Allison Transmission

DRIVELINE DESIGN
— SPECIAL CASES —

ALLISON ON-HIGHWAY TRANSMISSIONS

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

Contents:

DRIVELINE DESIGN – SPECIAL CASES

1.0 INTRODUCTION

The purpose of this document is to present guidelines for designing drivelines that are compatible with Allison transmissions and that include one of the following components:
- transfer case that is mounted remote from the transmission output
- split-shaft power take-off (PTO) installed in the output driveline
- auxiliary transmission installed in the output driveline
- retarder, or other large inertia component, installed in the output driveline
- input driveline for 4000 Product Family models with the remote-mount option

NOTE: Refer to *Basic Driveline Design* for guidelines that apply to all drivelines, including the ones described in this 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 OUTPUT DRIVELINE DESIGN CONSIDERATIONS FOR SPECIAL CASES

If the output driveline includes a non-propshaft component, additional concerns must be addressed. Two representative cases are discussed in the following paragraphs.

3.1 DRIVELINE WITH TRANSFER CASE, SPLIT-SHAFT PTO, OR AUXILIARY TRANSMISSION

This case applies to a driveline component that can be engaged and disengaged, such as a transfer case, an auxiliary transmission or a split-shaft PTO. When the mechanism is disengaged and re-engaged, the phasing of the driveline may change with respect to the transmission output. In installations of this type, it is impractical to attempt to consider system phasing, since it potentially changes each time the shifting mechanism is used.

The Allison approach to an installation of this type is to evaluate the individual driveline sections as independent drivelines. Figure 1 shows the most complicated situation – a transfer case with output drivelines to both front and rear axles. The process is similar for the following situations:
- a transfer case with a driveline to the rear axle only

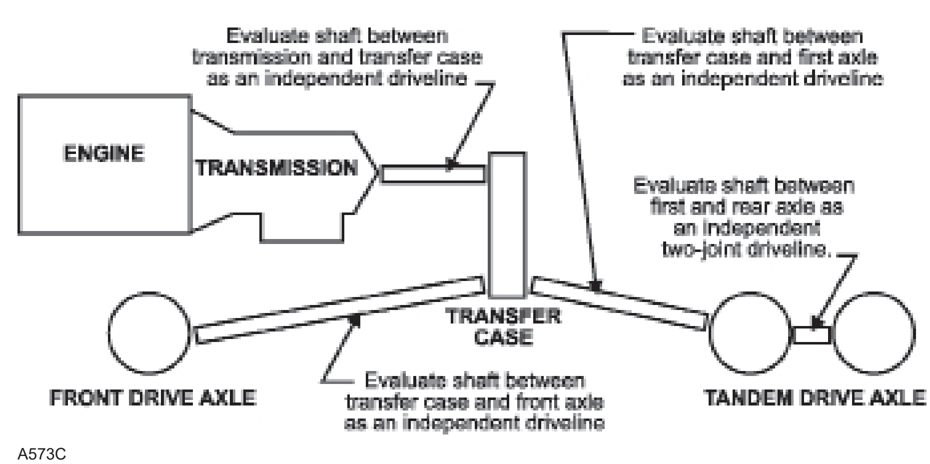

Figure 1: Driveline with Transfer Case

- an auxiliary transmission with the output driveline on the same center line as the driveline into the auxiliary transmission
- a split-shaft PTO with an input driveline from the transmission and an output driveline to the rear axle

For all of the above cases, each section of the driveline should comply with the torsional vibration acceptance criteria in Figure 2.

If the vehicle has a tandem drive axle, refer to *Basic Driveline Design* for requirements that apply specifically to the inter-axle propshaft.

The Multiple-Joint Driveline Analysis area of Allison's *Installation Design Calculation program, AllisonCalc*, can be used to calculate the torsional and inertial accelerations for each section of the driveline. Under Type of Driveline on the input screen, select "Output Without Propshaft-Mounted Retarder." A separate calculation must be made for each driveline section. The program will compare the calculated accelerations with the limits shown in Figure 2. *Technical Document 167 (TD167), Installation Design Calculations User's Guide*, contains detailed instructions for using *AllisonCalc*.

CHARACTERISTIC	MAXIMUM ACCEPTABLE (Radians / Sec^2)
Torsional Accelerations	
Design and Measured in Vehicle	500 max.
Inertial Accelerations	
Design Requirements:	
Drive mode	1000 max.
Coast mode	1000 max.
As Measured in Vehicle:	
Drive mode	1200 max.
Coast mode	1200 max.

Figure 2: Torsional Vibration Acceptance Criteria – Driveline with T-Case, Split-Shaft PTO or Auxiliary Transmission

3.2 DRIVELINE WITH A HIGH INERTIA COMPONENT

In this case, the driveline includes a driveline retarder or other large inertia component which rotates uniformly and in phase with the transmission output.

NOTE: Both the large inertia component installed in the driveline and the rear axle must rotate as uniformly as possible with the transmission output.

To create this condition, both the high inertia component and the axle must be parallel to the transmission. This configuration results in equal working angles at each end of the driveshaft between the transmission and the high inertia component. It also results in equal working angles at each end of the driveshaft between the high inertia component and the axle. See Figure 3. The angles of the front shaft need not necessarily be equal to the angles of the rear shaft.

The Allison approach to analyzing an installation of this type is a three-step process:

1. Evaluate the overall driveline as a multi-shaft design. Treat the high inertia component essentially as a propshaft with length but no mass.

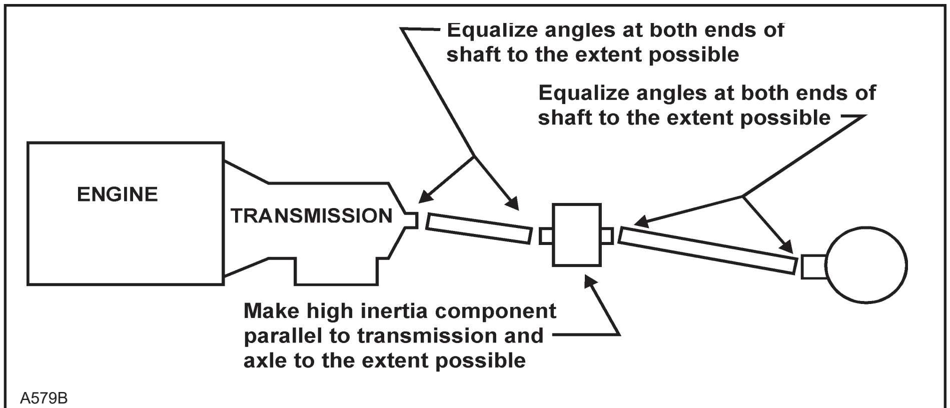

Figure 3: Driveline with a High Inertia Component

This step analyzes the total driveline, but does not recognize cancellation effects before or after the high inertia component.

2. Evaluate, independently, the torsional accelerations of only those components from the transmission to and including the high inertia component. This step accounts for the cancellation effects that may occur before the high inertia component.

3. Evaluate, independently, the torsional accelerations of only those components from the high inertia component to and including the axle. This step accounts for the cancellation effects that may occur after the high inertia component.

4. Compare the results with the appropriate Torsional Vibration Acceptance Criteria in Figure 4. The results of steps 2 and 3 require more restrictive acceptability limits than the results of step 1 for the following reasons:
   - to insure nearly uniform rotation
   - to compensate for the fact that the calculations do not consider the mass of the high inertia component

CHARACTERISTIC	MAXIMUM ACCEPTABLE (Radians / Sec^2)
Torsional Accelerations	
Design and Measured in Vehicle:	
Entire driveline	500 max.
Transmission to high inertia component	100 max.
High inertia component to axle	100 max.
Inertial Accelerations	
Design Requirements:	
Drive mode	1000 max.
Coast mode	1000 max.
As Measured in Vehicle:	
Drive mode	1200 max.
Coast mode	1200 max.

Figure 4: Torsional Vibration Acceptance Criteria – Driveline with High Inertia Component

The Driveline Analysis in *AllisonCalc* has an option, Output Driveline with Propshaft-Mounted Retarder, that guides the user through the steps above and evaluates the torsional vibrations using the criteria in Figure 4.

4.0 INPUT DRIVELINE DESIGN CONSIDERATIONS

Models in the 4000 Product Family are available with an optional remote input provision. A driveline connects the output of the engine to the input of the transmission. The input driveline must meet the same requirements as an output driveline per *Basic Driveline Design*. In addition, an input driveline must meet the more stringent requirements listed below:

- An input driveline must be a two joint, one shaft system.
- The angles must be as small as possible and equal at both joints.
- Yoke angles must be parallel as shown in Figure 5.

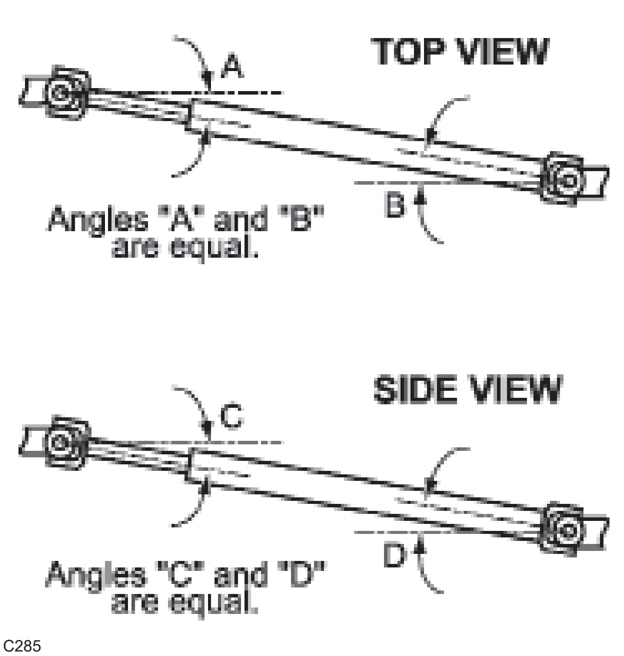

Figure 5: Shaft Angles for Input Driveline with Parallel Yokes

- Intersecting axes designs, also called broken-back drivelines, are not allowed. The transmission's remote input is not designed to accommodate high coupling loads. Refer to Figure 6 for a example of an intersecting axes design.
- The maximum allowable angles for an input driveline are shown in Figure 7. Note that the maximum angles are significantly less than the allowable angles for an output driveline. Figure 7 is applicable to input drivelines with angularity in one plane and with properly indexed joints. If the input driveline has angularity in both the vertical and horizontal planes, the Driveline Analysis in [AllisonCalc] can be used to determine the joint working angles.
- Refer to Figure 8 for the Torsional Vibration Acceptance Criteria for input drivelines. The Driveline Analysis in AllisonCalc has an input driveline option that evaluates the torsional vibrations using the criteria shown in Figure 8.
- All input driveline designs must be reviewed with Allison Engineering for acceptability. Consult your Allison representative.

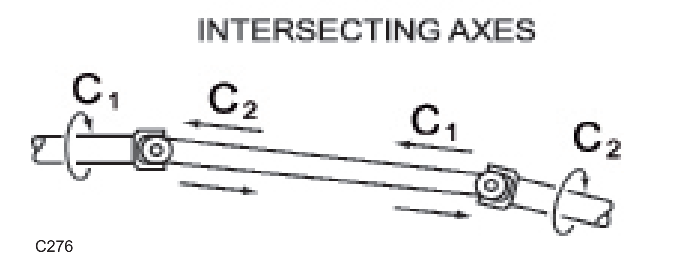

Figure 6: Coupling Loads from Drivelines with Intersecting Axes

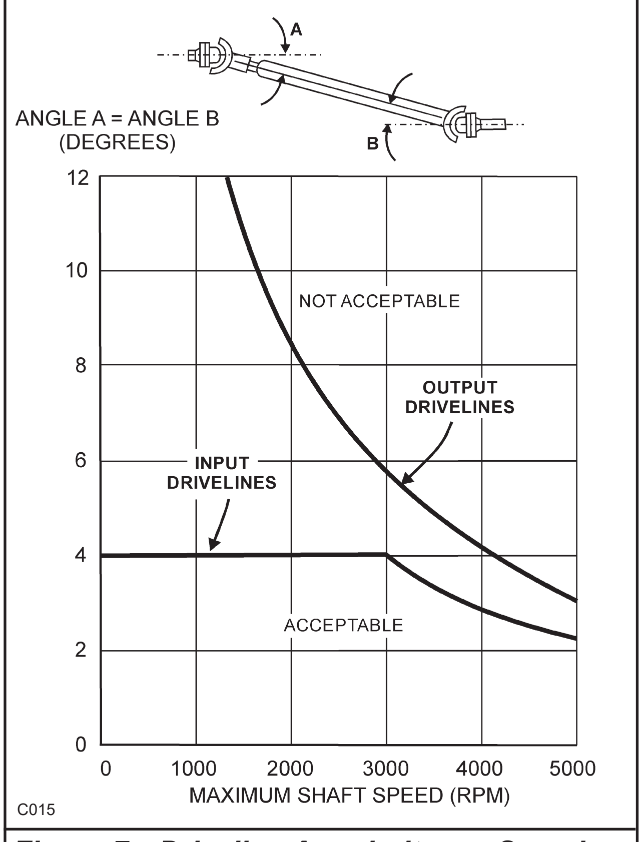

Figure 7: Driveline Angularity vs. Speed

CHARACTERISTIC	MAXIMUM ACCEPTABLE (Radians / Sec²)
Torsional Accelerations	
Input driveline - remote mount	100 max.
Inertial Accelerations	
Design requirements - 3000 rpm & above:	
Drive mode	500 max.
Coast mode	500 max.
Design requirements - below 3000 rpm: Inertial acceleration limits below 3000 rpm are based on a maximum recommended angle of 4 degrees. A limit is calculated using a 4 degree angle and the driveline speed. Thus, the limit varies with speed.	

Figure 8: Torsional Vibration Acceptance Criteria - Input Driveline

LIST OF REFERENCED DOCUMENTS

- *AllisonCalc, Installation Design Calculations Program*
- *Basic Driveline Design*

Technical Documents (TDs)

- *TD-167, Installation Design Calculations User's Guide*

REVISION HISTORY

April 8, 2022
- Add 2900 Product Family

July 17, 2008
- Prepared document for Extranet publication

October 9, 2007
- Created new module, Driveline Design – Special Cases