

GUIDE FOR

PASSENGER COMFORT ON SHIPS SEPTEMBER 2014

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GUIDE FOR

PASSENGER COMFORT ON SHIPS

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Foreword

ABS has produced *this Guide for Passenger Comfort on Ships* in order to provide a single source for comfort criteria suitable for passenger ships. ABS has established objective assessment criteria and measurement methodologies for comfort based on current research and standards relating to human psychological and physiological responses. This Guide may be applied to passenger vessels carrying more than twelve (12) passengers used for such purposes as commuting, traveling, vacationing, and recreating. This includes cruise ships and ferries (conventional and high-speed craft).

This Guide provides the assessment criteria and describes the measurement methodology for obtaining a Comfort notation. It is intended for use by vessel Owners or companies requesting the optional notations of Comfort (**COMF**) or Comfort Plus (**COMF+**).

For the Comfort (**COMF**) notation, this Guide focuses on four (4) categories of comfort criteria that can be controlled, measured, and assessed in passenger spaces of vessels. These categories are: whole-body vibration, noise, indoor climate, and lighting.

For the Comfort Plus (**COMF+**) notation, this Guide invokes more stringent whole-body vibration criteria aimed at the assessment of passenger comfort and potential motion sickness.

This Guide, originally published in December 2001, has undergone significant revision. Key revision areas include changes to the whole-body vibration (WBV) measurement and evaluation methodology and criteria, changes to the ambient lighting methodology and criteria, changes to the noise criteria and removal of the accommodation area criteria. These revisions are due to several factors, including:

1. Input from industry (i.e., Owners, designers, and construction yards)
2. Revisions to standards referenced in this Guide
3. Revised statutory regulations
4. Changes in current design practices and principles

This Guide becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of this Guide is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

GUIDE FOR PASSENGER COMFORT ON SHIPS

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SECTION 1 General

1 Introduction

ABS recognizes the positive impact that suitable comfort criteria and design practices may have on the comfort, safety, and overall well-being of passengers. The *ABS Guide for Passenger Comfort on Ships* has been developed with the objective of improving the comfort of the passengers on board passenger vessels. These comfort criteria have been chosen to provide a means to increase the comfort, enjoyment, and satisfaction of passengers.

2 Application

ABS has produced this *Guide for Passenger Comfort on Ships* in order to provide a single source for comfort criteria suitable for passenger ships. This Guide may be applied to passenger vessels carrying more than twelve (12) passengers used for such purposes as commuting, traveling, vacationing and recreating. This includes cruise ships and ferries (conventional and high-speed craft).

This Guide is applicable to new and existing passenger vessels for which an optional Comfort (**COMF**) or a Comfort Plus (**COMF+**) notation has been requested. The comfort criteria are a measure of the acceptability of passenger accommodation areas and their associated ambient environmental criteria.

3 Scope

The Guide focuses on four (4) comfort aspects of passenger ship design and layout that can be controlled, measured, and assessed.

The ambient environmental aspects of comfort pertain to the environment that the passengers are exposed to on board vessels. Specifically, this Guide provides criteria, limits and measurement methodologies for the following:

- i) Whole-body Vibration
- ii) Noise
- iii) Indoor Climate
- iv) Lighting.

The criteria provided in this Guide are based on currently available research data and standards for the purpose of providing a base level of passenger comfort. This Guide does not specifically address passenger safety since safety is comprehensively covered by the International Maritime Organization (IMO), Flag Administrations, Class Society Rules and Port States. However, where appropriate, compliance with this Guide may warrant an enhancement in some safety systems on board the vessel.

The various criteria, test conditions, measurement locations, test methods and instruments required by this Guide may differ from the more rigorous and scientific methods reported and practiced elsewhere by the scientific community. They were, however, selected with the aim of providing a practical Guide that could be applied internationally by ABS and vessel Owners/shipbuilders with reliability and acceptable validity.

While producing this Guide, ABS has taken a practical approach to measurements, test personnel (Testing Specialists) and test equipment.

4 Terminology

Accommodation Areas: Vessel areas where the primary purpose is to rest **and** recreate. Passenger accommodation spaces include cabins, staterooms, dining areas, recreation rooms, medical facilities and other public spaces. For the purposes of this Guide, accommodation **areas** are primarily restricted to the spaces passengers would normally use on board vessels.

Ambient Environment: Ambient environment refers to the environmental conditions that passengers are exposed to during periods of transit, leisure, or rest. Specifically, this Guide provides criteria and limits for whole-body vibration, noise, indoor climate and lighting.

Comfort: The acceptability of the conditions of a vessel as determined by its vibration, noise, thermal, indoor climate and lighting qualities as well as its physical and spatial characteristics, according to prevailing research and standards for human comfort.

Occupied Passenger Spaces: For the purposes of this Guide, any space where passengers may be present for twenty (20) minutes or longer at one time for transit, rest or leisure purposes.

Passenger: A passenger is every person other than the Master and the members of the crew or other persons employed or engaged in any capacity on board a vessel for the business of that vessel.

Passenger Vessel: A vessel whose primary purpose is to carry more than twelve (12) passengers for transportation or recreational purposes. **This includes** cruise **ships** and ferries (conventional and high-speed craft).

Recreation and Public Spaces: Those portions of the passenger spaces **that** are used for halls, dining **rooms**, lounges, theaters, and similar permanently enclosed spaces.

Shall: Expresses a provision that is mandatory.

Test Plan: Document containing the requisite information regarding vessel design and layout, test personnel, test conditions, measurement locations, data acquisition, instruments, data analysis and test schedule necessary for verifying the measurements for the ambient environmental aspects of comfort.

Test Report: Document containing the actual testing information from the Ambient Environmental tests including details of the testing conditions, measurement locations, measurement equipment, and the results of the data collected and analyzed.

Testing Specialists: Specialized test personnel who must meet the requirements of Appendix 2, "Procedural Requirements for ABS Recognized Ambient Environmental Testing Specialists".

5 Associated Documentation

- Appendix 2, "Procedural Requirements for **ABS Recognized Ambient Environmental Testing Specialists**"

6 Notation

At the **Owner's** or shipyard's request, a vessel complying with the minimum criteria for the ambient environmental **aspects** (i.e., **whole-body** vibration, noise, indoor climate, and lighting) provided in this Guide **may** be assigned a notation of **COMF**.

A vessel complying with the more stringent criteria with respect to whole-body vibration (including motion sickness) **may** be distinguished in the *Record* by the notation **COMF+**. A summary of the differences **among** each of these notations is **presented** below.

Notation	Ambient Environment			
	<i>Whole-Body Vibration</i>	<i>Noise</i>	<i>Indoor Climate</i>	<i>Lighting</i>
COMF	Must meet comfort-based vibration level criteria	Must meet criteria for noise No difference between COMF and COMF+	Must meet criteria for indoor climate No difference between COMF and COMF+	Must meet criteria for lighting No difference between COMF and COMF+
COMF+	Must meet comfort-based vibration level criteria as well as motion sickness criteria			

7 Data and Plans to be Submitted

7.1 General

The following General Arrangement type drawings of the vessel shall be submitted:

- i) Inboard profile detailing the location of the main vertical zone boundaries, the location of the main watertight bulkheads as well as the various deck levels.
- ii) Plan view of each deck annotating the various spaces on each deck.

7.2 Ambient Environment

The following items are to be submitted for each ambient environmental aspect.

7.2.1 Test Plans

Test plans shall serve as the principal means for verifying the measurements for the ambient environmental aspects of comfort. Separate test plans are required for **whole-body** vibration, noise, indoor climate and lighting. Specific test plan details for the various ambient environmental criteria are outlined in later sections of this Guide as follows:

<i>Environmental Aspect</i>	<i>Test Plan Details</i>
Whole-body Vibration	Subsection 2/6
Noise	Subsection 3/6
Indoor Climate	Subsection 4/6
Lighting	Subsection 5/6

The **Test Plans** require approval by ABS Engineering before any measurements are made. ABS shall notify the vessel **Owner** or shipyard whether the **Test Plans** have been approved or require alteration. An ABS approved copy of the Test Plan shall become part of the vessel's official documentation.

7.2.2 Test Reports

Upon completion of the ambient environmental testing, Test Reports shall be submitted to the ABS Surveyor. In addition, a copy of the **Test Reports** shall become part of the vessel's official documentation. These reports contain ambient environmental information such as test results, testing details, measurement equipment details, etc. The specific report contents for the various ambient environmental criteria are outlined in later sections of this Guide as follows:

<i>Environmental Aspect</i>	<i>Test Report Details</i>
Whole-body Vibration	Subsection 2/8
Noise	Subsection 3/8
Indoor Climate	Subsection 4/8
Lighting	Subsection 5/8

8 Process for Obtaining a Notation

Prior to scheduling ambient environmental testing activities, the vessel **Owner** or shipyard shall certify the operational status of the vessel as being fully operational and/or inclusive of all equipment and furnishings. If the vessel is not fully operational, a complete listing of **deficiencies of** areas, components, equipment, etc., shall be submitted to **ABS** for review.

ABS shall then make a determination and notify the vessel **Owner** or shipyard as to whether ambient environmental testing can commence. **The intent is to align sea trials/activities with the ambient environmental testing so that all testing is completed during this time.**

Section 1, Figure 1, “**Process for Obtaining a Comfort Notation**”, charts the process for obtaining a **COMF** or **COMF+** notation. The following paragraphs briefly describe the notation process.

8.1 Ambient Environment

Ambient environmental test plans for **whole-body** vibration, noise, indoor climate and lighting shall be prepared and submitted to **ABS**.

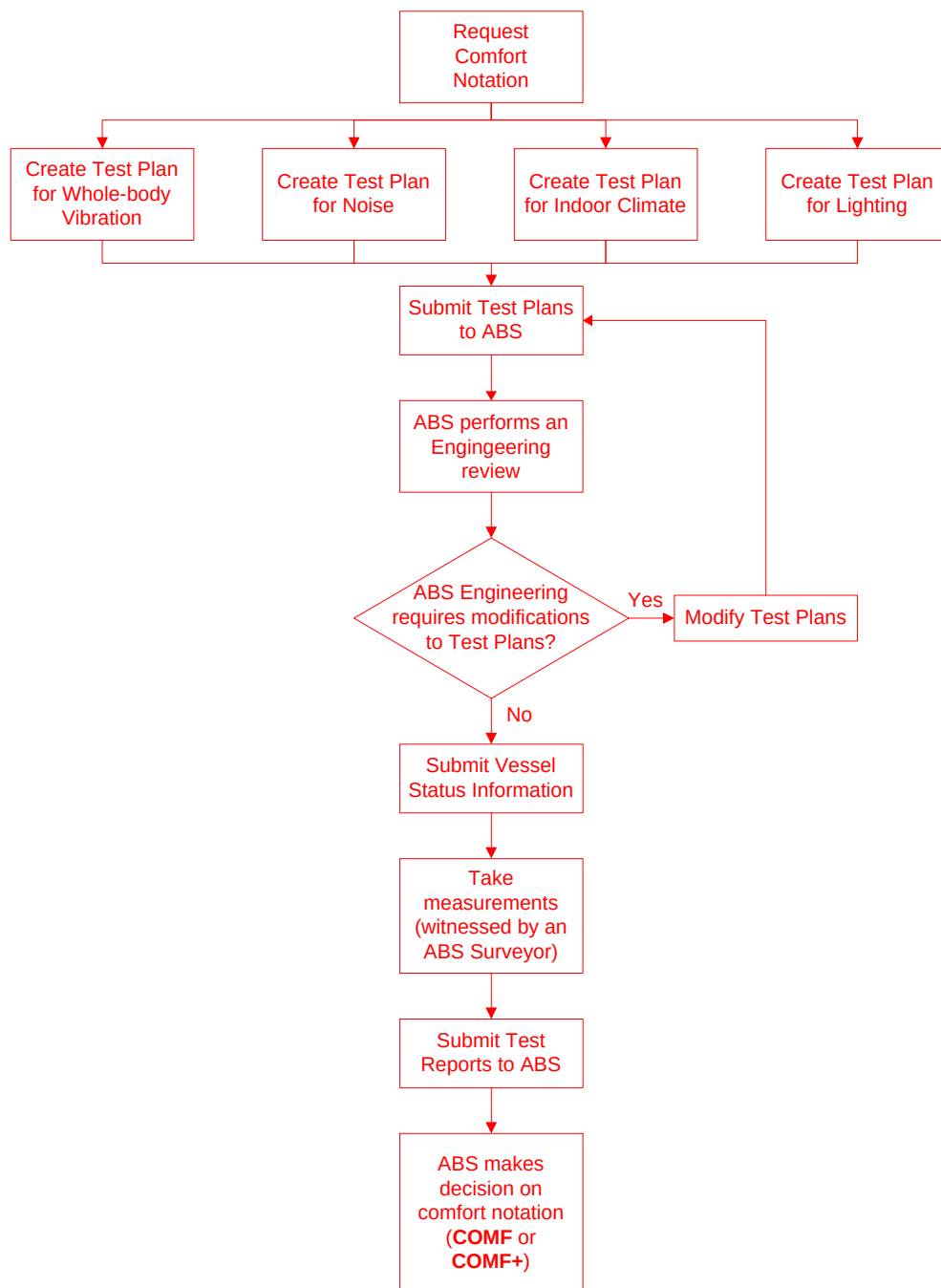
The Test Plans shall serve as a primary vehicle for verifying the measurement locations and measurement process, as well as specifying the **Testing Specialist** who will perform the ambient environmental testing.

Testing, inspections and data collection shall be performed by **the Testing Specialists** and witnessed by an **ABS Surveyor**. Test **Reports** for ambient environmental testing shall be prepared by **the Testing Specialists** and submitted to the **ABS Surveyor** for review.

8.2 Results

The **ABS Surveyor** verification measurements **and** ambient environmental Test **Reports** shall be reviewed by the **ABS Surveyor** for determination of notation confirmation.

FIGURE 1
Process for Obtaining a Comfort Notation



9 Initial Requirements

The initial process for obtaining **any passenger ship** Comfort notation shall comprise **ambient environmental testing and** ABS Surveyor verifications. Testing shall be in accordance with the submitted Test Plans reviewed and approved by ABS Engineering in advance of the testing. Testing shall be witnessed by an ABS Surveyor. If the criteria specified in this Guide have been met, then the appropriate notation **may** be confirmed.

10 Surveys after Construction

It is intended that all surveys after construction are to be aligned with Classification Surveys. Harmonization of surveys is to be carried out at the first available opportunity.

10.1 Annual Surveys

In order to maintain the **COMF** or **COMF+** notation, an Annual Survey shall be made within three (3) months before or after each annual anniversary date of the crediting of the Initial Survey or the previous Special Periodical Survey. The following information shall be reviewed by the attending ABS Surveyor **for** issues that could affect the Comfort notation:

- i) Collision and grounding reports since previous Initial, Annual or Special Periodical Survey
- ii) Fire, repair, and damage reports since previous Initial, Annual or Special Periodical Survey
- iii) A list of all **structural or mechanical modifications** to the vessel since previous Initial, Annual or Special Periodical Survey

During the attending ABS Surveyor's review of the submitted information, a determination will be made as to whether changes or alterations have taken place that could affect the Comfort notation. As a result, the vessel may be subject to the review, ambient environmental testing and inspection requirements of this Guide.

10.2 Special Periodical Surveys

In order to maintain the **COMF** or **COMF+** notation, a Special Periodical Survey shall be completed within five (5) years after the date of build or after the crediting date of the previous Special Periodical Survey. A Special Periodical Survey will be credited as of the completion date of the survey but not later than five (5) years from date of build or from the date recorded for the previous Special Periodical Survey. If the Special Periodical Survey is completed within three (3) months prior to the due date, the Special Periodical Survey will be credited to agree with the effective due date. The Special Periodical Survey may be commenced fifteen (15) months prior to the due date and be continued with completion by the due date.

10.2.1 Survey Requirements

The Survey shall comprise ABS Surveyor verifications and ambient environmental testing. The Survey will cover all **four (4)** Comfort aspects.

The following shall be submitted to **ABS** three (3) months prior to carrying out the ambient environmental testing:

- i) Fire, repair, **or** damage reports since previous Annual Survey
- ii) A list of all **structural or mechanical modifications** to the vessel since previous Annual Survey
- iii) **D**rawings//arrangements of passenger spaces, affected by alterations
- iv) Copy of approved Initial Test Plans and Test Reports
- v) Test Plans and Test Reports resulting from Annual Surveys
- vi) Proposed Special Periodical Survey Test Plans for the current survey.
- vii) **Previous Special Periodical Survey Test Plans and reports, if applicable.**

The Special Periodical Survey data submittal serves **two** purposes. The **first** purpose is to provide a history of ambient environmental testing, as well as the Special Periodical Survey ambient environmental Test Plans for review and approval. The **second** is to allow scheduling of measurement verifications and ambient environmental testing.

A Special Periodical Survey Test Plan for each ambient environmental aspect of **Comfort** shall be submitted in accordance with the criteria stated below. The approved Initial Test Plans **should** be used as a basis for creating the Special Periodical Survey Test Plans.

For creation of the Special Periodical Survey Test Plans, Subsection 6, "Test Plan" and Subsection 7, "Test Requirements" of this Guide specify the requirements for each ambient environmental aspect (i.e., 3/6, 3/7, 4/6, 4/7, etc.). For specifying measurement locations for the Special Periodical Survey Test Plans, the following changes to 7.4.1, "Selection of Spaces where Measurements are to be Conducted", of each ambient environmental aspect of Comfort shall be followed:

i) Measurements shall be taken in all areas affected by vessel alterations. Measurements **are** limited to the ambient environmental aspect affected by the alteration. For example, structural changes would require both **whole-body** vibration and noise measurements. Structural changes **do** not necessarily require indoor climate or lighting measurements. Changes to luminaires require lighting measurements but not **whole-body** vibration, noise, or indoor climate measurements.

ii) For whole-body vibration, additional measurements shall be taken in passenger cabins and staterooms **throughout the vessel**. For vessels with fewer than **one hundred (100)** passenger cabins and staterooms, **ten (10)** percent of cabins and staterooms shall be measured.

For vessels with **one hundred (100)** or more passenger cabins and staterooms, apply the following:

- In the forward one-third ($\frac{1}{3}$) of the vessel, **seven (7)** percent or 1 in **15** of cabins and staterooms shall be measured
- In the midsection (center $\frac{1}{3}$) of the vessel, **five (5)** percent or 1 in **25** of cabins and staterooms shall be measured
- In the aft one-third ($\frac{1}{3}$) of the vessel, **ten (10)** percent 1 in **10** of the cabins and staterooms shall be measured.

Within each one-third ($\frac{1}{3}$) section of the vessel, measurement locations shall be distributed throughout the length of each section and on each deck.

iii) For all ambient environmental aspects, measurements shall be taken in all worst case or problem area locations based on the requirements set forth in 7.4.1, "Selection of Spaces where Measurements are to be Conducted", of the appropriate section of this Guide. [For example, worst case for whole-body vibration is described in 2/7.4.1i)].

iv) For all ambient environmental aspects, measurements shall be taken in twenty-five (25) percent of passenger cabins identified in the initial Test Plans. The cabin locations must be representative of locations port, starboard, fore, amidships, and aft. Any worst case locations can be considered part of the representative sample for passenger cabins, if applicable.

v) For all ambient environmental aspects, measurements shall be taken where a single instance of one (1) type of a passenger space exists within the vessel (e.g., dining room, gymnasium, library, etc.). The worst case locations can be considered part of the single instance representative sample, if applicable.

vi) Where multiple instances of the same type space exist, a representative sample of at least twenty-five (25) percent of each type shall be selected for measurement for all ambient environmental aspects. The worst case locations are to be considered part of the representative sample, if applicable.

vii) For the **COMF+** notation, vibration measurement locations relating to motion sickness shall be selected in accordance with the applicable criteria in 2/7.4.1, "Selection of Spaces where Measurements are to be Conducted".

- viii) For lighting, select a sample of at least ten (10) percent of spaces where passengers are involved in recreational activities (e.g., dining rooms, lounges, theater, gymnasium, etc.) for measurement.

Where a number of cabins and sanitary spaces are identical in configuration in terms of lighting systems, surface treatments, geometry, furnishings and equipment layout, only two (2) of the spaces shall be selected to determine whether the lighting requirements are met. A sample of at least fifteen (15) percent of the remaining spaces shall be visually inspected.

The worst case locations can be considered part of these lighting representative samples, if applicable.

For all ambient environmental conditions, visual/**walkthrough** inspections shall be conducted in accordance with 7.4.2 of the appropriate **Section** of this Guide.

10.3 Requirements for Vessel Alterations

No alterations which affect or may affect the Comfort notation **awarded**, including alterations to the structure, machinery, electrical systems, piping, furnishings or lighting systems, are to be made to the vessel unless plans of the proposed alterations are submitted **to** and approved by **ABS** before the work of alteration is commenced. If **ABS** determines that the alteration will affect the Comfort notation, the altered vessel **may** be subject to the review, verification, and ambient environmental testing requirements of this Guide.

11 Alternatives

11.1 General

ABS will consider alternative arrangements, criteria and procedures, which can be shown to meet the **intent of the** criteria directly cited or referred to in this Guide. The demonstration of an alternative's acceptability can be made through either the presentation of satisfactory service experience or systematic analysis based on valid engineering principles.

11.2 National Regulations

ABS will consider for its acceptance alternative arrangements and details, which can be shown to comply with standards recognized in the country (flag **State**) in which the vessel is registered or built, provided they are not **deemed** less effective.

11.3 Departures from Criteria

The criteria contained in this Guide **are envisioned to apply** to vessels that are engaged in the usual trades and services expected of such vessels, within the scope of the following:

- *ABS Rules for Building and Classing Steel Vessels*
- *ABS Rules for Building and Classing High-Speed Craft*
- *ABS Rules for Materials and Welding*
- *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways*
- *ABS Rules for Materials and Welding: Aluminum and Fiber Reinforced Plastics*

It is recognized that unusual or unforeseen conditions may lead to a case where one or more of the parameters of interest in granting a notation may temporarily fall outside the range of acceptability.

When a departure from criteria is identified, during either the notation's initial issuance or reconfirmation process, it shall be reviewed by ABS in consultation with the **Owner**. When the ambient environmental test results contain departures from the stated criteria, these will be **subject to** special consideration upon the receipt of details about the departure. Depending on the degree and consequences of the departure, the **shipyard or Owner** may be required to provide an assessment and remediation plan to obtain or maintain the notation. Failure to complete the agreed remediation by the due date will lead to withdrawal of the notation.

SECTION 2 Whole-body Vibration

1 Background

Transport in vessels, whether conventional or high-speed, **imposes** a series of **generally** low-frequency mechanical vibrations, as well as single-impulse shock loads on the human body.

Low-frequency vibrations are **also** imposed by vessel motions, which are produced by the various sea states in conjunction with vessel speed. **These motions can** result in motion sickness, body instability, fatigue, discomfort, and increased health risk aggravated by shock loads induced by vessel slamming. Vessel slamming may be caused by dynamic impact loads being exerted on the vessel's bottom or bow flare **due to** vessel size, speed, and wave conditions.

Higher frequency vibration **influencing comfort** is often associated with rotating machinery. The imposition of higher frequency vibrations (**about 1 to 80 Hz**) induces corresponding motions and forces within the human body, creating discomfort and possibly resulting in degraded health (Griffin, 1990).

2 Scope

This Section provides the criteria and methods for assessing whole-body vibration relating to passenger comfort onboard vessels. The criteria were selected to limit **potential vibration-related** interference with passenger activities **and to improve passenger comfort**.

Consideration of the **vibration** loads imposed **on the body** is restricted to motions transmitted from surrounding structures to the entire human body through the feet of a standing person in the frequency range **1** to 80 Hertz (Hz). Motions transmitted to the body of a seated or recumbent person have been omitted from this Guide. Due to the provision of resilient or non-rigid surfaces on seats and beds, these surfaces will generally attenuate the transfer of **vibration** to levels that are lower than those experienced when standing. The motions transmitted through the feet are expected to be the highest vibration levels to which passengers will be exposed **and more prone to motion sickness**.

Whole-body vibration limits defined in this Section are based on currently available standards. Compliance with this Section is a prerequisite for the Comfort (**COMF**) or Comfort Plus (**COMF+**) notation confirmation.

3 Terminology

Acceleration: The rate of change of velocity **over time** (i.e., meters-per-second squared, m/s²).

Exposure Action Value: The value of vibration/repetitive shock above which controlling the whole-body vibration exposure to humans is recommended.

Exposure Limit Value: A value of vibration/repetitive shock above which humans should not be exposed.

Frequency: The number of complete cycles of a periodic process occurring per unit time. Frequency is expressed in Hertz (Hz) which corresponds to **the number of cycles observed-per-second**.

Frequency Weighting: A transfer function used to modify a signal according to a required dependence on vibration frequency.

- In human response to vibration, various frequency weightings have been defined in order to reflect known or hypothesized relationships between vibration frequency and human responses.
- The frequency weightings used to evaluate whole-body vibration in this Guide is W_m (whole-body) for all three axes (x, y, and z), in accordance with ISO 6954.

Motion Sickness: Various undesirable effects including sweating, nausea and vomiting caused by low-frequency (normally less than 0.5 Hz) oscillation in the vertical z-axis of the human body, primarily in the standing and sitting postures.

Motion Sickness Dose Value ($MSDV_z$): A cumulative measure of exposure to low-frequency oscillation that may be used to provide an indication of the probable incidence of motion sickness. The vertical Motion Sickness Dose Value $MSDV_z$, in $m/s^{1.5}$, is defined by the following expression:

$$MSDV_z = \sqrt{\int_0^T a_{zw}^2(t) dt}$$

Where $a_{zw}(t)$ is the z-axis acceleration as a function of time in meters-per-second squared (m/s^2), weighted by the W_f frequency weighting as defined in BS 6841:1987 and ISO 8041:1990/Amd.1:1999, and T is the duration of the motion in seconds.

In the case of shorter exposure periods with continuous motion of approximately constant magnitude, the Motion Sickness Dose Value may be estimated from the frequency-weighted **RMS** value determined over a short period. The Motion Sickness Dose Value ($m/s^{1.5}$) for the exposure period T_0 (s) is defined by the following expression:

$$MSDV_z = a_w T_0^{1/2}$$

Multi-Axis Acceleration Value: The Multi-Axis Acceleration Value is calculated from the root-sums-of-squares of the weighted **RMS** acceleration values in each axis (a_{xw} , a_{yw} and a_{zw}) at the measurement point using the following expression:

$$a_w = \sqrt{a_{xw}^2 + a_{yw}^2 + a_{zw}^2}$$

where a_{xw} , a_{yw} and a_{zw} are the weighted **RMS** acceleration values measured in the x-, y- and z-axes respectively.

Multi-Axis Vibration: Mechanical vibration or shock acting in more than one (1) direction simultaneously.

Passenger Space: Any space where a passenger may be present for twenty (20) minutes or longer at one (1) time during normal, routine, daily activities.

Reference Calibration: Calibration of a measuring instrument conducted by an accredited Testing and Calibration Laboratory with traceability to a national or international standard.

Velocity: The rate of change of distance over time (i.e., millimeters per second, mm/s)

Weighted Root-Mean-Square Acceleration Value (a_w): The weighted root-mean-square (**RMS**) acceleration a_w , in meters-per-second, is defined by the expression:

$$a_w = \sqrt{\frac{1}{T} \int_0^T a_w^2(t) dt}$$

where $a_w(t)$ is the weighted acceleration as a function of time in meters-per-second squared (m/s^2) and T is the duration of the measurement in seconds.

Whole-body Vibration: Mechanical vibration (or shock) transmitted to the human body as a whole. Whole-body vibration is often due to the vibration of a surface supporting the body.

4 Associated Documentation

The following documents provide details about **Test Plan** preparation, test measurement procedures and/or **Test Reporting**:

- ISO 6954:2000, Mechanical Vibration and Shock – Guidelines for the Measurement, Reporting and Evaluation of Vibration with Regard to Habitability on Passenger and Merchant Ships.
- ISO 2631-2:2003, Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole Body Vibration – Part 2, Vibration in Buildings.