HALE FIRE PUMP COMPANY
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SERVICE BULLETIN #6

April 12, 1965

TO: ALL MAJOR PUMP SERVICE PERSONNEL
MAJOR PUMP CUSTOMERS

SUBJECT: Midship Pump Noises - Drive Shaft Vibration

Gentlemen:

Occasionally we receive complaints of noises in our midship pump drive unit. When we track down these noises we frequently find they are caused by the drive shaft vibrating because the shaft is out of balance. The same noises that are attributed to our pump drive unit are also sometimes thought to be caused by the truck transmission or differential.

Since drive shaft disturbances are difficult to pinpoint and frequently not fully understood, they are usually the last to be checked out. By this time the noise has been blamed on the pump or truck manufacturer causing untold headaches.

To help you solve this problem and to give you a better understanding of drive shafts, we have enclosed two excellent dissertations. The one entitled simply "Drive Shaft Vibration" is by Mr. G.E.Dunn of the Chrysler Detroit Universal Plant and issued 3/17/64. The second, "Methods of Checking & Correcting Drive Line Noise", was issued by Rockwell-Standard Corporation 7/15/49. While both papers deal with the uncut shaft, etc., it is very easy to apply their explanations to midship pump drives. These detailed explanations might be summarized in the following manner:

The drive shaft that is out of balance can appear to be perfect. Attempts to spot the disturbance by sound are usually unsuccessful. The reason they are unsuccessful is that the rumbling sound produced by the out of balance is hard to distinguish above the pump drive unit noise. The drive unit case also acts as a sounding board which amplifies the drive shaft rumble.

The two main causes of drive shaft vibration or noises are (a) "Unbalance" and (b) "Joint Angularity."

(a) "Unbalance" can be caused by:

1. Misalignment of universal joint yoke lugs.
2. Unbalance in the propeller shaft.
3. Worn or loose joints or connections.
4. Runout in parts supporting the propeller shaft.
5. Excessive speed running the shaft in its critical range.

To check vibration due to "Unbalance", run the vehicle at high speed and then place the transmission in neutral and coast down. The vibration will be emphasized on coasting since there is no engine or transmission noise.

Worn or loose parts can be checked by working the throttle in and out. Sudden loading and unloading of the shaft will produce clicking or backlash noises.

Critical speed range can be noted by a severe vibration shaking the whole vehicle. To eliminate, use a greater diameter tube for the propeller shaft.

NOTE: These symptoms can overlap so it is best to first check for alignment of the yoke lugs. Next check the lugs for wear and looseness. Then check the runout of supporting parts.

(b) "Joint Angularity" vibration is caused by a difference in the mounting angles of the transmission, pump and rear differential

The difference in mounting angles becomes more critical with larger shaft or joint operating angles. For example, the transmission, pump and rear might be mounted within 1/2° of each other but the joint operating angle, due to a large drop between the pump and the rear, is up to 12°. This 12° joint operating angle along with the difference of a 1/2° mounting angle could cause as much vibration as the reverse condition of only 1° joint operating angle and a difference of 3-3/4° in the mounting angles. Actually the trouble starts when there is a difference in the joint operating angles, but it becomes more critical at large operating angles.

Joint angularity can be checked out with a protractor level. A tachometer is also helpful since the frequence of vibration is twice per revolution.

We hope this summary will help you to understand the more detailed explanations.

If you have questions, do not hesitate to fire away. By increasing both your and our knowledge of drive shaft operation we can decrease complaints and time spend on them.

A few extra copies of the enclosed material are available on a first request basis.

Very truly yours,
HALE FIRE PUMP COMPANY

"Skip" Shaffer

C.R. "Skip" Shaffer
Service Manager

Encl. Articles on "Drive Shaft Vibration" and
"Methods of Checking and Correcting Drive Line Noise"

CHRYSLER CORP. Detroit Universal Plant

Drive Shaft Vibration

Vibration in propeller shafts will occur from two chief conditions:

1. Forces due to unbalance.
2. Forces due to joint angularity.

Forces due to unbalance have a frequency equal to the number of revolutions of the shaft. They are called first order as they have one cycle per revolution.

Forces due to joint angularity have two cycles per revolution. They are called second order, denoting their occurrence every 180°.

The forces produce two kinds of vibration, torsional and transverse. Unbalance produces only transverse vibration. Joint angularity produces both kinds.

When two shafts are connected by a universal joint and run at an angle to one another, if the driving shaft runs at a constant speed, the driven shaft will slow down and speed up twice during each revolution. The amount of slow down and speed up is equal. This is obvious as the two shafts must make equal numbers of revolutions. It is also obvious that the driven shaft must accelerate and decelerate in order to speed up and slow down. The angular displacement between the two shafts causes torsional vibration. The severity of the vibration depends on the joint angularity.

In a propeller shaft containing two universal joints, they are phased to have one at its highest speed while the other is at its lowest speed. In this manner, if the joint angles are equal, a constant angular velocity will be transmitted through the system. Note, however, that the shaft connecting the two joints does not run at constant velocity, but has a torsional vibration with an amplitude dependent on the angle of the driving joint.

In general, torsional vibration in the shaft is not troublesome unless the shaft is very heavy or the joint operating angle is high. Trouble occurs when the two joints do not have equal angles. In this case a forced torsional vibration will be imposed on the whole drive train. To be properly in phase, the bearing holes in the yokes at each end of the shaft should be in line. Under this condition, generally, no trouble with torsional vibration should show up if the joints operate at 3° or less. As operating angles increase, the equality of angles in the two joints becomes more important. For example, at a 1° operating angle, if the rear joint is at 3-3/4°, it will produce no more oscillation than a joint at 12° operating angle with a rear joint at 12-1/2°. This shows the sensitivity of joints operating at large angles to slight variations.

Transverse vibration stems from several causes:

1. Unbalance in the propeller shaft.
2. Excessive clearance due to wear in component parts.
3. Runout in parts supporting the propeller shaft.
4. Excessive speed, running the shaft in its critical range.
5. Secondary couples due to joint angularity.

Excepting #5 all vibrations are first order and the frequency is the same as the propeller shaft speed. In vehicles, this is usually engine speed. To check the vibration, run the vehicle at high speed, then put the transmission in neutral and coast down. If the trouble is due to first order propeller shaft vibration , it will be emphasized on coast, as engine and transmission noise is alleviated. Note that first order vibration is independent of torque forces.

Second order vibration is dependent on joint angularity and torque because it is due to secondary couples. Its frequency is twice the engine speed. A tachometer is useful in determining the difference.

Vibration due to propeller shaft inertia can be picked out easiest on a boulevard ride. Work the throttle to go from road load plus to road load minus. This will demonstrate clicks and backlash due to worn parts.

If a shaft is operated in its critical speed range, severe vibration will take place, shaking the whole vehicle. This will show the need of a greater diameter tube in the propeller shaft.

G.E.Dunn
Resident Engineer
Chrysler Corp.

GED/ha
3/17/64