Classification of Agricultural Wheeled Tractors for Vibration Tests of Operator Seats

1. ***Scope***—This Recommended Practice defines classes of tractors having similar characteristics which affect the vibration transmitted to the operator through the operator seat. This recommended practice establishes input data parameters for conducting operator seat vibration tests for various classifications for agricultural wheeled tractors. The classification is intended to aid in the selection of a seat for a specific tractor model and to reduce the amount of testing necessary to determine compliance with applicable standards and/or recommendations. Classification is based on basic configuration and total mass. Instrumentation and measurement procedures are specified in SAE J1013 JAN80. Test procedures are defined in SAE J1384. This document is in compliance with DIS 5007 adopted by ISO/TC23/SC3 October 1984 in Madrid, Spain.

1.1 **Rationale**—Superseded by ISO 5007.

2. ***References***

2.1 **Applicable Publications**—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

    SAE J1013 JAN80—Measurement of Whole Body Vibration of the Seated Operator of Off-Highway Work Machines
    SAE J1163 JAN80—Determining Operator Seat Location on Off-Road Work Machines
    SAE J1384—Vibration Performance Evaluation of Operator Seats
    SAE J1385—Classification of Earthmoving Machines for Vibration Tests of Operator Seats

2.1.2 ISO PUBLICATIONS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

    ISO 7096—Earthmoving Machinery—Operator Seat—Measurement of Transmitted Vibration
    ISO/TR5007—Agricultural Wheeled Tractors—Operator Seat—Measurement of Transmitted Vibration (and Seat Dimensions)

3. *Definitions*

3.1 **Letter Symbols**

B_e - resolution bandwidth of frequency analysis, Hz
PSD - Power Spectral Density expressed as mean square acceleration per unit bandwidth $(m/s^2)^2/Hz$
Ø Max - Maximum value of PSD
rms - Root-mean-square
a_{wf} - Frequency weighted rms acceleration value (see SAE J1013 JAN80)
T - analysis time duration, seconds

3.2 **Operator Seat**—That portion of the tractor provided for the purpose of supporting the buttocks of the seated operator, including the seat suspension system, if any.

3.3 **Agricultural Tractor Class**—A group of agricultural wheeled tractors defined by mass having sufficiently similar vibration characteristics in representative working conditions that they can be represented by a standard vibration in a laboratory dynamic test of operator vibration.

4. *Agricultural Tractor Classification*

4.1 Basic specifications for agricultural tractors defined as having similar vibration characteristics are identified by class in Table 1.

4.2 The agricultural tractor classes of Table 1 include a broad range of tractor sizes within each class. The vibration spectra are representative envelopes for the various size tractors within the class to allow a single test to evaluate a single operator seat suitable for use on any tractor within the class. The data used in this document was developed on 100 m OECD standard track defined in ISO TR 5007 - 1980 and with tractor operating under actual field conditions.

5. *Vibration Characteristics*

5.1 The vibration spectra for each class of agricultural wheeled tractors are shown in Figures 1–3. Exact equations for the acceleration power spectral density (PSD) curves of Figures 1–3 are included in Tables 2 and 3. These curves, defined by these equations, are the target spectra to be produced at the base of the seat for the random vibration test of SAE J1384.

5.2 Table 4 further defines the test input vibration and gives the tolerances allowed on the actual test input PSD at the base of the seat.

5.3 Any means, including double integrators, analog signal generators and filters, or digital signal generators with digital to analog converters, may be used to produce the required PSD and rms characteristics at the base of the seat for the random vibration test.

5.4 Table 4 also specifies the acceleration probability density function required of the random vibration at the base of the seat during the test.

TABLE 1—AGRICULTURAL TRACTOR CLASSIFICATION[1]

Specification	Class 1	Class 2	Class 3
Unballasted mass – kg	up to 3600	3601 to 6500	6500 – over
Axle Suspension Rear	unsprung	unsprung	unsprung

1. For Agricultural Tractors not covered by the classifications in Table 1, refer to Section 6.3 of SAE J1384.

TABLE 2—EQUATIONS FOR PSD CURVES

CLASS 1	PSD – 9.25	$(H)^2$	$(L)^2$
CLASS 2	PSD – 7.22	$(H)^2$	$(L)^2$
CLASS 3	PSD – 5.85	$(H)^2$	$(L)^2$

Here H is the magnitude of the highpass Butterworth type filter frequency response function HP48 given below.

$$H = R^8 / \sqrt{1 - 13.137R^2 + 25.688R^4 - 13.137R^6 + R^{8^2}} \atop +(5.126R - 21.846R^3 + 21.846R^5 - 5.126R^7)^2 \qquad \text{(Eq. 1)}$$

where:

R = f/Fc where f = frequency, Hz and Fc = HP_{48} cutoff frequency for the particular tractor class per the Table below.

L is the magnitude ofthe lowpass Butterworth type filter frequency response function LP_{48} given below.

$$L = 1 / \sqrt{(1 - 13.137R^2 + 25.688R^4 - 13.137R^6 + R^8)^2} \atop +(5.126R - 21.846R^3 + 21.846R^5 - 5.126R^7)^2 \qquad \text{(Eq. 2)}$$

where:

R = f/FC where f = frequency, Hz, and Fc = LP_{48} cutoff frequency for the particular tractor class per the Table below.

The highpass Butterworth filter frequency response function is:

$$(HP_{48}) = S^8 / (1 + 5.126S + 13.137S^2 + 21.846S^3 + 25.688^4) \atop + 21.846S^5 + 13.137S^6 + 5.126S^7 + S^8 \qquad \text{(Eq. 3)}$$

The lowpass Butterworth filter frequency response function is:

$$(LP_{48}) = \quad / (1 + 5.126S + 13.137S^2 + 21.846S^3 + 25.688^4) \atop + 21.846S^5 + 13.137S^6 + 5.126S^7 + S^8 \qquad \text{(Eq. 4)}$$

where:

$S = \dfrac{jf}{Fc}$ $j = \sqrt{-1}$

F = frequency, Hz
Fc = Filter Cutoff Frequency, Hz, per Table 3

TABLE 3—FILTER CUT-OFF FREQUENCIES AND CURVE DATA[1]

Class	(LP$_{48}$)	(HP$_{48}$)	ϕ Max	Center Freq., Hz	a$_{wf}$
1	3.50	3.00	5.55	3.25	2.05
2	2.6	2.1	5.17	2.35	1.50
3	2.45	1.95	4.34	2.2	1.30

1. HP and LP designate high-pass and low-pass filters of the Butterworth type. The subscripts state the filter slope in dB/octave. Therefore the above table completely defines band-pass filters in terms of cut-off frequencies and slopes.

TABLE 4—TEST INPUT LEVELS AND TOLERANCES

1 Agricultural Tractor Class	2 True rms m/s^2	3 Weighted rms[1] Target m/s^2	4 Tolerance	5 Tolerance on Test Input PDS Curve[1]	6 Minimum % of Test True rms Within Frequency Bands[1]
1	2.25	2.05	±10%	±1 dB between 3.0 and 3.5 Hz ±2 dB between 2.5 and 4.0 Hz	65% between 3.0 and 3.5 Hz 95% between 2.5 and 4.0 Hz
2	1.94	1.50	±10%	±1 dB between 2.1 and 2.6 Hz ±2 dB between 1.8 and 2.9 Hz	70% between 2.1 and 2.6 Hz 95% between 1.8 and 2.9 Hz
3	1.74	1.30	±10%	±1 dB between 1.9 and 2.4 Hz ±2 dB between 1.6 and 2.7 Hz	70% between 1.9 and 2.4 Hz 95% between 1.6 and 2.7 Hz

1.To be analyzed in accordance with the restrictions on time (T) and bandwidth (Be) of Section 5.4.1 of SAE J1013 JAN80.

NOTES FOR TABLE 4:

1. Column 2 is a reference value for the true rms acceleration defined by the curves and equations of Figures 1 - 3 and Tables 2 and 3.
2. Column 3 is the target value for the frequency weighted rms acceleration test input at the base of the seat. Column 4 is the allowed tolerance on Column 3.
3. Column 5 is the allowed tolerance on the actual test input PSD curve at the base of the seat. This includes a restrictive tolerance of ±1 dB on the PSD curve in the stated frequency range which contains the major part of the test vibration, and a less restriction tolerance of ±2 dB on the PSD Curve over the wider frequency range.
4. Column 6 is an additional requirement which states the minimum percent of the actual test true rms acceleration which must be within the stated range of frequencies. The frequencies stated in Columns 5 and 5 are band-edge frequencies.

NOTE—   FOR ALL TESTS: CURVE AND TOLERANCE FOR PROBABILITY DENSITY FUNCTION. Under the conditions that the acceleration at the base of the seat shall be sampled at a minimum of 50 data points per second and analyzed into amplitude cells of no greater than 50% of the total true rms acceleration, the probability density function must be within ±20% of the ideal Gaussian function between + and – 200% of the total true rms acceleration, with a minimum of 93% of the data within + and – 200% of the total true rms acceleration, and with no data exceeding + or – 400% of the total true rms acceleration.
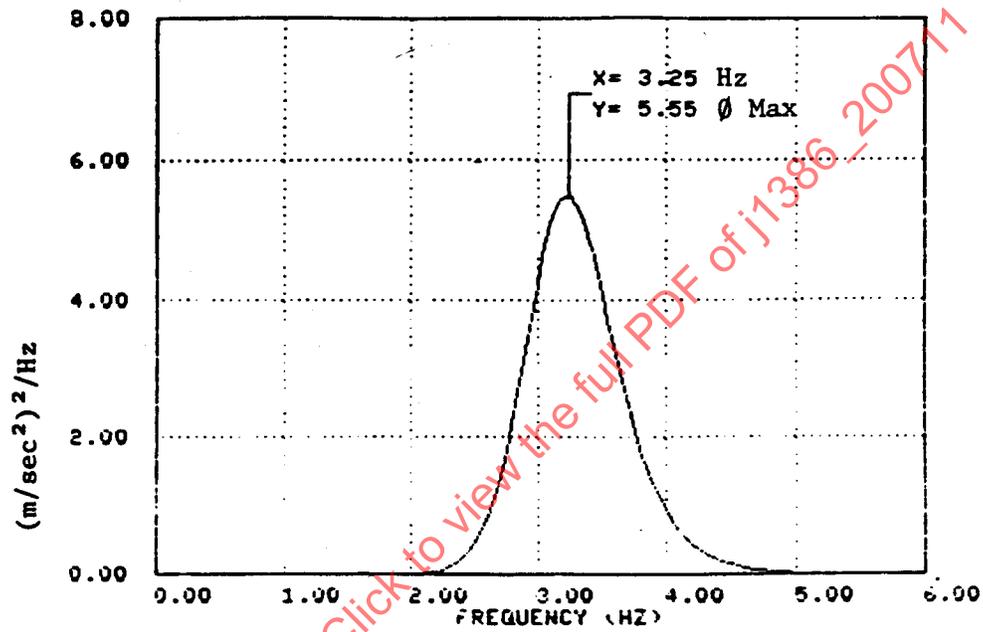
AGRICULTURAL TRACTOR

CLASS 1

FIGURE 1—AGRICULTURAL TRACTOR CLASS 1
2.25 m/s^2 TRUE RMS
2.05 m/s^2 WEIGHTED RMS