TRANSMISSION COOLING – BASIC

ALLISON ON-HIGHWAY TRANSMISSIONS

APPLICABLE MODELS: **1000 Product Family**
2000 Product Family
2900 Product Family
3000 Product Family
4000 Product Family

Contents:

TRANSMISSION COOLING – BASIC

1.0 INTRODUCTION

The purpose of this document is to provide basic transmission cooling guidelines which apply to all transmission installations. Cooling guidelines that apply specifically to retarder-equipped transmissions can be found in the *Transmission Cooling – Retarder* document.

2.0 REFERENCED DOCUMENTS

Unless otherwise noted, all documents referenced in this document may be found in the Allison HUB website at https://hub.allisontransmission.com/login. To locate the referenced documents look for Tech Data under the Engineering heading on the Allison HUB home page. In this document, these references are identified by italic font. Contact your Allison Transmission representative if you do not have access to the Allison HUB. A list of all items referenced in this document can be found at the end of this document.

3.0 TRANSMISSION COOLING SYSTEM REQUIREMENTS

In the propulsion mode, transmission operation generates heat due to converter slippage, charging pump losses and friction in the rotating components. The transmission fluid absorbs this heat, requiring an external cooling circuit to dissipate the heat. Maximum heat generation in the transmission occurs during converter operation in the lowest gears. Because most of the heat is generated by the converter, transmission cooling in the propulsion mode is usually referred to as converter-mode cooling.

Maximum transmission temperatures occur under the worst conditions of operation:

- steep grades
- high vehicle weight
- high ambient air temperatures

The transmission cooling system must meet the following requirements:

- Maintain transmission oil temperatures within transmission temperature limits, even during intermittent severe duty cycles and worst case operating conditions

- Maintain transmission oil temperatures within transmission temperature limits at the ambient temperature recommended where the vehicle will be in service. Refer to Appendix A for a list of Allison recommended design ambient conditions for various worldwide locations.

- Remove, as a minimum, the total transmission heat load corresponding to the appropriate converter efficiency point in first gear.
  - The total transmission heat load is the combined heat rejection from the converter and the transmission gearpack with no credit for radiation and convection losses from the transmission case and hydraulic lines.
  - The converter efficiency cooling point depends upon the vehicle's vocation. Typically, on-highway trucks are required to provide cooling at 85% converter efficiency. Vehicles in stop/start applications such as transit buses and refuse trucks are required to provide cooling at 80% converter efficiency. Off-highway vehicles are required to provide cooling at 70% converter efficiency. Refer to *Technical Document 157 (TD-157), Transmission Cooling Tests*, for required converter efficiency cooling points by vocation.
  - For some 85% converter efficiency cooling applications, the 85% converter efficiency point is close to or at engine full load governed speed. If this is the case, compare the heat rejection at the converter coupling point to the heat rejection at 85% converter efficiency. Use the point with the higher heat rejection for converter efficiency cooling calculations and tests.

- Verify by calculation or by test the ability to maintain transmission oil temperatures within transmission temperature limits at the appropriate converter efficiency cooling point as defined in *TD-157, Transmission Cooling Tests*.

- Converter-mode cooling must be accomplished on a continuous and stabilized basis within transmission temperature limits, in worst case ambient conditions, for the full life of the vehicle.

- Known duty cycle requirements for specific vocations can dictate cooling capacity above the minimum level. For example, if it is known that a vehicle will operate most of the time at severe conditions, the cooling capacity must be increased so that operating temperatures will remain well within the maximum limits.

- If the transmission is equipped with an output retarder, the cooling system must also meet the requirements defined in *Transmission Cooling – Retarder*.

3.1 TRANSMISSION TEMPERATURE LIMITS

Transmission temperature limits are shown in *Transmission Data* for each of the transmission Product Families. Temperature limits, which are common for all models, include the following:

- maximum converter out temperature
- maximum sump temperature
- minimum sump temperature
- minimum start-up temperature

CAUTION: Any operation above the maximum limits, or even continued operation within, but near, the maximum temperature limits can decrease transmission reliability and longevity.

Maintaining low transmission operating temperatures typically results in improved transmission life as well as extended oil change intervals.

To insure proper operation of the transmission controls, the transmission must not be over-cooled. Thus, a minimum sump temperature must also be maintained during normal operation.

3.2 VERIFYING TRANSMISSION COOLING AT CONVERTER EFFICIENCY POINT

The converter efficiency cooling performance may be calculated for oil-to-water coolers under the following conditions:

- the cooler performance curve is based on test data and is not just a calculated estimate of the cooler's performance
- the cooler performance test data represents cooler performance as installed in the vehicle

Otherwise, a converter efficiency cooling test is required.

A converter efficiency cooling test is required for the following transmission cooling systems:

- oil-to-air systems
- combination oil-to-water and oil-to-air systems

The converter efficiency cooling test has two purposes:

- verify that the cooling system is capable of maintaining transmission temperatures within limits
- verify that the transmission cooler capacity is as shown on the cooler performance curve

TD-157, Transmission Cooling Tests describes the converter efficiency test, including:
- test procedure
- test conditions
- required instrumentation
- interpretation of test results

3.3 IDLE STALL COOLING

Idle stall occurs when the engine is at idle, the transmission is in gear and the vehicle brakes are applied, thus stalling the converter. The converter generates heat because the input is turning and the output is being held. The engine thermostat is typically closed, eliminating water flow to an oil-to-water cooler. Unless an air-to-oil cooler is equipped with its own fan, there is no air flow to an air-to-oil cooler. Thus, the transmission is susceptible to overheating.

The idle stall condition typically occurs in two situations:
- The vehicle is stopped in traffic for an extended period with the transmission in gear, the engine running and the service brakes applied.
- The driver leaves the vehicle parked with the transmission in gear, the engine running and the parking brake applied.

Allison Transmission requires that an idle stall cooling test be performed as a part of the transmission cooling verification. *TD-157, Transmission Cooling Tests*, describes the idle stall test.

If the transmission temperature limits are exceeded during the idle stall cooling test, modifications to the cooling system are indicated. Possible modifications include:
- For an oil-to-water system, add an engine thermostat bypass to provide coolant flow to the transmission cooler when the engine thermostat is closed. Refer to 5.5, Water Bypass Requirements.
- For an oil-to-air system, turn on the fan when the transmission fluid reaches the temperature limits.

In addition, to address the problem of parking the vehicle with the transmission in gear, Allison Transmission recommends alerting the operator if the transmission is in gear when the parking brake is applied. A buzzer or dash light can be used to encourage the driver to shift the transmission to Neutral. In Neutral the converter output rotates with the input, which significantly reduces the amount of heat generated.

3.4 IMPLEMENTATION OF COOLING REQUIREMENTS

The vehicle builder is responsible for properly analyzing, designing and verifying the vehicle cooling system.

The engine speed and the transmission heat rejection at the converter efficiency cooling point are unique for each engine-converter match. A change to the engine power, torque or governed speed results in a change to the engine speed and transmission heat rejection at the converter efficiency cooling point, even if the same converter is used. Multiple engine ratings are often used with the same transmission product family in the same vehicle. For these cases, the transmission cooling system may be designed and verified for the engine-converter match with the highest heat rejection at the appropriate converter efficiency cooling point. The resulting cooling system should adequately cool applications of the same transmission product family that have less heat rejection.

A cooler manufacturer should be contacted for an oil cooler to remove the required heat load within transmission temperature limits. A cooler performance curve showing heat rejection capacity and pressure drop should be obtained from the manufacturer to determine if the cooling requirements can be met.

The following cooler arrangements are possible for converter-mode cooling:
- Allison Direct Mount oil-to-water cooler mounted directly to the rear of the transmission
- Oil-to-water cooler mounted remotely from the transmission
- Oil-to-air cooler mounted remotely from the transmission
- Combination of oil-to-water and oil-to-air coolers in series or parallel

CAUTION: Coolers that are mounted directly to the vehicle powerpack are susceptible to the potential detrimental effects of vibrations. The cooler supplier should be contacted to review any cooler installation that is mounted to the powerpack.

Allison Transmission offers direct-mount oil-to-water coolers mounted on the rear of the transmission. These direct-mount coolers have been designed and tested to withstand powerpack vibrations based on their location and integrated design. Additional information on the Allison direct-mount coolers can be found in 5.0, Transmission / Retarder Cooler Systems, and the *Transmission Data* section of Tech Data.

Because of the available transmission cooler circuit oil flow, additional cooling may be required to maintain the transmission oil within the required temperature limits for the following:
- off-highway applications requiring 70% converter efficiency cooling
- high power and torque applications such as crash trucks and crane carriers
- severe duty cycle conditions such as long, steep grades

The additional cooling may be accomplished using one or more of the following:
- lower water inlet temperature to a transmission oil-to-water cooler
- auxiliary oil-to-air cooler in series with a transmission oil-to-water cooler
- larger transmission oil-to-water cooler
- use of a large transmission oil-to-air cooler instead of an oil-to-water cooler

To assist in the selection of a transmission cooler, Allison provides a PC-based program, *AllisonCalc*, which calculates the following:
- oil-to-water (OTW) cooling system capacity and estimated temperatures
- oil-to-air (OTA) cooling system capacity and estimated temperatures
- combination (OTW + OTA) cooling system capacity and estimated temperatures
- estimated pressure drop for hoses and fittings

AllisonCalc is downloadable from the Extranet. Select "Installation Design Calcs" from the Engineering menu on the Extranet home page. Note that this is a downloadable program — it does not run interactively from the website. *Technical Document 167 (TD-167), Installation Design Calculations User's Guide*, is available at the same location on the Extranet.

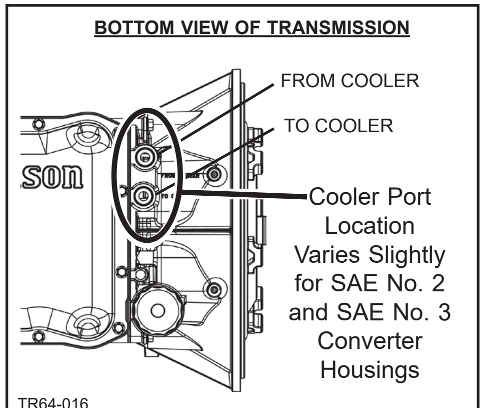


Figure 1: Cooler Ports, 1000/2000 Product Family

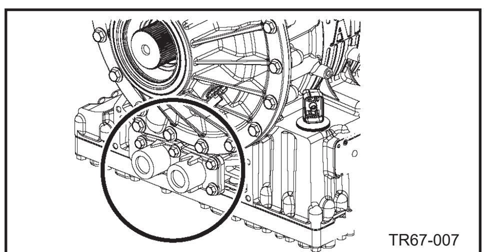


Figure 2: Rear Cooler Ports, 3000/4000 Product Families – 4000 Model Shown

4.0 TRANSMISSION COOLER PROVISIONS

Allison offers the following types of cooler provisions:

- Oil ports on the transmission for coolers mounted remotely from the transmission.
- Oil-to-water coolers mounted directly to the rear of the transmission – available for 3000 and 4000 Product Families only.

The transmission provisions for remote-mounted coolers incorporate inch-series straight thread O-ring ports on the transmission. The port locations vary by transmission family as described below:

- 1000/2000 Product Families – cooler ports are located at the front of the transmission, on the bottom of the converter housing, see Figure 1 and the *1000/2000 Basic Installation Drawings*
- 2900 Product Family – cooler ports are located at the front of the transmission, on the bottom of the converter housing, see the *2900 Basic Installation Drawing*
- All 3000 and 4000 Product Family models – cooler ports are located at the rear of the transmission below the output shaft, see Figure 2 and the *Basic Installation Drawings* for the *3000* and *4000* Product Families.
- 3000 and 4000 Product Family Models with Deep (4-inch) Sump – optional cooler ports are located at the front of the transmission below the converter housing, see Figure 3 and the *Front Cooler Port Provision Installation Drawings* for the *3000* and *4000* Product Families.

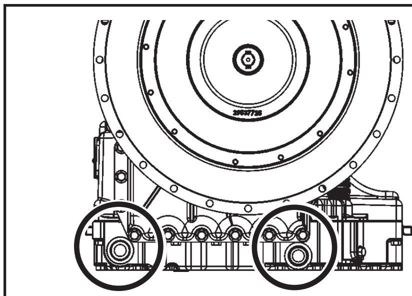


Figure 3: Front Cooler Ports, 3000/4000 Product Families – 4000 Model Shown

The Installation Drawings define the port sizes as well as the dimensional locations. The Installation Drawing numbers can be found in the List of Referenced Documents at the end of this document.

The direct-mount cooler option is described in 5.2, Allison Direct-Mount OTW Cooler.

5.0 OIL-TO-WATER (OTW) COOLERS

An oil-to-water cooler transfers the heat from the transmission oil to the engine coolant. The engine coolant carries the heat to the vehicle radiator where the heat is dissipated to the atmosphere.

Oil-to-water coolers have the following advantages:

- An oil-to-water cooler can warm or cool the transmission fluid. The heat from the engine cooling system can help maintain the minimum transmission temperature in colder climates, improving operation of the transmission controls and increasing transmission efficiency.
- An oil-to-water cooler can minimized the effect on vehicle configuration, especially when installed in the radiator.

Oil-to-water coolers can have the following disadvantages:

- Transmission temperatures are a direct function of engine water temperature. Increased water-side operating temperatures for emission controls will adversely affect transmission temperatures.
- Remote-mounted oil-to-water coolers may complicated the vehicle plumbing or affect the efficiency of the engine water system.
- The engine coolant or transmission oil could be contaminated in the event of a leak in the cooler.

5.1 OTW COOLER PERFORMANCE CALCULATION – CONVERTER-MODE

When calculating the converter efficiency cooling performance for an oil-to-water cooler, the following factors must be applied:

- **Engine water temperature:** typically 93ºC (200ºF) on the cold side and 100ºC (212ºF) on the hot side. If the engine manufacturer allows higher temperatures, those temperatures must be used.

- **Water flow through the transmission oil cooler:** as declared by the engine manufacturer at the iSCAAN calculated engine speed for the converter efficiency point appropriate for the vocation.
- **Oil flow through the transmission cooler:** at the *iSCAAN* calculated engine speed for the converter efficiency point appropriate for the vocation. For transmission oil flow data, refer to *Transmission Data* for the *1000/2000*, *2900*, *3000* and *4000* Product Families.
- **Transmission heat rejection:** as calculated by iSCAAN at the appropriate converter efficiency point for the vocation. Heat rejection values are included in the iSCAAN "Transmission Output Performance" and "Engine/Converter Match" data printouts. Converter and transmission losses are included in the iSCAAN analysis. If necessary, contact Allison Application Engineering for further assistance.
- **Cooler performance curves:** as provided by the cooler manufacturer. The cooler performance data must be based on test data or have been verified by a transmission cooling test.

NOTE: Be sure that the cooler performance curve used in the cooling analyses represents cooler performance as INSTALLED. This is critical for radiator tank oil coolers, particularly side-tank coolers, in which cooler location within the tank may have a significant effect on cooler performance.

Figure 4 illustrates a typical converter mode cooler performance calculation for an oil-to-water cooler.

1. CONDITIONS – 3500RDS refuse application at 80% converter efficiency

	Metric	**English**	**Data Source**
At 80% Converter Efficiency			
- Engine Speed	1750 rpm	1750 rpm	iSCAAN
- Water Flow	6.3 L/s	100 gpm	Engine Mfr.
- Water Temperature	93.3 °C	200 °F	Radiator Bottom Tank
- Oil Flow	0.69 L/s	11 gpm	Transmission Data
- Heat Load (Q)	39.55 kW	2250 Btu/min	iSCAAN
- Cooler Capacity (Q')	1.013 kW/°C	32.0 Btu/min/°F	Cooler Mfr.

2. ESTIMATE STABILIZED CONVERTER-OUT (COOLER-IN) TEMPERATURE

	Metric	English	
ITD* = (Q/Q')	ITD = 39.55 / 1.013	2250 / 32.0	*ITD = Cooler Inlet Temperature Differential
	= 39.0 °C	70.3 °F	= (T oil-in) - (T water-in)
T converter out = (T water) + (ITD)			
	= 93.3+ 39.0	200 + 70.3	
	= 132.3 °C	270.3 °F	

3. CALCULATE OIL TEMPERATURE DROP

	Metric	English
ΔT =	Q / (1.8 x L/s)	Q / (3.6 x gpm)
=	39.55 / (1.8 x 0.69)	2250/(3.6 x 11)
=	31.8 °C	56.8 °F

4. ESTIMATE OIL TEMPERATURE OUT OF COOLER

T cooler-out = (T converter-out) - (ΔT)

	Metric	English
=	132.3 - 31.8	270.3 - 56.8
=	100.5 °C	213.5 °F

5. SUMMARY AT 80% CONVERTER EFFICIENCY

	Metric	English
T converter-out =	132.3 °C	270.3 °F
Tcooler-out =	100.5 °C	213.5 °F
Tsump = Tcooler-out + 5.6 °C (10 °F) =	106.1 °C	223.5 °F

Because T converter-out is below the transmission limit (149°C, 300°F), and T sump is below the sump limit (121°C, 250°F), the cooler is acceptable.

6. NOTE: Cooler circuit pressure drop must be tested if remote cooler is used.

Figure 4: Sample Converter-Mode Cooler Performance Calculation – Oil-to-Water Cooler

5.2 ALLISON DIRECT-MOUNT OTW COOLER (3000, 4000 PRODUCT FAMILIES ONLY)

Allison offers two optional oil-to-water coolers mounted directly to the rear of the transmission for 3000 and 4000 Product Family non-retarder models (Figure 5). One is a 7-plate standard capacity cooler and the second is a 17-plate high capacity cooler. Refer to the following *Cooler Installation Requirements Installation Drawings*:

- *AS66-470, Direct-Mount Coolers, Non-Retarder, for 3000 Product Family, sheet 1*
- *AS67-470, Direct-Mount Coolers, Non-Retarder, for 4000 Product Family*

The 17-plate high capacity cooler is also available on the 3000 Product Family retarder equipped models. This will be discussed further in the *Transmission Cooling - Retarder* section of Tech Data. The transmission oil flows between the transmission and the cooler without external oil lines. Vehicle plumbing is simplified by requiring only water lines to the cooler.

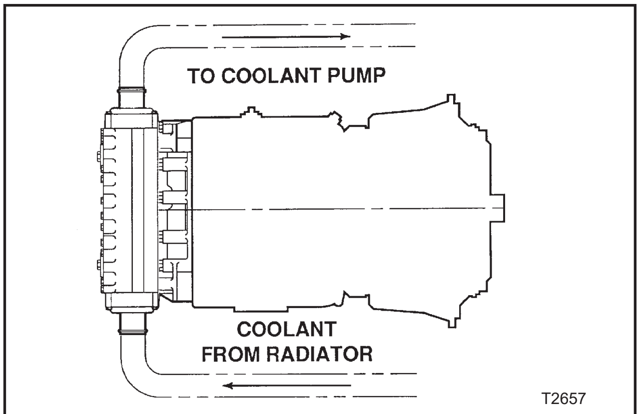


Figure 5: Direct-Mount Oil Cooler

Refer to the applicable *Transmission Data* for cooler performance charts. Not all direct-mount coolers are available on all Allison transmissions in all geographical areas. Refer to *Features & Options* and to the *Customer Specification Sheet (CSS)* to determine if a specific direct-mount cooler is available for your transmission in your geographical area.

These direct-mount coolers are available with two options for the water connections:

- 63.5 mm (2.5 inch) O.D. fittings which exit straight from the ends of the cooler
- 50 mm (1.97 inch) O.D. 90-degree elbow fittings which can be used to direct the coolant flow toward the engine.

Both options are shown on the *Direct-Mount Cooler Installations Drawings* for the *3000* and the *4000* Product Families. Refer to the applicable *Features & Options* and to the *Customer Specification Sheet (CSS)* to determine which coolant connections are available for your transmission model in your geographical area.

NOTE: Due to the pressure drop resulting from long hose length in some vehicle installations, the direct-mount cooler may not be appropriate for all engines. The vehicle manufacturer must verify that the coolant circuit meets the engine manufacturer's pressure requirements at the water pump inlet.

CAUTION: Untreated water can cause damage, such as electrolytic corrosion, to cast aluminum housings. The use of untreated or native tap water as a cooling medium, while discouraged for all vehicles, is STRICTLY PROHIBITED if an Allison cooler is used. Refer to 5.4, Coolants, for additional coolant requirements that apply to all installations.

5.3 REMOTE OTW COOLER INSTALLATION DESIGN GUIDELINES

Remote oil-to-water coolers require plumbing for both transmission oil and engine water.

Coolers should be located and oriented for optimum cooling performance. Coolers must be oriented so that they completely fill with transmission fluid and do not trap air. Trapped air reduces fluid flow and reduces cooling capability. Consult the cooler manufacturer for the best method to achieve optimal cooling for your installation.

5.3.1 TRANSMISSION OTW COOLERS IN THE RADIATOR

Figure 6 illustrates two typical configurations for transmission coolers located in the radiator. The configuration in the upper left shows a side mounted oil-to-water cooler in a cross-flow radiator. The configuration in the lower right shows a bottom tank oil-to-water cooler in a down-flow radiator.

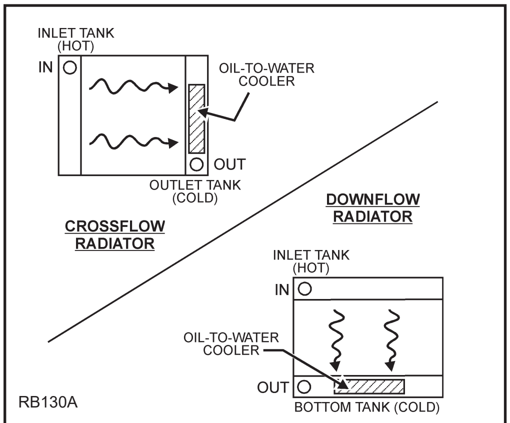


Figure 6: Typical In-Radiator Transmission Coolers

- In cross-flow radiators, the oil cooler should be positioned in the tank so as to receive maximum water flow. Consult the radiator and cooler manufacturers for installation recommendations.
- For coolers mounted vertically, such as a radiator side-tank, the best practice is to direct oil into the cooler at the bottom, exiting at the top. This provides cross-flow and purges air from the cooler.
- For coolers in the bottom tank of the radiator, the best practice is to assure cooled water flows over as much of the entire length of the cooler as possible. This is especially important for side-by-side radiator and air-to-air charge cooler arrangements.

5.3.2 REMOTE OTW COOLERS NOT MOUNTED IN RADIATOR

Figure 7 shows an example of a remote oil cooler that is not mounted in a radiator.

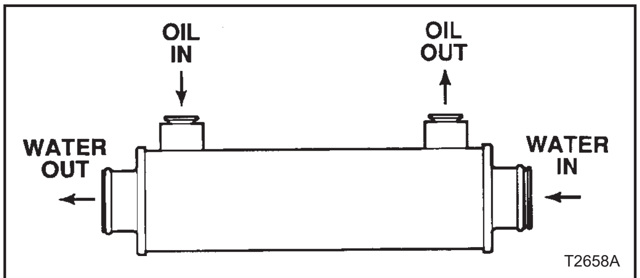


Figure 7: Example of Remote Oil Cooler

- In most cases, the best practice is for the water and transmission fluid to flow in opposite directions, called "counter-flow", as shown in Figure 7. Counter-flow may be more advantageous in longer coolers and less important for shorter, more compact coolers. Consult the cooler manufacturer to determine the advantage counter-flow might have on your particular application.
- For coolers mounted horizontally, locate the oil ports on the top in order to prevent the entrapment of air in the cooler. Refer again to Figure 7.
- For coolers mounted vertically, direct oil into the cooler at the bottom, exiting at the top. This provides cross-flow and purges air from the cooler.
- When locating a remote-mounted oil-to-water cooler, consider the plumbing complexity, protection from operational damage, and the effect on the engine-water system.

Refer to *Transmission Support Equipment* for a list of available remote OTW cooler suppliers.

CAUTION: Coolers that are mounted directly to the vehicle powerpack are susceptible to the potential detrimental effects of vibrations. The cooler supplier should be contacted to review any cooler installation that is mounted to the powerpack. (The Allison direct-mount coolers have been designed to withstand powerpack vibrations.)

5.4 COOLANTS

The use of untreated or native tap water is detrimental to any vehicle cooling system.

CAUTION: Untreated water can cause damage, such as electrolytic corrosion, to cast aluminum housings. The use of untreated or native tap water as a cooling medium, while discouraged for all vehicles, is STRICTLY PROHIBITED if an Allison cooler is used.

COOLANT REQUIREMENTS – If freeze protection is required, use ethylene glycol-based permanent type antifreeze, which includes an appropriate inhibitor. No additional inhibitors are required at initial fill if the antifreeze content is a minimum of 30% content by volume. **DO NOT** use a methyl alcohol-based antifreeze.

If freeze protection is not required, use a corrosion inhibitor which provides corrosion protection, pH control of acidity level, and water softening ability appropriate for hardness and mineral content of the water to be used.

CORROSION INHIBITORS – Non-chromate inhibitors are recommended due to their compatibility with water and permanent-type antifreezes. Conversely, chromate-type inhibitors, in addition to their toxic nature, are not compatible with many permanent-type antifreezes should it become necessary to add antifreeze to an installation for cold weather protection.

IMPORTANT: Consult with engine manufacturer regarding the specific recommendations for use of corrosion inhibitors in the cooling system, maximum water hardness level, and maximum allowable mineral content of the water.

5.5 WATER BYPASS REQUIREMENTS

5.5.1 TRANSMISSION COOLER ON PRESSURE-SIDE OF WATER PUMP

The pressure-side of the water pump is the preferred location for oil-to-water transmission coolers. This location ensures continuous coolant flow to the transmission cooler, even when the engine thermostat is closed. Figures 8 and 9 illustrate non-retarder transmission installations which utilize oil-to-water coolers on the pressure-side of the water pump. Figure 8 shows the use of the rear cooler ports as the transmission oil source. Figure 9 shows the use of the front cooler ports on the transmission.

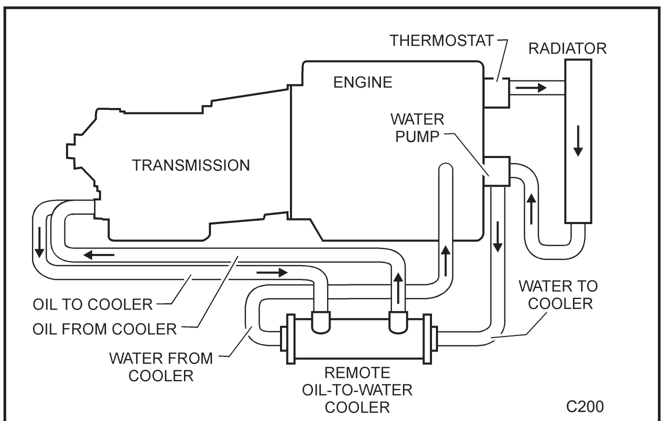


Figure 8: OTW Cooler Installation on Pressure-Side of Water Pump, Using Rear Cooler Ports (3000 Model Shown)

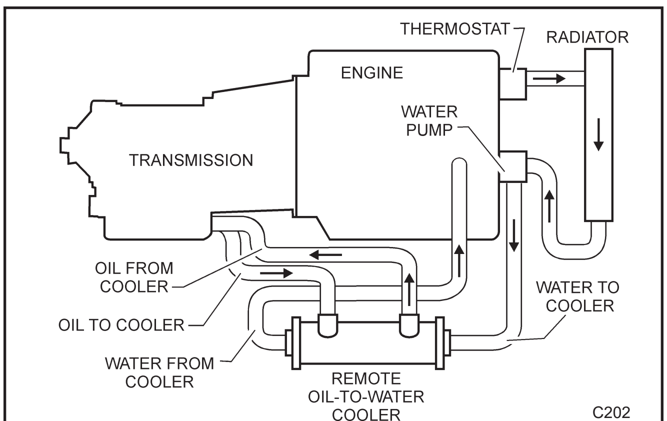


Figure 9: OTW Cooler Installation on Pressure-Side of Water Pump, Using Front Cooler Ports (3000 Model Shown)

5.5.2 TRANSMISSION COOLER ON SUCTION-SIDE OF WATER PUMP

Figure 10 illustrates an installation of a transmission cooler on the suction-side of the water pump between the radiator and pump inlet. The orifice in the line from the thermostat housing to the water pump housing is an engine manufacturer requirement to insure the deaeration system functions properly. Contact your engine manufacturer to verify the orifice size.

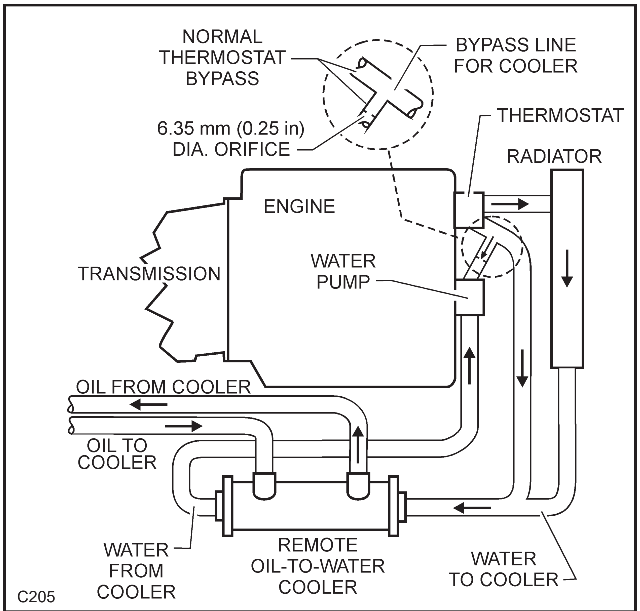


Figure 10: OTW Cooler Installation on Suction-Side of Water Pump

When the cooler must be located on the suction side of the engine water pump, water bypass flow through the transmission cooler should be considered, especially for the following situations:

- vehicles that operate for extended periods at low speed
- vehicles that operate in cold ambient temperatures
- vehicles that immediately climb a grade after a cold start-up

In the above situations, the engine thermostat is typically closed, blocking flow to the radiator and the transmission cooler. Initially, the bypass flow provides some transmission cooling. As the engine coolant flows through the transmission cooler, the coolant temperature will increase. As the heated coolant is circulated through the engine system, it will cause the engine thermostat to open and allow full coolant flow to the transmission cooler.

NOTE: If the transmission is equipped with an output retarder, full bypass flow through the retarder cooler is required. Refer to *Transmission Cooling – Retarder* for more information.

Although specifics will vary from engine to engine, the following are general guidelines for providing bypass flow to the cooler:

- Engine manufacturers generally require that a small amount of water be allowed to flow in the normal bypass circuitry through an orifice so that bypass flow is not completely re-routed to the transmission cooler.
- The transmission cooler should be located as close to the water pump inlet as possible, away from radiator outlets.
- The bypass connection upstream of the cooler should be blended and directed towards the cooler to prevent reverse flow through the radiator.
- The recommended minimum inner diameter for bypass piping is 44.45 mm (1.75 inch), although this will be dependent on the capabilities of the particular engine model.

There may be some engines, particularly medium duty models, for which access to engine bypass flow is not possible. For these models, bypass routing is internal to the block or external connections are too inaccessible to allow piping changes as described above. Special engine hardware has been developed for many of these engines to allow transmission coolers to be connected to the engine system. Contact the respective engine manufacturer for details.

NOTE: The use of a water return source through the transmission cooler, such as that from vehicle heaters, may be acceptable in lieu of full bypass flow for non-retarder installations. However, these flow rates may be too low to prevent transmission overheating before engine thermostats open. A thorough evaluation must be completed before such a design is implemented.

6.0 OIL-TO-AIR (OTA) COOLING

An oil-to-air cooler dissipates the transmission heat directly to the atmosphere. A typical oil-to-air cooler installation is illustrated in Figure 11.

Oil-to-air coolers have the following advantages:

- The transmission cooling can have little or no effect on engine cooling, especially if a separate fan is used.
- Transmission and engine cooling systems are independent; thus, the possibility of cross-contamination of the two fluids is eliminated.
- An auxiliary air-to-oil cooler can be added to an oil-to-water cooling system to increase cooling capacity and reduce transmission temperatures.

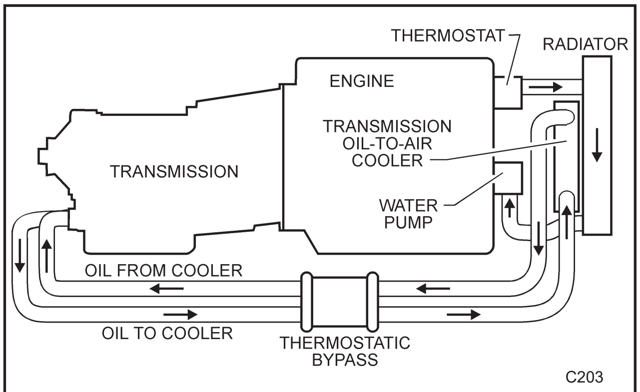


Figure 11: Oil-to-Air Cooler Installed Behind the Radiator

Oil-to-air coolers have the following disadvantages:

- If the oil-to-air cooler does not have its own fan, space must be available to use the airflow from the engine radiator fan. When installed in this manner, the oil-to-air cooler may effect the engine cooling.
- Oil-to-air cooler performance is sensitive to cooler orientation and fitting location. If not installed properly, poor transmission cooling can result.
- In cold ambient temperatures the transmission can be cooled too much by this system, particularly when installed in front of the radiator. A thermostatically-controlled bypass valve in the cooler line can reduce this problem, but adds complexity and cost.
- Oil-to-air coolers are generally not acceptable for retarder cooling because the oil-side restriction is too high at the retarder's oil flow rate.

6.1 OTA COOLER PERFORMANCE CALCULATION – CONVERTER-MODE

The process for evaluating an oil-to-air cooler is similar to oil-to-water. Air flow and air temperature are substituted for water flow and water temperature. The following factors are used for oil-to-air cooling analyses:

- **Air speed:** 24 km/hr (15 mph)
- **Air temperature into the cooler:**
  - for an OTA cooler installed behind radiator, the input air temperature must include the temperature rise across the radiator. Typically, ambient air plus 10º C (50º F) or more. Consult the cooler manufacturer or the cooling system designer for assistance in estimating this value.
  - for an OTA cooler mounted in front of the radiator, the input temperature is typically 38ºC (100ºF) or the Recommended Design Ambient Temperature for the geographical area where the vehicle will be in service; refer to Appendix A.
- **Transmission cooler oil flow:** at the *iSCAAN* calculated engine speed for the converter efficiency point appropriate for the vocation. For transmission oil flow data, refer to *Transmission Data* for the *1000/2000*, *2900*, *3000* and *4000* Product Families.

- **Transmission heat rejection:** as calculated by iSCAAN at the appropriate converter efficiency point for the vocation. Heat rejection values are included in the iSCAAN "Transmission Output Performance" and "Engine/Converter Match" data printouts. Converter and transmission losses are included in the iSCAAN analysis. If necessary, contact Allison Application Engineering for further assistance.
- **Cooler performance curves:** as provided by the cooler manufacturer.

> **NOTE: Be sure that the input data used in oil-to-air analyses represent the cooler's INSTALLED location. This is important for oil-to-air coolers. Cooler location with respect to the radiator and to the fan has a significant effect on cooler performance.**

Figure 12 illustrates a typical converter mode cooler performance calculation for an oil-to-air cooler.

1. CONDITIONS (For refuse application, 80% converter efficiency assumed)

	Metric	English	Data Source
At 80% Converter Efficiency			
- Engine Speed	1750 rpm	1750 rpm	iSCAAN
- Air Flow	6.7 m/s	1320 ft/min	24 kph (15 mph), fan off
- Air Temperature	65.6 °C	150 °F	Cooler behind radiator
- Oil Flow	0.69 L/s	11 gpm	Transmission Data
- Heat Load (Q)	39.55 kW	2250 Btu/min	iSCAAN
- Cooler Capacity (Q')	0.57 kW/°C	18.0 Btu/min/°F	Cooler Mfr.

2. ESTIMATE STABILIZED CONVERTER-OUT (COOLER-IN) TEMPERATURE

		Metric	English	
ITD* = (Q/Q')	ITD =	39.55 / 0.57	2250 / 18.0	*ITD = Cooler Inlet Temperature Differential
	=	69.4 °C	125.0 °F	= (T oil-in) - (T air-in)
T converter out = (T air) + (ITD)				
	=	65.6 + 69.4	150 + 125	
	=	135.0 °C	275.0 °F	

3. CALCULATE OIL TEMPERATURE DROP

	Metric	English
ΔT =	Q / (1.8 x L/s)	Q / (3.6 x gpm)
=	39.55 / (1.8 x 0.69)	2250/(3.6 x 11)
=	31.8 °C	56.8 °F

4. ESTIMATE OIL TEMPERATURE OUT OF COOLER

T cooler-out = (T converter-out) - (ΔT)

	Metric	English
=	135.0 - 31.8	275.0 - 56.8
=	103.2 °C	218.2 °F

5. SUMMARY AT 80% CONVERTER EFFICIENCY

	Metric	English
T converter-out =	135.0 °C	275.0 °F
Tcooler-out =	103.2 °C	218.2 °F
Tsump = Tcooler-out + 5.6 °C (10 °F) =	108.8 °C	228.2 °F

Because T converter-out is below the transmission limit (149°C, 300°F), and T sump is below the sump limit (121°C, 250°F), the cooler is acceptable.

6. NOTE: Cooler circuit pressure drop must be tested if remote cooler is used.

Figure 12: Sample Converter-Mode Cooler Performance Calculation – Oil-to-Air Cooler

6.2 OTA INSTALLATION DESIGN GUIDELINES

Installation guidelines for oil-to-air coolers are listed below:

- Allison recommends mounting oil-to-air coolers between the engine radiator and fan whenever possible. This minimizes the impact on engine cooling and provides some protection against transmission over-cooling.

- For maximum performance, oil-to-air coolers must be oriented such that air is easily purged and the core is always full of oil. Figure 13 illustrates recommended orientations for oil-to-air coolers.
  - When the cooler is mounted so that the ports are located on the side of the cooler, oil should be directed in at the bottom and out at the top. Refer to the left view of Figure 13. This assures that air is purged from the cooler.
  - In cases where an oil-to-air cooler is mounted so that the ports are not located on the side, the ports should be mounted at the top of the cooler, as shown in the right view of Figure 13.
  - Do not install an oil-to-air cooler with the ports at the bottom of the cooler. Ports located at the bottom of the cooler can create venting and filling problems. With bottom ported coolers in low oil flow conditions, the core may not become full and the hot oil is allowed to pass through only a portion of the core.

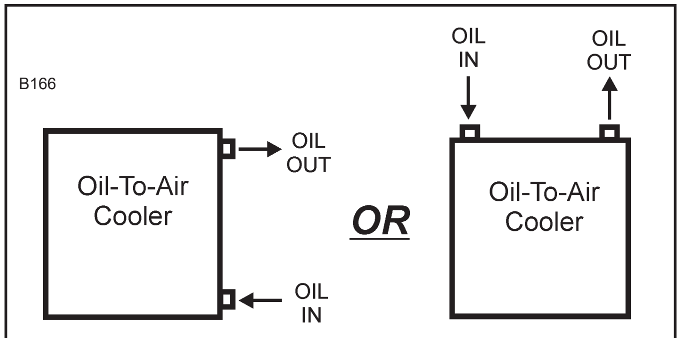


Figure 13: Oil-to-Air Oil Cooler Orientation

- To determine the best location and orientation for an oil-to-air cooler in your installation, consult the cooler manufacturer and follow the manufacturer's guidelines.

- When using radiator shutters controlled by thermostatic devices sensing engine water temperature, include a parallel shutter control system that senses transmission fluid temperature. This will prevent cold water temperatures from keeping shutters closed if transmission requires cooling.

- The following guidelines apply when a thermostatic bypass valve is used to prevent transmission over-cooling:
  - Consult the valve manufacturer for installation recommendations.
  - When the oil-to-air cooler is the primary cooler and the bypass valve is designed to fail to the bypass mode, the installation should include a transmission over-temperature warning. Refer to paragraph 9.0, Temperature Sensing, for methods of providing transmission over-temperature warning to the operator.

• CAUTION: An oil-to-air cooler that is mounted remotely from the radiator with it's own thermally-controlled electric fan must utilize an over-temperature warning device such as a light or buzzer. The warning device should sense "cooler out" temperature and trigger a warning at 121°C (250°F). This is required to warn the operator of transmission overheat in case the oil-to-air fan fails during operation in hot ambients.

• CAUTION: Coolers that are mounted directly to the vehicle powerpack are susceptible to the potential detrimental effects of vibrations. The cooler supplier should be contacted to review any cooler installation that is mounted to the powerpack.

7.0 COMBINATION OIL-TO-WATER AND OIL-TO-AIR SYSTEMS

Combination oil-to-water and oil-to-air systems can be used to increase transmission cooling.

Combination systems have the following advantages:

- Provide increased transmission cooling capacity for vehicles operating on severe duty cycles or in off-highway vocations that require cooling at 70% converter efficiency
- Increase cooling capacity when there are system limitations to a stand-alone oil-to-water or oil-to-air system. For example, an installation where high water inlet temperature limits effectiveness of an oil-to-water cooler and space constraints limit the size of an oil-to-air cooler
- An oil-to-air cooler can be added to an existing remote oil-to-water system when additional cooling is required for a particular vehicle application
- May eliminate the need for an engine water bypass circuit to the oil-to-water cooler if the coolers are installed in series

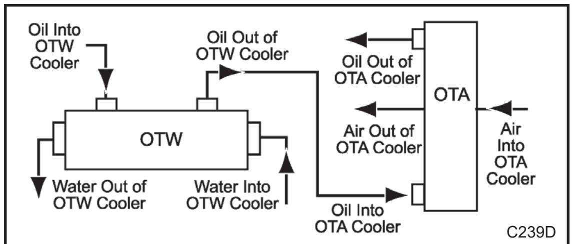


Figure 14: Coolers in Series – OTW before OTA

Combination systems have the following disadvantages:

- Increase cooling system cost
- Increase complexity of vehicle cooling system
- Increase complexity of external hydraulic circuit
- Combination systems are not acceptable for the retarder cooling circuit because the total restriction is too high for the retarder's flow rate

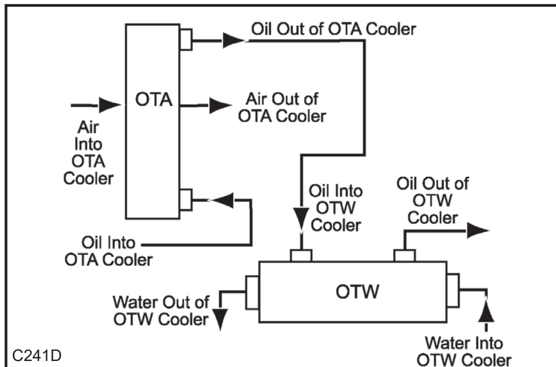


Figure 15: Coolers in Series – OTA before OTW

Combination systems have two different arrangements:

- Series – all of the transmission oil flows sequentially through one cooler and then the other as shown in Figures 14 and 15.
  - Routing the transmission oil through the oil-to-water cooler first (Figure 14) typically results in a lower oil temperature into the transmission sump.
  - Routing the oil through the oil-to-air cooler first (Figure 15) allows the oil-to-water cooler to warm the transmission oil. In cold climates, this helps to maintain the transmission's minimum sump operating temperature.
- Parallel – the transmission oil flows simultaneously through both coolers as shown in Figure 16. The amount of oil flow through each cooler depends upon the relative pressure drop between the two cooler circuits.

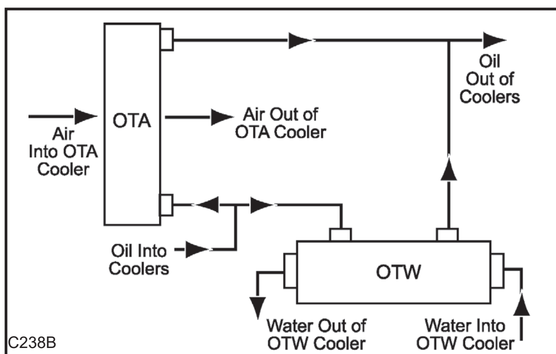


Figure 16: Parallel Cooler Configuration

7.1 COOLER PERFORMANCE CALCULATION FOR COMBINATION SYSTEMS

Calculating the converter efficiency cooling performance of a combination system is more complex than for a stand-alone oil-to-water or oil-to-air system. The Allison Installation Design Calculations program, *AllisonCalc*, can be used to estimate the cooling performance of both series and parallel systems. For coolers in series, the user can specify which cooler the transmission oil flows through first. Thus allowing a comparison between a system with the oil-to-water cooler before the oil-to-air cooler versus a system with the oil-to-air cooler first. Most cooler manufacturers can assist with analyzing the performance of combination systems.

The same factors must be applied to a combination system as are applied to oil-to-water and oil-to-air systems. Refer to 5.1, OTW Cooler Performance Calculation, and to 6.1, OTA Cooler Performance Calculation, for calculation requirements.

7.2 INSTALLATION DESIGN GUIDELINES FOR COMBINATION SYSTEMS

- Follow all installation guidelines for oil-to-water systems in 5.3, Remote OTW Cooler Installation Design Guidelines.
- Follow all installation guidelines for oil-to-air systems in 6.2, OTA Cooler Installation Design Guidelines.
- The following guidelines apply when the OTA cooler system includes a thermostatic bypass valve:
  - Consult the valve manufacturer for installation recommendations.
  - When the oil-to-air cooler is an auxiliary transmission cooler and includes a bypass valve, the oil-to-air system must be installed in parallel with primary oil-to-water cooler. This arrangement allows oil flow through the primary cooler, even if the oil-to-air bypass valve fails.
  - Typically, an auxiliary air-to-oil cooler installed in series with an oil-to-water cooler does not require a thermostatic bypass valve. Even in cold conditions, the transmission oil will be warmed when it flows through the oil-to-water cooler.

8.0 HYDRAULIC CIRCUIT REQUIREMENTS FOR REMOTE COOLERS

8.1 HYDRAULIC CIRCUIT PRESSURE DROP

The total cooler circuit pressure drop must meet all of the following conditions:

- be less than the maximum allowable pressure drop as defined in the following:
  - *1000/2000 Product Family Transmission Data*
  - *2900 Product Family Transmission Data*
  - *3000 Product Family Transmission Data*
  - *4000 Product Family Transmission Data*
- allow sufficient oil flow to meet the transmission cooling requirements
- be verified by test under the following conditions:
  - transmission sump temperature of 66-93º C (150-200º F)
  - engine speed of 1500 rpm or greater for 1000/2000 and 2900 Product Families
  - engine speed of 1000 rpm or greater for 3000 and 4000 Product Families

CAUTION: Excess pressure drop in the cooler circuit can be detrimental to the cooling system as described below:

• by reducing flow through the cooler circuit, creating an overheat condition and leading to premature deterioration of the transmission fluid

• by causing the controls to become unstable, resulting in higher than expected pressure spikes in the cooling circuit.

The total cooler circuit pressure drop is measured from the transmission's To Cooler port to the transmission's Cooler Return port, as shown in Figure 17. The total cooler circuit includes the following:

- all fittings and connectors – straight and elbow
- all hydraulic lines, hoses and tubing, including all bends
- the transmission cooler or coolers
- the optional cooler circuit oil filter when installed (applies to 1000/2000 and 2900 Product Families only)
- thermostatic bypass valve, when installed in an oil-to-air system

Procedures for measuring the cooler circuit pressure drop can be found in the following Appendices:

- Appendix B for the 1000/2000 and 2900 Product Families
- Appendix C for the 3000 and 4000 Product Families

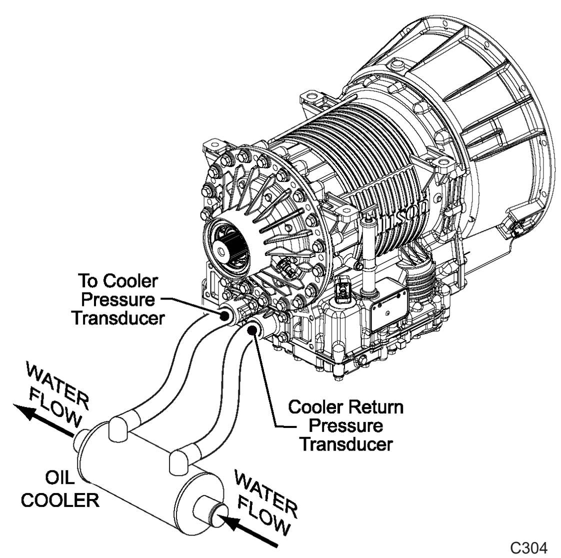


Figure 17: Cooler Circuit Pressure Drop Measurement (3000 Model Shown)

During the design phase, the cooler circuit pressure drop may be estimated. *AllisonCalc*, Allison's Installation Design Program, may be used to estimate the pressure drop of the hoses and fittings in the cooler circuit. The total pressure drop can be calculated by adding the following restrictions:

- hose and fitting pressure drop
- cooler pressure drop
- the pressure drop of an optional cooler circuit filter, if installed (1000/2000 and 2900 Product Families only)
- the pressure drop of a thermostatic, oil-bypass valve, if installed

8.2 HYDRAULIC CIRCUIT INSTALLATION DESIGN GUIDELINES

Good installation practices for hose and tube routing include:

- Verify that the total cooler circuit meets the pressure drop requirements defined in the External Hydraulic Circuit table in *Transmission Data* that it applicable to your transmission model.
- Use hoses, tubing, fittings and seals that meet the requirements in the External Hydraulic Circuit table in the appropriate *Transmission Data* document.
- Minimize line lengths to reduce line losses.
- Comply with the hose manufacturer's guidelines for minimum bend radius
- Avoid the use of restricted elbows and fittings.
- Provide couplings to permit ease of installation and removal.
- Avoid external heat sources such as exhaust pipes.
- Protect the cooler circuit and cooler from road hazards.
- When metal tubing is used, provide flexible sections to permit relative movement between the powerpack and the cooler.
- Avoid routing cooler lines close to sharp edges, abrasive surfaces, bolt heads, screws and brackets. Provide a protective covering wherever the cooler line has the potential to contact such objects.
- Avoid routing cooler lines close to moving parts such as belts, fans and pulleys.
- Provide support and tie-downs as recommended by the hose manufacturer. If tubing is used, minimize the stress and movement at fittings and joints by clamping the tubing securely.

9.0 TEMPERATURE SENSING

The transmission electronic controls continuously monitor the transmission fluid temperature. When the controls detect that the fluid temperature limits have been exceeded, the controls restrict the operation of the transmission or of the transmission integral retarder. For a description of the transmission controls' operational response to over-temperature conditions, refer to *Allison 6th Generation Controls Section B: System Operation* for *1000/2000, 2900, or 3000/4000 Product Families.*

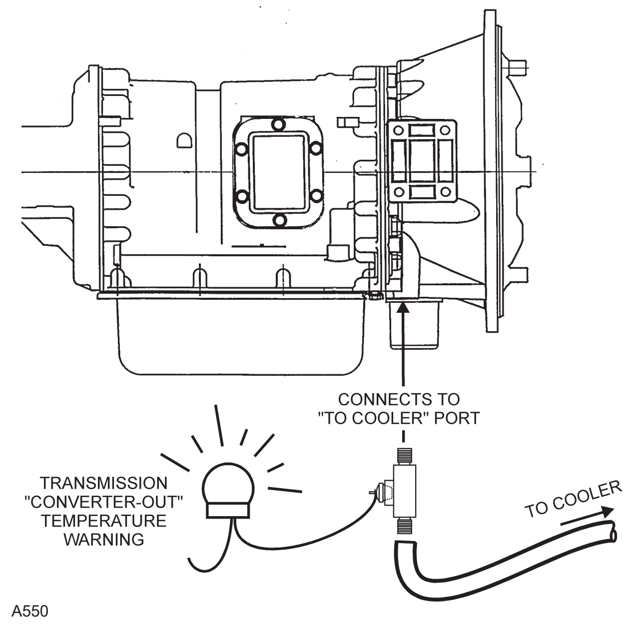


Figure 18: Temperature Sensing System (1000/2000 Product Family Shown)

The transmission controls provide several temperature signals for use by the vehicle builder. These signals may be used to alert the driver to transmission over-temperature conditions and to the resulting restrictions to transmission or retarder operation. Listed below are descriptions of the available transmission over-temperature signals for non-retarder transmissions:

NON-RETARDER TRANSMISSIONS

- Transmission over-temperature warning is optional for non-retarder transmissions.

- The transmission electronic controls will register a diagnostic code in memory in the event of high fluid temperatures in the transmission sump. For a description of the diagnostic code and its retrieval, refer to *Allison 6th Generation Controls Section B: System Operation* for *1000/2000, 2900, or 3000/4000* Product Families.

- The electronic controls have available Output Function B, Sump/Retarder Temp Indicator. Typically, the output is used to activate a dash light or audible alarm. The dash light or alarm is supplied and installed by the vehicle builder.
  - For all non-retarder transmissions, this output indicates when an over-temperature condition is detected in the transmission sump.
  - In addition for 1000/2000 models, this output provides Converter Over-Temperature Warning Protection. The output activates the Sump Temp Indicator when the controls detect excessive and sustained slip across the converter. This condition indicates the potential for converter damage due to high heat generation.

  For installation and wiring details, refer to *Output Function B, Sump Over-Temp Indicator*. For communication of this signal over the SAE J1939 datalink, refer to *Datalink Communications*.

- In addition to the discrete over-temperature signal, Allison continuously broadcasts the transmission sump temperature over the J1939 datalink (refer to *Datalink Communications*). The vehicle builder can use this broadcast message for a dash gauge or other transmission temperature display. The label for the gauge or display must indicate that transmission sump temperature is being shown. The gauge or display must identify the maximum transmission sump temperature. For example, a gauge could be green or white below the maximum transmission sump temperature and red above the maximum sump temperature. Refer to *Transmission Data* for your transmission model for the maximum transmission sump temperature limit.

- For those customers who desire a means to monitor converter-out fluid temperature during operation, a temperature sensor may be mounted in a tee-fitting on the "To Cooler" line near the transmission To Cooler port (Figure 18) It is recommended that the sensor activate a dash mounted, transmission temperature warning light at the maximum converter-out temperature. Optionally, a sensor in the same location could be used with a temperature gauge. The gauge must identify that the transmission converter-out temperature is being displayed. The gauge must identify the maximum converter-out temperature limit. For example, a gauge could be green or white below the maximum converter-out temperature and red above the maximum converter-out temperature. Typically, the vehicle builder supplies and installs the temperature sensor, the tee-fitting, and the warning light, alarm or gauge. Refer to the *Transmission Data* document for your transmission model for the maximum converter-out temperature limit. For sources of the gauge and sensor see *Transmission Support Equipment*.

NOTE: Transmission over-temperature warning is required for retarder-equipped transmissions in most vocations. Refer to *Transmission Cooling – Retarder* for specific requirements and implementation.

10.0 ADDITIONAL GUIDELINES

10.1 EXTERNAL HEAT

Emission controls have greatly increased engine exhaust gas temperatures. Consequently, it is essential that exhaust system components be installed such that heat input to the transmission is minimized. This is particularly critical in the following areas:

- around the transmission sump
- near the transmission cooler lines
- near transmission wiring harness connections

Heat shielding is recommended when clearance is less than 152.0 mm (6.0 in.). The heat shield must not restrict normal air flow.

The temperature at the surface of the transmission must not exceed the limit defined in the Temperatures table in each of the *Transmission Data* documents.

10.2 SERVICE CONSIDERATIONS

The Allison Transmission Service Department has established maximum removal and replacement (R&R) requirements for Allison transmissions and related components. For R&R information which relates to components discussed in this document, refer to *Technical Document (TD) 176, Service Requirements – Removal and Replacement Times for Allison Transmissions*.

APPENDIX A: RECOMMENDED DESIGN AMBIENT TEMPERATURES

SELECT AMBIENT (°C) FOR LOCATION OF VEHICLE USAGE

AFRICA

Algeria	*50*	*Equatorial Guinea*	*38*	*Malawi*	*45*	*South Africa*	*38*
Angola	*38*	*Ethiopia*	*45*	*Mali*	*50*	*Sudan*	*50*
Benin	*45*	*Gabon*	*38*	*Mauritania*	*45*	*Swaziland*	*38*
Bothuthatswana	*38*	*Gambia*	*38*	*Morocco*	*45*	*Tanzania*	*38*
Botswana	*38*	*Ghana*	*45*	*Mozambique*	*45*	*Togo*	*45*
Burundi	*38*	*Guinea*	*45*	*Namibia*	*38*	*Transkei*	*38*
Cameroon	*45*	*Guinea Bissau*	*38*	*Niger*	*45*	*Tunisia*	*45*
Central African Rep.	*45*	*Ivory Coast*	*45*	*Nigeria*	*45*	*Uganda*	*38*
Chad	*50*	*Kenya*	*38*	*Rwanda*	*38*	*Upper Volta Rep.*	*45*
Ciskei	*38*	*Lesotho*	*38*	*Senegal*	*38*	*Venda*	*38*
Congo Republic	*38*	*Liberia*	*38*	*Seychelles*	*38*	*West Sahara*	*45*
Dem. Rep. of Congo	*38*	*Libya*	*50*	*Sierra Leone*	*38*	*Zambia*	*38*
Djibouti	*45*	*Madagascar*	*38*	*Somalia*	*45*	*Zimbabwe*	*38*
Egypt	*50*						

ASIA

Afghanistan	*45*	*Iraq*	*50*	*Nepal*	*38*	*Sri Lanka*	*38*
Bahrain	*50*	*Israel*	*45*	*North Korea*	*38*	*Syria*	*45*
Bangladesh	*45*	*Japan*	*38*	*Oman*	*50*	*Taiwan*	*38*
Bhutan	*38*	*Jordan*	*45*	*Pakistan*	*50*	*Thailand*	*45*
Burma	*45*	*Kampuchea*	*38*	*Phillipines*	*38*	*United Arab*	*50*
China	*38 (1)*	*Kuwait*	*50*	*Qatar*	*50*	*Vietnam*	*38*
Hong Kong	*38*	*Laos*	*45*	*Saudi Arabia*	*50*	*Yemen Arab Rep.*	*50*
India	*45 (2)*	*Lebanon*	*45*	*Sikkin*	*38*	*Yemen, People's Democratic Rep.*	*50*
Indonesia	*38*	*Malaysia*	*38*	*Singapore*	*38*		
Iran	*50*	*Mongolia*	*38*	*South Korea*	*38*		

AUSTRALIA

Australia	*45*	*New Guinea*	*38*	*New Zealand*	*38*

CARIBBEAN ISLANDS

The Bahamas	*38*	*Haiti*	*38*	*The Netherlands Antilles*	*38*	*Trinidad*	*38*
Cuba	*38*	*Jamaica*	*38*			*The Windward Islands*	*38*
Dominican Repub.	*38*	*Leeward Islands*	*38*	*Puerto Rico*	*38*		

CENTRAL and SOUTH AMERICA

Argentina	*38 (3)*	*Colombia*	*38*	*Guatemala*	*38*	*Paraguay*	*45*
Belize	*38*	*Costa Rica*	*38*	*Guyana*	*38*	*Peru*	*38*
Bolivia	*45*	*Ecuador*	*38*	*Honduras*	*38*	*Surinam*	*38*
Brazil	*38*	*El Salvador*	*38*	*Nicaragua*	*38*	*Uruguay*	*38*
Chile	*38*	*French Guiana*	*38*	*Panama*	*38*	*Venezuela*	*38*

EUROPE

Albania	*38*	*Denmark*	*38*	*Italy*	*38*	*San Marino*	*38*
Andorra	*38*	*The Faeroe Islands*	*38*	*Liechtenstein*	*38*	*Solvakia*	*38*
Austria	*38*	*Finland*	*38*	*Luxembourg*	*38*	*Spain*	*38*
Belgium	*38*	*France*	*38*	*Malta*	*38*	*Sweden*	*38*
Bosnia-H'zogovina	*38*	*Germany*	*38*	*Monaco*	*38*	*Switzerland*	*38*
Bulgaria	*38*	*Gibraltar*	*38*	*The Netherlands*	*38*	*Turkey*	*38*
Conf. Indep. States	*38*	*Greece*	*38*	*Norway*	*38*	*United Kingdom*	*38*
Croatia	*38*	*Hungary*	*38*	*Poland*	*38*	*Yugoslavia*	*38*
Cyprus	*38*	*Iceland*	*38*	*Portugal*	*38*		
Czech Republic	*38*	*Ireland (Eire)*	*38*	*Rumania*	*38*		

NORTH AMERICA

Canada	*38*	*Greenland*	*38*	*Mexico*	*33, 38, 45 (4)*	*United States*	*38 (5)*

OCEANIC ISLANDS

Ascension Island	*38*	*Galapagos Islands*	*38*	*Mauritius*	*38*	*Sao Tome & Principe*	*38*
The Azores	*38*	*Gilbert Islands*	*38*	*New Caledonia*	*38*		
Bermuda	*38*	*Graham Island*	*38*	*New Hebrides*	*38*	*Seychelles*	*38*
Canary Islands	*38*	*Madeira*	*38*	*Reunion*	*38*	*Society Islands*	*38*
Cape Verde Islands	*38*	*Maldive Islands*	*38*	*St. Helena*	*38*	*Solomon Islands*	*38*
Falkland Islands	*38*	*Marianas Islands*	*38*	*Samoa & Tonga*	*38*	*Tuamotu Islands*	*38*
Fiji	*38*	*Marshall Islands*	*38*				

(1) Inland areas of central China (ex., Chungking) recommendation is 45°C.
(2) Northern plains area of Rajasthan Desert of India, recommendation is 50°C.
(3) Northern interior (ex., Santiago del Estero) of Argentina, recommendation is 45°C.
(4) For areas higher than 2,000 meters above sea level, the recommendation is 33°C.
For areas between 1,000 and 2,000 meters above sea level, the recommendation is 38°C.
For areas with altitude less than 1,000 meters above sea level and the Northern inland areas, the recommendation is 45°C.
(5) Certain areas of the Southwest region of the USA may require higher ambient capability.

38°C = 100°F
45°C = 113°F
50°C = 122°F

APPENDIX B: MEASURING PRESSURE DROP FOR THE 1000/2000 AND 2900 PRODUCT FAMILIES

Allison recommends measuring the pressure drop for at least two different input speeds:
- at engine governed speed
- at an engine speed point that is less than engine governed speed but greater than 1500 rpm

WITH A FLOW METER IN THE COOLER CIRCUIT

If the pressure drop is measured with an oil flow meter in the transmission cooler circuit, for example during a cooling test, follow the procedure below:

1. Install the following instrumentation:
   - pressure transducers in the To Cooler and the Cooler Return ports on the transmission
   - a flow meter in the cooler circuit
   - a thermocouple in the transmission sump

2. Warm the transmission to a sump temperature of 66-93º C (150-200º F).

3. With the transmission in Neutral and the vehicle brakes applied, hold a constant engine speed. The selected engine speed must be at least 1500 rpm and no greater than engine governed speed.

   If the data is taken during a transmission cooling test, one of the data points may be taken under the following conditions:
   - with the transmission in the gear range used for the cooling test
   - with the engine speed at the converter efficiency test point

4. Record the following data:
   - engine speed
   - oil flow rate
   - pressure at the To Cooler port
   - pressure at the Cooler Return port
   - sump temperature

   Return the engine to idle speed.

5. Repeat steps 3 and 4 for a second engine speed point.

6. Calculate the cooler circuit pressure drop between the Cooler Return port and the To Cooler port.

7. Compare the measured pressure drop to Table 16.2, Cooler Circuit Drop Requirements, in *1000/2000 Product Family Transmission Data* or *2900 Product Family Transmission Data*. The pressure drop must be less than the Maximum Allowable Restriction at the measured oil flow rate.

APPENDIX B: MEASURING 1000/2000 AND 2900 PRESSURE DROP (CONTINUED)

WITHOUT A FLOW METER IN THE COOLER CIRCUIT

If the pressure drop is measured without an oil flow meter in the transmission cooler circuit, follow the procedure below:

1. Install pressure transducers in the To Cooler and the Cooler Return ports on the transmission

2. Warm the transmission to a sump temperature of 66-93º C (150-200º F). This can be accomplished by driving the vehicle until the engine coolant reaches normal operating temperature, typically 82-99º C (180-210º F). If desired, a thermocouple may be installed in the transmission sump to verify sump temperature.

3. With the transmission in Neutral and the vehicle brakes applied, hold a constant engine speed. The selected engine speed must be at least 1500 rpm and no greater than engine governed speed.

4. Record the following data:
   - engine speed
   - pressure at the To Cooler port
   - pressure at the Cooler Return port
   - sump temperature if a thermocouple is installed in the transmission sump

   Return the engine to idle speed.

5. Calculate the cooler circuit pressure drop between the Cooler Return port and the To Cooler port.

6. For the 1000/2000 go to the following tables in *1000/2000 Product Family Transmission Data*:
   - Table 16.3.1, External Hydraulic Circuit Characteristics at Nominal Sump Temperature, 93º C (200º F) (Converter Operation)
   - Table 16.2, Cooler Circuit Pressure Drop Requirements

7. For the 2900 go to the following tables in *2900 Product Family Transmission Data*:
   - Table 16.3.1, External Hydraulic Circuit Characteristics at Nominal Sump Temperature, 90-100º C (194-212º F) (Converter Operation)
   - Table 16.2, Cooler Circuit Pressure Drop Requirements

APPENDIX B: MEASURING 1000/2000 AND 2900 PRESSURE DROP (CONTINUED)

8. Determine the maximum allowable pressure drop for the selected input speed as described below:
   - Use Table 16.3, to determine the cooler flow at the input speed point, using the curve for the Maximum Allowable Restriction for the 1000/2000 Product Family. For example, Figure B-1 shows that a test run at 2400 rpm engine speed would have an estimate oil flow rate of 26 liters/minute at the maximum allowable restriction.
   - On the graph in Table 16.2, plot the cooler flow on the curve for the Maximum Allowable Restriction for the 1000/2000 Product Families. Figure B-2 shows the 26 liters/minute flow plotted on the maximum allowable restriction curve.
   - The measured pressure drop is acceptable if it is less than or equal to the corresponding cooler circuit restriction shown on Table 16.2. In the example, the circuit pressure drop is acceptable if the measured pressure drop is less than 310 kPa.

9. Repeat steps 3-8 for a second input speed point.

Note: This example uses the 1000/2000 Product Family Data. For 2900 Product Family Data see *2900 Product Family Transmission Data*

16.3 — EXTERNAL HYDRAULIC CIRCUIT CHARACTERISTICS AT NOMINAL SUMP TEMPERATURE (93ºC, 200ºF) (CONVERTER OPERATION)

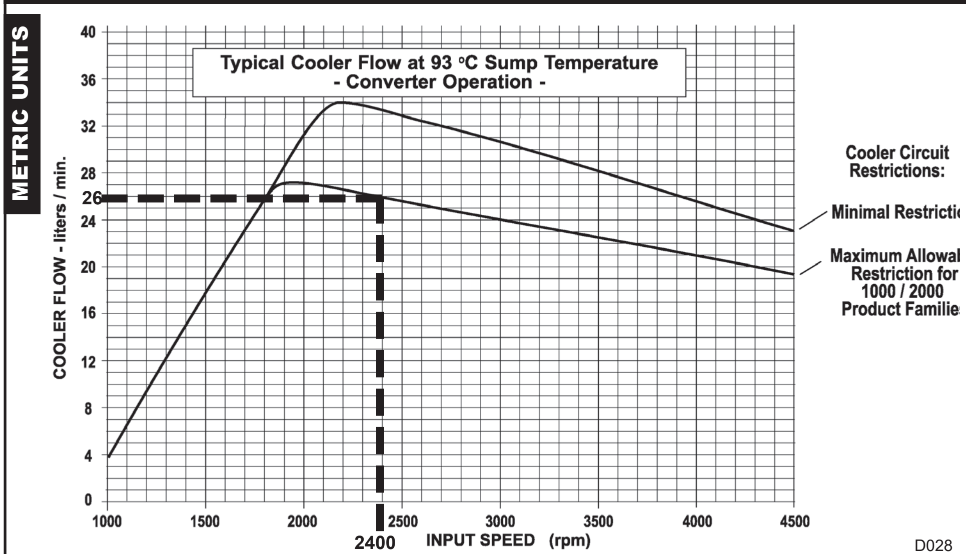


Figure B-1: Example Showing Cooler Flow at Maximum Allowable Restriction for 1000/2000 Models

16.2 — COOLER CIRCUIT PRESSURE DROP REQUIREMENTS METRIC UNITS

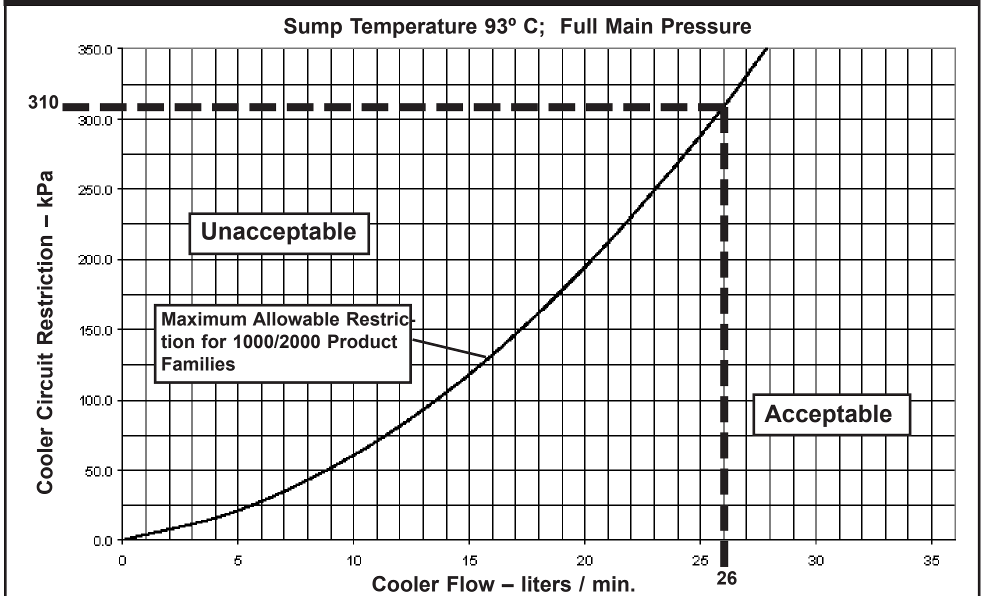


Figure B-2: Example Showing Maximum Allowable Restriction for 1000/2000 Models

APPENDIX C: MEASURING PRESSURE DROP FOR THE 3000 AND 4000 PRODUCT FAMILIES

Allison recommends measuring the pressure drop for at least two different input speeds:
- at engine governed speed
- at an engine speed point that is less than engine governed speed but greater than 1000 rpm

1. Install pressure transducers in the To Cooler and the Cooler Return ports on the transmission as shown in Figure C-1.

2. Warm the transmission to a sump temperature of 66-93º C (150-200º F). This can be accomplished by driving the vehicle until the engine coolant reaches normal operating temperature, typically 82-99º C (180-210º F). If available, Allison DOC™ for PC can be used to verify the sump temperature.

3. With the transmission in Neutral and the vehicle brakes applied, hold a constant engine speed. The selected engine speed must be at least 1000 rpm and no greater than engine governed speed.

4. Record the following data:
   - engine speed
   - pressure at the To Cooler port
   - pressure at the Cooler Return port
   - sump temperature if available

   Return the engine to idle speed.

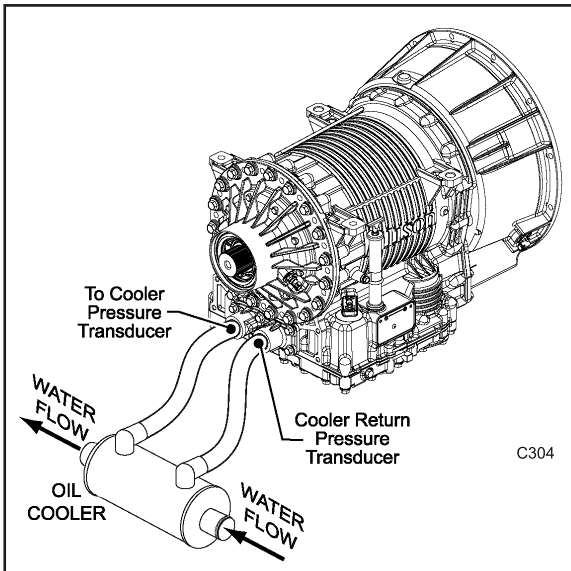


Figure C-1: Cooler Circuit Pressure Drop Measurement (3000 Model Shown)

5. Calculate the cooler circuit pressure drop between the Cooler Return port and the To Cooler port.

6. Go to the appropriate table in *Transmission Data*:
   - For the *3000 Product Family*: Table 17.3, External Hydraulic Circuit Characteristics, Non-Retarder, Power Take-Off – Converter Operation
   - For the *4000 Product Family*: Table 16.3, External Hydraulic Circuit Characteristics, Non-Retarder, Power Take-Off – Converter Operation

7. Plot the measured pressure drop value on the appropriate input speed line. If the measured pressure drop is less than or equal to the maximum allowable pressure, then the cooler circuit pressure drop is acceptable.

   For example, the following restrictions were measured for a 3000 RDS cooler circuit:
   - 350 kPa at the engine governed speed of 2400 rpm
   - 225 kPa at an engine speed of 1600 rpm

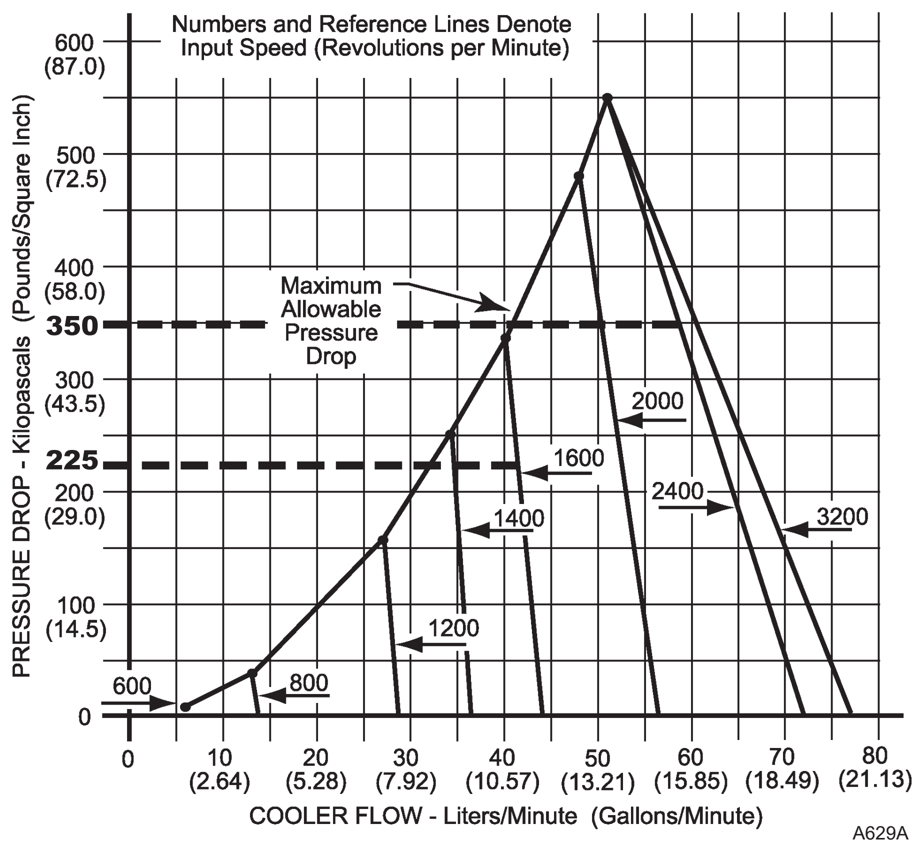
   The pressure drop values are plotted on the 3000 Product Family graph in Figure C-2. Both measurements are below the maximum allowable pressure drop, so the cooler circuit restriction is acceptable.

17.3 EXTERNAL HYDRAULIC CIRCUIT CHARACTERISTICS NON-RETARDER, POWER TAKE-OFF – CONVERTER OPERATION *

		FLOW		PRESSURE DROP	
	INPUT REVOLUTIONS PER MINUTE	LITERS PER SECOND	GALLONS PER MINUTE	kPa	POUNDS PER SQUARE INCH
MAXIMUM COOLER FLOW AT MINIMUM PRESSURE DROP	600	0.10	1.6	0	0
	800	0.23	3.7	0	0
	1200	0.47	7.4	0	0
	1400	0.61	9.7	0	0
	1600	0.74	11.7	0	0
	2000	0.94	14.9	0	0
	2400	1.19	18.9	0	0
	3200	1.28	20.3	0	0

		FLOW		PRESSURE DROP	
	INPUT REVOLUTIONS PER MINUTE	LITERS PER SECOND	GALLONS PER MINUTE	kPa	POUNDS PER SQUARE INCH
COOLER FLOW AT MAXIMUM ALLOWABLE PRESSURE DROP	600	0.10	1.6	10	1.5
	800	0.22	3.5	40	5.8
	1200	0.45	7.1	159	23.1
	1400	0.57	9.0	252	36.6
	1600	0.67	10.6	338	49.0
	2000	0.80	12.7	481	69.8
	2400	0.85	13.5	549	79.6
	3200	0.85	13.5	549	79.6

*** 93ºC (200ºF) SUMP TEMPERATURE**



NOTE: Values in U.S. units shown in parenthesis ( ) are for reference only. Conversions between metric and U.S. units are not necessarily exactly equivalent.

Figure C-2: Example Showing Cooler Circuit Pressure Drop for 3000 Product Family

LIST OF REFERENCED DOCUMENTS

- *Allison 6th Generation Controls*
  - *Section B: System Operation* for *1000/2000*, *2900*, or *3000/4000* *Product Families*
  - *Output Function B, Sump Over-Temp Indicator*
- *AllisonCalc, Installation Design Calculations Program*
- *CSS, Customer Specifications Sheet*
- *Datalink Communications*
- *Features and Options* for *1000/2000*, *2900*, *3000* or *4000* Product Family
- *iSCAAN*, Allison's vehicle performance calculation program
- *Support Equipment for 1000/2000, 2900, 3000 and 4000 Product Families*
- *Transmission Cooling – Retarder*
- *Transmission Data* for *1000/2000*, *2900*, *3000* or *4000* Product Family

Installation Drawings – 1000/2000 Product Family

- *AS64-401, AS64-402, AS64-403, Basic Installation Drawings*
- *AS64-471, External Hydraulic Circuit Requirements*

Installation Drawings – 2900 Product Family

- *AS64-902, AS64-903, Basic Installation Drawings*
- *AS64-971, External Hydraulic Circuit Requirements*

Installation Drawings – 3000 Product Family

- *AS66-416 Basic Installation Drawing, 6-Speed*
- *AS66-417, Basic Installation Drawing, 7-Speed Dropbox Option*
- *AS66-470, Direct-Mount Coolers, Non-Retarder*
- *AS66-474, Front Cooler Port Provision*

Installation Drawings – 4000 Product Family

- *AS67-416, Basic Installation Drawing, 6-Speed*
- *AS67-417 Basic Installation Drawing, 7-Speed*
- *AS67-470, Direct-Mount Coolers, Non-Retarder*
- *AS67-474, Front Cooler Port Provision*

Technical Documents

- *TD-157, Transmission Cooling Tests*
- *TD-167, Installation Design Calculations User's Guide*
- *TD-176, Service Requirements – Removal and Replacement Times for Allison Transmissions*

REVISION HISTORY

October 4, 2022
- Added the 2900 Product Family

November 7, 2016
- In 3.4, added caution note about cooler powerpack mounting and paragraph referring to Allison direct mount coolers with new link to Transmission Data section of Tech Data.
- In List of Referenced Documents, revised 3000 and 4000 drawings to reflect new consolidated Basic Installation Drawings; AS66-416, AS66-417, AS67-416, AS67-417.

February 10, 2016
- In 5.2, added detail regarding the 7-plate standard capacity and 17-plate high capacity direct mount cooler
- In 5.3.2, added link to Transmission Support Equipment
- In 5.5.2, clarified that the orifice between the thermostat housing and the water pump housing is an engine manufacturers requirement.

January 7, 2014
- Updated Allison 4th Generation Controls to Allison 5th Generation Controls.

March 11, 2011
- In 3.0, added procedure for determining converter cooling point when the 85% converter efficiency point is close to the engine governed speed.

July 21, 2010
- Updated references and links to Input and Output Functions.

September 30, 2009
- Added converter over-temp warning protection to 9.0, Temperature Sensing.

February 10, 2009
- Updated Figure 1 to show integral cooler ports instead of cooler port manifold.

November 5, 2008
- In Appendix C, Step 7 example, changed engine speed from 1400 rpm to 1600 rpm in order to be consistent with Figure C-2.

July 17, 2008
- Prepared document for Extranet publication

June 10, 2008
- Created new document, *Transmission Cooling – Basic*