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COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS AND ON THE GLOBALLY HARMONIZED SYSTEM OF CLASSIFICATION AND LABELLING OF CHEMICALS
Sub-Committee of Experts on the Transport of Dangerous Goods
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PACKAGINGS

Assessment of the proposal of the DOT vibration standard for the UN Recommendations on the Transport of Dangerous Goods

Transmitted by the European Secretariat of Manufacturers of Light Metal Packaging (SEFEL)

1. Problem formulation

The UN Sub-Committee of Experts on the Transport of Dangerous Goods made a decision in 1999 "... that in principle, at some time in the future, a vibration test should be included in the Model Regulations, on the understanding that the forms the test would take and the criteria for it were still to be defined and should take account of pertinent ISO standards and existing vibration test standards". Detailed proposals for a vibration test have been submitted to the UN Sub-Committee meeting of July 2002, the content of which methodologically reflects the US Vibration Standard.

2. Simulation of transportation induced loads and stresses

Based on the knowledge of transportation induced loads and stresses, it is possible in a laboratory, in principle, to expose the freight, i.e. goods to be transported, or the design type of a package, to a simulated transportation environment. Issues of accelerated testing and time compression by means of increasing the real stresses play an important role in the area of fatigue investigations, which according to the current state of scientific findings, can be comprehended perfectly only if the correlations of cause and effect for each individual combination of stresses and strains have been determined beforehand or are known already.

Some of the testing methods currently being used, however, originate from a time when such investigations were not yet possible or not usual. Using grades of severity selected arbitrarily, the technical justification for which is debateable, every specimen may be damaged or destroyed without necessarily providing reference to real transport conditions. Therefore, the meaningfulness of such testing is doubtful.

3. Current developments in standardising of transport simulation testing

As a result of the problems described, various national and international standardising bodies are, at present, intensely working new development of testing regulations for transport simulation. Examples to be mentioned are:

- the US military standard Mil-Std 810 F with data also on non-military road transportation
- the work of IEC (counterpart of ISO in the field of electrical engineering) within its TC 107, where practically relevant dynamic load profiles are currently being compiled

- the work of CEN TC 261 ("Packaging"), whereby transport stresses that are now being introduced in determining acceleration spectra for the vibration test have been ascertained in a co-normative research project ("SRETS") funded by the EU Commission
- the work of the German DIN standardising commission on packaging ("NAVp"), whereby the conditions and measuring procedures for ascertaining mechanical-dynamic transportation loads have been determined in a multi-part standardisation exercise (DIN 30787).

In this connection, the Confederation of European Environmental Engineering Societies (CEEES) is providing preliminary work for international standardisation by its "Transportation Stress" Working Group.

A common technical basic principle of all these activities mentioned is the finding that the vehicle platform vibrations will occur as random vibrations superimposed by shock-type loads . Any transport simulation meeting the present state of knowledge will have to take into account this character of the dynamic loads. The excitation profiles are usually represented as power density spectra of acceleration and characterised by an effective value of acceleration as a parameter for the total load. The typical related frequency ranges will extend from a few Hertz up to several thousand Hertz (e.g. 5 to 2000 Hertz). Amplitude peaks in specific frequency bands will occur in a stochastic distribution.

4. Performing vibration testing

The selection and determination of actual excitation spectra then requires a great know-how and experience in vibration technology. Nowadays, electrohydraulic or electrodynamic shaker systems, which are available meanwhile around the world in qualified laboratories, are being used almost exclusively for such transport simulations. For introducing the force into the test object, clamping devices and (for horizontal stimulation) sliding tables are being used. By means of the measuring and control technology being used, a closed control loop is being formed which will ensure that the vibration excitation being introduced will be appropriate to the required vibration profile. This will make sure that the specimen being tested will be exposed to dynamic loads that are neither too weak nor too strong, but appropriate.

5. The proposed US vibration test

The proposed procedure is published in DOT Hazardous Materials Regulations and Procedures/Part 178 Subpart M/178.608.

The content of the procedure is equivalent to the standard ISO 2247 "Packaging – Complete, filled transport packages – Vibration Test at fixed low frequency".

6. Assessment of the proposed procedure

The proposed procedure clearly does not represent a vibration test, even if it wrongly bears that name. The specimen being tested is placed loosely on a support which typically is forced to perform a sinusoidal motion by an unbalance stimulator. The sinusoidal motion is related to one single frequency which, moreover, is not representing real dynamic transportation loads – such as effected by characteristic natural vibrations of the transport means, but is being selected to cause the object being transported to just lift off due to its inertia of mass. This frequency occurs in the range between 3 Hertz and 4 Hertz. However, typical resonance peaks e.g. of trucks will range between 1 and 2 Hertz (Chassis natural frequency) and between 10 and 15 Hertz (resonance of axle suspension) and, moreover, comprise the random vibration level in the range from 1 to 2000 Hertz and higher. Therefore a single sinusoidal frequency is not suitable for simulation of real transport stresses.
The actual stress of this test is an impact on the testing surface. Therefore, in precise scrutiny, it amounts to a quick succession of this action: vertical, sinusoidal upward acceleration, brief zero-gravity and subsequent impact on the support. Consequently, the test will actually simulate permanent bouncing or permanent jolting with an undefined force application , as the object being tested will be allowed to "migrate" freely within limits, possibly also to tip over or rotate. Determining a test duration of one hour appears arbitrary and unjustified.

The proposed testing procedure is an elementary version of mechanical-dynamic load simulation . Whether it will simulate transport loads in close relation to reality must be subject, at least, to severe doubt. No transport means will generate a mono-frequency stress of this type. Likewise, it is rather improbable, at least in industrial countries, that dangerous goods will be transported loosely on the loading area without any method of securing the load, so that a state of permanent bouncing due to poor road conditions will occur.

The testing technology and testing regulation being used appears to be based on the efficiency of the testing machine rather than on actual stresses encountered. More than thirty years ago, such unbalanced stimulators frequently provided the only possibility of creating dynamic stresses. It is a known fact that, particularly in the United .States of America., numerous package testing laboratories possess that type of testing equipment and would probably not be interested in a modern version of vibration testing.

7. Proposals for standardising of transport simulation

Should the introduction of a vibration test make sense on account of real observations of incidents of damage, then it is proposed to evaluate the current standardising work of CEN, IEC, Mil, and DIN and to define the vibration test accordingly. Where appropriate, it will be necessary to perform transportation measuring trips for typical transports of dangerous goods. However, when doing so, a discussion will also have to take place as to what mechanisms of damage may be expected to occur to the package (e.g. loosening and detaching of bolts and gaskets, fatigue of structural components) and by what testing procedures such defects may be imitated. Likewise, the influences of load-securing methods will have to be considered.

On the other hand, typical transportation scenarios for dangerous goods will have to be considered, i.e.

- transport means used (railway, truck, vessel , aircraft , handling equipment)
- economic regions (EU, North America, Eastern Europe, industrial countries in Asia, developing countries) and their traffic infrastructure
- climate zones.

At the end of that analysis, a typical stress profile will be created from which specific testing requirements may be derived . It is hardly to be supposed that the proposed test has been based on such a systematic approach.

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