SAE INTERNATIONAL

SURFACE VEHICLE RECOMMENDED PRACTICE

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Drivetrain Systems Vibration Analysis Data Requirements

RATIONALE

This technical report is being Stabilized because it covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

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1. ***Scope***—Product for which data is to be available is for class 6 and larger, i.e., gross vehicle weight > 9.6 kg (19 500 lb).

1.1 **Objective—**Establish a set of data requirements which powertrain component suppliers would have readily available to facilitate drivetrain system vibration compatibility and control studies.

2. ***References***—There are no referenced publications specified herein.

3. ***Intent—***Component suppliers will readily share data across the industry to maximize vehicle resistance to vibrations.

4. ***Exception to the Intent Section 3***—Because the clutch is designed and applied to tune drivetrain systems, clutch manufacturers may desire to share detailed data only with vehicle OEM's doing their own analysis. Please refer to the clutch section to see which data may be considered proprietary to the clutch manufacturer.

5. *Data Required*

5.1 Engine—See Figures 1A through 1D.

Note1. Rotating inertias associated with a particular cylinder of the engine are understood as the equivalent rotating inertia of the proper part of the crank, counterweights, and connecting rod. Masses of the piston, piston pin, and part of the connecting rod are to be introduced only as part of engine inertia torque calculations.

Note 2. Note that the damping coefficient of the viscous damper is not a viscosity coefficient. In case of any problems with this type of data, contact the damper manufacturer for an actual damping coefficient.

Note 3. It is desirable that engine forcing data are collected for (1) full fuel and (2) minimum fuel over a wide range of crankshaft speeds. The lowest speed at which the data is collected should be low idle speed. At the high end, the data should span at least up to the governed speed. The increment should be not greater than 150 RPM.

Note 4. It is desirable that the cylinder gas pressure torque and inertia torque information are specified in the form of either cosine and sine components or as magnitudes and phase angles.

Note 5. It is desirable that all harmonics up to and including the fourth multiple (4X) of the firing frequency are specified in ½ order steps.

Note 6. In addition to the above, provide the nominal engine torque at (1) Full Fuel, and (2) Minimum Fuel, for the entire engine speed range from low idle speed to governed speed.

Note 7. If gas pressure data is given (instead of gas torque), the crank radius, piston area, and the length of the connecting rod must also be specified. Provide pressure data from 0° (top dead center) to 720° of crankshaft rotation, in 10° increments or smaller.

Note 8. If harmonics for the inertia torques are not given, then the following additional data is required: Connecting rod CG location, connecting rod inertia about CG in plane of articulation, and piston and pin weights.

Note 9. Note that all rotational inertia and stiffness data must be reflected to the crankshaft.

FIGURE 1A—ENGINE

1.	Engine Make & Model: Rated Power @ Speed	
2.	Engine peak torque (ft.lbs/Nm) @ Peak RPM:	
3.	Governed RPM:	
4.	Low Idle Speed:	
5.	Description:	
6.	Mass-elastic data (suggested format below; modify descriptions as needed!)	

Mass Moment of Inertia Data (lb-in.S^2)/[Nm-S^2]

Viscous damper housing	
Viscous damper floating mass	
Gear train, pulleys, etc.	
Cylinder 1	
Cylinder 2	
Cylinder 3	
Cylinder 4	
Cylinder 5	
Cylinder 6	

Cylinder 7	
Cylinder 8	
Cylinder 9	
Cylinder 10	
Cylinder 11	
Cylinder 12	

Crankshaft Torsional Stiffness Data (lb-in/radian)/[Nm/rad]

Between damper & accessories	
Between accessories & Cylinder 1	
Between Cylinder 2 & Cylinder 3	
Between Cylinder 3 & Cylinder 4	
Between Cylinder 4 & Cylinder 5 (or Flywheel, if 4 cylinder engine)	
Between Cylinder 5 & Cylinder 6	
Between Cylinder 6 & Cylinder 7 (or Flywheel, if 6 cylinder engine)	
Between Cylinder 7 & Cylinder 8	
Between Cylinder 8 & Cylinder 9 (or Flywheel, if 8 cylinder engine)	
Between Cylinder 9 & Cylinder 10	
Between Cylinder 10 & Cylinder 11	
Between Cylinder 11 & Cylinder 12	
Between Cylinder 12 & Flywheel	

Damping coefficient for the viscous damper: ______________________ lb-in/[Nm]
Cylinder damping (if known):______________________ lb-in/[Nm]
Other damping:______________________ lb-in/[Nm]

FIGURE 1B—ENGINE (CONTINUED)

7. Engine Crank Arrangement (degrees)

Cylinder 1	0°	Cylinder 4		Cylinder 7		Cylinder 10	
Cylinder 2		Cylinder 5		Cylinder 8		Cylinder 11	
Cylinder 3		Cylinder 6		Cylinder 9		Cylinder 12	

8. Firing Order: ____

9. Single cylinder forcing data for both full fuel and minimum fuel conditions (provide either TABLE I or TABLE II type info at each RPM)

Harmonics of single cylinder Gas torque (lb-in)/[Nm]

Table I

Order	Cosine Component	Sine Component
0.0		
0.5		
…		
11.5		
12.0		

(or)

Table II

Order	Magnitude	Phase (deg. or rad.)
0.0		
0.5		
…		
11.5		
12.0		

Harmonics of single cylinder Inertia torque (lb-in)/[Nm]

Table I

Order	Cosine Component	Sine Component
0.0		
0.5		
…		
11.5		
12.0		

(or)

Table II

Order	Magnitude	Phase (deg. or rad.)
0.0		
0.5		
…		
11.5		
12.0		

FIGURE 1C—ENGINE (CONTINUED)

10. Alternative: Gas Pressure rather than Gas Torque Harmonics (psi)/[kpa]

Crank Angle	Gas Pressure	Crank Angle	Gas Pressure	Crank Angle	Gas Pressure	Crank Angle	Gas Pressure
0°		190°		370°		550°	
10°		200°		380°		560°	
20°		210°		390°		570°	
30°		220°		400°		580°	
40°		230°		410°		590°	
50°		240°		420°		600°	
60°		250°		430°		610°	
70°		260°		440°		620°	
80°		270°		450°		630°	
90°		280°		460°		640°	
100°		290°		470°		650°	
110°		300°		480°		660°	
120°		310°		490°		670°	
130°		320°		500°		680°	
140°		330°		510°		690°	
150°		340°		520°		700°	
160°		350°		530°		710°	
170°		360°		540°		720°	
180°							

Plus for Inertia Torque: Crank Throw Geometry and Masses rather than Inertia Torque Harmonics

FIGURE 1D—ENGINE (CONTINUED)

5.2 Flywheel

1. Component make, model, and description:____
2. Mass-elastic data:

Mass moment of inertia(Nm S^2)/ =
[lb-in-S^2]

5.3 Clutch—See Figure 2.

1. Component make, model and description: ___________________________________

2. Mass elastic data:

Note:	Mass elastic data must be a composite specification for the clutch as a whole and not to be broken down per driven disc assembly, etc.

Number of clutch disks	
Mass moment of inertia of the clutch assembly (less inertia of hub(s)	$(lb\text{-}in\text{-}S^2)/[Nm\text{-}S^2]$
Mass moment of inertia of the driven disc hub(s) + rigid attachments (if possible)	$(lb\text{-}in\text{-}S^2)/[Nm\text{-}S^2]$
Nominal Torque rating	(lb-in)/[Nm]
Nominal stop torque, drive and coast	(lb-in)/[Nm]

Clutch stiffness and hysteresis characteristics (this data may be considered "proprietary" to the clutch manufacturer.)

Stage	Travel Limits (rad.)	lb-in/rad. Stiffness [Nm/rad.]	lb-in Hysteresis [Nm]
1			
2			
3			
4			
…			

FIGURE 2—CLUTCH

5.4 Countershaft Mechanical Transmission—See Figures 3A and 3B.

1. Component make, model and description: ______________________________

Note 1. Transmission mass-elastic data are to be provided for each of the gear ratios separately.

Note 2. It is desirable, that inertias of gears, shafts, synchronizers, etc. are lumped to places where active (transmitting power) gear couples are located. According to this assumption, stiffness' of shafts ahead of the first active couple (inertia), between any two adjacent inertias, and behind the last inertia are to be calculated.

Note 3. Mass elastic data are to be reflected (reduced) to the input shaft of the transmission.

1A. Gear #: ______________________________ Gear Ratio: ______________________

2A. Mass-elastic data: (Mass moment of inertia [MOI] & Torsional Stiffness of the shafts [K])

FIGURE 3A—COUNTERSHAFT MECHANICAL TRANSMISSION

#	Inertia Label	MOI (lb-in-S^2) /[Nm S^2]
1		
2		
3		
4		
…		

Stiffness Desc.	K (lb-in/rad) /[Nm/rad]
Ahead of 1st inertia	
Between 1st & 2nd inertia	
Between 2nd & 3rd inertia	
After last inertia	

1B. Gear #: ______________________________ Gear Ratio: ______________________

2B. Mass-elastic data:

Table as above

Provide additional information as appropriate for transmission model

FIGURE 3B—COUNTERSHAFT MECHANICAL TRANSMISSION (CONTINUED)

5.5 Torque Converter Planetary Transmission—See Figure 4.

1. Torque converter (with oil mass) inertia, converter clutch disengaged

Inertia = lb-in S^2
= N-m S^2

2. Torque converter mode ranges

Range	Inertia	lb-in S^2 [N-m S^2]	Output Stiffness	lb-in/rad [Nm/rad]
1				
2				
3				
4				
…				

Note: Prior to converter lock-up, no torsional vibration is transmitted through the converter.

3. Converter Clutch engaged ranges
Turbine shaft stiffness =________________________lb-in/rad[Nm/rad]

Torque Converter	Inertia	lb-in S^2 [N-m S^2]
1st range planet section		
2nd range planet sections		
3rd range planet sections		
4th range planet sections		
…		

Note: Some vehicles may be equipped with a drop box or an auxiliary transmission. Such cases will require more data for a vibration analysis.

FIGURE 4—TORQUE CONVERTER PLANETARY TRANSMISSION