Gearbox Torque Capacity and LRTP SB-179

April 28, 2020

Dear Valued Customer,

With the rising popularity of the Cummins X15, Hale has seen an increased interest in the torque capacity of current Hale gearbox offerings. Hale's G Series gearbox (LG, XG, RG, SG) is capable of 16,000 ft-lb, while the K Series gearbox (LK, XK) is capable of 18,500 ft-lb of torque. In some cases, apparatus are configured in a manner in which the combination of the lowest gear ratio (usually reverse), the maximum engine torque, and the torque converter ratio can cause excessive torque on both the standard G gearbox and the K gearbox.

Hale provides the pump recommendation list (029-0020-52-0) that contains Form F-72 which details how to determine the maximum allowable engine torque when choosing a gearbox. It is the responsibility of the OEM to configure their apparatus in a manner to ensure that values for maximum torque are not exceeded. In many cases meeting the torque constant can be achieved by choosing the appropriate torque converter. Hale derives this value using the formula below.

$$\begin{pmatrix}\text{MAXIMUM ALLOWABLE GROSS}\\ \text{ENGINE TORQUE (FT – LBS)}\end{pmatrix} = \frac{\text{TORQUE CONSTANT (FROM TABLE)}}{\begin{pmatrix}\text{HIGHEST TRUCK TRANSMISSION RATIO}\\ \text{(FIRST GEAR OR REVERSE)}\end{pmatrix} \text{X} \begin{pmatrix}\text{TORQUE CONVERTER RATIO}\\ \text{(IF APPLICALBE)}\end{pmatrix}}$$

Where an apparatus can exceed the maximum torque of the gearbox it is the responsibility of the OEM to address the torque. There are multiple ways that torque can be mitigated on a modern chassis. Specific gears can be locked out to lower the ratio that is used in the calculation. Also, torque can be limited by the engine or transmission. When using Allison transmissions OEMs may integrate Low Range Torque Protection (LRTP) into the software to limit torque. According to Allison, LRTP limits the output torque from the torque converter electronically to a predetermined value. Allison uses LRTP to protect the transmission from the torque converter to the output of the transmission. For 4000/4500 EVS transmissions the maximum turbine torque is limited to a value of 2600 lb-ft. This value can be multiplied by the ratio of the highest ratio gears in the transmission to attain the input torque to the Hale gearbox. The table below shows the specifics (as of March, 2020):

Transmission	Maximum Turbine Torque (lb-ft)	Gear	Ratio	Maximum Transmission Output Torque (lb-ft)
4000EVS	2600	Rev 1	4.80	12480
		Fwd 1	3.51	9126
4500EVS	2600	Rev 1	5.55	14430
		Fwd 1	4.70	12220

LRTP ensures that the Hale gearbox is protected in most driving scenarios as none of the examples in the table above exceed 16,000 ft-lbs. However, because this is an electronic control through feedback loop communication, it may not be able to react fast enough to protect drivetrain in all instances. Of concern, there may be rare cases where the chassis drive wheels are spinning due to low traction such as ice or mud and suddenly catch on dry hard pavement. This may create a sudden torque spike. If this spike is in excess of the torque rating of the gearbox, there is a chance damage could occur. Due to the excessive force created there is also a chance for damage in this example on applications where LRTP is not needed because calculated maximum torque does not exceed the ratings for Hale's gearbox. Any failure of Hale's gearbox should be processed

through Hale's normal warranty process. Hale will evaluate the components and determine if the failure was caused by a material defect or workmanship and provide coverage as stated in their warranty statement.

In summary, Hale recommends that, when configuring apparatus chassis, care should be taken to limit the torque through the proper combination of engines, torque converters, and ratios so LRTP is not the only means for limiting driveline torque below the maximum published by Hale.

The tables below depict the combinations that Hale recommends (green highlight) and advises against (red highlight). The engine torque ratings cover the range of torque ratings available for Cummins X12 and X15 series engines.

Allison 4000EVS						
		Highest Ratio	4.8			
Torque Converter Data		Engine Torque Rating (ft-lb)				
TC Model/Ratio	TC Ratio	1450	1550	1650	1750	1850
TC-521	2.42	16843	18005	19166	20328	21490
TC-531	2.34	16286	17410	18533	19656	20779
TC-541	1.9	13224	14136	15048	15960	16872
TC-551	1.79	12458	13318	14177	15036	15895
TC-561	1.58	10997	11755	12514	13272	14030
Allison 4500EVS						
		Highest Ratio	5.55			
Torque Converter Data		Engine Torque Rating (ft-lb)				
TC Model/Ratio	TC Ratio	1450	1550	1650	1750	1850
TC-521	2.42	19475	20818	22161	23504	24847
TC-531	2.34	18831	20130	21429	22727	24026
TC-541	1.9	15290	16345	17399	18454	19508
TC-551	1.79	14405	15398	16392	17385	18379
TC-561	1.58	12715	13592	14469	15346	16223

Table 1: G Gearbox

Allison 4000EVS						
		Highest Ratio	4.8			
Torque Converter Data		Engine Torque Rating (ft-lb)				
TC Model/Ratio	TC Ratio	1450	1550	1650	1750	1850
TC-521	2.42	16843	18005	19166	20328	21490
TC-531	2.34	16286	17410	18533	19656	20779
TC-541	1.9	13224	14136	15048	15960	16872
TC-551	1.79	12458	13318	14177	15036	15895
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		Highest Ratio	5.55			
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TC-551	1.79	14405	15398	16392	17385	18379
TC-561	1.58	12715	13592	14469	15346	16223

Table 2: K Gearbox