Applications

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Technical Report

Investigations to specify the MixMate® vortex function

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Abstract

This Technical Note deals with the hand-arm vibration exposure transmitted through the Eppendorf vortex mixer MixMate as compared to a common competitor's instrument. The results of these investigations show that due to the ^{2D}Mix Control Technology the MixMate causes considerably lower vibration strain than the competitor's instrument examined in parallel. Using the MixMate, more tubes may be mixed per day without the risk of excessive strain to the hand-arm region.

Introduction

The guideline 2002/44/EG of the European Parliament and Council states minimum regulations regarding the protection of workers from excessive strain caused by mechanical oscillation (vibration) [1].
The guideline defines an exposure action value and an exposure limit value for daily vibration stress. In the case where the exposure action value is reached or exceeded, the employer is compelled to monitor the risk posed by hand-arm vibration and to initiate preventive measures. The exposure limit value should not be exceeded at any time, i.e. upon reaching this value, immediate action is to be undertaken.

The daily vibration exposure action value EAV of 2.5 m/s² A(8) *is equivalent to 100 exposure points. Upon reaching or exceeding this value, the extent of hand-arm vibration must be monitored, and preventive measures are to be initiated.*

The exposure limit value ELV of 5 m/s² A(8) *is equivalent to 400 exposure points. Upon reaching this limit, measurements of the vibrational stress are to be performed immediately, followed by immediate implementation of measures for stress reduction.*

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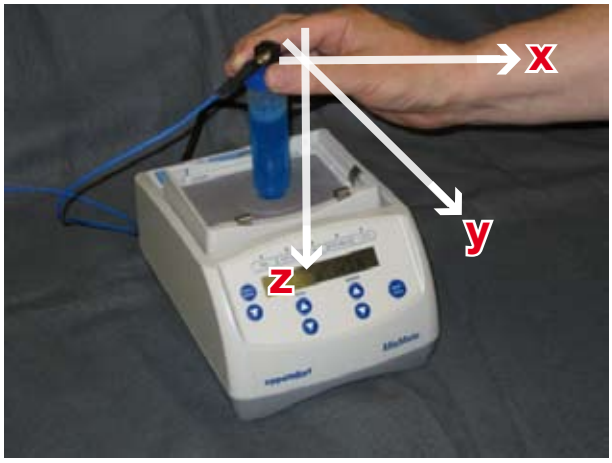
It has been known for some time that excessive vibration influence (oscillation influence) on the human body may have adverse effects on health. Workers who are continually exposed to vibrations above the exposure action value may be suffering in the long term from impaired circulation in the fingers and/or from functional neurological and motorical damage in the hands and arms [1, 2, 3].
Vortexing, i.e. fast mixing of solutions or resuspending of pellets in single micro test tubes or larger screw cap tubes (e.g. 15 ml, 50 ml), is an activity frequently performed in biochemical laboratories. In the context of the PhysioCare Concept® Eppendorf investigated the intensity of vibration strain caused by vortexing of single tubes in the touch vortex operation mode (3500 rpm) using the MixMate.
The daily vibration exposure of a person is determined by the total vibration value and the duration of exposure. To this end, the total vibration value accumulated during vortexing of 15 ml and 50 ml screw cap tubes was measured. The daily vibration exposure, the vortexing time permitted for one user, as well as the number of tubes which may be mixed per day without exceeding the exposure action value and the exposure limit value, were derived from these measured data. If these times are adhered to, the user will not be at risk of excessive strain.

Materials and Methods

The measurement of the total vibration value (vibration acceleration assessed by frequency in m/s^2) was performed in accordance with DIN EN ISO 5349-1:2001 “Mechanical vibration – measurement and assessment of human exposure to hand-transmitted vibration – part 1“.
In each axis of vibration (x,y,z) an effective value assessed by frequency of vibration acceleration was measured (a_{hw}).
For the assessment of exposure, the total vibration value a_{hv} is the determining factor. It combines three a_{hw} values for the axes x,y and z as follows:

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2}$$



This assessment takes place at the point where the vibrations reach the hand. The measurements were performed on the MixMate set to touch vortex operation mode (3500 rpm), using 15 and 50 ml screw cap tubes which were filled to two thirds with water. For comparison, a common laboratory vortexer was examined, which is subsequently abbreviated “VG“.
Each individual test consisted of a representative pattern of 5 successive vortex phases of 30 seconds (very long vortex times were consciously selected in order to include a simulation of those strains far above average), interspersed by gaps of 5 seconds each. The interruption represents a change of tubes. For each of the three orthogonal directions (x,y,z) three tests were performed, thus the result represents the arithmetic mean of 9 tests.
The measurements were performed by the Industrial Noise & Vibration Centre Limited (INVC), an independent institute in Berkshire, UK.

Results

Table 1 shows the measured total vibration values which occurred during vortexing of 15 ml and 50 ml screw cap tubes. The values refer to the usage pattern described above – 30 seconds vortexing, 5 seconds gap. The respective daily vibration exposures were derived from the measured total vibration values: the vortexing of 15 ml tubes resulted in a daily exposure value of 1.8 m/s^2. Therefore the vibration strain lies considerably below the exposure action value of 2.5 m/s^2. Expressed in a time value, this means that 15 ml tubes (filled to 2/3) may be mixed for 111 minutes per day using the touch vortex operation mode (3500 rpm) without exceeding the exposure action value, which is equivalent to 190 tubes.
The total vibration value and thus the daily vibration exposure were considerably higher for the competitor's instrument "VG": The daily vibration exposure of 2.6 m/s^2 already reaches the exposure action value and actually slightly exceeds it. In order to reach the exposure action value, 15 ml tubes could thus be mixed for 55 min in succession. This is equivalent to 94 tubes.

Since the vibration strain is also dependent on the weight of the tubes, the total vibration value is higher for 50 ml screw cap tubes (filled to 2/3). The daily vibration exposure for the MixMate equals 3.3 m/s^2. Thus, under the conditions selected here, the exposure action value of 2.5 m/s^2 is exceeded even by the MixMate. However, 34 minutes of mixing would not exceed the exposure action value, which corresponds to 58 tubes (30 seconds each). The competitor's instrument reaches a daily vibration exposure which exceeds the exposure limit value: 6.0 m/s^2. This means that 50 ml tubes (filled to 2/3) may be mixed for only 10 min, which is equivalent to 17 tubes. In addition, the number of tubes was calculated which could be mixed without exceeding the exposure action value when different durations were chosen for the vortex phase. Each test consisted of 5 successive vortex phases of 15, 30 or 45 seconds, interrupted by gaps of 5 seconds. The tubes were filled to 2/3 with water (tables 2 and 3).

	Total vibration value a_{hv} [m/s^2]	**Daily vibration exposure** [m/s^2]	**Exposure points** (per hour) 100 pts = exposure action value 400 pts = exposure limit value	**Permitted vortexing time per day without exceeding the exposure action value A(8) 2.5 m/s^2 or the exposure limit value of 5.0 m/s^2** [min]	
15 ml screw cap tube				EAV	ELV
MixMate 3500 rpm	5.2	1,8 (< 2.5 m/s^2)	54	111	444
Competitor VG Setting 10+ (= approx. 3200 rpm)	7.4	2,6 (>2.5 m/s^2)	110	55	219
50 ml screw cap tube					
MixMate 3500 rpm	9.4	3.3 (>2.5 m/s^2)	177	34	136
Competitor VG Setting 10+ (= approx. 3200 rpm)	17	6.0 (>5.0 m/s^2)	578	10	42

Table 1 Measured total vibration value, the daily vibration exposure derived from this, and permitted daily vortexing time without exceeding the exposure action value and the exposure limit value. Each test consisted of a representative usage pattern of 5 successive touch vortex operations of 30 seconds, each followed by a 5 second gap. This resulted in a total of 2 minutes and 30 seconds of exclusive vortexing time and 20 seconds gap. The tubes were filled to 2/3 with water.

15 ml screw cap tube Time		Number of tubes which may be mixed per day without exceeding the Exposure action value EAV	 Exposure limit value ELV
15 s	MixMate	333	1332
	Competitor VG	165	660
30 s	MixMate	190	761
	Competitor VG	94	376
45 s	MixMate	133	532
	Competitor VG	66	264

Table 2 Number of 15 ml tubes which may be vortexed per day without exceeding the exposure action value or the exposure limit value.

Usage pattern: Each test consisted of one representative usage pattern of 5 successive touch vortex operations of 15, 30 or 45 seconds and a respective gap of 5 seconds. The tubes were filled to 2/3 with water.

15 ml screw cap tube Time		Number of tubes which may be mixed per day without exceeding the Exposure action value EAV	 Exposure limit value ELV
15 s	MixMate	102	408
	Competitor VG	30	120
30 s	MixMate	58	233
	Competitor VG	17	68
45 s	MixMate	40	163
	Competitor VG	12	48

Table 3 Number of 50 ml tubes which may be vortexed per day without exceeding the exposure action value or the exposure limit value.

Usage pattern: Each test consisted of one representative usage pattern of 5 successive touch vortex operations of 15, 30 or 45 seconds and a respective gap of 5 seconds. The tubes were filled to 2/3 with water.

Discussion

Taken together, the results demonstrate that vortexing using the Eppendorf MixMate causes less vibration strain than the competitor's instrument "VG". Thus, the number of tubes which may be mixed without risk, i.e. the permitted duration of vortexing, is considerably higher than that calculated for the competitor's instrument, even though the MixMate runs at a higher mixing frequency when set to touch-vortex mode than the instrument made by the competitor. Evidently, the special ^{2D}Mix Control Technology contributes considerably to this advantage. This technology allows maximum smoothness with a planar 2-dimensional circular mixing motion. Inherent instrument vibrations, as well as chaotic and vertical mixing movements, were minimized during construction of the MixMate. Hence, no unnecessary and additional vibration strain influences the user's hand-arm region. The MixMate is the first vortex mixer for which the hand-arm vibration strain was specified and which thus contributes to the lasting safety of the user.

Literature

[1] GUIDELINE 2002/44/EG OF THE EUROPEAN PARLIAMENT AND COUNCIL from 25th June 2002 about minimum regulations regarding the protection of safety and health of employees from the hazards of physical influences (vibrations) (16th single guideline representing article 16, paragraph 1of the guideline 89/391/EWG)

[2] Measurement and evaluation of the influence of vibrations on the hand-arm system of the human part 2: Applied instructions for measurement in the workplace (ISO 5349-2:2001) German version EN ISO 5349-2:2001

[3] HSE (2005): Control the risks from hand-arm-vibration: Advice for employers on the Control of Vibration at Work Regulations 2005. Leaflet INDG175 (rev2) HSE Books 2005 ISBN 0 7176 6117 2

Ordering information

Product name	Order No. International	Order No. North America
MixMate®	5353 000.014	022674200

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