TESTING INSTRUMENTS USED FOR MONITORING LINEAR DIMENSIONS UNDER CONDITIONS OF VIBRATION

Yu. S. Mironov

Measuring instruments subjected to random vibrations; their reaction to the vibrations may result in a change in their readings. Table 1 indicates the kind of vibrations experienced in various cases which have been mentioned in the literature and presents a broad classification of the working conditions and types of instrument encountered in measuring and testing linear dimensions in relation to their vibration resistance.

Let us consider the effect of a three-dimensional, symphase monoharmonic vibration on a measuring system. It was shown in [1] that vibrational perturbation might be considered as a random, narrow-band process, and it was shown in [2] that this perturbation might be replaced in tests by a monoharmonic action. Experience shows, moreover, that to a first approximation many linear-measurement instruments may be regarded as linear systems. Omitting the intermediate calculations, let us simply give the final relationship obtained for the response of a linear system

\[ U = \overline{q} \psi, \]

where \( \psi = \{x, y, z\} \) is the vector of the vibrational action; \( \overline{q} = \frac{\partial U}{\partial x} \overline{i} + \frac{\partial U}{\partial y} \overline{j} + \frac{\partial U}{\partial z} \overline{k} \); \( \overline{i}, \overline{j} \) and \( \overline{k} \) are the unit vectors of the X, Y, and Z axes (linked to the instruments), in which Z is directed along the measuring axis, X lies in the plane of displacement of the indicator (characteristic) perpendicular to Z.

### Table 1

<table>
<thead>
<tr>
<th>Distribution of linear-measurement instruments in groups, depending on their working conditions</th>
<th>Forms of measurement and testing</th>
<th>Maximum level of vibrational action for each group of conditions</th>
<th>Groups of instruments in terms of their stability with respect to permissible vibrations (W_{\text{p}, \text{m/sec}^2} )</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Special Spec. bases, foundations</td>
<td>Especially accurate measurements and testing of standard measures and instruments</td>
<td>1–20</td>
<td>(10^{-3} - 10^{-2})</td>
<td>Basic and intermediate standard interference installations</td>
</tr>
<tr>
<td>II. Laboratory No spec. foundations, remote from work. equip.</td>
<td>Accurate measurements; testing of working measures and instruments</td>
<td>1–40</td>
<td>(10^{-2} - 10^{-1})</td>
<td>Contact interferometers</td>
</tr>
<tr>
<td>III. Production Not too near work. equip.</td>
<td>Production (industrial) monitoring, manual measurements, and measurements in testing equipment</td>
<td>1–100</td>
<td>(10^{-1} - 1)</td>
<td>Sprung heads, limiting electrical-contact converters</td>
</tr>
<tr>
<td>IV. Heavy Direct. attach. to equip. or nearby</td>
<td>Monitoring in the course of various forms of treatment</td>
<td>5–1000</td>
<td>(1 - 20)</td>
<td>Indicators of the dial type, active monitoring instruments</td>
</tr>
</tbody>
</table>

Translated from Izmeritel'naya Tekhnika, No. 5, pp. 29–30, May, 1975.
Let us call $\vec{q}$ the vibration-sensitivity vector: $\vec{q} = \text{grad} \ U$. This is directly related to the apparatus and depends very little on its disposition in space.

On analyzing Eq. (1) we see that, in order to increase the vibration-resistance, i.e., in order to reduce the response $U$, the following ways are open:

- a reduction in $q = |\vec{q}|$ by a constructional change in the instrument,
- a reduction in $\psi = |\vec{\psi}|$ by shock absorption, by moving the source of interference further from the receiver, and by changing the source characteristics.

We may distinguish three zones representing different states of the instrument. In zone I $R_0 > |\delta_0|$, a situation which in linear-measurement instruments is mainly associated with dry-friction couplings, the change in the readings due to vibrations $R < R_0$ may be interpreted as a displacement of $U$. In such cases as in the case of instruments with a relay-type characteristic (for example, electrical-contact instruments) it is desirable to carry out the tests by comparing the readings of the instrument under test with a standard device having a vibration sensitivity of $|\vec{K}_0| \approx 0$. In the apparatus developed for this purpose in [4], the readings compared on the longitudinal-comparison principle. The character of the change in $R_0(W, \nu)$ was not simply studied for linear-measurement instruments; tests were made on a number of instruments used in routine measurements. It was found that for many of these the variation in the readings $R$ depended very considerably on $W$ but little on $\nu$:

$$R(W) = \begin{cases} R_0 - \alpha W, & 0 \leq W \leq W_I \\ R_{II}, & W_I \leq W \leq W_{II} \end{cases}$$

where $\alpha$ is a coefficient.

On testing a number of models of routine instruments for the effects of vibrations along the axis of measurement, we obtained the following results: