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Road vehicles — Crosstalk determination for multi-axis load cell

Véhicules routiers — Détermination de l'effet transverse sur capteur de force multi axial

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Foreword

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 36, *Safety and impact testing*.

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Road vehicles — Crosstalk determination for multi-axis load cell

1 Scope

This document establishes an adequate procedure to determine crosstalk values in order to improve comparability of measurement results between testing laboratories and to enable a load cell performance rating in accordance to the crosstalk specification for transducers in vehicle crash testing given in ISO 6487, SAE-J211-1 and SAE J2570.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
crosstalk
undesired measured output of a transverse channel under defined load on the calibrated axis

Note 1 to entry: Crosstalk is alternatively known as transverse or cross sensitivity.

4 Field of application

The described measurement procedure refers to any multi-axis load cell.

The crosstalk value helps to check the transducer's performance and to identify sources of error during the calibration process. Therefore, it is recommended to determine the load cell's crosstalk value during the calibration. It could be an indicator for a wrong test setup (loading point, fixtures, channel allocation, overloading, etc.).

5 Crosstalk determination

5.1 Test setup requirements and general preconditions

Prior to determination of crosstalk values, the conditions as follows need to be maintained.

— The load cell calibration test setup follows the common standards for vehicle crash transducers for forces and moments.

— The crosstalk value is only considered for the traceable calibration range, which is defined in the calibration standard by a minimum and a maximum.

— Manufacturer's calibration fixtures or calibration fixtures which have been validated in regard to the manufacturer's fixture characteristics are utilised. While using a fixture for moment loading, consider the force range limits specified by the load cell manufacturer for the neutral axis in which the eccentric force is applied. Avoid applying forces exceeding the manufacturer's limits, for example in order to reach the desired moment with a shorter moment arm. Inappropriate calibration fixtures or insufficiently defined calibration ranges can cause extrapolation errors.

— The data acquisition (DAQ) and filter settings of all recorded channels follow the common calibration standards.

— All force and moment channels are measured during the calibration process of each axis. All channels are to be offset corrected in unloaded condition prior to the calibration test.

— For force loading the force is applied within the neutral axes of the load cell.

— Considering material settling for better comparability it is necessary to apply the loading process sequence given by the manufacturer of the calibration fixture.

In order to keep accuracy and to prevent misalignment it should be avoided to exert torque within the mounting plane between load cell and fixture. This load case should be last in the sequence. It can cause rotation of the load cell within the fixture. Thus subsequently exerted loads can be shifted from the intended load axis.

5.2 Additional test information

Identify the calibration range for each axis (if different from the nominal range of the load cell).

Identify the order of the loading sequence, e.g. $F_x \rightarrow M_y \rightarrow M_z \rightarrow F_y \rightarrow F_z \rightarrow M_x$.

Identify the loading force direction at the moment of calibration for the correct polarity of the crosstalk value.

Identify the typical sensitivity for each axis in order to select the appropriate gain settings for the measurement. If the sensitivity is known (e.g. value from a former calibration existing in the data base), the known value can be used for the test setup.

5.3 Crosstalk determination

For a loading in discrete steps or a continuous loading procedure, the output voltages in [mV/V] of all transverse channels need to be recorded.

After the calibration of all axes, the current sensitivities of these channels are known and can be used for the calculation of the crosstalk as percentage of the transducer axis' calibration range.

For the force and moment channels, the transverse channels' output voltage recorded in [mV/V] (see NOTE 1) shall be converted to the physical dimension force or moment by applying the current sensitivity determined from the calibration test before.

NOTE 1 For digital sensors signal conditioning and A/D conversion moved into the sensor. The transducer itself is strain gage based and delivers an mV/V output. Digital sensors are covered if the transition from [mV/V] to [LSB] is validated.

The crosstalk of the transverse axes as percentage of the calibration range can be calculated following Formula (1):

$$X_T = \frac{V_{trans} \times S_{trans}}{R_{cal,trans}} \times 100 \quad (1)$$

where

X_T is the crosstalk in percent of the transverse axis of a force channel in [%];

V_{trans} is the measured output voltage of the transverse axis in [mV/V];

S_{trans} is the current inverse sensitivity of the transverse axis in [EU/mV/V];

$R_{cal, trans}$ is the nominal calibration range of the transverse axis in [EU].

A moment loading by a force out of the neutral axis (moment calibration) results in a measurement of a force on one transverse force channel within the neutral axis. Under eccentric force only (moment loading) this is an undesired load and shall be corrected. Given that the eccentric force producing a moment is parallel to the neutral axis, the measured force on the neutral axis is known to be identical. Therefore, the applied eccentric force measured as reference for the calibration shall be subtracted from the measured force in the neutral axis. The crosstalk value of the neutral axis has been recorded in [mV/V] and needs to be converted to the physical dimension force by applying the actual sensitivity determined from the calibration test before. Thus, the crosstalk as percent of the calibration range is calculated following Formula (2):

$$X_T = \frac{V_{neutral} \times S_{neutral} - F_{ref}}{R_{cal,neutral}} \times 100 \quad (2)$$

where

X_T is the crosstalk in percent of the calibration range of the neutral axis of a moment channel in [%];

F_{ref} is the measured output of the reference load cell in [EU] (force for moment load);

$V_{neutral}$ is the measured output voltage of the neutral axis in [mV/V];

$S_{neutral}$ is the current inverse sensitivity of the neutral axis in [EU/mV/V];

$R_{cal, neutral}$ is the nominal calibration range of the neutral axis in [EU].

For a loading procedure in discrete load steps, the value from the output voltages in [mV/V] at the highest load level of the calibration range (see NOTE 2) of each transverse channel is calculated and recorded. From this value the crosstalk in percent for each channel is calculated, evaluated and recorded.

NOTE 2 The highest load level considers the calibration ranges: only positive, only negative, positive and negative. If the calibration test covers both load directions (e.g. push and pull) the maximum crosstalk is the highest amplitude of the transverse channel whether at the upper or the lower bound of the calibration range. Because traceability is not given outside the calibration range, the calibration range can be considered as full-scale capacity.

For a continuous loading procedure, the crosstalk in percent is calculated from the output voltage in [mV/V] of a transverse channel measured under the maximum load of the calibration range (see NOTE 2). This value is to be evaluated and recorded.

The entire process is shown in a flow chart in Figure A.1.

5.4 Data record

For static (discrete steps) and quasi-static (continuous) loading, at least the output voltage in [mV/V], calibration range, sensitivity and the scaled crosstalk value for each channel at the highest load in calibration range is to be captured and stored for reference.

Because load in different axes can affect the transverse channels differently, the values of the transverse channels need to be captured for each load case (e.g. display as matrix).

The calibration protocol contains information as follows:

— traceability of the reference equipment;

— crosstalk values displayed in percent [%] (transverse sensitivity ratio) of the specified full calibration range of the unloaded channels.

Annex A
(informative)

Workflow diagram crosstalk determination

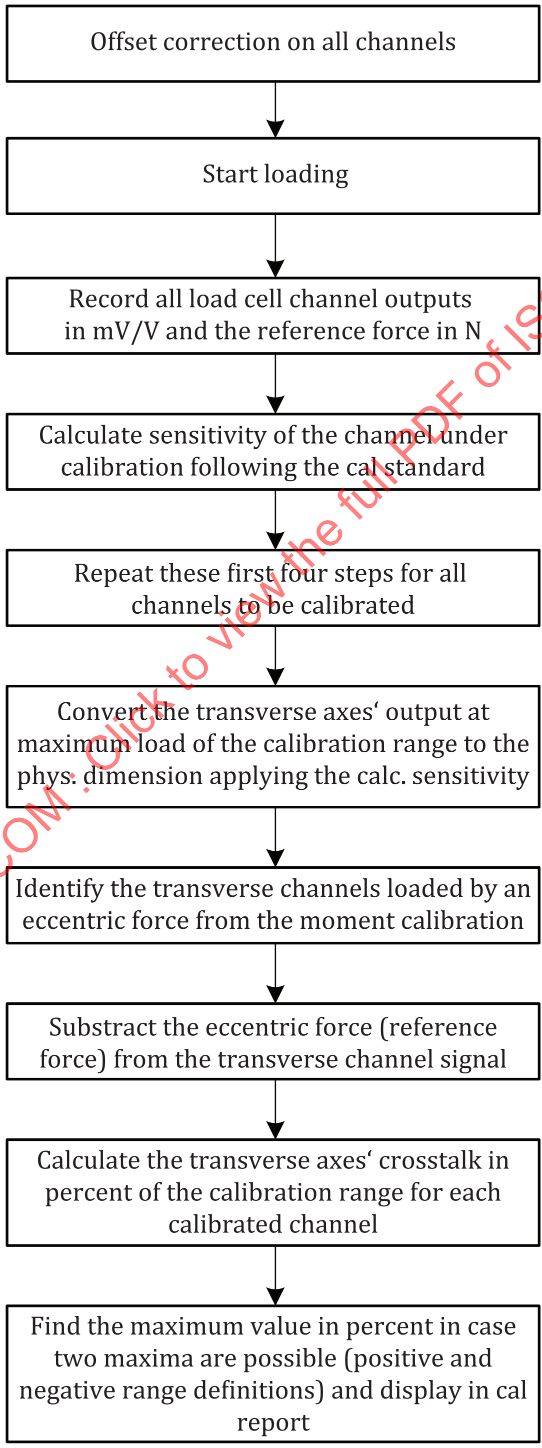

Figure A.1 — Workflow diagram crosstalk determination

