ESF II project of the University of West Bohemia in Pilsen

reg. number: CZ.02.2.69/0.0/0.0/18_056/0013239

EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education

MINISTRY OF EDUCATION,
YOUTH AND SPORTS

Selected Topics in Electrical Machines (KEV/VPS)

Vibration standards overview

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2021/2022

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Standards - vibration of machines or machine parts

- International clasification: ***ICS 17.160 - Vibrations, shock and vibration measurements***

- Include ***nomenclature***, ***measurement*** (methods, instrumentation, sensors) and ***vibration evaluation*** in general as well as for a specific machine or drive classes, ***condition monitoring*** and machine ***diagnostics***

- Do not include:
  - Vibration and shock with respect to human beings (*13.160*)
  - Balancing and balancing machines (*21.120.40*)
  - Vibration protection of buildings (*91.120.25*)

Standards - vibration of machines or machine parts

- General nomenclature
  - ČSN ISO 2041 Mechanical vibration, shock and condition monitoring - Vocabulary
  - ČSN ISO 13372 Condition monitoring and diagnostics of machines - Vocabulary

Standards - vibration of machines or machine parts

- Vibration and shock – Signal processing
  - *ČSN ISO 18431-1* Mechanical vibration and shock - Signal processing - Part 1: General introduction
  - *ČSN ISO 18431-2* Mechanical vibration and shock - Signal processing - Part 2: Time domain windows for Fourier Transform analysis
  - *ČSN ISO 18431-3* Mechanical vibration and shock - Signal processing - Part 3: Methods of time-frequency analysis
  - *ČSN ISO 18431-4* Mechanical vibration and shock - Signal processing - Part 4: Shock-response spectrum analysis

Standards - vibration of machines or machine parts

- Condition monitoring and machine diagnostics
  - *ČSN ISO 13373-1* Condition monitoring and diagnostics of machines - Vibration condition monitoring - Part 1: General procedures
  - *ČSN ISO 13373-2* Condition monitoring and diagnostics of machines - Vibration condition monitoring - Part 2: Processing, analysis and presentation of vibration data
  - *ČSN ISO 13373-3* Condition monitoring and diagnostics of machines - Vibration condition monitoring - Part 3: Guidelines for vibration diagnosis

Standards - vibration of machines or machine parts

- Electrical machines – in general
  - *ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines
  - *ČSN EN IEC 60034-14 ed. 3* Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity
  - *ČSN ISO 10816-3* Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured *in situ*

Standards - vibration of machines or machine parts

- ***ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines**

- General conditions and vibration measurement procedures
  - Rotating, non-rotating parts and reciprocating parts
  - Absolute and relative radial shaft vibration
  - Vibration value and its variation evaluation
  - Condition monitoring and acceptance tests

Standards - vibration of machines or machine parts

- ***ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines**

- Measured quantities
  - Displacement (µm)
  - Velocity (mm/s)
  - Acceleration (m/s^2)

- Evaluated values
  - RMS
  - Zero to peak (0-p)
  - Peak to peak (p-p)

Standards - vibration of machines or machine parts

- ***ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines**

- Frequency range => bandwidth adjustment to the frequency spectrum of a machine
  - Operation RPM (possibly RPM range)
  - Machine type
  - Measurement purpose (acceptance test, condition monitoring etc.)
  - Bearing diagnostics? (rolling elements or sleeve bearings)

Standards - vibration of machines or machine parts

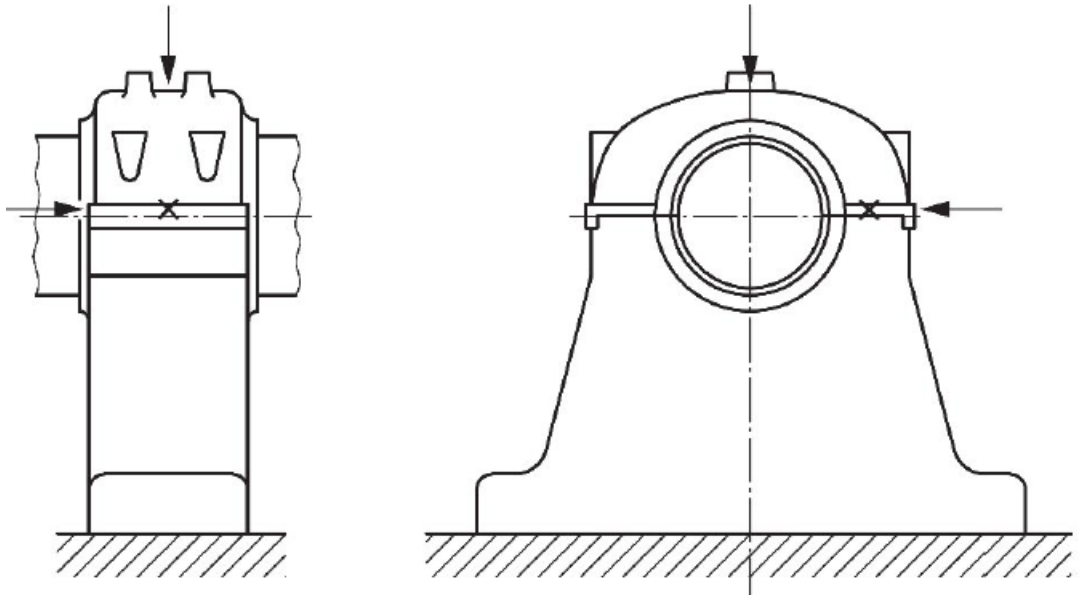
- ***ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines**

- Measurement spots on non-rotating parts
  - Bearings
  - Bearing brackets
  - Other structural parts close to bearings which are sensitive to dynamic forces transmitted from rotating elements
  - In any selected spot measurement in three perpendicular directions or at least radial vibration in both horizontal and vertical plane

Standards - vibration of machines or machine parts

- ***ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines**

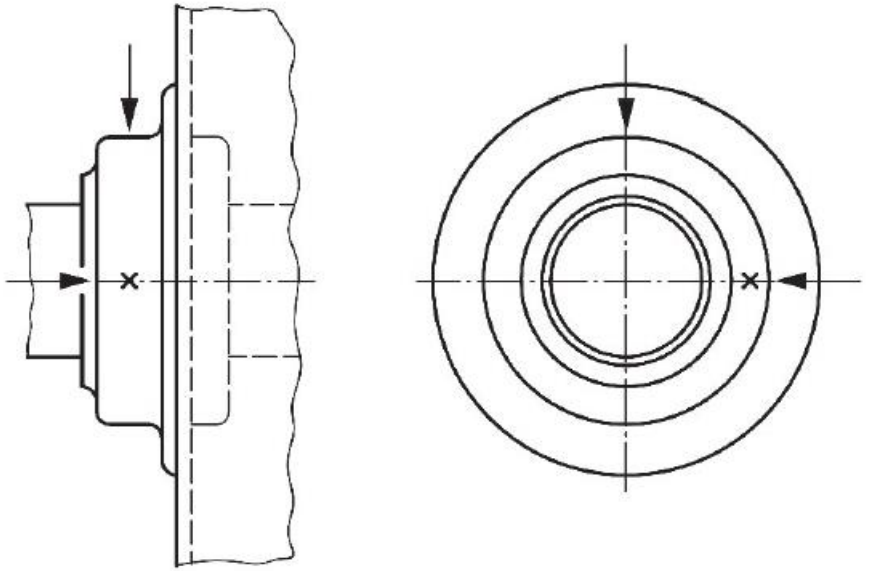
- Measurement spots on bearing blocks



Standards - vibration of machines or machine parts

- ***ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines**

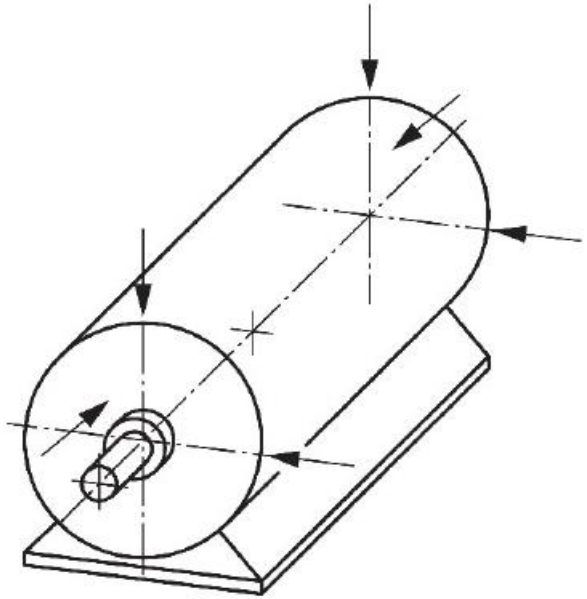
- Measurement spots on bearing brackets



Standards - vibration of machines or machine parts

- ***ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines**

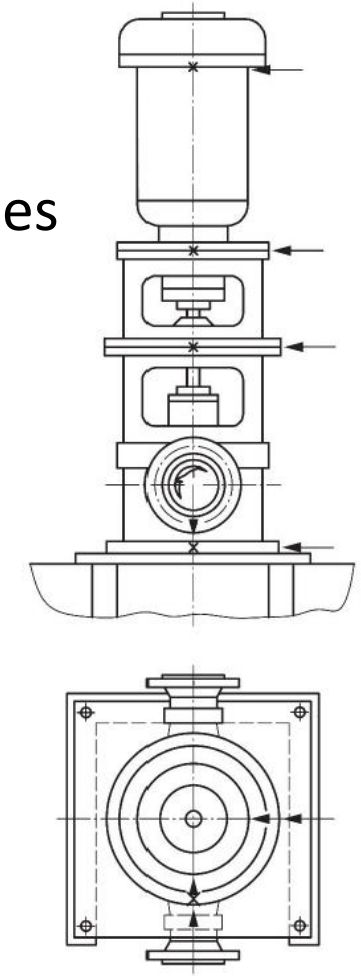
- Measurement spots on small electric machines



Standards - vibration of machines or machine parts

- ***ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines**

- Measurement spots on vertical mounted machines



Standards - vibration of machines or machine parts

- ***ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines**

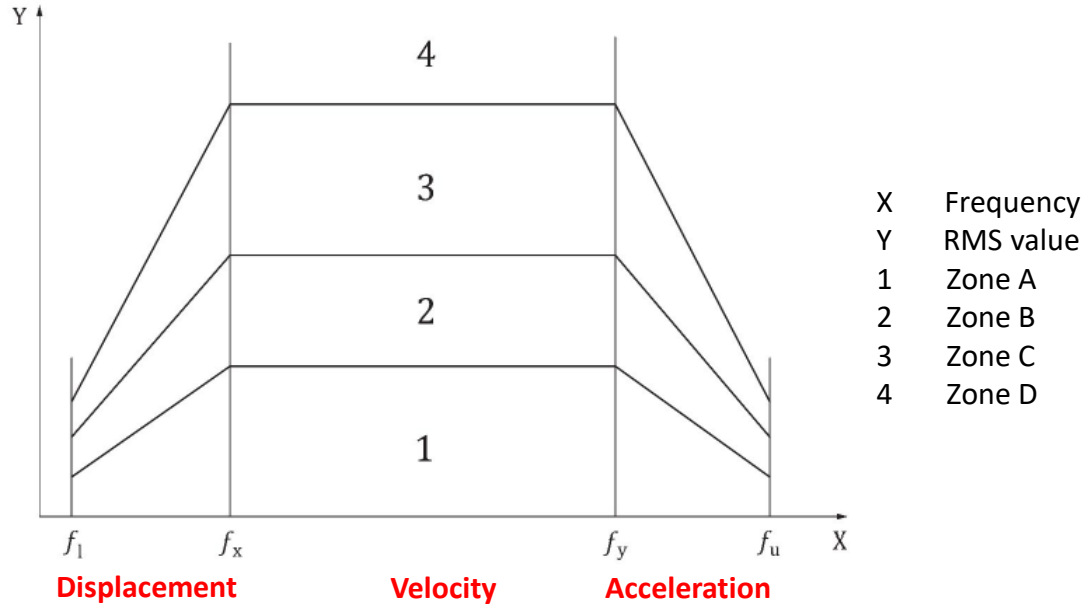
- Vibration severity zones
  - Zone A: vibration of a new machines
  - Zone B: usually unlimited operation time period
  - Zone C: not suitable for a long –term operation (maintenance ASAP)
  - Zone D: risk of machine damage

- Severity zone thresholds valid in general for machine types not classified by own standard

Standards - vibration of machines or machine parts

- ***ČSN ISO 20816-1* Mechanical vibration - Measurement and evaluation of machine vibration - Part 1: General guidelines**

- Vibration severity zones
  - Broadband velocity RMS value
  - Under f_x and above f_y necessary scaling towards constant velocity between f_x a f_y



Standards - vibration of machines or machine parts

- ***ČSN EN IEC 60034-14 ed. 3* Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity**

- Valid:
  - Acceptation tests or machines not coupled to the load or drive machine
  - DC and 3-phase AC machines – axis heights above 56 mm, power up to 50 MW, RPM between 120 and 15k

- Not valid:
  - Machines measured *in situ*
  - 3-phase commutator motors, 1-phase machines, 3-phase machines in 1-phase grids, horizontal hydrogenerators, turbine generators above 20 MW, magnetic bearing machines, series DC machines

Standards - vibration of machines or machine parts

- ***ČSN EN IEC 60034-14 ed. 3* Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity**

- Measured quantities
  - Displacement, velocity, acceleration on machine bearings (broadband RMS value)
  - Relative displacement of shaft vibration inside or close to bearings

- Minimal frequency range 10 Hz to 1 kHz

Standards - vibration of machines or machine parts

- ***ČSN EN IEC 60034-14 ed. 3* Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity**

- Machine foundation

  - Rigid foundation (maximal vibration velocity on motor feet or base =< 25% of maximal velocity on the closest bearing bracket)

  - Flexible foundation (spring suspension or flexible element placement – springs, rubber)

Standards - vibration of machines or machine parts

- ***ČSN EN IEC 60034-14 ed. 3* Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity**

- Testing condition
  - No-load, rated values of required quantities
  - For every rated RPM value (regulated drives for operating RPM value)
  - Only single rotation direction (however vibration limits are valid for both directions)
  - Measuring spots according to ČSN ISO 20816-1 for a small electric machines
  - Mass of sensor assembly < 1/50 of the machine mass

Standards - vibration of machines or machine parts

- ***ČSN EN IEC 60034-14 ed. 3* Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity**

- Evaluation criteria
  - Table with A and B severity zone threshholds (displacement, velocity, acceleration)
  - Flexible / rigid foundation
  - Axis heights 56 mm to 132 mm, 132 mm to 280 mm and above 280 mm
  - Table with relative shaft vibration thresholds

Standards - vibration of machines or machine parts

- ***ČSN ISO 10816-3* Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured *in situ***

- Valid:
  - Steam turbines up to 50 MW, steam driven turbosets above 50 MW and RPM below 1500 or above 3600
  - Rotary compressors
  - Industrial gas turbinesup to 3 MW
  - Generators
  - Any electric motors
  - Blowers or fans

Standards - vibration of machines or machine parts

- ***ČSN ISO 10816-3*** **Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured *in situ***

- Not valid:
  - Turbosets on ground foundations, power above 50 MW and RPM 1500, 1800, 3000 or 3600 (see ISO 10816-2)
  - Gas turbine sets above 3 MW (see ISO 10816-4)
  - Sets in hydro power plants and pumping stations (see ISO 10816-5)
  - Reciprocating machines (see ISO 10816-6)
  - Centrifugal pumps with integrated electric motors (see ISO 10816-7)
  - Comressors – rotary volumetric compressors (e.g. screw-rotary), reciprocating
  - Reciprocating pumps, submersible motors-pumps
  - Wind turbines

Standards - vibration of machines or machine parts

- ***ČSN ISO 10816-3*** **Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured *in situ***

- Measuring spots according to ČSN ISO 20816-1

- Evaluation criteria
  - Table with A/B, B/C a C/D severity zone threshholds (displacement, velocity)
  - Flexible / rigid foundation
  - Axis heights 160 mm to 315 mm (power 15 kW to 300 kW), above 315 mm (power 300 kW to 50 MW)
  - **Do not deals with** relative shaft vibration measurement and evaluation

Thank you

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