

Automatic Transmission Fluid Overheating: New Jersey Forest Fire Service's Solution to High Temperature Problems in Ford F-350 and F-450

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National Association of State Foresters
in Cooperation with
Michigan's Forest Fire Experiment Station

Until recently, manual transmissions were the norm for most wildfire control trucks. Automatic transmissions have a wide acceptance now for several reasons. A major advantage is the shorter learning curve for new operators. Also, some agencies have started using their wildland fire engines to tow trailers hauling other equipment. The automatic allows for greater start up torque and smoother shifting when towing. Oil is used to shift gears in the automatic transmission. The friction losses of this process heat the transmission fluid. Under certain operations, such as towing heavy loads, the oil temperatures may reach a point where the oil will break down. When this occurs, the result is a damaged transmission or a shorter life for one. It is important to design the transmission cooling system for these heavy-duty applications. This report discusses the transmission heat problems and potential solutions for preventing its occurrence.

Automatic Transmission Basics

The transmission connects to the back of the engine and directs the engine's power to the drive wheels. A truck engine runs best within a certain RPM (revolutions per minute) range. The gear combinations of the transmission allow power to be delivered to the wheels while keeping the engine within that range. To change gears, the engine is temporarily disconnected from the vehicle. A manual transmission does this by physically separating two clutch plates when the operator depresses the clutch pedal. When the clutch pedal is released, the friction between the plates forms a direct drive link with very little loss of efficiency.

An automatic transmission accomplishes the gear shift using a complicated set of components that use oil flow acting on turbine blades. During this process, heat is generated from the friction of the fluid churning inside the torque converter as well as friction created from movements of clutch plates, gears, and bearings. Cooling of transmission fluid is critical. Normally, the oil is circulated to a heat exchanger in the lower radiator. Under harsher conditions, auxiliary cooling is necessary.

Automatic Transmission Fluid Temperature

Automatic transmission fluid (ATF) has a life of about 100,000 miles at 175°F. At high temperatures, it oxidizes, turns from red to brown and exhibits a burnt smell. In addition to reducing the oil's lubricating quality, high temperature produces a varnish on internal parts

interfering with the operation of the transmission. Above 250°F., rubber seals harden, leading to pressure loss and leaks. Also, the transmission can slip. In the worst cases, clutches fail and costly repairs result.

ATF manufacturers suggest that for every 20°F. increase in operating temperature above 175°F., the life of the fluid is cut in half. Hence at 195°F., oil life will be about 50,000 miles. Above 240°F., it becomes nil. Without adequate cooling, the heavy duty use of wildland fire engines will likely push the ATF operating temperature very high.

Monitoring and Reducing ATF Temperature

Driving conditions determine the likelihood of generating high ATF temperature. These include trailer towing, climbing hills or mountains, stop-and-go driving, repeated drive-to-reverse shifting, and high ambient operating temperatures. Any of these are common to wildfire fighting. Since the vehicle's cooling system helps to cool the transmission fluid, low coolant levels and dirty radiators can add to the problem. High ATF temperature will add heat to your radiator, possibly overheating the engine coolant. Many new truck models have a transmission oil temperature gauge installed as a standard feature. If your truck does not and you suspect that the fluid is getting too hot during operation, consider adding an after-market temperature sensor and gauge.

Select optimum gear ratios when ordering the vehicle.

There are several ways for reducing this ATF overheating. One is to order the proper gear ratios when purchasing the truck. Optimum gearing reduces heat produced. You need to determine the projected use for the truck. Then find a knowledgeable source for selecting the best ratios available for the truck models that fit your need. If you have no one capable within your agency, talk to the truck manufacturers. They have advisors within their sales force to help. It is also good to use their expertise as a double check. In any case, the most efficient gear ratios for both the transmission and axle are determined by how you use your truck and this in turn decides how much work your transmission will do.

Adding increased cooling with a different oil pan.

A supply of transmission oil is stored in its sump or oil pan. Some heat dissipation occurs as the oil sits here, waiting to be pumped back through the system to the transmission. There may be an after-market transmission

pan available for the truck that helps reduce oil temperature. Usually these work in two ways. Most are larger than the original pan which adds more oil capacity and thus more oil to absorb the heat. Some are made of aluminum which conducts heat quickly, exchanging more of it to the air. Additionally, fins increase the surface area enhancing heat exchange. This is a relatively low cost way to achieve some reduction in oil temperature. Before trying this option, check to see if the new pan affects ground clearance adversely.

Adding an external ATF cooler. This is the most common and efficient way to gain additional cooling. Auxiliary coolers are heat exchangers that are readily available as they are often added to motorhomes and trucks used to tow trailers. Usually the cooler is added in front of the vehicle's radiator. The transmission oil is routed to the new heat exchanger after leaving the factory-installed cooler located in the radiator. It then returns to the transmission. A fan can be added to increase air flow through the exchanger, thus adding more cooling capacity.

It is important to select an ATF cooler that has enough heat exchange capacity for your use. There are many shops which install these devices should your agency not have the capability. They should be able to help select the proper cooler. Use the words **transmission oil cooler** with a good internet search engine and a number of potential suppliers will appear. Most have a guide to help in selecting the right cooler. The New Jersey Forest Fire Service (NJFFS) used this method to solve ATF temperature problems with their Ford Super-Duty vehicles. The following describes the step-by-step process performed in the NJFFS shops. While Ford trucks are used in the example, the method could be used with other vehicles as well.

Adding a Heat Exchanger to a Truck

The NJFFS found that, under their use conditions, the transmission oil temperature exceeded the recommended maximum for their Ford F-350 and F-450 chassis, Type 6x wildland fire engines. NJFFS engines are equipped to work off-road and have brush guards to withstand knocking down brush and small trees. This allows them to drive to the fire and keep it small. The vehicles had an auxiliary engine driven water pump, hose reel, utility body, steel reinforcement and 250-gallon water tank. The operating vehicle weight of the F-350 and F-450 engines was 11,800 lbs. and 12,600 lbs., respectively, with a respective GVWR of 12,500 lbs. and 15,000 lbs. The automatic transmission installed was Ford model #4R100.

During operation, transmission heat problems occurred even with a factory-available auxiliary heat exchanger. The highest temperature measured approached 240°F., the upper limit set by Ford. Telephone conversations with Ford representatives and research conducted by the NJFFS Research and Development staff indicated these

high temperatures were likely the result of driving with constant, heavy loads. The manufacturer's representative and the dealer suggested the installation of an additional inline, auxiliary ATF cooler. NJFFS selected a Flex-a-Lite model #45951 cooler. It has a built-in thermostatically controlled electric fan that they set at 200°F. The unit was mounted just in front of the radiator, in a place chosen to provide sufficient airflow for proper cooling yet still be protected from potential brush coming up from the undercarriage. The hoses connecting the cooler needed to be protected as well.

Figure 1 shows a flow diagram for the ATF system before addition of the second auxiliary cooler. Under normal operating conditions, ATF flows from the outlet port at the front of the transmission, to the heat exchanger located in the radiator, and then to the factory-mounted auxiliary cooler. From here, the cooled fluid returns through an inlet port located at the rear of the transmission. A temperature controlled valve and recirculation line is located at the transmission outlet port. When the fluid is cold, this valve is open and the fluid travels directly back to the transmission via the bypass tube rather than through the coolers.

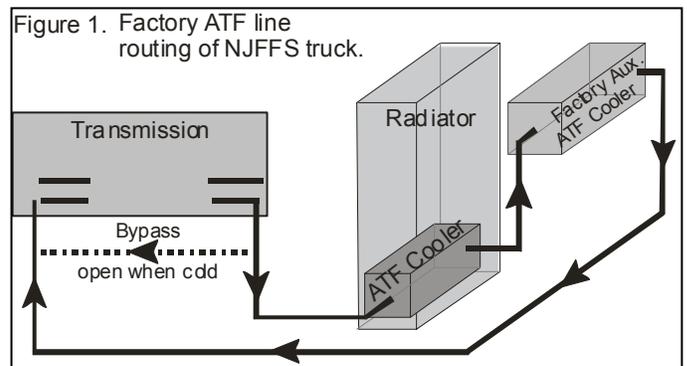
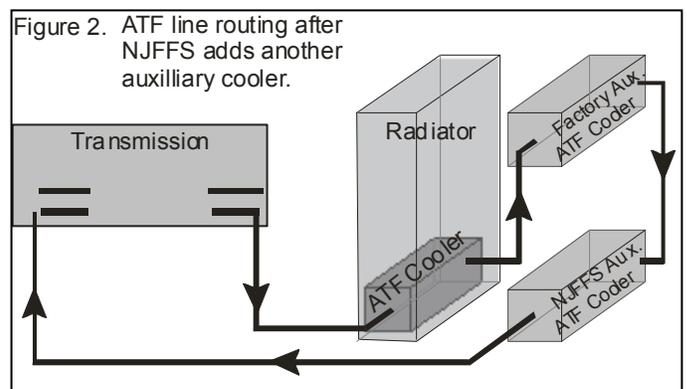


Figure 2 shows the ATF flow diagram after NJFFS added the additional ATF cooler. This new cooler was added downstream from the factory installed cooler. By doing this, the auxiliary cooler fan does not have to run as often. Also note that they removed the bypass tube (Figure 4) which was mounted on the right side of the transmission with two bolts. Doing this causes the ATF to circulate through the coolers at engine startup. This delays the



heat up of the ATF. However, no measurements were taken to verify how much gain this might add. In cold weather, the fluid may stay cold enough to cause sluggish shifting for a while. The normally high ambient temperatures during wildland fire operations probably make this a minor consideration. The process to show how the bypass was eliminated will be discussed later should you choose to do that as well.

Step-by-Step Auxiliary Cooler Installation

The NJFFS modification used the following components.

- Flex-a-Lite #45951 Fan Assist Heavy Duty Oil Cooler.
- Self-fabricated mounting brackets for installing the oil cooler.
- 3/8 inch Rubber Hose, ATF compatible.
- 2 Each, hose barb to 1/2 inch threaded adapters.
- Hose clamps to fit new hose.
- Transmission temperature gauge with mounting bezel and sender unit (optional).
- 12 Gauge high temperature automotive electrical wire with connector ends.

First, determine the location of the new auxiliary cooler, fabricate mounting brackets and install the device. Figures 3 and 4 show examples of the mounting brackets

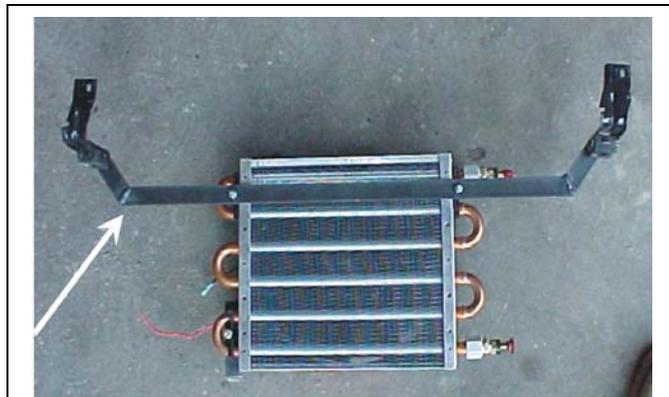


Figure 3. Using existing bolts, a flat steel bar was fastened to the front of the cooler. Other steel pieces were welded to this flat stock to match the existing radiator bracket locations with the desired location for the auxiliary cooler.



Figure 4. The factory stock radiator brackets were welded to the flat steel bracket to provide a mounting point for the cooler. Make sure that the bracket is solid enough to take some shock and vibration.

used. Figure 5 shows the NJFFS mounting located in front of the radiator.

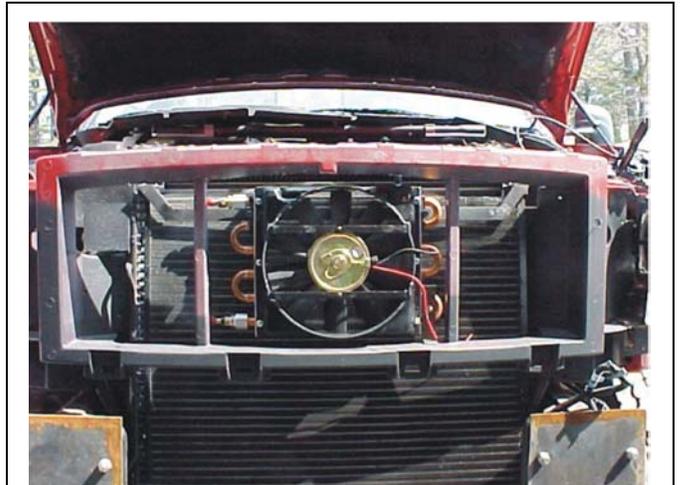


Figure 5. The new cooler mounted in front of the radiator by the fabricated bracket. Note the integrated fan, part of the cooler assembly.

Next, the ATF line was cut where the fluid exits from the factory-installed auxiliary cooler. If your vehicle does not have this cooler, cut the line where it exits the radiator-installed cooler. Use a flexible, 3/8 inch diameter rubber hose designed for use with ATF to connect from this point to the new cooler. Dayco's 3/8 inch ID #3311 Transmission Oil Cooler Hose or equivalent would fit this specification.

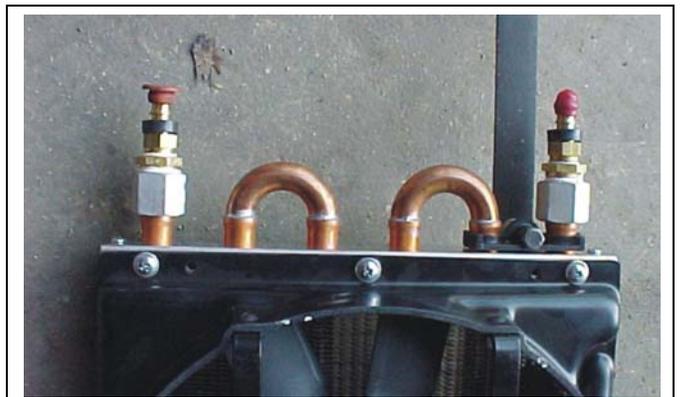


Figure 6. Hose barb adapter fittings are used to attach the hose to the 1/2 inch tube fittings on the inlet and outlet of the new cooler.

Hose barb adapter fittings were installed on the auxiliary cooler as shown in Figure 6. The 3/8 inch rubber hose was installed over the hose barbs and fastened with hose clamps.

A fused electrical connection for the fan was made to a key-on terminal located on or near the firewall of the vehicle. Protect the wire terminals from the elements by plastic connector covers and electrical tape. By using a key-on circuit, the fan will only run if the ignition key is in the on position, protecting anyone working near the fan

and preventing battery drain. Follow the truck manufacturer's recommendation concerning additions to electric circuits.

Caution: Do not interrupt or tap into any air bag electrical circuits.

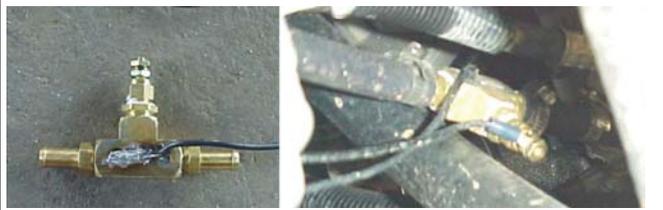


Figure 7. The inline sending unit was installed in the ATF return line (right photo) after the new auxiliary cooler. One wire goes to the temperature gauge mounted in the cab and the other is grounded to the chassis.

A temperature gauge with an inline sending unit (Figure 7) can be installed after the auxiliary cooler to determine the final temperature of the fluid. Both dashboard and roof pillar mounted gauges are available.

Make sure that wiring added in the last two steps is placed away from hot surfaces. Use wire ties or other fasteners to secure wires so they stay in place.

Expect to add about 1 pint of ATF to the system. The amount will vary depending on the size of the cooler selected and the amount of hose used.

As noted earlier the NJFFS eliminated the bypass tube (Figure 8) located on the right side of Ford transmissions. If you choose to remove the bypass, two things must be done. There is a bolt that attaches the bypass tube and return line to the right rear of the transmission (Figure 9). It contains a check valve shown in Figure 10. Remove the spring and check ball by cutting off the very tip of the bolt. This bolt and the one where the front of the bypass tube



Figure 8. ATF bypass tube from the Ford Super Duty truck.

mounts are reused. Make sure to clean off any contaminants before reinstalling them.

Each end of the bypass tube has a boss which the bolts pass through for attaching. Make spacers (Figure 11) of the same size and thickness as these bosses to allow the ATF lines to mount in their original place.



Figure 9. The ATF temperature relief ball valve, shown by the arrow and in Figure 10, closes when the oil temperature heats up sending the fluid through the coolers.



Figure 10. Cutting off the tip of the bolt allows removal of the check valve parts.



Figure 11. The spacers used to replace the bypass tube.

Disclaimer

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