TRANSMISSION COOLING – RETARDER

ALLISON ON-HIGHWAY TRANSMISSIONS

APPLICABLE MODELS: **3000 Product Family**
4000 Product Family

Contents:

TRANSMISSION COOLING – RETARDER

1.0 INTRODUCTION

The purpose of this document is to provide cooling guidelines for transmissions equipped with the output retarder option. Refer to *Transmission Cooling – Basic* for cooling system requirements that apply to all transmission installations, including those with the retarder.

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 / RETARDER COOLING REQUIREMENTS

When activated, the retarder generates significantly more heat than a non-retarder transmission. The fluid in the retarder housing impedes the rotation of the retarder rotor, slowing the output shaft and the vehicle. Significant heat is generated as the rotor is forced through the transmission fluid. The transmission fluid dissipates the heat through the transmission and vehicle cooling systems. Field experience has shown that rapid heat-up of the system is possible with retarders.

For retarder-equipped transmissions, the 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 the Appendix for a list of Allison recommended design ambient conditions for various worldwide locations.

- dissipate the heat generated at the maximum level of the selected retarder capacity

- demonstrate by test the ability to maintain transmission oil temperatures within transmission temperature limits on the duty cycles specified in *Technical Document 157 (TD-157), Transmission Cooling Tests*.

3.1 TRANSMISSION TEMPERATURE LIMITS

Transmission temperature limits are shown in *3000 Product Family Transmission Data* and *4000 Product Family Transmission Data*. Temperature limits include the following:
- maximum to cooler temperature
- maximum retarder out temperature
- maximum sump temperature
- minimum sump continuous temperature
- minimum start-up temperature

Any operation above the maximum limits, or even continued operation within, but near, the maximum temperature limits can contribute to decreased transmission reliability and longevity. Maintaining low transmission operating temperatures typically result in improved transmission life as well as extended oil change intervals.

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

3.2 VERIFYING TRANSMISSION/RETARDER COOLING

Because of the transient nature of retarder operation, retarder cooling can only be evaluated experimentally in the vehicle. Allison requires duty cycle cooling tests based on the vehicle's vocation. The required cooling tests include:

- idle stall test
- start/stop tests at various vehicle speeds
- downgrade cooling test appropriate for the geographical region where the vehicle will be operated
- converter efficiency cooling test

Not all tests are required for all vocations. Appendix A of *TD-157, Transmission Cooling Tests,* lists the duty-cycle cooling tests required for each vocation.

TD-157 contains a complete description of each test, including:

- test procedure
- test conditions
- required instrumentation
- interpretation of test results

3.3 IMPLEMENTATION OF COOLING REQUIREMENTS

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

Retarder coolers must be capable of higher heat rejection rates and higher transmission oil flow rates than coolers typically used in non-retarder applications.

When designing the cooling system for retarder operation, the following factors should be applied:

- **Engine water temperature:** typically 93º C (200º F) on the cold side and 100º C (212º F) on the hot side. If the engine manufacturer allows higher temperatures, those higher temperatures must be used.
- **Water flow through the transmission/retarder oil cooler:** as declared by the engine manufacturer at the engine speed corresponding to the vehicle speed to be maintained on the expected downgrade for the vocation and location.
- **Oil flow through the transmission/retarder cooler:** at the output speed corresponding to the vehicle speed to be maintained on the expected downgrade for the vocation and location. For transmission oil flow data, refer to *Transmission Data* for the *3000* and *4000* Product Families.

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.

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

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 oil-to-water coolers mounted on the rear of the transmission. These direct-mount coolers have been designed and tested to withstand powerpack vibrations. Additional information on the Allison direct-mount coolers can be found in 5.0, Transmission / Retarder Cooler Systems.

4.0 RETARDER COOLING SYSTEM DESIGN

The following types of operation must be considered when designing the cooling system for a retarder-equipped transmission:

- start/stop duty cycles
- downgrade retardation
- idle cooling
- propulsion-mode cooling at the converter efficiency point appropriate for the vocation

NOTE: Typically, a cooler selected to cool retarder mode (either downgrade or start/stop) should also cool the propulsion (converter) mode adequately. However, converter mode cooling capacity should be verified. Refer to *Transmission Cooling – Basic*.

4.1 START/STOP RETARDER CYCLE

Cooling requirements cannot be calculated easily for a Start/Stop duty cycle. The amount of heat generated by the retarder depends upon the speed at which the stop is initiated. The frequency of the stops affects the ability of the cooling system to recover between stops.

For vocations that include start/stop operation, Allison requires one or more of the following duty cycle cooling tests that best represents expected vehicle operation:

- 0-20-0 mph
- 0-30-0 mph
- 0-40-0 mph

For start/stop vocations where some continuous severe grade operation may be encountered, a downgrade cooling test may also be required. Appendix A of *TD-157, Transmission Cooling Tests,* lists the duty-cycle cooling tests required for each vocation.

4.2 DOWNGRADE RETARDATION

For downhill retardation, the recommended approach to providing adequate cooling is to determine the required vehicle retardation capacity and the corresponding heat rejection. The required vehicle retardation capacity is based on the vehicle weight and the speed-on-downgrade conditions that must be met. Although this design point may be an intermittent condition, the vehicle cooling system (transmission cooling and engine cooling) should be designed to dissipate this heat load on a continuous basis within transmission and engine temperature limits. Transmission overheat will be prevented as long as this level of retardation is not exceeded.

Appendix B describes one approach to estimating downgrade retarder cooling requirements. The data used in the procedure come from *iSCAAN*, Allison Transmission's vehicle performance program. iSCAAN is available on the Extranet under Engineering. If iSCAAN does not appear in the Engineering menu, contact your Allison representative.

4.3 SUMP COOLING REQUIREMENTS

In the traditional transmission/retarder cooling system, when the retarder is applied, only the retarder oil flows out of the retarder to the cooler. No oil from the sump or converter is routed to the cooler. During long, high-speed downgrade operation, the transmission fluid in the sump can exceed the sump temperature limit. High sump temperatures may also result from repeatedly applying the retarder on continuous start/stop duty cycles.

To address this concern, **a separate cooling provision for the fluid in the transmission sump during retarder operation is required** for retarder-equipped transmissions used in the following types of vehicle applications:

- Tour Coaches
- Intercity Buses

Refer to Appendix A in *TD157, Transmission Cooling Tests,* to determine which specific vocations require sump cooling.

Retarder-equipped transmissions used in other vocations such as, line or regional haul, may also need sump cooling to meet the temperature limits and cooling tests as described in 3.0, Cooling Requirements.

4.4 WATER BYPASS REQUIREMENTS

The engine thermostat is typically closed during vehicle braking when the retarder is operating and generating heat. Therefore, the preferred location for a transmission/retarder oil-to-water cooler is on the pressure side (outlet side) of the engine water pump. This ensures continuous flow to the retarder cooler even when engine thermostat is closed.

If the cooler must be located on the suction side (inlet side) of the engine water pump, between radiator and pump inlet, full bypass flow through the retarder cooler is required. The amount of bypass flow to the retarder cooler should be a high percentage of the flow available when engine thermostat is open and coolant is flowing to the radiator. Initially, this flow ensures that the retarder will receive some cooling. When the retarder is applied repeatedly or for an extended period, the bypass flow through the retarder cooler will increase the temperature of the engine coolant. 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 radiator and the retarder cooler.

Although specifics will vary from engine to engine, the following outlines the general approach to provide 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.
- Experience has shown that bypass piping should be at least 44.45 mm (1.75 inch) inner diameter, 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.

CAUTION: For retarder cooling it is not acceptable to route water returns, such as that from vehicle heaters, through the transmission cooler in lieu of full bypass flow. During retarder operation, these flow rates are too low to prevent transmission overheating before engine thermostat opens.

5.0 TRANSMISSION / RETARDER COOLER SYSTEMS

The following cooler arrangements are possible for retarder cooling with sump cooling:

- Allison combination retarder/sump cooler mounted directly to the rear of the retarder housing
- Allison combination retarder/sump cooler mounted remotely from the transmission
- Two non-Allison remote-mounted coolers, one for the retarder cooling circuit and one for the sump cooling circuit

The following cooler arrangements are possible for retarder cooling without sump cooling:

- Allison high capacity direct-mount cooler mounted directly to the rear of the retarder housing, 3000 Product Family only
- A non-Allison cooler mounted remotely from the transmission

CAUTION: Untreated water can produce potentially damaging results, including electrolytic corrosion, to cast aluminum housings. The use of untreated or native tap water as a cooling medium is STRICTLY PROHIBITED if an Allison cooler is used for transmission, sump, or retarder cooling.

Refer to *Transmission Cooling – Basic* for additional coolant requirements that apply to all installations, including those with the retarder.

NOTE: Not all of the cooler arrangements and cooler types discussed in this document are available with all transmission models. In addition, some cooler options are available only in certain geographical locations. To determine the availability of a cooler option for a particular transmission model by geographical region refer to the *unit Customer Specification System (uCSS)* or contact your Allison representative.

5.1 INSTALLATIONS WITH TRANSMISSION SUMP COOLING

5.1.1 INSTALLATIONS USING THE ALLISON DIRECT-MOUNT RETARDER/SUMP COOLER

Allison offers an oil-to-water retarder/sump cooler mounted on the transmission. This cooler is bolted to a manifold on the rear face of the retarder housing, as shown in Figure 1. To determine if the direct-mount retarder/sump cooler is available for your transmission in your geographical region, refer to the *unit Customer Specification System (uCSS)* or consult your Allison representative.

The direct-mount retarder/sump cooler is a flat plate cooler with two oil compartments, one for propulsion mode/retarder mode cooling, and a second compartment for sump cooling during retarder operation. The cooler has 50 mm beaded fittings for the engine/radiator coolant lines. The direct-mount cooler assembly includes an M14 port for a transmission temperature sensor and an M12 port for an engine coolant temperature sensor.

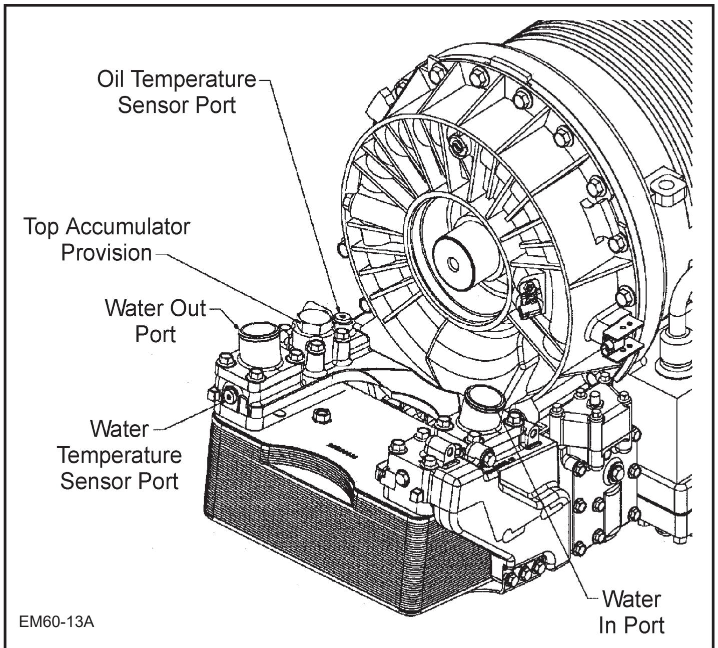


Figure 1: Integral Retarder/Sump Cooler

Cooler details are shown on the *Retarder and Sump Cooler – Direct Mount Installation Drawings*:
- *AS66-476 for the 3000 Product Family*
- *AS67-476 for the 4000 Product Family*

Cooler performance curves are located in *Transmission Data* for the *3000* or *4000* Product Family.

The direct-mount cooler is at a angle of 7º relative to the center-line of the transmission. This provides ground clearance in rear engine buses and coaches.

The direct-mount retarder/sump cooler assembly includes a retarder accumulator port which can be used in place of the accumulator port on the left side of the retarder housing. The accumulator provision on the direct-mount cooler assembly is a number 16 straight thread O-ring port, versus the number 20 straight thread O-ring port in the retarder housing. The use of the number 16 port for the retarder accumulator affects the retarder response. If the number 16 port is used, the vehicle builder must evaluate the retarder response for acceptability, taking into account vehicle loaded weight and driveline reduction.

5.1.2 INSTALLATIONS USING THE ALLISON REMOTE RETARDER/SUMP COOLER

A remote-mounted, combination retarder/sump cooler (Figure 2) is available from the Allison Parts Distribution Center (Refer to *Support Equipment*). Similar to the Allison direct-mount retarder/sump cooler, the remote-mounted version is a flat plate cooler with two compartments. One compartment provides transmission cooling during propulsion mode and for the retarder circuit during retardation. The second compartment provides cooling for the transmission sump when the retarder is applied.

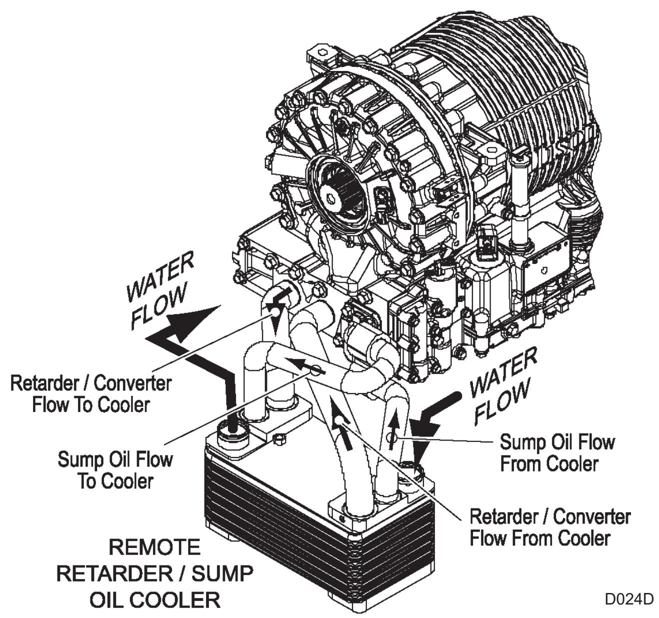


Figure 2: Allison Remote Retarder/Sump Cooler

The cooler may be mounted as follows:

- The bottom surface of the cooler has four M10x1.5 threaded holes which may be used for mounting the cooler.
- Recommended mounting location is on the vehicle frame.

> **NOTE: The cooler must not be mounted directly to the powerpack.**

Cooler details are shown on the *Retarder and Sump Cooler – Remote Mount* Installation Drawings:

- *AS66-477 for the 3000 Product Family*
- *AS67-477 for the 4000 Product Family*

Cooler performance data is summarized in *Transmission Data* for the *3000* or *4000* Product Family.

The transmission retarder housing must be equipped with a remote sump cooler manifold as illustrated in Figure 3. During retarder operation, transmission fluid from the converter flows out of this manifold to the cooler and returns to the transmission sump.

Installation of the following cooler hoses is required to complete the two separate transmission cooling circuits. Refer to Figures 2. Refer to the appropriate *Retarder and Sump Cooler – Remote Mount Installation Drawing* for additional details. All hoses must meet requirements listed in *Transmission Data*.

- **Retarder / Transmission (Primary) Cooler Circuit** – This circuit requires 1.125 inch (28.6 mm) I.D. hoses. The circuit routes fluid from the To Cooler port on the retarder housing (left port, as viewed from rear), to an oil port on the cooler. The transmission fluid exits the cooler from the oil port at the opposite end of the cooler and returns to the From Cooler port on the retarder housing (right side, as viewed from rear).

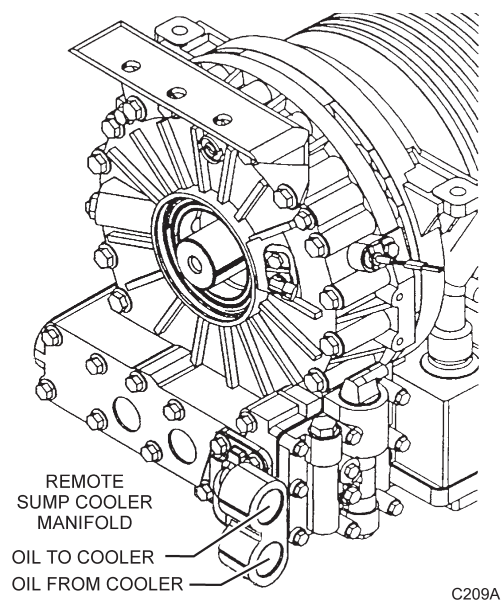


Figure 3: Remote Sump Cooler Manifold

- **Sump Cooler Circuit** – This circuit requires 0.875 inch (22.2 mm) I.D. hoses. Fluid is routed from the To Cooler port on the remote sump cooler manifold to the cooler. The transmission fluid exits the returns to the From Cooler port on the remote sump cooler manifold.

NOTE: In order to optimize the cooler capability, the sump cooler flow should be parallel to the flow in the retarder / transmission (primary) cooler flow and in the opposite direction to the water flow through the cooler. This is accomplished by routing oil and water as illustrated in Figure 2.

Coolant line fittings on this Allison cooler are 50 mm diameter beaded fittings.

5.1.3 INSTALLATIONS USING NON-ALLISON REMOTE COOLERS FOR RETARDER/SUMP COOLING

As an alternative to the Allison combination retarder/sump coolers, the requirements for sump cooling can also be met through two other means:

- a non-Allison, remote-mounted, combination retarder/sump cooler which meets all requirements for this application. Refer to *Support Equipment* for source information.
- two separate remote coolers, one for retarder/converter cooling and a second cooler for the transmission sump.

Both of the above cooler arrangements require that the transmission be equipped with the remote sump-cooler manifold provision (Figure 3). During retarder operation, transmission fluid from the converter flows out of this manifold to the cooler and back to the transmission sump (Figure 4).

When two separate coolers are used, the retarder/converter cooler must meet the requirements and guidelines outlined in 3.0, Cooling Requirements, and *TD157, Transmission Cooling Tests*. This cooler accommodates the primary cooling needs of the transmission during both propulsion mode (primary heat source is the torque converter) and during retardation mode (the retarder is the primary heat source). Heated transmission fluid is routed out of the transmission via the straight thread O-ring ports on the rear of the retarder housing.

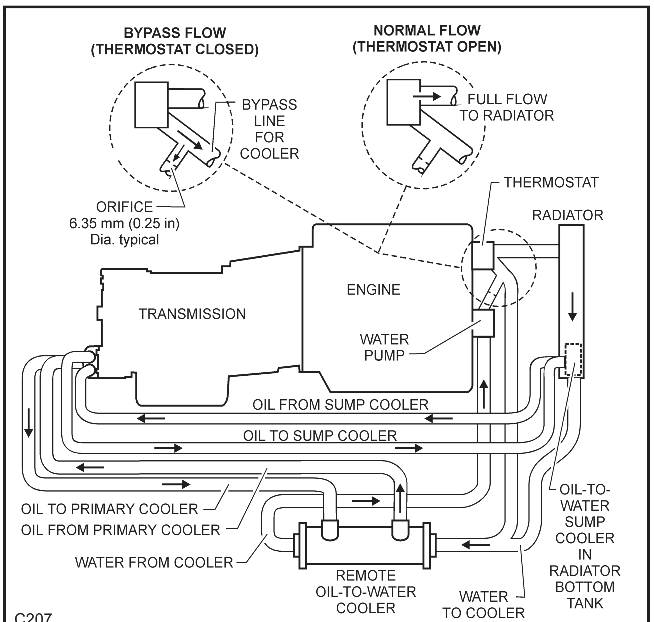


Figure 4: Installation of a Non-Allison Remote Retarder Cooler and Bottom Tank Oil-to-Water Sump Cooler

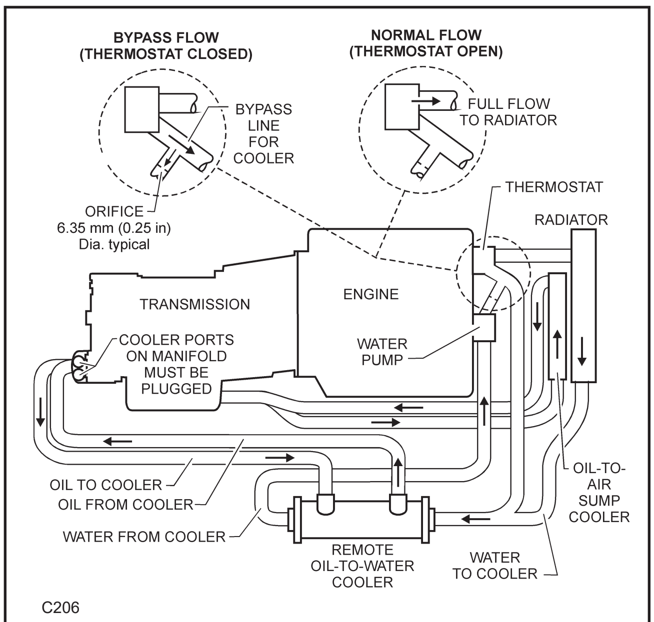


Figure 5: Installation of a Non-Allison Remote Retarder Cooler. Using Front Cooler Ports and Oil-to-Air Cooler for Sump Cooling

The separate sump cooler can be an oil-to-water cooler, such as a radiator bottom tank cooler (See Figure 4), or an oil-to-air cooler (Figure 5). The orifice in the line from the thermostat housing to the water pump housing shown in Figures 4 & 5 is an engine manufacturer requirement to insure the deaeration system functions properly. Contact your engine manufacturer to verify the orifice size. A heat rejection capacity similar to the sump-side of the Allison remote retarder/sump cooler is suggested as a starting point for the non-Allison sump cooler. Performance data for the Allison cooler is summarized in *Transmission Data* for the 3000 or the 4000 Product Family. In order to meet the transmission temperature limits, the size of the sump cooler may need to be adjusted during the retarder cooling tests specified in *TD-157*. Refer to the External Hydraulic Circuit Characteristics in *Transmission Data* for transmission oil flow.

The transmission oil to the separate sump cooler can come from one of two locations:

- from the remote sump-cooler manifold; refer to the *Remote Retarder Cooler Option Installation Drawings*, *AS66-477 (3000 Product Family)* and *AS67-477 (4000 Product Family)*
- the straight thread O-ring ports on the front of the control module refer to the *Cooler Port Installation Drawings*, *AS66-474 (3000 Product Family)* and *AS67-474 (4000 Product Family)*

If the front cooler ports are used, the straight thread O-ring ports in the remote sump-cooler manifold must be plugged. During propulsion mode (retarder off) the oil flow is divided between the rear ports and the front ports in proportion to the relative pressure drop between these two external circuits. See Figure 7.

NOTE: When using the front cooler ports for sump cooling, the transmission must be equipped with the remote sump cooler manifold and the manifold ports must be plugged. This is required to ensure adequate flow through the front cooler ports to the sump cooler.

5.2 INSTALLATIONS WITHOUT TRANSMISSION SUMP COOLING

One of the cooling arrangements described below may be used if sump cooling is not required. The transmission/retarder installation must still meet all of the cooling requirements outlined in 3.0, Cooling Requirements, and pass the cooling tests specified in *TD-157, Transmission Cooling Tests*. This includes not exceeding the maximum sump temperature during retarder operation.

5.2.1 INSTALLATIONS USING THE ALLISON DIRECT-MOUNT HIGH CAPACITY COOLER (3000 PRODUCT FAMILY ONLY)

Refer to Figure 6 and to *Installation Drawing AS66-472, Direct-Mount Cooler – Retarder Models*. When specified, the Allison direct-mount 17-plate high capacity cooler is provided as a factory-installed option on the transmission assembly retarder housing. This cooler has no provision for sump cooling. This option is available only on transmissions in the 3000 Product Family. For availability, refer to *3000 Product Family Features and Options* or to the *unit Customer Specification System (uCSS)*.

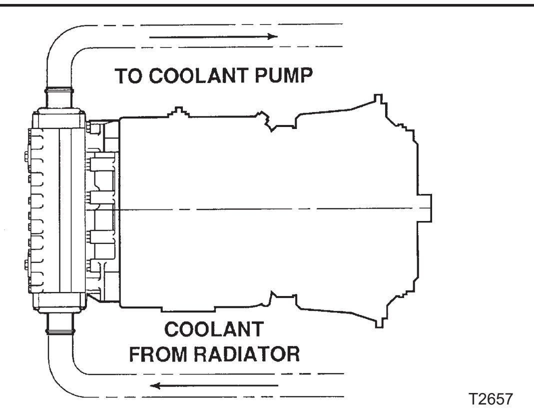


Figure 6: Direct-Mount Oil Cooler

5.2.2 INSTALLATIONS USING A NON-ALLISON REMOTE COOLER

If sump cooling is not required for an installation, the remote sump cooler manifold, discussed in 5.1.2 and shown in Figure 3, is replaced with a sump cooling bypass cover, shown in Figure 7. This cover creates a bypass path for the sump oil across the back of the retarder, recirculating the oil which would normally flow through the sump cooler circuit.

The sump cooling bypass cover protrudes 8 mm (0.315 inch) beyond the rear face of the retarder as shown on the *Retarder and Sump Cooler - Remote Mount Installation Drawings*. The bypass cover or its mounting bolts may interfere with the installation of a short 90º fitting in the oil return port on the retarder housing. Possible alternatives are a straight fitting, a 45º fitting or an extended 90º fitting.

The retarder oil flow is the same as shown in *Transmission Data for 3000 Product Family* or in *Transmission Data for 4000 Product Family*. It is not affected by the recirculation of oil in the sump circuit.

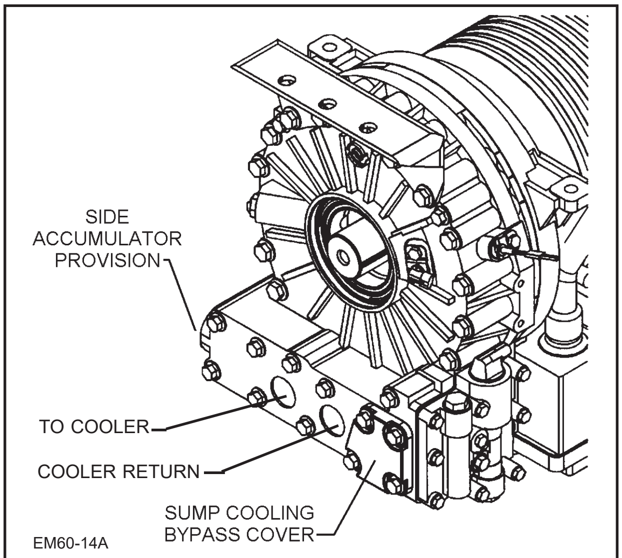


Figure 7: Installation of Sump Cooling Bypass Cover to Eliminate Sump Cooler Circuit

Refer to *Retarder and Sump Cooler – Remote Mount Installation Drawings*, *AS66-477 (3000 Product Family)* and *AS67-477(4000 Product Family)*.

NOTE: When using the front cooler ports on the 4-inch oil sump for sump cooling, DO NOT USE THE SUMP COOLING BYPASS COVER, as this may cause loss of flow to the front cooler ports. Instead, the bypass cover MUST be replaced with the remote sump cooler manifold and the manifold ports must be plugged as described in 5.1.3, Installations Using Non-Allison Remote Coolers.

5.3 HYDRAULIC CIRCUITS FOR REMOTE COOLERS

For remote-mounted retarder coolers, the pressure drop in the retarder cooler circuit must allow sufficient oil flow to meet the retarder cooling guidelines and pass the required retarder cooling tests defined in *TD-157, Transmission Cooling Tests*. For remote-mounted sump coolers, the total cooler circuit pressure drop must not exceed the pressure drop requirements for non-retarder coolers as defined in the applicable *Transmission Data*.

CAUTION: Excessive pressure drop will result in reduced flow through the circuit, creating an overheat condition, leading to premature deterioration of the transmission fluid.

Refer to *Transmission Cooling – Basic* for the following requirements and guidelines:

- Location and orientation guidelines for remote-mounted coolers
- Hydraulic circuit installation and routing guidelines
- Pressure drop measurement for sump cooler circuit

5.4 TEMPERATURE SENSING

The transmission 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 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 3000/4000 Product Families*

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 Allison's requirements for over-temperature warning and descriptions of the available transmission over-temperature signals for retarder-equipped transmissions:

- **NOTE: Over-temperature warning is REQUIRED for retarder-equipped transmissions in non-transit bus applications.**

- Over-temperature warning is optional for retarder-equipped transmissions in transit bus applications.

- A dash mounted light or audible alarm is preferred for retarder over-temperature warning. A temperature gauge may be used in addition to the warning light, or as an alternative.

- The electronic controls have available Output Function B, Sump/Retarder Temp Indicator. For retarder-equipped transmissions, this discrete electronic output indicates when an over-temperature condition is detected in either the transmission sump or the retarder-out hydraulic circuit. 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 installation and wiring details, refer to *Output Function B: Sump/Retarder Temperature 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 and the retarder-out temperature over the J1939 datalink (refer to *Datalink Communications*). The vehicle builder can use these broadcast messages for dash gauges or other transmission temperature display. The gauge or display must correctly indicate whether the transmission sump temperature or the retarder-out temperature is being displayed. The gauge or display must also identify the maximum transmission sump temperature or the maximum retarder-out temperature, as appropriate. For example, a gauge could be green or white below the maximum temperature and red above the maximum temperature. Refer to *3000 Product Family Transmission Data* or *4000 Product Family Transmission Data* for the maximum transmission sump and the maximum retarder-out temperature limits.

- For an analog retarder-out temperature gauge, a sensor may be mounted in a tee-fitting on the To Cooler line near the transmission To Cooler port. The temperature gauge must appropriately identify the retarder-out temperature limit per *Transmission Data.*

- The transmission electronic controls will register a diagnostic code in memory in the event of high fluid temperatures in the transmission sump or in the retarder-out hydraulic circuit. Refer to *Allison 6th Generation Controls, Section B: System Operation for 3000/4000 Product Families* for a description of the diagnostic codes and their retrieval.

APPENDIX A: RECOMMENDED DESIGN AMBIENT TEMPERATURES

SELECT AMBIENT (°C) FOR LOCATION OF VEHICLE USAGE

AFRICA

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

ASIA

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

AUSTRALIA

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

CARIBBEAN ISLANDS

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

CENTRAL and SOUTH AMERICA

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

EUROPE

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

NORTH AMERICA

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

OCEANIC ISLANDS

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

(1) Inland areas of central China (ex., Chungking) recommendation is 45°C.
(2) Northern plains area of Ragasthan 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: SAMPLE RETARDER COOLING CALCULATION – DOWNGRADE OPERATION

1. Define vehicle retardation requirements – downhill grade and speed

- Expected downgrade 6.0%
- Speed to be maintained on downgrade 64.4 km/hr (40 mph)

2. Generate an *iSCAAN* run for the vehicle

- Enter negative (downhill) values for the Vehicle Wheel Power Requirements Grades. Include expected downgrade identified in step 1. Refer to Figure B-1.
- Output reports must include Vehicle Wheel Power Requirements and Vehicle Retardation Performance.

> **NOTE: The iSCAAN engine library normally includes friction data for each engine. If entering your own engine data, be certain to include engine friction data for the engine. This is more important in the Vehicle Retardation Performance analysis than in the overall cooling estimate.**

(continued)

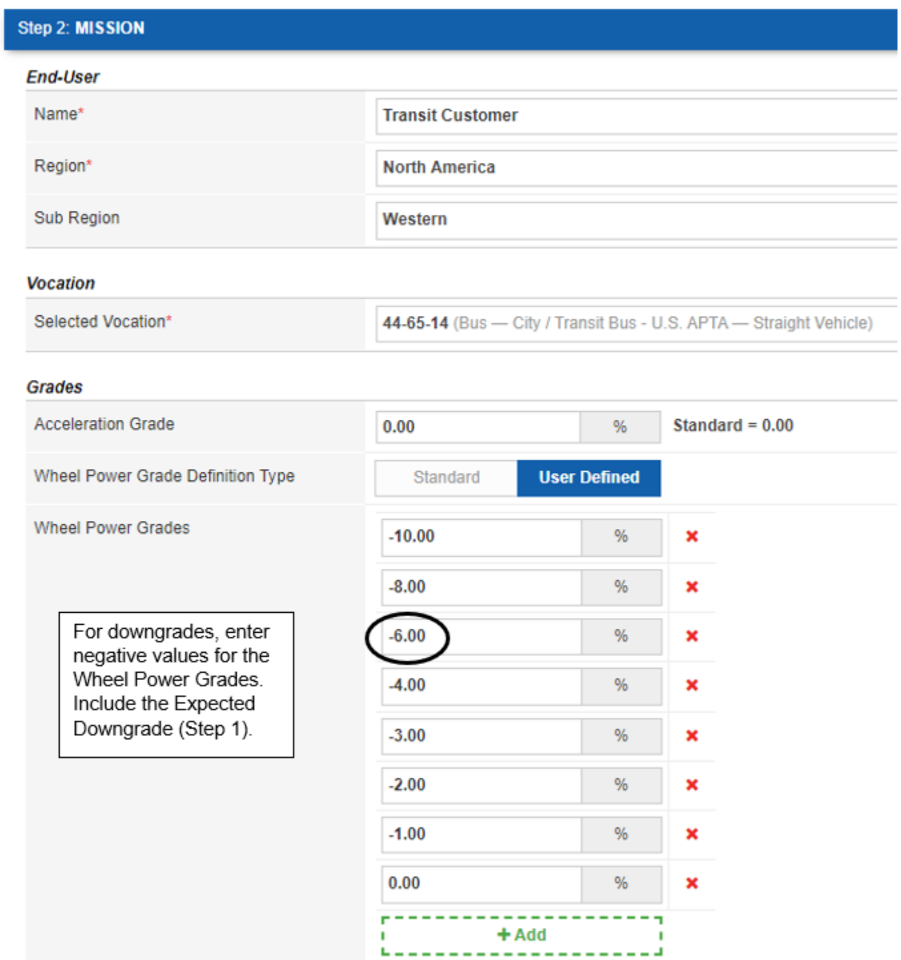


Figure B-1: Example of Entering Downgrades in iSCAAN for the Vehicle Wheel Power Requirements report

NOTE

This SCAAN information is subject to the SCAAN Disclaimer set forth elsewhere.

The data presented in this report defines the actual wheel power required to maintain a specified vehicle speed on various grades. The results are based on the physical characteristics of the vehicle – weight, aerodynamics, and rolling resistance – and are independent of engine rating, transmission model, and shift schedule.

Positive grades indicate uphill operation and negative grades indicate downhill operation.

Positive wheel power values indicate propulsion power required, and negative wheel power values indicate braking power required. Wheel power values that exceed the available propulsion or braking wheel power indicate operating conditions that are not possible with the specified vehicle configuration.

WHEEL POWER REQUIRED ON GRADE - STANDARD, FAN ON, AC OFF, AXLE RATIO = 5.870, AUX RATIO = 1.000, STANDARD POWER CURVE, DRIVELINE RATIO MODE = SINGLE

Engine Fan	On	Air Conditioning	Off
Engine Power	Standard Power Curve	Vehicle Parameters	Standard
Axle Ratio	5.87	Auxiliary Gearing Ratio	1

Download Results

Vehicle Speed (km/h)	Wheel Power Available (kW)	-10%	-8%	-6%	-4%	-3%	-2%	-1%	0%
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	152.0	-56.7	-44.9	-33.0	-21.1	-15.2	-9.2	-3.3	2.7
16.1	157.1	-112.9	-89.3	-65.6	-41.8	-29.9	-18.0	-6.1	5.9
24.1	186.1	-168.5	-133.1	-97.6	-61.9	-44.0	-26.2	-8.3	9.6
32.2	204.4	-223.3	-176.1	-128.7	-81.2	-57.4	-33.5	-9.7	14.2
40.2	213.4	-277.2	-218.2	-159.0	-99.6	-69.8	-40.0	-10.2	19.6
48.3	190.5	-330.0	-259.2	-188.2	-116.9	-81.1	-45.4	-9.6	26.2
56.3	209.6	-381.5	-299.0	-216.1	-132.9	-91.2	-49.5	-7.8	34.0
64.4	183.8	-431.7	-337.4	-242.6	-147.6	-99.9	-52.2	-4.5	43.2
72.4	202.6	-480.3	-374.2	-267.6	-160.6	-107.0	-53.4	0.3	54.0
80.5	197.9	-527.2	-409.3	-290.9	-172.0	[illegible]	-52.8	6.8	66.4
88.5	198.0	-572.2	-442.5	-312.2	-181.5	[illegible]	-50.4	15.2	80.8
96.6	187.9	-615.1	-473.7	-331.6	-188.9	-117.5	-45.9	25.6	97.2
104.6	107.7	-655.9	-502.7	-348.7	-194.2	-116.8	-39.3	38.2	115.8
112.7	-110.3	-694.3	-529.3	-363.5	-197.1	-113.7	-30.3	53.2	136.7

Step 3

Figure B-2: Sample iSCAAN Vehicle Wheel Power Requirements Report (SI Units Shown)

3. From Vehicle Wheel Power Requirements report, determine the wheel power (WP) required for the grade and speed defined in step 1. Refer to Figure B-2.

WP = 242.6 kW (325.3 hp)

4. From Vehicle Retardation Performance report, determine the equilibrium grade and the retardation power available at the wheels for the desired speed identified in step 1. Refer to Engine Retarder Off, Transmission Retarder On reports shown in Figure B-3.

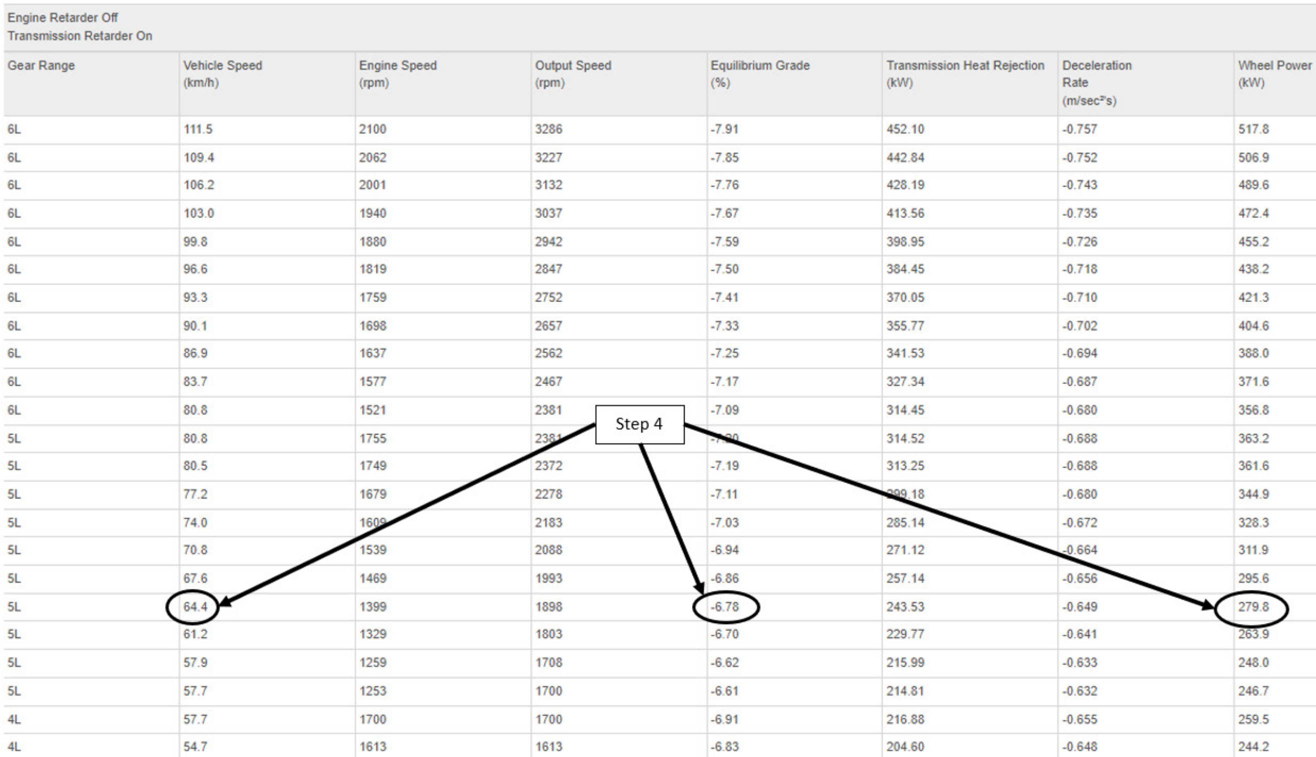
- Equilibrium grade 6.78%
  exceeds expected downhill grade identified in step 1

- Retardation Wheel Power 279.8 kW (375 hp)
  exceeds wheel power required to maintain desired speed on expected downgrade

Retarder capacity is sufficient to maintain desired speed on expected downgrade.

NOTE: The wheel power listed in the Vehicle Retardation Performance report is at the maximum level of the selected retarder capacity. Full retarder apply may not always be required to maintain the desired speed-on-downgrade.

(continued)



Engine Retarder Off Transmission Retarder On							
Gear Range	Vehicle Speed (km/h)	Engine Speed (rpm)	Output Speed (rpm)	Equilibrium Grade (%)	Transmission Heat Rejection (kW)	Deceleration Rate (m/sec²s)	Wheel Power (kW)
6L	111.5	2100	3286	-7.91	452.10	-0.757	517.8
6L	109.4	2062	3227	-7.85	442.84	-0.752	506.9
6L	106.2	2001	3132	-7.76	428.19	-0.743	489.6
6L	103.0	1940	3037	-7.67	413.56	-0.735	472.4
6L	99.8	1880	2942	-7.59	398.95	-0.726	455.2
6L	96.6	1819	2847	-7.50	384.45	-0.718	438.2
6L	93.3	1759	2752	-7.41	370.05	-0.710	421.3
6L	90.1	1698	2657	-7.33	355.77	-0.702	404.6
6L	86.9	1637	2562	-7.25	341.53	-0.694	388.0
6L	83.7	1577	2467	-7.17	327.34	-0.687	371.6
6L	80.8	1521	2381	-7.09	314.45	-0.680	356.8
5L	80.8	1755	2381	-7.20	314.52	-0.688	363.2
5L	80.5	1749	2372	-7.19	313.25	-0.688	361.6
5L	77.2	1679	2278	-7.11	299.18	-0.680	344.9
5L	74.0	1609	2183	-7.03	285.14	-0.672	328.3
5L	70.8	1539	2088	-6.94	271.12	-0.664	311.9
5L	67.6	1469	1993	-6.86	257.14	-0.656	295.6
5L	64.4	1399	1898	-6.78	243.53	-0.649	279.8
5L	61.2	1329	1803	-6.70	229.77	-0.641	263.9
5L	57.9	1259	1708	-6.62	215.99	-0.633	248.0
5L	57.7	1253	1700	-6.61	214.81	-0.632	246.7
4L	57.7	1700	1700	-6.91	216.88	-0.655	259.5
4L	54.7	1613	1613	-6.83	204.60	-0.648	244.2

Figure B-3: Sample iSCAAN Vehicle Retardation Performance Report (SI Units Shown)

5. **From Vehicle Retardation Performance report, determine the braking wheel power due to engine friction and vehicle accessory losses. Refer to Engine Retarder- Off report in Figure B-4.**

   P_{ENG} = 41.1 kW (55.1 hp)

Step 5

Engine Retarder Off Transmission Retarder Off							
Gear Range	Vehicle Speed (km/h)	Engine Speed (rpm)	Output Speed (rpm)	Equilibrium Grade (%)	Transmission Heat Rejection (kW)	Deceleration Rate (m/sec²s)	Wheel Power (kW)
6L	111.5	2100	3286	-2.62	36.00	-0.251	82.9
6L	109.4	2062	3227	-2.57	34.82	-0.247	80.4
6L	106.2	2001	3132	-2.49	33.00	-0.239	76.6
6L	103.0	1940	3037	-2.42	31.20	-0.232	72.7
6L	99.8	1880	2942	-2.34	29.43	-0.225	69.0
6L	96.6	1819	2847	-2.27	27.75	-0.218	65.3
6L	93.3	1759	2752	-2.20	26.18	-0.211	61.9
6L	90.1	1698	2657	-2.13	24.73	-0.205	58.6
6L	86.9	1637	2562	-2.07	23.32	-0.198	55.4
6L	83.7	1577	2467	-2.00	21.96	-0.192	52.4
6L	80.8	1521	2381	-1.95	20.74	-0.187	49.8
5L	80.8	1755	2381	-2.06	20.82	-0.197	56.2
5L	80.5	1749	2372	-2.05	20.70	-0.196	55.9
5L	77.2	1679	2278	-1.99	19.46	-0.190	52.5
5L	74.0	1609	2183	-1.93	18.25	-0.184	49.3
5L	70.8	1539	2088	-1.87	17.05	-0.179	46.3
5L	67.6	1469	1993	-1.81	15.91	-0.174	43.5
5L	64.4	1399	1898	-1.77	15.13	-0.169	41.1
5L	61.2	1329	1803	-1.72	14.19	-0.165	38.6
5L	57.9	1259	1708	-1.67	13.25	-0.160	36.1
5L	57.7	1253	1700	-1.67	13.17	-0.160	35.9
4L	57.7	1700	1700	-1.97	15.25	-0.187	48.7
4L	54.7	1613	1613	-1.92	14.68	-0.183	45.7
4L	51.5	1518	1518	-1.88	13.90	-0.178	42.6
4L	48.3	1423	1423	-1.83	12.75	-0.173	39.2
4L	45.1	1329	1329	-1.79	11.93	-0.170	36.2
4L	41.8	1234	1234	-1.74	10.87	-0.165	33.1
4L	39.0	1150	1150	-1.70	9.88	-0.161	30.4

Figure B-4: Vehicle Closed Throttle Braking Performance Report - Transmission Retarder OFF

6. Calculate transmission retarder power and cooling capacity required for the conditions identified in step 1

$P_{RET} = P_{COOLING}$ = WP (Driveline Efficiency) - P_{ENG}

= 242.6 kW (95.64%) - 41.1 kW = 190.9. kW (metric)
= 325.3 hp (95.64%) - 55.1 hp = 256.0 hp (U.S.)

This is the minimum cooling capacity required to continuously cool the retarder while maintaining the desired speed on the expected downgrade as identified in step 1.

NOTE: P_{RET} is the heat load, in terms of horsepower or kilowatts, which the transmission cooler must remove from the transmission oil. The vehicle cooling system must be capable of removing (P_{RET} + P_{ENG}) while operating at the above speed-on-downgrade conditions.

LIST OF REFERENCED DOCUMENTS

- Allison 6th Generation Controls Manual for 3000/4000 Product Families
    - Section B: System Operation
    - Output Function B: Sump/Retarder Temperature Indicator

- unit Customer Specification System (uCSS)

- Datalink Communications

- Features and Options for the:
  - 3000 Product Family
  - 4000 Product Family

- iSCAAN, Allison's vehicle performance calculation program

- Support Equipment

- Transmission Cooling – Basic

- Transmission Data for the:
  - 3000 Product Family
  - 4000 Product Family

Installation Drawings – 3000 Product Family

- AS66-472, Direct-Mount Cooler – Retarder Models

- AS66-474, Cooler Port Provisions

- AS66-476, Retarder and Sump Cooler – Direct-Mount

- AS66-477, Retarder and Sump Cooler – Remote-Mount

Installation Drawings – 4000 Product Family

- AS67-474, Cooler Port Provisions

- AS67-476, Retarder and Sump Cooler – Direct-Mount

- AS67-477, Retarder and Sump Cooler – Remote-Mount

Technical Documents (TDs)

- TD-157, Transmission Cooling Tests

REVISION HISTORY

March 11, 2024
- In 3.1, replaced, "*converter out*" with, "*to cooler*".
- In 3.1, replaced, "*minimum sump temperature*" with, "*minimum continuous sump temperature*".
- In 3.3, added, "for the vocation and location".
- In 4.0, added, "idle cooling".
- In 4.1, added, "that best represents expected vehicle operation".
- In 4.3, added, "such as line or regional haul".
- In 5.1.2, added note "The cooler must not be mounted directly to the powerpack" and correct figure reference
- In 5.1.3, added hyperlinks to Installation Drawings AS66-477 and AS67-477
- Removed references to, "AllisonCalc" and replaced with, "DesignCalcs".
- In Appendix B, added new figures using the current version of iSCANN
- Removed references to "*CSS Customer Specification Sheets*" and replaced with*, "uCSS unit Customer Specification System".*

November 7, 2016
- Updated the document to reflect the new consolidated 3000 and 4000 Installation Drawings; AS66-416, AS66-417, AS66-418, AS67-416, AS67-417, AS67-418.

February 10, 2016
- Re-write of 5.0 for improved clarity
- In 5.1.3, add information regarding orifice in bypass line from the thermostat housing to the water pump housing shown in Figures 5 & 6
- Refer to high capacity cooler in 5.2.1
- In 5.2.2, re-write of first paragraph for improved clarity

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

July 23, 2010
- Updated references and links to Input and Output Functions.

July 17, 2008
- Prepared document for Extranet publication

June 11, 2008
- Created new document, *Transmission Cooling – Retarder*.