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DETERMINING PROPER DRIVELINE ANGLES

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Proper Driveline Angles Are Essential in Preventing Premature Component Failure

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Over the past five years, tremendous strides have been made in driveline technology. Today, component manufacturers provide operators with an endless choice of low maintenance, longer life drivelines. But no matter how well a driveline is built, if it operates at a less than optimal angle, chances are it will fail prematurely.

When a u-joint is working at an improper angle, it creates a vibration that travels through the driveline and can lead to increased driveline wear and premature failure. In addition, harsh vibration throughout the driveline can also lead to shortened u-joint life, transmission gear failure, synchronizer damage and potential damage to the differential. Seal leaks and premature seal failures have also been associated with driveline vibrations.

Although drivelines are not as expensive as their primary counterparts in the drivetrain -- like axles or the transmission -- they are just as important. If a driveline fails, the vehicle is helpless, the operator is inconvenienced and revenue production stops.

Perhaps the easiest way to get maximum life from your drivetrain is to check the driveline if noises are heard from the rear of the vehicle. Meritor engineers advise that all operators, particularly when purchasing a new or used truck, pay close attention to any unusual sounds coming from the vehicle's drivetrain and carefully inspect the driveline.

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Angles Can Be Influenced By a Number of Factors
From a maintenance standpoint, there are a number of factors that can influence the angle of a vehicle's driveline and cause unnecessary and costly component damage.

Air-ride suspensions, for example, present a unique challenge in maintaining proper u-joint angles. The wide range of adjustment capabilities of air-ride suspensions makes it harder to control u-joint angles. Most air-ride suspensions also lack longitudinal torque arms on the axle housings. This can cause severe u-joint angles under high engine torque, because the suspension's compliancy permits axles to "roll-up" or tilt.

In addition, fleet maintenance personnel should pay particularly close attention when replacing or servicing a vehicle's suspension. By adjusting suspension wedges to raise or lower a vehicle's ride height, driveline angles can inadvertently be altered.

By the same token, operators should also be aware that by adjusting the ride height of their vehicle with the leveling valve, they too could inadvertently alter the drivelines' angles.

Proper Diagnosis is Critical

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Correct diagnosis through road testing is of utmost importance before taking corrective measures. It is often difficult to determine where noise or vibration is coming from and what is causing it. For example, transmission, axle gear and bearing noise or vibration is difficult to distinguish from driveline noise or vibration.

Transmission or axle gear and bearing noise are constant and generally will be felt throughout the vehicle's entire speed range. It will vary in tone and intensity with individual characteristics of the specific transmission or drive unit. This type of noise may also be caused by slight changes in gear tooth contacts or bearing adjustments.

In contrast, u-joints and propeller shaft noise and vibration is intermittent and is generally present only at certain vehicle speed ranges. For example, 30-37 miles-per-hour.

If an operator does feel vibration in the front of the vehicle, or hear excessive noise that sounds like it is coming from the driveline, it is recommended that he or she immediately contact their driveline supplier and ask for assistance in analyzing the angles so the necessary measures can be taken.

General Guidelines in Determining Optimum Driveline Angles

The driveline working angle should not exceed six degrees, and the adjoining u-joints at either end of a shaft should be different by no more than one-and-a-half degrees.

If an operator believes that they are qualified enough to service the driveline themselves, then it is very important that they understand the application philosophy behind calculating driveline angles. There are a number of highly technical mathematical equations that are required to determine the precise angles of the driveline.

For this reason, it is recommended that operators seek appropriate assistance from the driveline manufacturer if they are not completely comfortable with calculating the residual angles of the driveline system. When determining the optimum driveline angles for a vehicle, a good rule of thumb to follow is the six to one-and-a-half rule. The driveline working angle should not exceed six degrees, and the adjoining u-joints at either end of a shaft should be different by no more than one-and-a-half degrees. When u-joints are arranged this way, the angles are said to be "canceled."

Operators should remember that if the six to one-and-a-half degree angle boundaries are exceeded, the u-joint is working in unfamiliar, undesirable territory, resulting in driveline, and potentially, drivetrain problems.

Generally speaking, if a driveline is used in low speed applications, the angles can be higher. On the other hand, great care must be exercised with higher speed applications to keep the angles below the recommended residual angles.

To calculate the residual angles of the driveline, operators can refer to Society of Automotive Engineers (SAE) publication AE-7 (Section 3.1.1, Cardan or Hooke Universal Joint). But again, remember these are highly technical in nature and best left to a professional.

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For vehicles equipped with a two-joint driveline system, the following chart can be a helpful aid in determining the optimum operating angles.

Calculation of Allowable Difference Between Joint Angles For Two-Joint System

Driveline RPM	Angle of joint #1									
	0	1	2	3	4	5	6	7	8	9
	Allowable Angles of joint #2									
1500	7.3	7.4	7.6	7.9	8.3	8.9	9.5	10.1	10.8	11.6
1600	6.9	6.9	7.1	7.5	7.9	8.5	9.1	9.8	10.5	
1700	6.5	6.5	6.8	7.1	7.6	8.2	8.8	9.5		
1800	6.1	6.2	6.4	6.8	7.3	7.9	8.5	9.3		
1900	5.8	5.9	6.1	6.5	7.0	7.6	8.3	9.1		
2000	5.5	5.6	5.8	6.2	6.8	7.4	8.1			
2100	5.2	5.3	5.6	6.0	6.6	7.2	8.0			
2200	5.0	5.1	5.4	5.8	6.4	7.1	7.8			
2300	4.8	4.9	5.2	5.6	6.2	6.9				
2400	4.6	4.7	5.0	5.5	6.1	6.8				
2500	4.4	4.5	4.8	5.3	5.9	6.6				
2600	4.2	4.3	4.7	5.2	5.8	6.5				
2700	4.1	4.2	4.5	5.0	5.7					
2800	3.9	4.0	4.4	4.9	5.6					
2900	3.8	3.9	4.3	4.8	5.5					
3000	3.7	3.8	4.2	4.7	5.4					
3100	3.5	3.7	4.1	4.6	5.3					
3200	3.4	3.6	4.0	4.6	5.3					
3300	3.3	3.5	3.9	4.5	5.2					
3400	3.2	3.4	3.8	4.4						

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To use the above chart:

1. Find the RPM speed of the driveline.
2. Next find the lower joint angle which is along the top of the chart from left to right.
3. Then, look up the maximum allowable second joint angle next to the speed.

Meritor Offers Driveline Angle Analysis

To help assure customers are operating with the correct angles, Meritor offers its customers the benefit of computer-aided driveline angle analysis through the company's engineering department. And for one-on-one assistance, the company's field representatives are capable of analyzing a vehicle's driveline through the use of specially programmed laptop computers.

An engineer from the company will fax operators a driveline worksheet and

For customers with vehicles equipped with a Meritor driveline, the first step in determining the optimum operating angles is to contact the company's Customer Support Center and request assistance.

request that they fill in the needed information

An engineer from the company will fax operators a driveline worksheet and request that they fill in the needed information, such as current angles of the transmission, u-joints and axles.

To illustrate how the procedure works, the following example uses a tandem axle vehicle equipped with a Meritor driveline. In order for the engineer to make the proper calculations, a few key pieces of information will be required. Vital statistics, such as the make and model of the vehicle will be needed, as well as the truck's maximum engine RPM and transmission's lowest gear ratio. For vehicles equipped with direct drive transmissions, the ratio would be 1:1.

The next step is to determine the phase type of the vehicle's driveline. In general, there are four types of driveline configurations: parallel-parallel, crossed-parallel, parallel-crossed and crossed-crossed. The majority of today's drivelines, however, are phased as a parallel-parallel configuration.

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Next, it is necessary for the operator to determine the axis angles of the transmission, coupling shaft, slip shaft, front axle input shaft, inter axle angle and rear axle angle. This is done, under the assumption that the drivelines are in the same plane (top view shows all drivelines in a straight line). If this is not true, the operator will need to measure the offsets of each joint to the frame and measure the joint center to joint center lengths of each shaft.

Once all angle measurements are determined, the information should be inputted to the worksheet and submitted to Meritor for evaluation. Based on the driveline's current operating angles, calculations will be made to determine the optimum configuration.

It is important to remember, however, that there are a number of factors that can influence the operating angles of a vehicle's driveline.

Because some suspensions can cause driveline angles to change when under loaded conditions, it is imperative that maintenance personnel refer to the vehicle manufacturer's specifications to determine the load condition under which the vehicle driveline angles should be checked or corrected.

Long-Term Maintenance is the Key to Maximum Driveline Life and Performance

In today's highly competitive trucking industry, reliability is absolutely essential, and breakdowns and unscheduled maintenance are too costly to tolerate.

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Once a vehicle operator has determined that his or her driveline is operating at its optimal angles, the following seven basic inspection steps can be performed to ensure that operators get the maximum performance and life from their driveline.

1. Check input and output end yokes for looseness
2. Check input and output shafts for radial looseness
3. Check for looseness at ends of u-joints
4. Check slip splines for excessive radial looseness
5. Check shaft for damage, missing balance weights, or foreign material

vehicle manufacturer's specifications

6. Check for loose or missing welch plug in the slip yoke
7. Check center bearing

By performing the simple maintenance recommendations listed above, operators can increase the life of their driveline components and help keep their vehicles on the road where they belong.

Even though the driveline is out of sight and often neglected, operators should remember, if something does go wrong, this simple assembly can shut down the toughest of trucks and bring their profitability to a screeching halt.

For more information on this topic, or for copies of other Issues & Trends, contact Meritor Business Communications at 248-435-1933, fax your request to 248-435-9946, or send e-mail to:
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