



**International  
Standard**

**ISO 16063-31**

**Methods for the calibration of  
vibration and shock transducers —**

**Part 31:  
Testing of transverse vibration  
sensitivity**

**AMENDMENT 1**

*Méthodes pour l'étalonnage des transducteurs de vibrations et  
de chocs —*

*Partie 31: Essai de sensibilité aux vibrations transversales*

*AMENDEMENT 1*

**First edition  
2009-08-15  
AMENDMENT 1  
2025-03**



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Published in Switzerland

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# Methods for the calibration of vibration and shock transducers —

## Part 31: Testing of transverse vibration sensitivity

### AMENDMENT 1

#### 7.3

Add the following subclause at the end of Clause 7:

**"7.3 Determination of the transverse sensitivity using elliptical orbits**

Annex B shall be used for testing of transverse sensitivity using elliptical orbits."

#### *Annex B*

Add the following annex after Annex A, before the Bibliography.

## Annex B

### (normative)

## Testing of transverse sensitivity using elliptical orbits

This annex gives a brief insight into a method that can be used to test the transverse sensitivity of vibration and shock transducers in the bi-axial transverse directions by actuating the test set up exciters in the X- and Y- directions at any phase and amplitude as described in Formulae (B.1) and (B.2). A full description of a method that can be used is included in Reference [13].

$$a_X(t) = \hat{a}_X \cos(2\pi ft + \phi_X) \quad (\text{B.1})$$

$$a_Y(t) = \hat{a}_Y \cos(2\pi ft + \phi_Y) \quad (\text{B.2})$$

where

- $a_X(t)$  is the time-varying value of the X-axis acceleration;
- $\hat{a}_X$  is the amplitude of the acceleration component along the X-axis;
- $\phi_X$  is the initial phase of the acceleration component along the X-axis;
- $a_Y(t)$  is the time-varying value of the Y-axis acceleration;
- $\hat{a}_Y$  is the amplitude of the acceleration component along the Y-axis;
- $\phi_Y$  is the initial phase of the acceleration component along the Y-axis;
- $f$  is the frequency of oscillation; and
- $t$  is the time.

In general case, Formulae (B.1) and (B.2) describe an elliptical orbit motion in the X-Y plane and in those cases the transducer under test output is given by Formula (B.3).

$$V_T(t) = S_X \hat{a}_X \cos(2\pi ft + \phi_X) + S_Y \hat{a}_Y \cos(2\pi ft + \phi_Y) \quad (\text{B.3})$$

where

- $S_X$  is the transverse sensitivity in the X-direction;
- $S_Y$  is the transverse sensitivity in the Y-direction.

In addition, the expressions that describe the relationships between the magnitude  $\hat{V}_T$  and the initial phase  $\phi$  of the output  $V_T(t)$  and the amplitudes and initial phases of the X- and Y-axis accelerations are given by Formulae (B.4) and (B.5).

$$\hat{V}_T^2(t) = (S_X \hat{a}_X \cos \phi_X + S_Y \hat{a}_Y \cos \phi_Y)^2 + (S_X \hat{a}_X \sin \phi_X + S_Y \hat{a}_Y \sin \phi_Y)^2 \quad (\text{B.4})$$

$$\tan \phi = (S_X \hat{a}_X \sin \phi_X + S_Y \hat{a}_Y \sin \phi_Y) / (S_X \hat{a}_X \cos \phi_X + S_Y \hat{a}_Y \cos \phi_Y) \quad (\text{B.5})$$

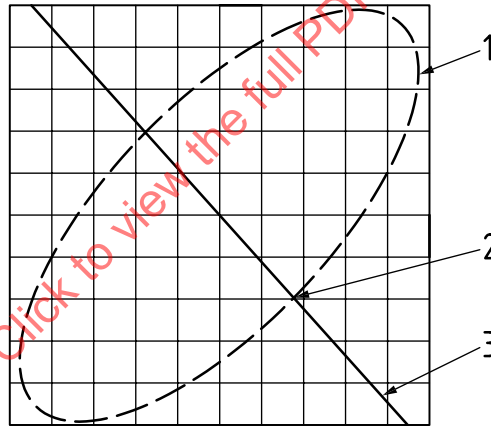
In Formulae (B.4) and (B.5), the magnitudes of the acceleration components,  $\hat{a}_X$  and  $\hat{a}_Y$ , the initial phases of the acceleration components,  $\phi_X$  and  $\phi_Y$ , the magnitude of the output,  $\hat{V}_T$ , and the initial phase of the output,  $\phi$ , can be obtained by means of measurement. Formula (B.4) describes that the transverse sensitivities,  $S_X$  and  $S_Y$ , locate on a standard ellipse which is determined by the magnitudes,  $\hat{a}_X$  and  $\hat{a}_Y$ , and the initial phases,  $\phi_X$  and  $\phi_Y$ , of the X- and Y-axis accelerations as well as the amplitude of the output,  $\hat{V}_T$ . Formula (B.5) describes that the transverse sensitivities,  $S_X$  and  $S_Y$ , locate on a straight line passing through the origin, whose slope is given by Formula (B.6).

$$K = S_Y / S_X = -(\hat{a}_X \sin \phi_X - \hat{a}_X \cos \phi_X \tan \phi) / (\hat{a}_Y \sin \phi_Y - \hat{a}_Y \cos \phi_Y \tan \phi) \quad (\text{B.6})$$

Then the transverse sensitivity of the transducer under test can be determined by the intersection of the sensitivity ellipse that is expressed in Formula (B.4) and the sensitivity straight line that is expressed by Formula (B.5), as shown in Figure B.1. In addition, the formulae for the transverse sensitivity are given by Formulae (B.7) and (B.8).

$$S_T = \sqrt{S_X^2 + S_Y^2} = \hat{V}_T(t) \sqrt{1 + K^2} / \sqrt{\hat{a}_X^2 + 2\hat{a}_X \hat{a}_Y \cos(\phi_X - \phi_Y) K + \hat{a}_Y^2 K^2} \quad (\text{B.7})$$

$$\beta_T = \tan^{-1}(S_Y / S_X) = \tan^{-1}(K) \quad (\text{B.8})$$



**Key**

- 1 sensitivity ellipse
- 2 transverse sensitivity
- 3 sensitivity line

**Figure B.1 — Transverse sensitivities determined by the intersection of the sensitivity ellipse and the sensitivity line**

Circular orbit motion is a special case of the elliptical orbit motion where the acceleration components along the X- and the Y-axes have the same magnitude (i.e.  $\hat{a}_X = \hat{a}_Y = \hat{a}_T$ ) and are in quadrature with each other (i.e.  $\phi_X = 0$  and  $\phi_Y = -90^\circ$  in Formulae (B.6), (B.7), and (B.8)). In this case, the transverse sensitivity  $S_T$  and its angle  $\beta_T$  can be obtained by using Formulae (B.9) and (B.10).

$$S_T = \sqrt{S_X^2 + S_Y^2} = \hat{V}_T / \hat{a}_T \quad (\text{B.9})$$

$$\beta_T = \tan^{-1} (S_Y / S_X) = -\phi \quad (\text{B.10})$$

*Bibliography*

Add the following at the end of the list of references:

[13] LIU Z, CAI C, YU M, et al. Testing of accelerometer transverse sensitivity using elliptical orbits. *MAPAN*, 2018, 33(3), 217-226. DOI: 10.1007/s12647-018-0255-7

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