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SIL 10-TR-86, Rev. C
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Page 1 of 23

SUBJECT: Driveline Technical Information

MODELS AFFECTED: All Product Family Transmissions

Introduction:

An incorrectly designed and/or installed driveline can create drivability complaints and cause transmission damage and/or failure. Vibration and noise generated by the driveline is frequently misdiagnosed as a transmission issue.

Several features of driveline design have a critical effect on transmission reliability. Key factors include shaft length and runout, diameter, wall thickness, rotational speed, universal joint angles and phasing, and properly functioning slip joints. A general inspection of these driveline components is the first step when analyzing a driveline.

Inspection of Driveline Components

- Inspect driveshafts for damage and missing balance weights
- Inspect universal joints for damage and excessive movement
- Inspect transmission and axle yoke/flange bolts/nuts to ensure they are tight
- Inspect the driveline support bearings for damage, wear, and looseness
- Inspect drive axle mounts for wear and looseness
- Inspect driveshaft slip joint for free movement and wear

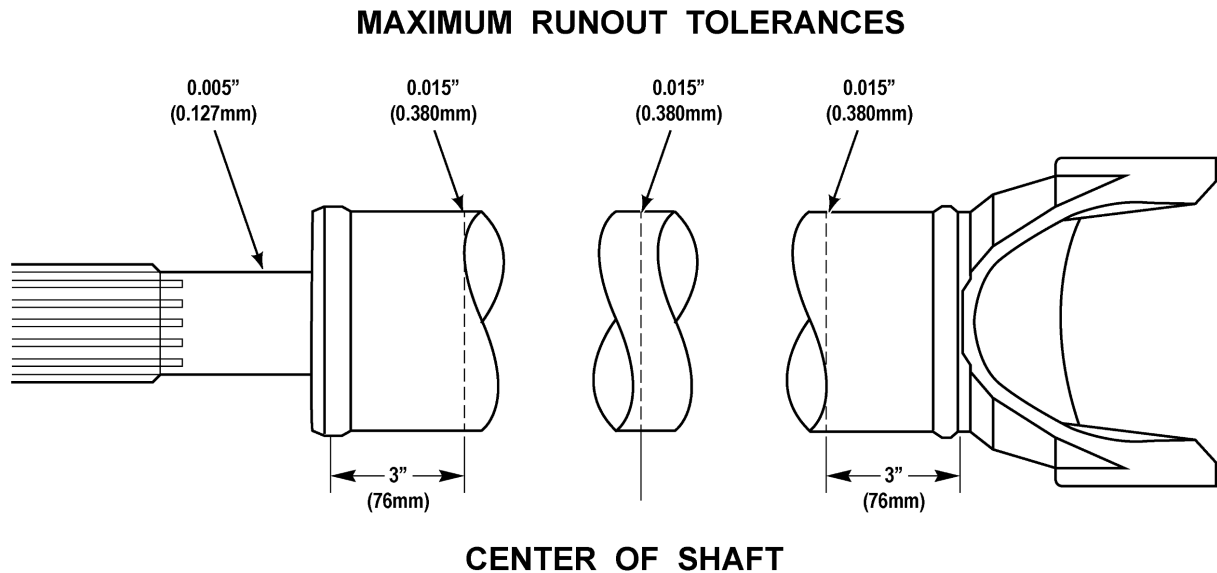
Allison's maximum runout tolerances are shown in [Figure 1](#) below. If the driveline manufacturer or vehicle OEM has different tolerances, the driveline must meet the manufacturer's requirements.

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Please Note: Allison Transmission Service Information Letters are intended for use by professional, trained technicians, not for the "do-it-yourselfer." They are written to inform those technicians of conditions that may occur on some transmission models (or serial numbers ranges) or to provide information that could assist in the proper servicing of a specific Allison transmission. Properly trained technicians have the equipment, tools, safety instructions, and know-how to do a job properly and safely. If a condition is described, do not assume that the Service Information Letter applies to your transmission, or that your transmission has the condition described. Product evolution and information updates are inevitable. Please see your authorized Allison Transmission service dealer or distributor to understand if your particular transmission may benefit from the information contained within the Service Information Letter.



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Figure 1. Runout Tolerances

Runout Inspection

- Inspect the shaft runout or position of the shaft around its operating centerline. Visually inspect the shafts for damage, missing balance weights or anything that might be out of position.
- To measure shaft runout, use a dial indicator. Measure the runout in three positions along each shaft. Clean the areas to be measured by removing paint and debris. Also avoid damaging the area being measured during measurement (refer to [Figure 2](#)).
- When a potential runout problem is discovered, look for the following:
 - Worn driveline intermediate support bearing
 - Worn universal joint
 - Physically damaged/bent shafts



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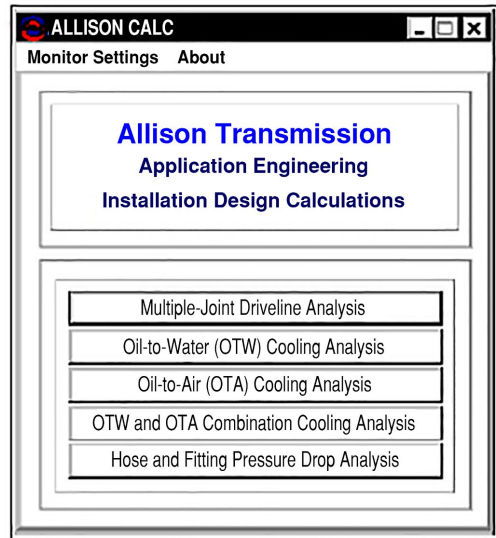
Figure 2. Runout Inspection

The Allison Transmission Multiple Driveline Analysis Program provides step-by-step instructions by asking a series of questions. Once all of the required data has been entered, the software will summarize the information and calculate the specifics of the driveline and provide the Torsional and Inertial angle and acceleration for drive and coast conditions. Allison Transmission Multiple Driveline Analysis Program can be found in Allison DOC® in the Help Menu or on the Allison Extranet at www.allisontransmission.com in Tech Data.

Performing a Driveline Analysis using Allison Transmission Multiple Driveline Analysis Program



NOTE: Refer to [Figure 3](#) for additional information concerning the menu of available programs.



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Figure 3. Menu of Available Programs

Opening Menu and General Instructions:

- Multiple-Joint Driveline Analysis
- Oil-to-Water (OTW) Cooling Analysis
- Oil-to-Air (OTA) Cooling Analysis
- OTW and OTA Combination Cooling Analysis
- Hose and Fitting Pressure Drop Analysis

Select the desired analysis. The input screen for the chosen analysis will appear.



NOTE: The command buttons listed below are common to all of the analyses.

Command Buttons:

- **Back:** Returns to previous screen without clearing the data.
- **Calculate:** Calculates data and displays the results screen.
- **Clear:** Clears the data on the current screen.
- **Continue:** Advances to the next screen.
- **Done:** Returns to the first input screen of the current analysis and clears the data.
- **End:** Closes the program. On the last screen of each analysis it returns to the opening menu.

- **File:** Opens a dialog box for saving the output to a file. The default file type is text (filename.txt).
- **Menu:** Returns to the opening menu screen.
- **OK:** Advances to next screen.
- **Print:** Opens a dialog box for sending the output to a printer. Cannot be used for printing to a file. Use the file command to print to a file.

Multiple Joint Driveline Analysis:

Allison Transmission Multiple Driveline Analysis Program assumes that the user is familiar with driveline design. Refer to the Extranet channel of the Allison Transmission website, www.allisontransmission.com. To locate the referenced documents, which are identified by italic font, look for Tech Data under the Engineering heading on the Extranet home page. Contact your Allison Transmission representative if you do not have access to the Allison Transmission Extranet. A list of all items referenced in this document can be found at the end of this document.

Descriptions of Calculations:

Allison Transmission Multiple Driveline Analysis Program calculates angular accelerations resulting from a vehicle drivetrain with Cardan universal joints operating at angles. These accelerations are checked against Allison Transmission limits for satisfactory driveline and transmission operation. In addition to the accelerations, joint coordinates are provided to assist with driveline design.

Three driveline configurations are available in the program:

- **Output Driveline Without Propshaft-Mounted Driveline Retarder:** This is the most common vehicle driveline configuration. The driveline consists of multiple shafts and joints connecting the transmission and the axle.
- **Output Driveline With Propshaft-Mounted Driveline Retarder:** This driveline configuration contains a retarding device, or another high inertia source, that is attached to a propshaft between the transmission and axle. This is not an Allison output retarder which is integral to the transmission.
- **Input Driveline Between Engine and Transmission:** This is the typical arrangement for a remote-mounted transmission. The driveline consists of shafts and joints between the engine and the transmission input.

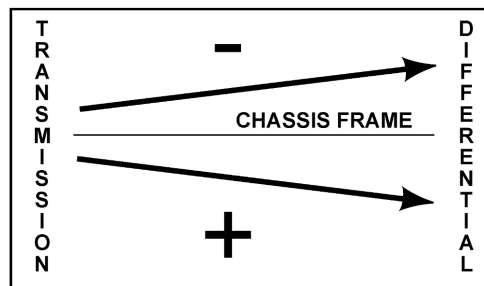
Since the majority of analyses involve the output driveline without a propshaft-mounted retarder, the discussion and example concentrate on this configuration. The two other driveline configurations are covered briefly.

Input Data:

Figure 15 illustrates the various input parameters required for the typical output driveline. During driveline design, angles and dimensions are obtained from engineering drawings. However, when troubleshooting vehicles in service, angles and dimensions are obtained from actual measurements. The Multiple Joint Driveline Analysis has two input screens. When all data has been entered on the initial screen, select OK for the second input screen to appear. The input parameters are described as follows:

- **Title or Comments (optional)** – Enter information that describes the vehicle and driveline. Two lines are provided. This entry is optional.
- **Input Data** – Select Imperial units or SI Metric units.
- **Output Data** – Select Imperial units or SI Metric units.
- **Analyst Name (optional)** – Enter name of the user. This entry is optional.
- **Type of Driveline** – Select type of driveline to be analyzed.

- **Number of Universal Joints** – Enter the number of universal joints in the driveline. The minimum number of universal joints is 2, the maximum number of universal joints is 8.
- **Transmission Output rpm** – Determine the "no load" speed of the engine and the highest available forward range. Transmission gear ratios are located on the Allison Transmission website, www.allisontransmission.com. To locate the referenced documents, which are identified by italic font, look for Tech Data in the Engineering heading on the Extranet home page following the path Tech Data, Product ratings and data. If the transmissions highest available range is an over-drive, transmission output rpm is calculated as no-load rpm/gear ratio.
- **Vertical Slope (degrees) (refer to Figure 6 and Figure 12):**
 - **Transmission** – Enter the vertical slope of the transmission as viewed from the side. If applicable, a negative slope (-) may be entered.
 - **Axle** – Enter the vertical slope of the axle as viewed from the side. If applicable, a negative slope (-) may be entered.
- **Horizontal Slope (degrees) (refer to Figure 12)**
 - **Transmission** – Enter the angle formed by the centerline of the transmission and the centerline of the frame rail, when viewed from above. This assumes that the frame rails are parallel to each other. If the transmission and frame centerlines are parallel, enter zero (0). This parameter is typically used for a V-drive transmission which is not parallel to the frame rails. If applicable, a negative slope (-) may be entered.
 - **Axle** – Enter the angle formed by the centerline of the differential pinion and the centerline of the frame rails, when viewed from above. This assumes that the frame rails are parallel. If the axle and frame centerlines are parallel, enter zero (0). If applicable, a negative slope (-) may be entered.
- **Shaft Slopes (degrees) (refer to Figure 7 and Figure 12)** – Enter the vertical slopes of the shafts, as viewed from the side. The propshafts are numbered from the transmission to the axle. The first propshaft is the one attached to the transmission. If applicable, negative slopes may be entered. Record and enter each shaft's slope in degrees. **If a driveline element points down, the angle is positive. If a driveline element points up, the angle is negative (refer to Figure 4).**



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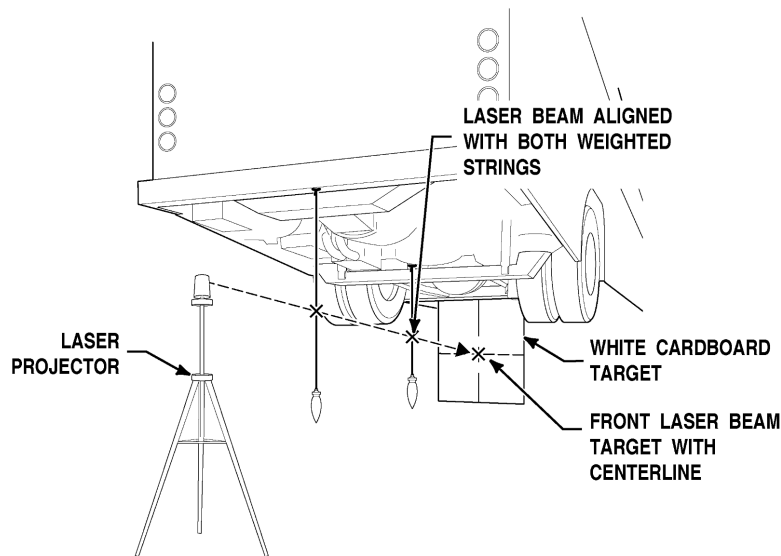
Figure 4. Shaft Slopes

- **Joint Offsets (inches or millimeters) (refer to Figure 11 and Figure 12)** – Enter the distance from the center of the U-joint to a frame rail. This assumes the frame rails are parallel and do not have any offsets along the length from which the joint offsets are measured. These values can also be entered as relative offsets. Establish a centerline on the first joint and measure the offsets of the other joints relative to this centerline. For example, if the joints are all on the centerline, then enter zeros (0's) for all of the joint offsets. Any method which establishes the relative distance from the center of each U-joint to the center of the powertrain or frame rails, which are parallel with the powertrain, is acceptable.

If the frame rails are not parallel, a reference line can be made on the floor going from the center of the engine crankshaft to the transmission output shaft. Extend this center line the length of the driveline. Drop the

plumb bob from the center of each U-joint and mark the floor. The offsets are a relative measurement so the offset can be entered as the measurements from the U-joint centers to the established powertrain center line.

An alternate method to measure universal joint offset utilizes a laser projector. Locate and mark the center of the engine crankshaft and hang a weighted string from it long enough to intersect the laser beam. Located and mark the center of the first U-joint connected to the transmission output yoke/flange. Hang a second weighted string from it long enough to intersect the laser beam. Universal joints must have the yokes on the driveshaft vertical. Adjust the laser until the beam is aligned with the two weighted strings. Using an appropriately sized white cardboard as a target, place the target by each U-joint. Measure from center of the U-joint to the beam projected on the target (refer to [Figure 5](#)).



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Figure 5. Laser Alignment

Shaft Lengths (inches or millimeters) (refer to [Figure 9](#), [Figure 10](#), and [Figure 12](#)) – The distance from joint center to joint center of the yokes at each end of each shaft.

- **Shaft Phases (degrees)** (refer to [Figure 13](#) and [Figure 14](#)) – This input defines any mis-phasing of the yokes. A mis-phased shaft will have one yoke rotated from the parallel position. Shaft phase is measured counterclockwise, viewed from the rear, and is always entered as a positive value between 0 and 180 degrees. If shaft yoke phasing is 5 degrees or less, enter 0 for phasing in the new driveline calculation program.



Figure 6. Checking Installed Transmission Angle Using Inclinometer



Figure 7. Checking Driveshaft Angle Using Inclinometer



Figure 8. Checking Axle Pinion Angle



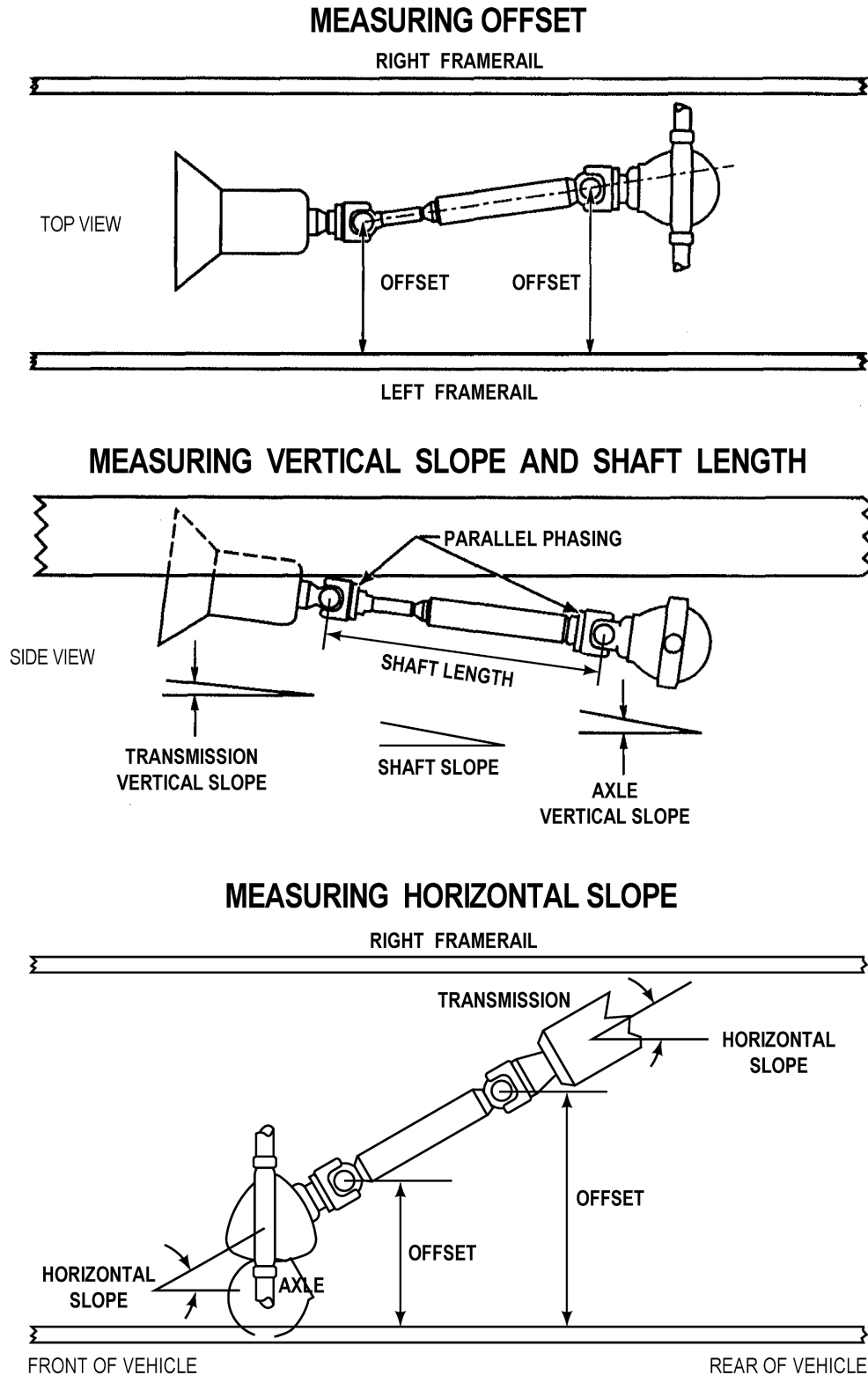
Figure 9. Measuring the Driveshaft Length



Figure 10. Measuring the Driveshaft Length



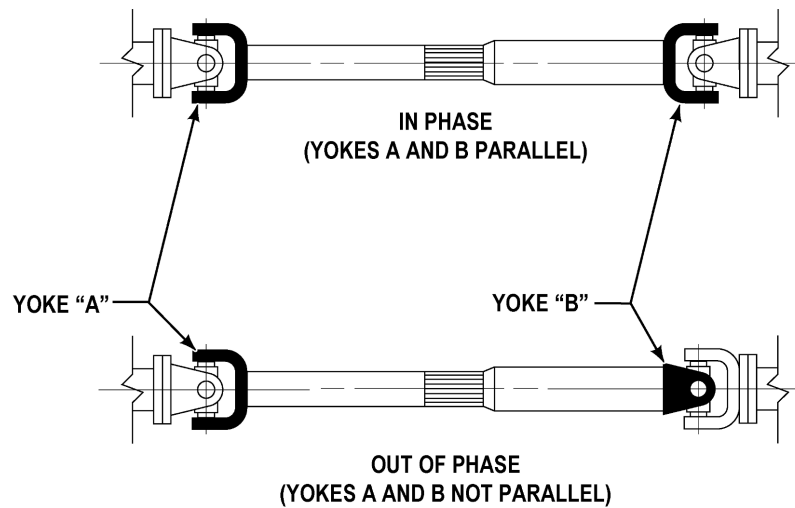
Figure 11. Measuring Horizontal Offset



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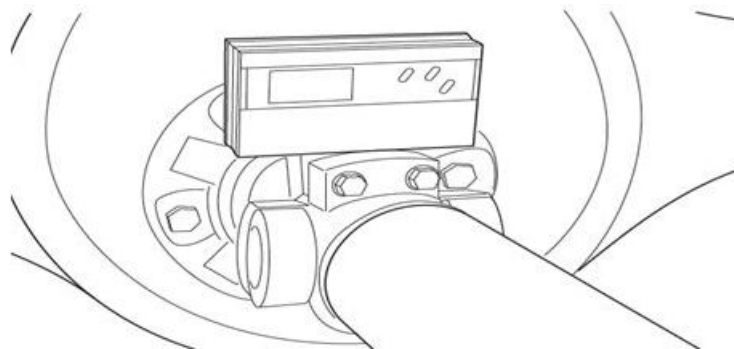
Figure 12. Measuring Vertical Slope and Joint Offset

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Figure 13. Shaft Phasing



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Figure 14. Determining Yoke Phasing

Results:

The first output screen is a summary of the input data. The second output screen is a tabulation of the results and a tabulation of the joint coordinates. The results tabulation includes:

- calculated effective angles
- angular accelerations
- Allison Transmission's acceleration limits: "OK" if within Allison Transmission's limits, "Over Max Limit" if Allison's limits are exceeded
- joint coordinate data for designing or redesigning a driveline

The output parameters are described below:

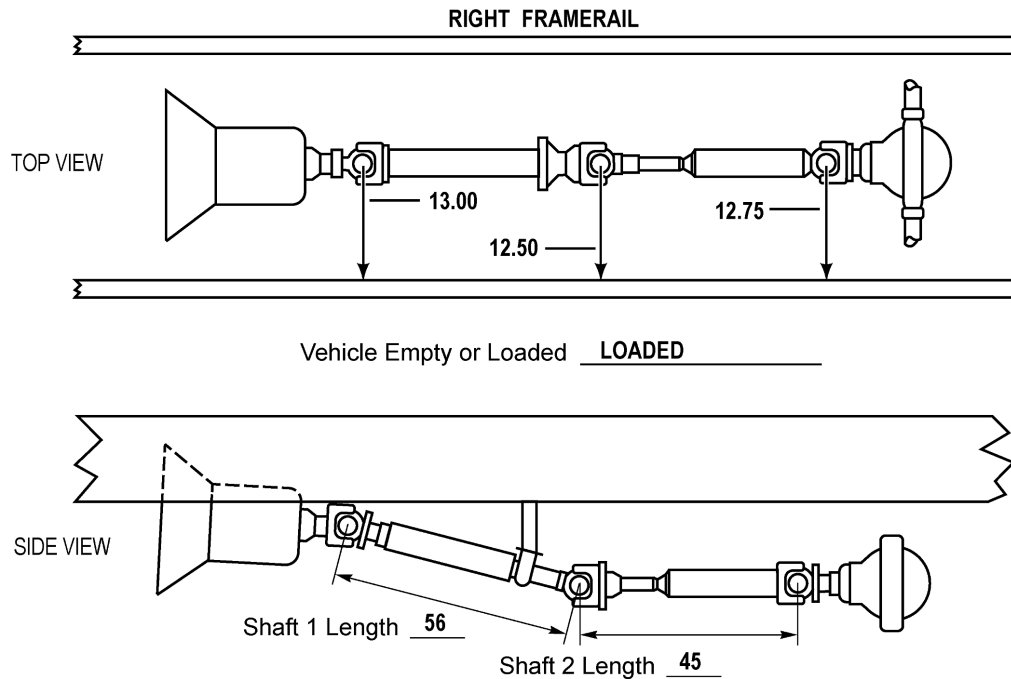
- **Torsional Acceleration (radians/sec²)** – The non-uniform (accelerating and decelerating) motion which would exist at the input shaft of the axle if the transmission were turning uniformly. Torsional acceleration is the same regardless which end of the driveline rotates uniformly (drive or coast).
- **Inertial Accelerations – Drive and Coast (radians/sec²)** – A measure of the peak acceleration of each propshaft imparted by the U-joint angles. Acceleration in the drive mode is determined from the front with the

input to the driveline (transmission output) rotating uniformly. Acceleration in the coast mode is determined from the rear with the output of the driveline (input to the axle) rotating uniformly.

- **Effective Angle (degrees)** – The resultant effect of the multiple angles reduced to a single equivalent angle. In other words, a single joint operating at this angle produces the same output motion as the multiple joint driveline. An effective angle is determined for torsional, inertial drive and inertial coast conditions. The effective angles are intermediate results used to determine accelerations.
- **Acceleration Limits (radians/ sec²)** – [Figure 24](#) lists Allison's angular acceleration limits for the various driveline configurations.
- **X, Y, and Z Coordinates (inches or millimeters)** – These coordinates locate a joint in the three-dimensional space used in the analysis:
 - X coordinate is along the horizontal axis, viewed from the side
 - Y coordinate is along the vertical axis, viewed from the side
 - Z coordinate is along the vertical axis, viewed from the top
- **Joint Angle (degrees)** – The vertical (viewed from side), horizontal (viewed from top), and true or actual joint angle.

Typical Case: Output Driveline

[Figure 15](#) illustrates a typical 3-joint, 2-shaft output driveline and the parameters required for analysis. Collect the data before beginning the analysis. Worksheets for various driveline configurations can be found in the Transmission Installation Checklists for each transmission Product Family. This example is in imperial units. The process is the same for metric units.



Vehicle Empty or Loaded LOADED

Vehicle Driveline Description: SAMPLE VEHICLE
SAMPLE 3-JOINT DRIVE

Number of Joints:	<u>3</u>
Transmission Output Speed:	<u>3281 RPM</u>
Transmission Vertical Slope:	<u>4°</u>
Axle Vertical Slope:	<u>3°</u>
Transmission Horizontal Slope:	<u>0°</u>
Axle Horizontal Slope:	<u>0°</u>
Shaft 1 Slope:	<u>6°</u>
Shaft 2 Slope:	<u>1°</u>
Joint 1 Offset:	<u>13.00 INCH</u>
Joint 2 Offset:	<u>12.50 INCH</u>
Joint 3 Offset:	<u>12.75 INCH</u>
Shaft 1 Length:	<u>56 INCHES</u>
Shaft 2 Length:	<u>45 INCHES</u>
Shaft 1 Phase:	<u>0°</u>
Shaft 2 Phase:	<u>0°</u>

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Figure 15. Output Driveline

Figure 16 shows the data from the worksheet entered on the first input screen.

Multiple Joint Driveline Analysis

Title or Comments (optional)

Sample Vehicle - Outuput Driveline

3-Joint, 2-Shaft Driveline

Input Data

☒ US
☐ SI Metric

Output Data

☒ US
☐ SI Metric

Analyst Name: Driveline Engineer

12/14/2017

Type of Driveline

☒ Output, Without Propshaft-mounted Driveline Retarder
☐ Output, With Propshaft-mounted Driveline Retarder
☐ Input (Between Engine and Transmission)

Data Input

Number of Joints: 3

Transmission Output rpm: 3281

Vertical Slope (degrees)

Transmission: 4

Axle: 3

Horizontal Slope (degrees)

Transmission: 0

Axle: 0

Calculate

Clear

Menu

End

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Figure 16. Sample Driveline-First Screen

Select **Calculate** to go to the second input screen. [Figure 17](#) shows the data from the worksheet entered on the second input screen. Note that the number of data boxes is based on the number of joints in the driveline, as specified on the first input screen.

MJDLA Input

Shafts and Joints are numbered from Transmission to Axle

Shaft Slopes (degrees)

Shaft #16

Shaft #21

Joint Offsets (in)

Joint #113.00

Joint #212.5

Joint #312.75

Shaft Lengths (in)

Shaft #156

Shaft #245

Shaft Phases (degrees)

Shaft #10

Shaft #20

OK

Back

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Figure 17. Sample Driveline Input-Second Screen

Select **OK** to display the first output screen. [Figure 18](#) shows the first output screen. This screen is a summary of the input data. Select Continue to display the Results screen.

MJDLA

Allison Transmission

Multiple Joint Driveline Analysis

Output Driveline

Sample Vehicle - Output Driveline

3-Joint, 2-Shaft Driveline

Analyst: Driveline Engineer

12/14/2017

	Vertical Slope (degrees)	Horizontal Slope (degrees)	Shaft Length (in)	Shaft Phase (degrees)	Joint offset (in)
Transmission	4.0	0.0	N/A	N/A	
shaft # 1	6.0	-0.5	56.00	0.0	Joint # 1 13.00
shaft # 2	1.0	0.3	45.00	0.0	Joint # 2 12.50
Axle	3.0	0.0	N/A	N/A	Joint # 3 12.75

Transmission Output rpm :

3281

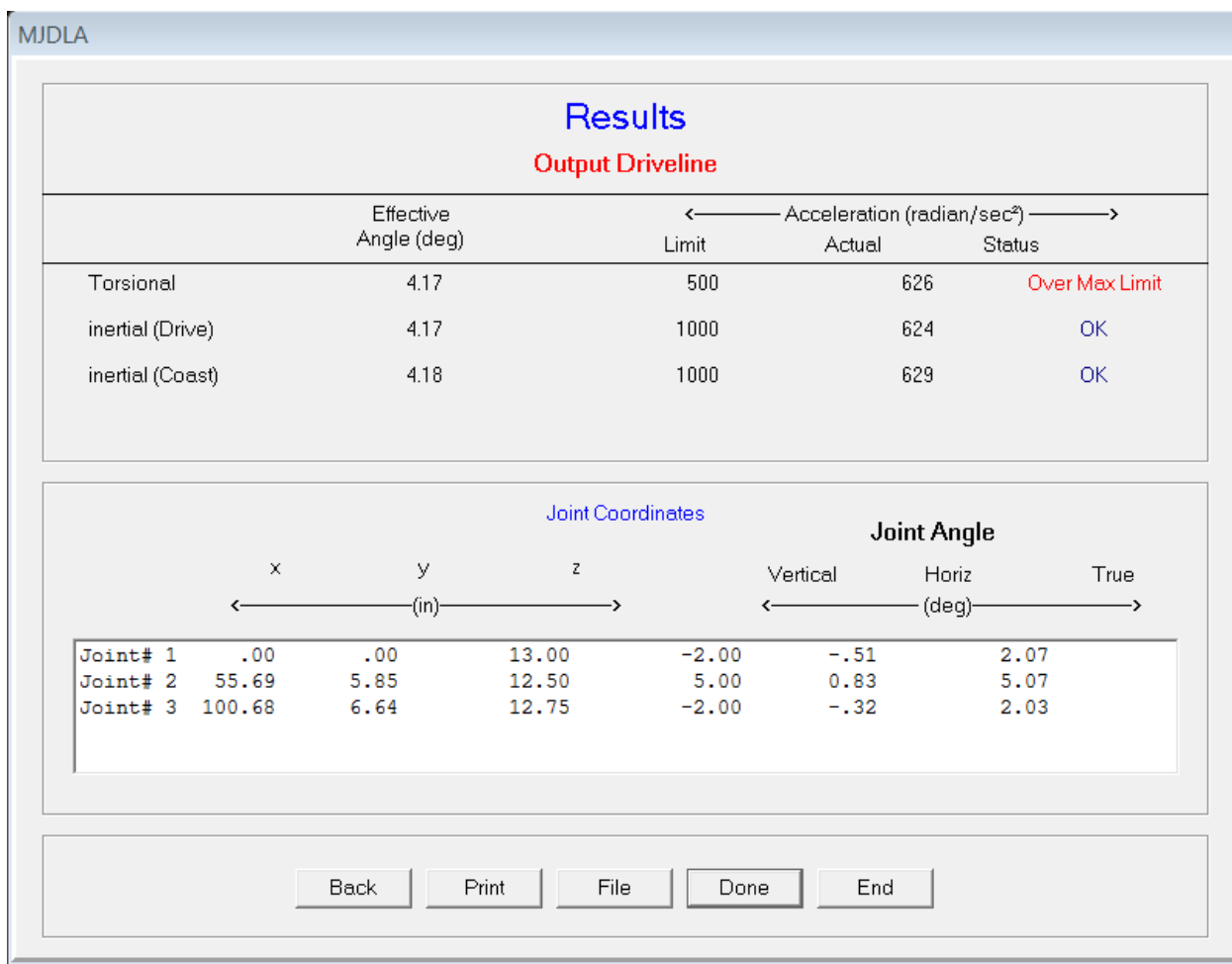
Continue

Back

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Figure 18. Sample Driveline Output-Input Data Summary Screen

Figure 19 shows the Driveline Analysis Results screen. The calculated accelerations are checked against Allison Transmission's limits and labeled as follows:



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Figure 19. Sample Driveline-Results Screen

- “OK” if within Allison’s limits
- “Over Max Limit” if Allison’s limits are exceeded

As described earlier in Command Buttons, use the buttons at the bottom of the screen to:

- go back to the previous screen
- print the analysis
- save the output to a file
- end the program

Output Driveline with Propshaft-Mounted Driveline Retarder:

To analyze this configuration, three calculations must be made:

- Overall driveline, transmission to axle
- Driveline from transmission to retarder
- Driveline from retarder to axle

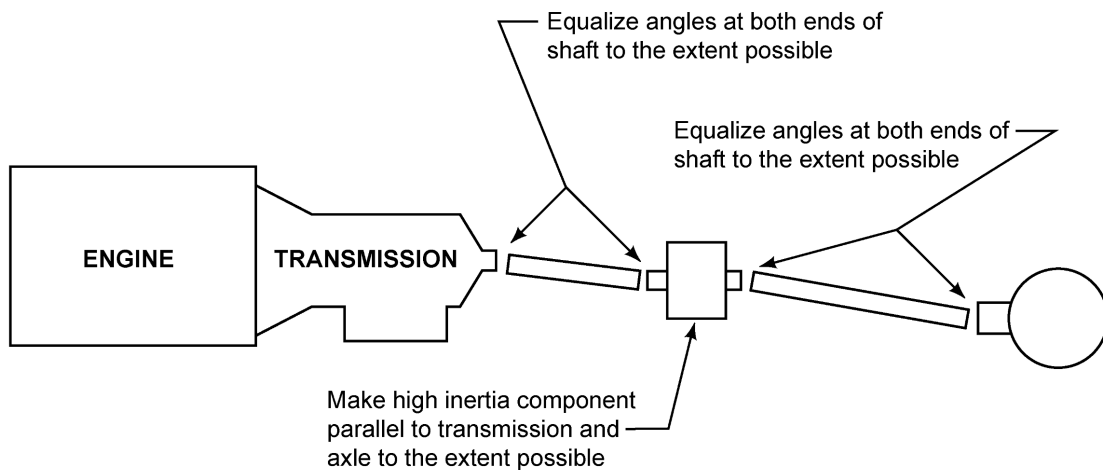
Allison Transmission Multiple Driveline Analysis Program prompts the user for the necessary input for each of the three calculations. All of the input is basically the same as for the standard output driveline.

The torsional acceleration limits for the transmission to retarder and the retarder to axle sections are lower than for the overall driveline (refer to [Figure 24](#)). The lower limits ensure that the retarder or other large inertia source rotates nearly uniformly.

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.
Inertia Accelerations	
Design Requirements:	
Drive mode	1000 max.
Coast mode	1000 max.
As Measured in Vehicle:	
Drive mode	1200 max.
Coast mode	1200 max.

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Figure 20. Acceptance Criteria Chart



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Figure 21. Driveline with High Inertia Component

Input Driveline:

This driveline analysis is used when there is a driveline between the engine and the transmission. The input data for the input driveline is similar to the input data for the typical output driveline. Engine speed is entered instead of transmission output speed. The torsional and inertial acceleration limits are different for the input driveline (refer to [Figure 24](#)).

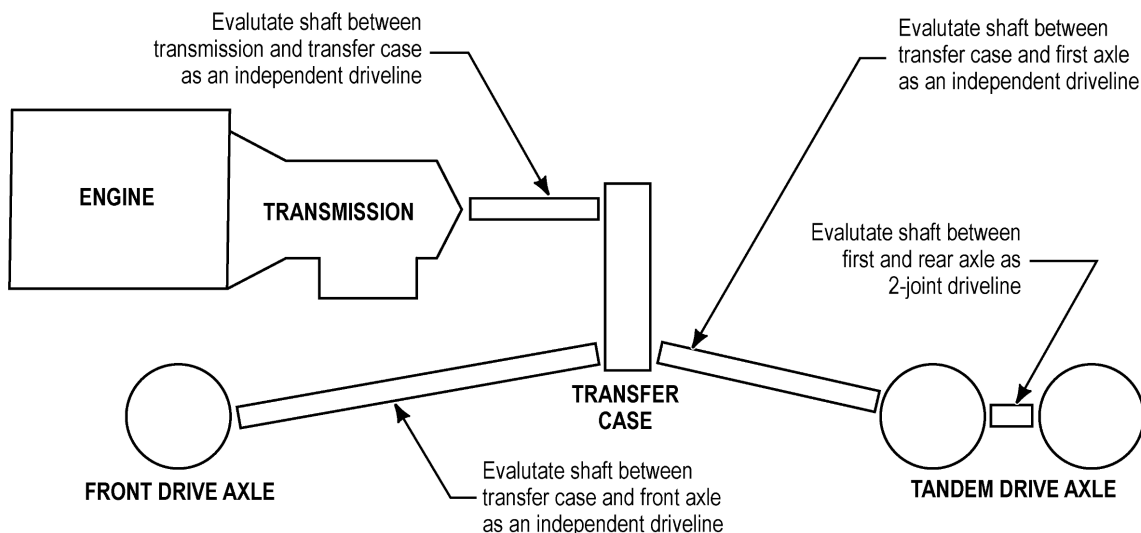
TORSIONAL VIBRATION ACCEPTANCE CRITERIA - INPUT DRIVELINE	
CHARACTERISTIC	MAXIMUM ACCEPTABLE (Radians / Sec ²)
Torsional Accelerations	
<u>Input driveline - remote mount</u>	100 max.
Inertia Accelerations	
<u>Design requirements - 3000 rpm & above</u>	
Drive mode	500 max.
Coast mode	500 max.
<u>Design requirements - below 3000 rpm</u>	
Inertia 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 and thus varies with speed.	

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Figure 22. Torsional Vibration Acceptance Criteria-Input Driveline

Appendix A Inter-Axle Analysis (Refer to [Figure 23](#) and [Figure 25](#))

- Inter-axle driveshaft's should be analyzed independently as a standard multiple joint driveline.
- If equipped with both a transfer case and tandem drive axles, each drive shaft must be measured and analyzed separately.



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Figure 23. Inter-Axle and/or Transfer Case Driveline Analysis

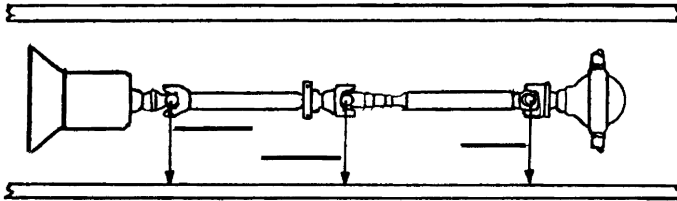
TORSIONAL VIBRATION ACCEPTANCE CRITERIA - OUTPUT DRIVELINE	
CHARACTERISTIC	MAXIMUM ACCEPTABLE (Radians / Sec ²)
Torsional Accelerations	
<u>Entire driveline - all installations</u>	500 max.
<u>If installation has high inertia component:</u>	
Transmission to component	100 max.
Component to axle	100 max.
Inertia Accelerations	
<u>Design requirements</u>	
Drive mode	1000 max.
Coast mode	1000 max.
<u>As measured in vehicle</u>	
Drive mode	1200 max.
Coast mode	1200 max.

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Figure 24. Torsional Vibration Acceptance Criteria-Output Driveline

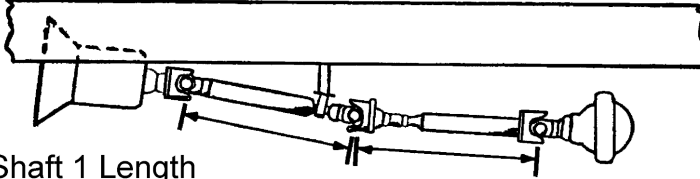
Right Framerrail

Top View



Vehicle Empty or Loaded _____

Side View



Shaft 1 Length _____

Shaft 2 Length _____

Vehicle Driveline Description: _____

Number of Joints: _____

Transmission Output Speed: _____

Transmission Vertical Slope: _____

Axle Vertical Slope: _____

Transmission Horizontal Slope: _____

Axle Horizontal Slope: _____

Shaft 1 Slope: _____

Shaft 2 Slope: _____

Joint 1 Offset: _____

Joint 2 Offset: _____

Joint 3 Offset: _____

Shaft 1 Length: _____

Shaft 2 Length: _____

Shaft 1 Phase: _____

Shaft 2 Phase: _____

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Figure 25. Angle Checklist Worksheet

Referenced Documents:

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

The technical background for the driveline calculations can be found in the following documents: Driveline Troubleshooting Review Booklet: TS2714EN; Installation Design Calculation Software (Allison Transmission Multiple Driveline Analysis Program) User's Guide: TD167; Installation Design Calculations Software (Allison Transmission Multiple Driveline Analysis Program), Found in Allison DOC® or Extranet Automatic Transmission Driveline Video.