowered cars have found out the hard way just how effective this technique is after removing the factory air dam.

Water Flow

Many times water flow is the last aspect of the cooling system to be addressed. Ironically, it is also where the majority of problems lie. This is our focus at Meziere. The typical stock water pump has excessive clearance and straight impeller blades, usually open front and back. **At low rpm** this produces little flow and is responsible for cars overheating in traffic. **At high rpm** this design will cause cavitation and aeration. Circle track racers crutch this high rpm condition with under-drive pulleys only to find the engine overheats during caution laps. **A common misconception comes from this under-drive solution**. Many people believe they have fixed their overheating problem by slowing the water flow, when in fact it was reducing the cavitation by slowing the pump that provided the solution. In engine driven situations the only remedy is a quality racing pump with tight clearances and a swept blade closed impeller. Where rules and conditions permit, **electric water pumps can be a solution with multiple benefits**. The constant speed of an electric pump eliminates high and low RPM problems. The bonus is that you can run the pump when the engine is shut off. **Never run your engine without the water pump on because hot spots can form in the cylinder head before your temperature gauge begins to register.** Mated with a good electric fan you can easily regulate water temperature for consistency and rapidly cool the engine between rounds after shutdown.

Pump and System Pressure

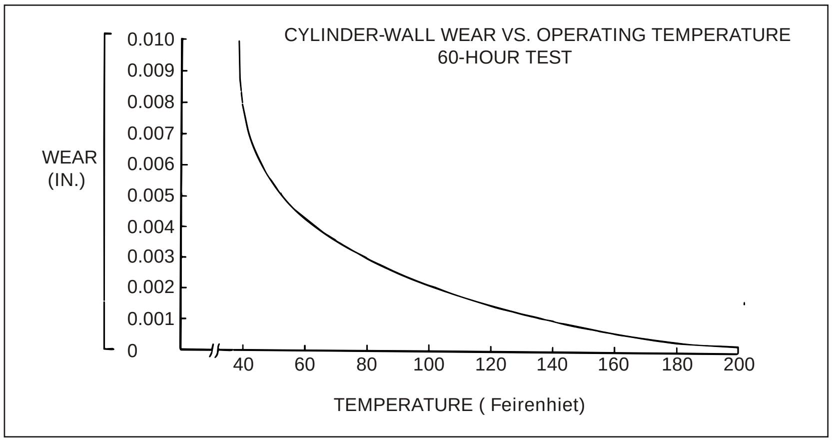
The most widely known cooling system fact is: For every pound of pressure in a closed system the boiling point is increased three degrees. For example a 16 lb cap can increase your boil-over point to 260° (16x3=48+212=260). You may be thinking, “I’d never run over 210° water temp so what is the benefit?” Although your gauge reads 190° hot spots around the combustion chamber can be well over boiling temp (212°F @ sea level). A poorly sealed system, low pressure cap or low water level can allow a runaway boil-over. The lack of pressure allows boiling to start prematurely. Gasses produced by this boiling pushes water out and aerates the coolant compounding the situation. Water is diverted around these steam pockets leading to more serious problems; surface distortion, metal fatigue and cracks. Once this process begins, it will not stop while the engine is under a load. Water flow, temp and pressure all work to manage this boiling at hot spots which can produce steam pockets that insulate the metal from the coolant.

The higher the pressure produced by the water pump, the less chance of the steam pockets. The same boiling point law is in effect here. Racing pumps can generate pressure in the water jacket in excess of 30 psi to control hot spots and reduce detonation or pre-ignition.

Recommended Operating Temperatures

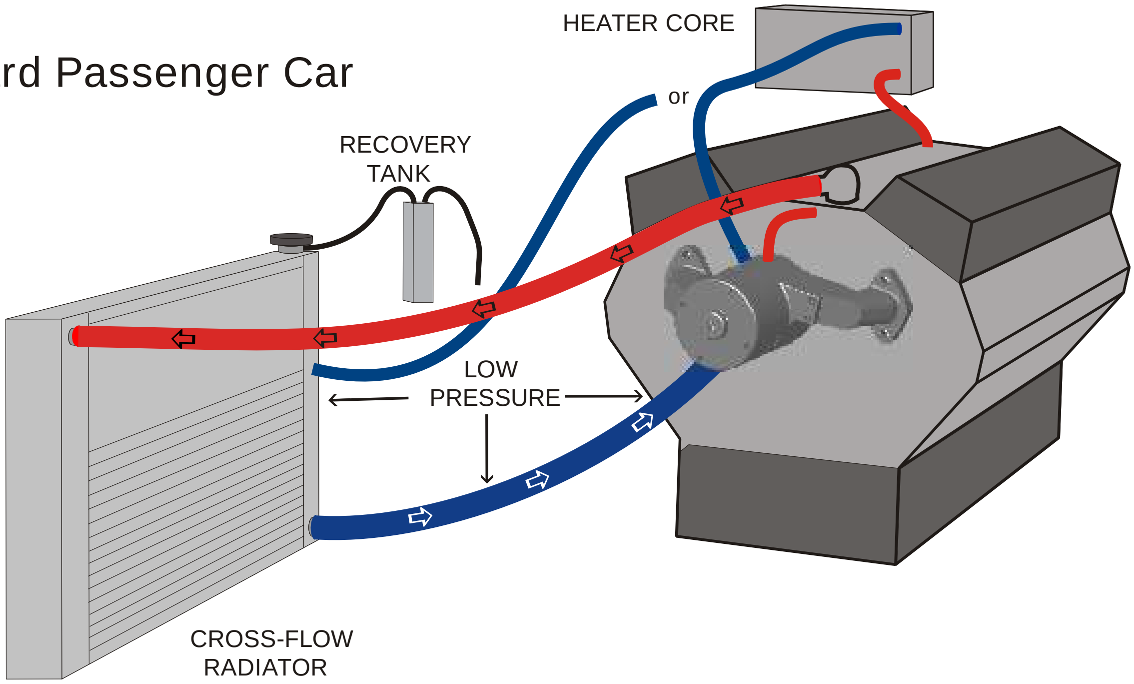
There are a few different theories on coolant temperature and most have their place. Cold water (under 170°F)and hot oil (230°F) make power. Most drag racers live by this. Internal clearances, tuning, and other factors play the biggest roll in where you make the most power. In most other forms of racing and street applications, the engine is under power for minutes or hours rather than a few seconds. In this case, higher temperatures in the range of 190° to 210°F are ideal. Many factors determine this temperature; block and head castings, metal properties, proper combustion and machined clearances. Either inherently or by design small block Chevrolet engines prefer 190° to 210°F. Most early domestic V8s are right in that neighborhood.

Recommended Operating Temperatures (cont.)
Fuels react to engine temperature and combustion pressure. Low octane gasoline burns more completely at higher temperatures, so manufacturers design late model engines to operate up to 210°F for reduced emissions. Alcohol has a narrow window for proper combustion. Many tuners recommend a water temperature above 195° to avoid fuel washing the cylinders from an incomplete burn and below 205° where the combustion byproduct can leave harmful deposits. The internal clearances such as piston to wall and ring gap are set for a predetermined operating temperature by the engine builder. The chart below illustrates the excessive wear that occurs with coolant temperatures below 180°F.

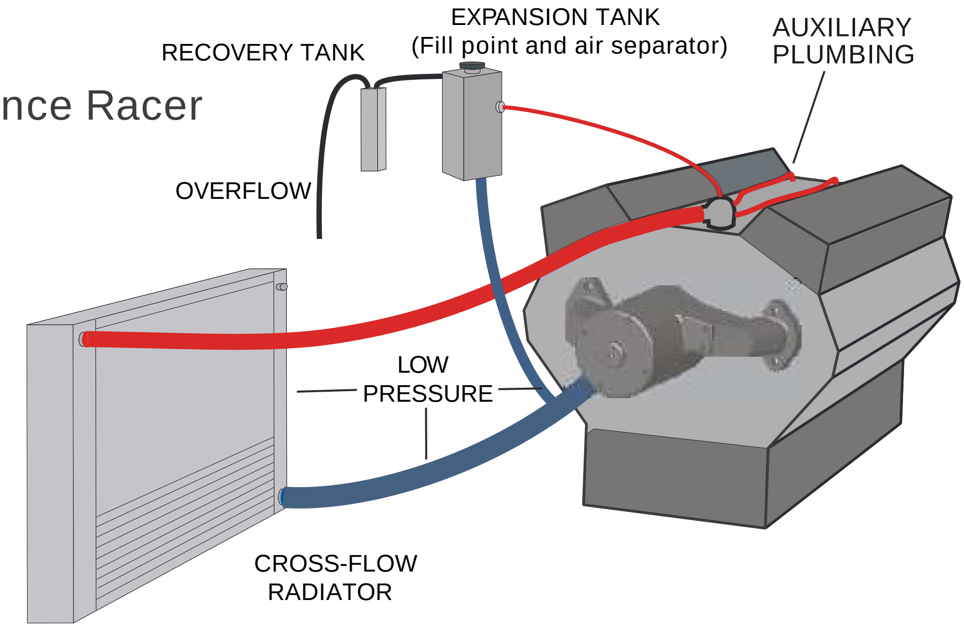


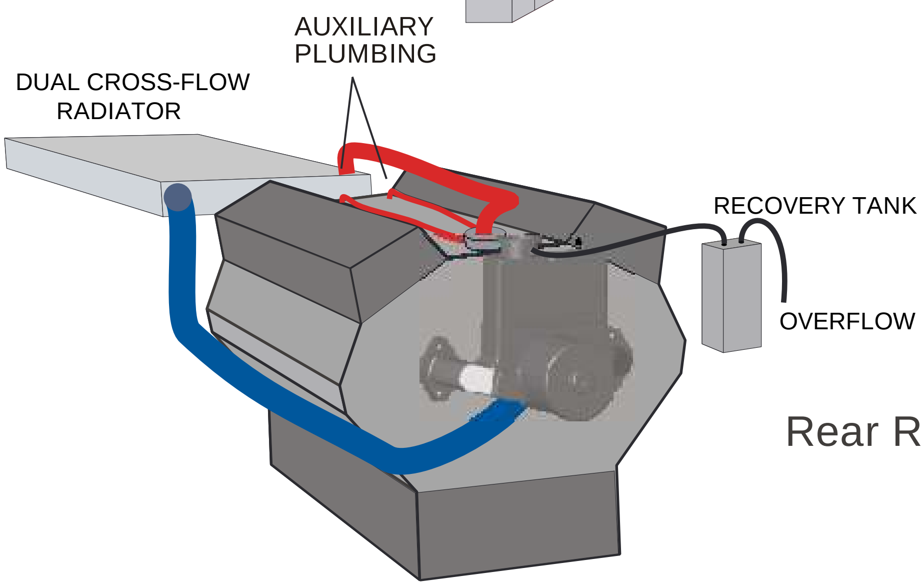
Regular and Irregular System Configurations
The following illustrations are examples of the correct way to plumb typical automotive and racing cooling systems

Standard Passenger Car



Stock Car / Endurance Racer



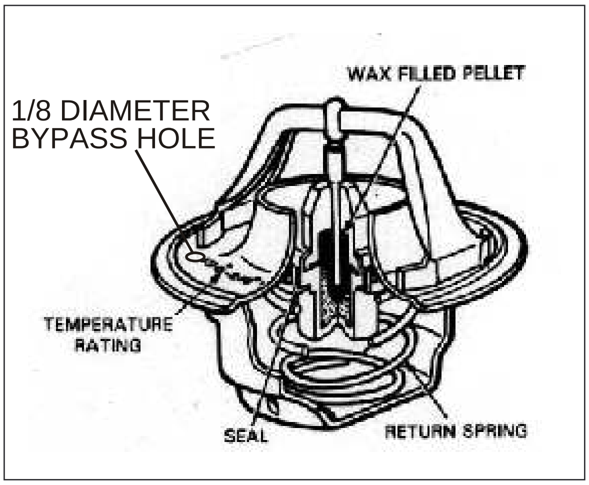


Rear Radiator Dragster

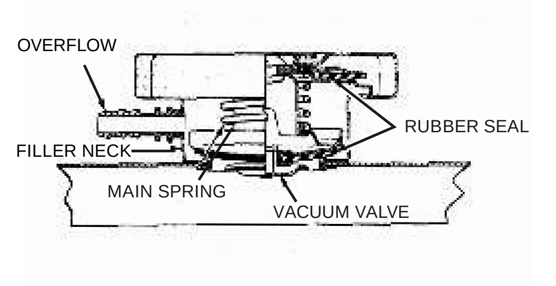
SYSTEM COMPONENTS

THERMOSTAT

A thermostat's primary purpose is to quickly bring the engine up to operating temperature. (see section entitled Recommended Operating Temp). With the exception of drag racing, a thermostat is recommended for most applications. Most racers avoid thermostats, seeing them as another part to fail. Their benefits far out weigh their stigma. In our opinion, the Robertshaw high flow thermostat, the Stant Superstat, or the highly reliable Cloristat used in the Volvo 4 cylinder engines (fits Chevy V8s) is your best choice. The Robertshaw thermostat (available from Mr. Gasket) offers the least amount of restriction when fully open which is desirable with electric pumps. When the cooling system is not equipped with a bypass system, we suggest drilling two small holes in the thermostat's outer ring.

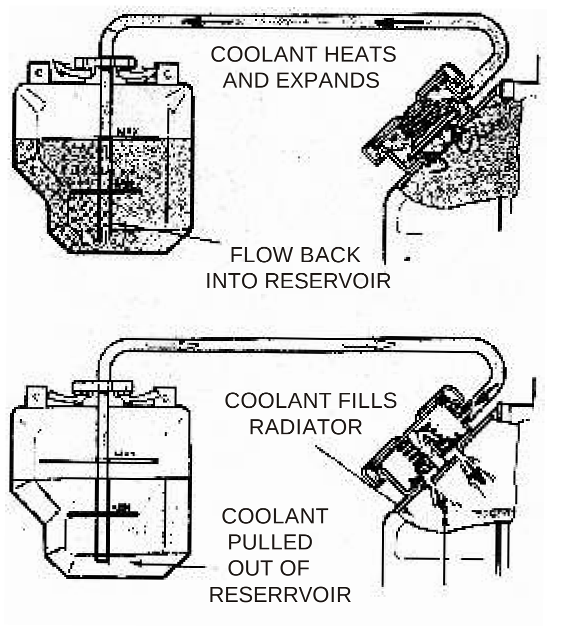


Pressure Cap



As mentioned previously, the more pressure you can hold in a closed system, the higher your boiling point. Run the highest pressure cap your system can handle. The weakest link is typically the radiator or hoses. The radiator manufacturer should be able to suggest the appropriate cap pressure. Check the cap periodically to make sure it is maintaining the advertised pressure. The rubber seal on the cap may harden and form an impression from the seat in the filler neck. A new cap should be used whenever the filler neck or radiator is replaced. One commonly over looked component is the water neck/filler neck. Most are cast or formed metal. If the pressure cap seat is defective, distorted or poorly designed you will loose water while the engine is running. This situation acts like a bad head gasket. You will notice the engine gets hot faster every round or hot lap session. You wouldn't be the first or the last person fooled into thinking an engine problem was the cause for water pushing through the cap. Lack of pressure on the system builds heat faster and the quick boil-over is pushing all the water out.

Recovery System



DROP IN COOLANT TEMPERATURE CREATES A VACUUM

Keeping the system full reduces aeration and maintains pressure. As the temperature increases the water expands and pressure builds. If the system is completely full the expansion pressure will exceed the cap pressure and over flow into the recovery tank. If your pressure cap is properly located on the suction side of the system, air is pushed out first. When the system cools a vacuum is created. When your radiator cap is equipped with a valve that opens under negative pressure it will draw coolant back into the system. The tube that extends to the bottom of the recovery tank transfers the coolant back to the radiator. Mount the tank as close as possible to the pressure cap. The line should be short and level, reducing restriction and the effect of gravity. If the recovery tank is kept 1/3 full (with the engine cold) every heat cycle will automatically purge more air out of the system.

The opposite is true without a recovery system. With every heat cycle water will be pushed out, leaving more air space. This air space can be compressed lowering the boiling point.

Catch Can

What is normally referred to as a catch can should not be confused with a recovery tank. Most sanctioning bodies require a one pint or larger catch can to contain water overflow from the cooling system. The function is to keep coolant off the track. It will also give you some idea of how bad your over heating condition is based on the amount of coolant you drain from it.

Expansion Tank

An expansion tank is sometimes referred to as a surge tank, header tank or air separator. The tank has two main functions. It is used as a fill point when the top of your radiator is lower than the engine's water outlet. As the name infers, it can be used to deal with the expanding volume of water when a recovery system is not utilized. The bottom of the tank is plumbed to the low pressure (suction) side of the cooling system (after the radiator core and before the pump impeller). The smaller fitting on the upper portion of the tank is plumbed to the high points on the engine and radiator to remove trapped air and aerated water. This reservoir located high and out of the main flow of water allows air to separate out of the water making your cooling system more efficient.

TROUBLE SHOOTING

Correct Motor Rotation All of our electric pumps turn clockwise (as viewed from the front)except for LT-1, Modular, and Toyota Supra. The pump will flow a fraction of its potential when spun backwards. Remove the inspection plug in the motor end cap and you will see the 5/32" hex in the end of the motor shaft. Give the pump momentary power and observe the rotation as it comes to a stop. Switch the positive and ground wires if you need to reverse the electric motor.

No Rotation Check the fuse and replace if blown. Inspect the wiring from the power source to pump. Check the ground for possible faults. Check to see if the electric motor moves freely by removing the inspection plug and turning the shaft with a 5/32 hex wrench before testing pump operation. Turning the shaft back and fourth with the hex wrench may dislodge any foreign objects jamming the impeller without disassembling the pump. Failure to install a fuse inline on the positive lead may result in motor failure in a jammed impeller situation.

Electrical Faults Start from the pump ground. It should be free of paint, dirt and corrosion. The ground must also have a good path back to the battery; i.e. block to frame, frame to battery and block or frame to body. A chromoly chassis has poor conductivity and should not be used as a ground path. Inspect wiring for shorts. Check all the connections, especially crimp terminals. Tug on crimp connections and look for signs of overheating. Resistance at crimp connections can be reduced by adding a small amount of solder. This technique will increase reliability and reduce power consumption. Use a test light or jumper lead to check for an open circuit or switch.

No Flow - Air Locked If the rotation is correct and you still have no water flow, the pump may be air locked. This occurs most frequently when the cooling system has been drained and refilled. Occasionally by raising the drivers side of the car, or squeezing the lower hose you can purge enough air to allow the pump to prime. There are a few ways you can modify the pump to rectify this problem if it continues to reoccur. Please call us 8am to 5pm Pacific Time for more information.

ABOUT US

Meziere Enterprises was born out of a love for racing that spans three generations. Since the late 70's we have been building, driving and winning in NHRA, SCCA, IMSA, and NASCAR. This passion for racing is the driving force behind our desire to build the highest quality, most innovative products available.

The company began operation as Meziere Enterprises in 1980 and quickly grew from a machine parts and chassis fabrication shop to become one of the largest suppliers of chassis parts in the racing industry.

Over the years we have won awards and the admiration of industry professionals, but it wasn't until we released our line of electric water pumps that we gained national recognition among racers. Immediate acceptance by the top names in Pro Stock helped to launch this new product. Talk of the performance and unmatched reliability among sportsman racers continues to boost sales and fuel our growth.

The entire staff; sales, customer service, engineering, design, and the Meziere family, are highly involved in racing so we understand our customer's needs. We also know it's never "good enough" and certainly never "fast enough". In our daily effort to remain leaders in this industry, we continue to improve existing designs and develop new products.

From "weekend warrior" to "Pro Stock icon", your questions or ideas are always welcome. We look forward to helping your racing effort. Our motivation is customer satisfaction.

Ordering from Meziere Enterprises Inc.

Business Hours: Phone hours are 8:30a.m. To 5:00 p.m. Pacific time, Monday through Friday. Closed Saturday and Sunday and all major Holidays. Phone orders are taken at (800) 208-1755. Technical information line is (760) 746-3273. Fax orders are taken 24 hours at (760) 746-8469.

Phone Orders: Anyone who answers our order line can direct you to the sales department. Fax orders please use part numbers including color when applicable. Please include your phone number in case there are questions.

Mail Orders: Please supply your name, address, zip code, phone number, and preferred method of shipment. Clearly state what you want, including part number if possible. When using VISA/MASTERCARD or American Express you must supply the card number, expiration date, and the name as it read on the card. If the order is prepaid, it must be in certified funds. You will be notified if there is any delay in shipment.

Foreign Orders: Foreign orders please prearrange your own shipping arrangements. Some Canadian destinations fall into this situation also.

Special Orders: If you have a special request or need for an item not listed in our catalog, check with our salesperson or technical advisor to see if it is available. We constantly add new items to our inventory, making it possible that we have what you are looking for, but it is not mentioned in our catalog. Payment in full must accompany all special orders. No exceptions. No returns.

When you Receive Your Order

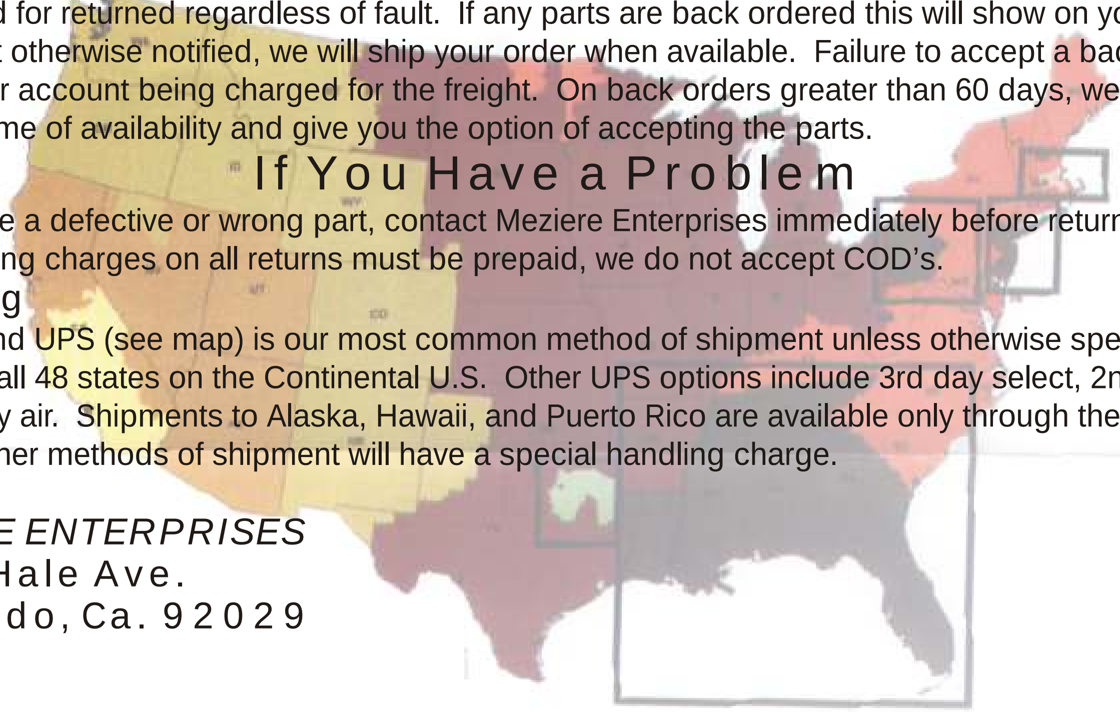
Check your order carefully as soon as you receive it to ensure that you have received what you ordered. Do not use or modify parts in any way before checking them. A part that is modified in any way cannot be accepted for returned regardless of fault. If any parts are back ordered this will show on your invoice. If we are not otherwise notified, we will ship your order when available. Failure to accept a back order will result in your account being charged for the freight. On back orders greater than 60 days, we will notify you at the time of availability and give you the option of accepting the parts.

If You Have a Problem

If you receive a defective or wrong part, contact Meziere Enterprises immediately before returning the part. Shipping charges on all returns must be prepaid, we do not accept COD's.

Shipping

UPS: Ground UPS (see map) is our most common method of shipment unless otherwise specified. It is available in all 48 states on the Continental U.S. Other UPS options include 3rd day select, 2nd day air, and next day air. Shipments to Alaska, Hawaii, and Puerto Rico are available only through the air options. Other methods of shipment will have a special handling charge.



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