ATF Cooler Failures Stump Everyone

CJ Readers invited to weigh in…

By **Thomas C. Coleman**

Editor's Note: *This article addresses an unusually frequent and perplexing product failure for which no one seems to have answers. For years, and with surprising frequency, in-tank automatic transmission coolers used on a variety of heavy duty work trucks, especially snow plows, dump trucks and refuse haulers, as well as some school buses and RVs have failed catastrophically as shown in our cover photo and in the article below. No definitive cause for these failures have been found, which has left vehicle and transmission manufacturers and cooling system distributors and repair specialists debating the potential causes, and dealing with warranty returns, associated costs, and the frustrations of not being able to identify a root cause for the problem.*

In response to this article, which outlines a basic description of the product and circumstances surrounding these failures, the Cooling Journal is asking readers to provide any information they may have about similar ATF cooler failures in order to gather as much information as possible about when and how they occur. By compiling the knowledge and expertise of our readers, especially those from the heavy duty sector, it is possible we can shed some much needed light on this issue.

As the article suggests, if you've had involvement in ATF cooler failures as described, please email us at info@narsa.org and use Cooler Failure in the subject line of your email.

Even with today's engineering and manufacturing capabilities in the cooling industry, product failures sometimes occur. To the relief of most, especially those that must pay warranty claims; these are relatively rare occurrences owing to a part or component with a manufacturing defect slipping through the manufacturer's quality control system. Even Six Sigma rated manufacturers can't claim statistical perfection.

In most of these cases, the cause of the failure is relatively easy to detect – a bad weld, damage during shipment, etc. But, every once in a while, a product type or model that seems to meet or exceed design specifications, will fail with unexpected frequency and for reasons that no one can seem to figure out.

Photo 1 shows a 7 plate, 18 inch, in-tank transmission cooler which experienced a catastrophic failure early in its service life and was returned to the distributor. Note the ballooning of the plate located toward the bottom of the cooler as shown in Photo 1. This plate deformed almost across its entire length. Also present in the ballooned portion of the cooler was a one inch crack located about 1 mm from the side flange.


Photo 1

The ballooning of the plate suggests that the cooler was exposed to excessive internal pressures which caused the plate to bulge outward. Such a failure should be an extremely rare occurrence. Unfortunately, it doesn't seem to be. Many cooling system specialists have run into this type of failure quite often and such cooler failures have become a serious issue for the entire industry.

These stacked plate ATF coolers are installed in the outlet tanks of the radiators of many trucks. Transmission oil flows through the interior of the cooler at a temperature of approximately 195°F (90.5°C) at an operating pressure of approximately 70 psi at idle. The cooler is surrounded by the engine coolant at operating temperatures of approximately 180°F (82.2°C) at 7 psi. Assuming that the engine operating temperature and pressure remain in normal operating ranges, temperatures and pressures sufficient to do such damage should not occur.

Each stacked plate is a three layer sandwich of 304 stainless steel. A turbulator plate is placed between the top and bottom layers of steel. The sandwich is then brazed together using a copper alloy. The turbulator disrupts and slows down the flow of the transmission fluid to allow more time for heat transfer and provide additional structure to the cooler.

These cooler failures are showing up most regularly on heavy duty trucks used as refuse haulers, dump trucks, and snow plows which have on-board hydraulic systems. Reports have come in associating the failed coolers with a wide variety of truck makes and models. The problems have most often occurred in vehicles which use, or have, power take offs (PTOs) on the transmission to drive auxiliary equipment. The problem has also been reported to occur in school buses and some recreational vehicles.

After corresponding with a number of people in the industry, there doesn't seem to be any explanation as to why, or how, such a failure occurs. So, we need the help of *Cooling Journal* readers who may have experienced or seen a similar failure or failures. The information currently available regarding this failure and some questions that need answered are outlined below. And, if you have any information, theories, or advice for us, please send them to info@narsa.org and use "Cooler Failure" in the subject line. Reader responses will be compiled and sorted to see if there are patterns, or similar circumstances surrounding these failures. Here's what we think we know.

FAILURE FREQUENCY

In examining product failures, frequency is the first dimension to be examined. If particular failures are extremely rare and occur without any apparent relation to one another, then the easiest explanation is usually the right one. A bad product just slipped through the manufacturer's quality control system, or was damaged during shipment, or installation. Unfortunately, distributors and installers pay claims on this kind of damage regularly, but not on any significant portion of the inventory they handle.

In the case of these stack-plate ATF coolers, however, the failures reported are much more frequent than they would be if an occasional quality lapse were to blame. Additionally, the failures are geographically dispersed across the nation arguing against a climate related cause.

EXCESSIVE PRESSURE AS THE LIKELY CAUSE

It seems obvious that excessive pressure is the likely cause of the bulging of the bottom plate as shown in the cooler returned by the customer. But how did pressure, sufficient to deform 304 stainless steel, get into or build up within the ATF cooler and/or the transmission itself?

Under normal operating conditions, ATF fluid is circulated through the transmission by a transmission pump which, at idle, is operating at a pressure of about 70 psi and intended merely to circulate the fluid through the transmission and cooler. As engine speed and vehicle load increases, the ATF pressure builds somewhat, but a regulator valve dumps excess pressure beyond design limits. In most heavy duty trucks, the transmission pressure relief valve will vent pressure before it exceeds 300 psi; confirming that such failures should not occur under normal operating conditions. But, even with a defective regulator valve, it is almost impossible to imagine sufficient pressure building to deform the cooler plates.

Faced with a number of warranty returns, one distributor sought some answers. Coolers were obtained from the same manufacturing batch as the failed cooler and sent to a testing company to determine if they would exhibit the same bulging characteristics at failure, and to determine roughly the amount of pressure necessary to deform the plates.

The testing company conducted a high pressure test, followed by a high pressure/high temperature test of the coolers. Standard leak tests of the coolers were conducted at 125 psi for one minute and found no leaks.

HIGH PRESSURE TEST

The first cooler was then filled with transmission fluid, pressure gages at inlet and outlet were calibrated, and the high pressure line was attached to the inlet fitting. At an ambient temperature of approximately 75°F (23.8°C), the pressure was steadily increased from 0 psi upward at 20-50 psi increments. At approximately 1400 psi, the oil cooler yielded at the second plate underneath the outlet fitting. As shown in Photos 2 and 3, the stainless steel plate had ballooned in a linear front across the three inch width and extended for about 1 inch along the plate.


Photo 2

While the cooler did not leak, it certainly exhibiting the ballooning found in the failed cooler.


Photo 3

HIGH PRESSURE/HIGH TEMPERATURE TEST

For the second test, a cooler was filled with transmission fluid and prepared the same way the first one was. However, it was placed into a 200°F (93.3°C) bath of 50-50 ethylene glycol and water and allowed to reach temperature. Pressure was gradually increased from 0 psi to 350 psi. Temperature and pressure were maintained for 30 minutes without effect.

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Pressure in the cooler was then gradually increased to 1300 psi at which time the cooler began to yield. As pressure rebuilt to 1300 psi again, the fifth plate on the inlet side ballooned. The testing company indicated that, "Continued pressure would have caused a seam fracture between the plates or at a fitting."

So, what did these tests show?

First, because the coolers tested were from the same manufacturing batch as the original failed product, we can probably (although not with 100 percent certainty) rule out a systemic material and/or manufacturing quality issue, that is, a quality issue that would affect an entire manufacturing run. Examples of systemic failure might include using defective steel, an incorrect grade of steel, or an ineffective brazing technique to join the plates. Additionally, both the number of failures in the field and the fact that failed coolers cannot be traced to one manufacturer suggests a non-manufacturing cause.

Second, at ambient temperature, the high pressure test determined that cooler plates such as these will fail at approximately 1400 psi. We know that the internal pressure inside a transmission should never reach 1400 psi, but both the failed cooler from the field and the test coolers from the high pressure and high temperature/high pressure tests exhibited the same kind of ballooning suggesting that somehow, really excessive amounts of pressure may have gotten into the transmission.

Third, one has to wonder about the effect of both heat and pressure acting simultaneously on the cooler. In the first test, the cooler failed at 1400 psi at ambient temperatures. In the second, high pressure/high temperature test, a similar cooler at 200°F (93.3°C) failed at approximately 1300 psi. On the one hand, could the failure of the second cooler at 100 psi less pressure be due to the increased temperature (200°F (93.3°C) as opposed to approximately 75°F (23.8°C)? And, if so, would an even higher temperature result in failure at even lower pressure. Or, is the 100 psi difference within the normal yield range of the materials or manufacturing processes used?

FAILED COOLER EXAMINED

The cooler that failed in the field was also sent out for examination to determine if corrosion was involved in the formation of the fracture. The examination, conducted by another third party testing company found, "There was no discernable corrosion activity in or near the fracture."

The report concluded, "This workup raises the possibility that much higher internal pressures (*Ed.- well over the normal operating pressure*) may be required to cause this failure without factoring in the strength imparted to the union of the turbulator to the stainless casing. The possibility of unexpectedly high internal pressures in the cooler should be given due consideration in any root cause analysis."

According to the manufacturer, this cooler design specification requires the cooler to maintain a minimum of 2.5 MPa (362 psi) for five minutes. In a sample test they conducted, the cooler began to yield at 10.6 MPa (1537 psi).

So we know that it takes a lot more pressure than we would normally find in an ATF cooler circuit to cause the ballooning. What happens if the cooler itself becomes plugged? It would seem that the pressure between the transmission pump and the cooler would increase, but would the pump produce sufficient psi increase to balloon the cooler? It seems unlikely.

LOOKING AT THE WHOLE TRANSMISSION SYSTEM

What's been done to this point is to test some of the obvious and pretty straightforward potential causes – excess pressure, and to some extent excess temperature, on bench tests. The tests and discussion to this point have looked only at the cooler itself. But this is a long way from testing all of the variables of a working system and falls woefully short of being able to diagnose such problems as they occur in the field. So, we may need to look at these failures from other perspectives. The cooler is only one part of a complex system in which the forces developed within one part or component impact, directly or indirectly, many other parts of the system.

For example, the ATF cooler is one of hundreds of parts and components in the transmission system. This leads us to ask a whole new series of questions. What happens to the ATF cooler, when other parts, seals, or relief valves fail? When the coolers have failed, are there other components of the transmission system that tend to fail with them, or even before they do? And could their failure produce the pressure necessary to deform or fracture the cooler?

Has anyone serviced such a cooler failure at the same time that other, potentially related transmission repairs, were being made?

What is the significance of the vehicles having auxiliary hydraulic systems and power take offs? Can excess pressure from these sources get into the transmission and ATF cooler circuit?

Are the extreme operating conditions and uses that these work trucks experience causing unanticipated situations in which design limits for various components are exceeded? Is auxiliary equipment being mismatched to the capabilities of the vehicle transmissions?

Have auxiliary ATF coolers been installed on the vehicle, perhaps signaling that the transmission has already been diagnosed as running hot?

There are literally hundreds of questions that could be asked. So, here's where we need your help. If you have knowledge regarding similar ATF cooler failures, please let us know.

Here are the kinds of things you might let us know about: vehicle make and model; engine make and model; transmission make and model; auxiliary hydraulic system description (plow, dump, compactor, etc.); power take-off (PTO) equipment on vehicle; geographic region; components repaired or replaced at the same approximate time; original equipment or aftermarket cooler; the presence of auxiliary coolers; and anything else that seem relevant in the service history of the vehicle (previous transmission issues, replacement parts, etc.). Please provide as much specific information as you can.

We also want to know what you may have found out by talking with OEs, suppliers, and colleagues regarding these types of cooler failures. In the next few issues of the *Cooling Journal*, we'll report back to you on the feedback, theories, and information we receive. ■