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UKAS TESTING
No. 9388

TEST REPORT

Document Title:

Determination of the Pendulum Test Value (PTV) for a sample specimen referenced as:

MD-MW Metawalk, supplied by Metamark (UK) Limited.

Test procedure(s) in accordance with:

BS 7976-2:2002+A1:2013
Pendulum testers – method of operation.

UKSRG Guidelines-4:2011
The assessment of floor slip resistance.

Client:

Metamark (UK) Limited.

Client address:

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Octimum Business Park
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Prepared by:

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1st november 2016.

Report number:

11012-16/1191

Contract/Job number:

11012-16/1

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1 SCOPE:

We were instructed by Metamark (UK) Limited to determine the Pendulum Test Value (PTV) of the sample specimen referenced as: **MD-MW Metawalk.**

Pendulum slip tests were therefore undertaken using standard HSE techniques in accordance with BS 7976-2:2002+A1:2013, and the UK Slip Resistance Guidelines (UKSRG) – Issue 4:2011, where appropriate. Tests were carried out in both dry and wet conditions using a calibrated Wessex Pendulum Tester, rubber slider 96 which is a hard shoe heel type material and is the primary test rubber when evaluating flooring materials for pedestrian use, slider 55 which is used to simulate barefoot users and a Surtronic Micro-Roughness Tester.

Testing in wet surface conditions was completed using a fine mist of potable water applied using a hand held sprayer.

Photo 1.1: Sample specimen referenced as: MD-MW Metawalk.

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2 SUMMARY OF ASSESSMENT RESULTS[1]:

Pendulum Test Values (PTV) were determined in both dry and wet conditions. Wet conditions were simulated by the application of a fine mist of potable water using a hand held spray (see Section 3.1). The surface roughness (Rz) of each test area was also measured (see Section 3.2).

DETERMINATION OF PENDULUM TEST VALUE
IN ACCORDANCE WITH BS 7976-2:2001+A1:2013 AND THE UK SLIP RESISTANCE GROUP GUIDELINES, ISSUE 4:2011

Sample Specimen(s) Tested	Condition	Temp	Pendulum Test Value [PTV] & Direction of Test					Overall Slip Risk Potential	Overall Slip Risk [1] [Wet]
			A[1]	B[2]	C[3]	D[4]	MEAN		
(1) MD-MW Metawalk – Slider 96.	Dry	N/A	71	72	72	---	**72**	Low	1 in 1,000,000 users
	Wet		40	41	40	---	**40**	Low	
(2) MD-MW Metawalk – Slider 55.	Dry	16.4 °C	97	99	100	---	**99**	Low	Between 1 in 200 and 1 in 10,000
	Wet		28	28	29	---	**28**	Moderate	

Surface Roughness (Rz) Readings	MEAN
(1) MD-MW Metawalk.	**39.7 µm**

IMPORTANT: "When considering the Pendulum Test Value (PTV) and slip potential results, care should be taken when interpreting results that are close to the boundaries of the categories. The slip potential presented by a floor with a PTV of 35 is not significantly different from one with a PTV of 37. However, the slip potential presented by a floor with a PTV of 23 is considerably higher than one with a PTV of 26, when considering the biomechanical data currently available". [- UK Slip Resisitance Group Guidelines 2011,Issue 4].

Current UKSRG guidance suggests that the reading in the direction that gives the lowest PTV is likely to indicate the lowest slip resistance that a pedestrian would experience when walking at different angles and so should be considered when assessing the slip potential and design of any in-situ surfaces using this material.

[1] The risk ratios and results above are based on the basic condition of a reasonably active pedestrian aged between 18 -60 years, walking in a straight line at moderate pace, not rushing, turning, carrying, pushing or pulling a load. Moving away from this basic condition creates additional risks to users of the area and therefore increases slip potential. If such risks are identified then the likihood of a slip accident occurring is even higher than stated.

[1]Test Direction A = 180° parallel to the principle direction.
[2]Test Direction B = 90° to same.
[3]Test Direction C = 45° to same.
[4]Test Direction D = Not applicable to the sample submitted.

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3 EXPLANATION OF ASSESSMENT METHODS:

Research carried out by the Health and Safety Laboratory (HSL), in conjunction with the UK Slip Resistance Group (UKSRG), has shown that it is possible to assess the characteristics of floor surface materials needed for satisfactory slip resistance. The Health and Safety Laboratory has developed a set of "reliable and robust" test methods that forms the basis of our assessment protocols.

3.1 BS 7976-2:2002 + A1:2013 Pendulum Testers, Method of Operation:

Pendulum testing is carried out in accordance with BS 7976-2 and the UKSRG Guidelines 2011, where appropriate. These industry standard methods of testing are essentially the same but with a slight difference between the two methods of preparation of the rubber sliders.

A prepared rubber slider attached to a weighted "shoe" is allowed to swing from a horizontal point of release. The slider is mounted on a spring loaded bracket and makes contact with the floor for a known distance of 124 ± 1mm.

The rubber slider that contacts the floor is constructed of "4S" rubber (Standard Simulated Shoe Sole) also referred to as "Slider 96" and is designed to replicate the most common slipping motion experienced by pedestrians wearing shoes. A softer, more malleable rubber called "Slider 55" can be used to simulate a barefoot slip. Profiled surfaces are tested with both Slider 96 and Slider 55, on the basis that profiles have been shown to give a wide range of slip resistance values with different footwear. The height to which the shoe travels after contacting the floor gives a reading of the Pendulum Test Value (PTV), formally known as the Slip resistance Value (SRV). Pendulum testing is one of the few methods that model the formation of a hydrodynamic squeeze film between the floor and sole, a known major factor in a wet slip.

Test surfaces are subject to eight measurements of the PTV with the first three being discounted from any calculations. Tests are normally carried out in the [A] principal direction, [B] at 45° to the principal direction and [C] at 90° to the principal direction. A fourth direction is also measured when testing profiled surfaces. All testing is carried out in both dry and wet conditions as is intended to give a representative view of the floors intended service conditions. A total of at least 48 measurements are recorded and a mean PTV value is generated for wet and dry tests based on the performance in different directions.

The Pendulum Test Value (PTV) for each direction is calculated as the mean of five swings using the formula:

$$PTV = \frac{\sum (v4 + v5 + v6 + v7 + v8)}{5}$$

where $v4$ to $v8$ are individual values for each swing, or where there is significant variation through $v1$ to $v8$ it may be necessary to draw attention to the first readings. Although the dry results may not be of interest to the client it should be noted that the wet results might be reduced slightly if the dry testing was not undertaken as it is known that the slider is conditioned by the flooring material during the course of the dry tests.

When using "Slider 55" is it becomes necessary to correct the PTV value as PTV_{corr} using the table below:

Surface Temperature (°C)	PTV Correction to PTV_{corr}
8 to 11	Subtract 3 units
12 to 15	Subtract 2 units
16 to 18	Subtract 1 unit
19 to 22	No correction
23 to 28	Add 1 unit
29 to 35	Add 2 units

The PTV for each location is the mean of three individual PTV or PTV_{corr} determinations. A slip potential classification can then be applied using the UKSRG Guidelines, see the table below.

Pendulum Test Value (PTV)	Slip Potential
0 – 24	High
25 – 35	Moderate
36 +	Low

To further help reduce the slip potential it is important to understand the friction requirements of pedestrians. Data published by the Building Research Establishment (BRE): Floors and flooring – *performance, diagnosis, maintenance, repair and avoidance of defects (*P.W Pye & H.W Harrison 2003) showed that people have different friction requirements. This range of requirements was analysed and related to risk. If the Pendulum Test Value (PTV) is 36 the risk of slipping is one in a million, as the PTV reduces the risk increases and at a PTV of 19 the risk is one in two, see the table below.

Risk	Minimum PTV	Slip Potential
1 : 2	19	High
1 : 20	24	High
1 : 200	27	Moderate
1 : 10,000	29	Moderate
1 : 100,000	34	Moderate
1 : 1,000,000	36	Low

The risk ratios above are for the basic condition of a reasonably active pedestrian aged between 18 -60 years, walking in a straight line at moderate pace, not turning, carrying, pushing or pulling a load. Moving away from this basic condition will increase the required Pendulum Test Value. Similarily, if a sloping surface has to be negotiated then the PTV requirements will be greater and must be increased by:

$$100 \times \text{tangent } \alpha$$

where α is the slope angle. For example, a three degree slope (about 1 in 20 gradient) the tangent is 0.05. Therefore, the require PTV increases by 5 units and a PTV of 41 or above would only be considered acceptable.

An alternative measure of flooring slip resistance is its coefficient of dynamic friction (CoDF). PTV can be converted to CoDF using the formula below. It should be noted that CoDF describes an interaction between two specific surfaces and that this relationship is further complicated by the behaviour of any lubricating film between the two surfaces.

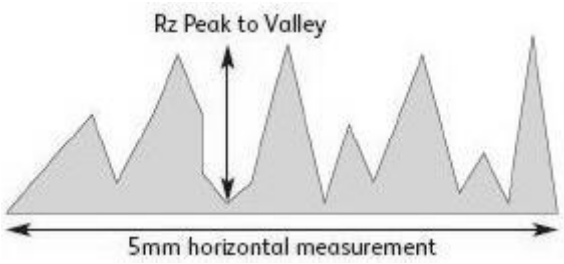
$$CoDF = (3xPTV) / (330-PTV)$$

The pendulum skid tester is one of the few test methods that accurately models the hydrodynamic squeeze film formed in a contaminated slip as experienced by pedestrians. This should be taken into account when comparing CoDF values for contaminated surfaces from other test methods.

3.2 Surface Roughness Measurement (Rz):

Surface roughness, in particular the Rz value describes the mean vertical peak to valley distance over a given horizontal sample. The microscopic construction of a surface affects its ability to puncture the fluid film generated in a slip. It is also a valuable tool to assess the wear level as over time traffic will smooth a floor surface, changing its slip potential.

National Testing use a Surtronic Duo surface roughness meter for assessment. The meter moves a stylus along a 5mm test surface, measuring the floor profile's average vertical peak to valley distance in microns (Rz). A test site will be measured ten times using this method, with samples taken randomly across the surface. Where results indicate a directional profile, ten measurements will be conducted along the profile and ten across the profile. This is in line with UKSRG guidance.



Surface roughness can be used to give a general indication of the slip risk potential of a floor, though it is by no means a comprehensive test. National Testing use surface roughness measurements married to pendulum results to enable accurate on-going monitoring of the surface. The UKSRG published the data shown in the table below to use in conjunction with pendulum testing.

Surface Roughness Rz (Microns)	Slip Potential
Less than 10µm	High
10 - 20µm	Moderate
Greater than 20µm	Low

Classification for the potential for slipping using Rz roughness in water-wet low level pedestrian areas.

As the viscosity of contaminants increases, the surface roughness required to maintain an acceptable level of slip resistance also increases.

Minimum Roughness	Contaminant
20 microns	Clean water, coffee, soft drinks
45 microns	Soap solution, milk
60 microns	Cooking stock
70 microns	Motor oil, olive oil
Greater than 70 microns	Gear oil, magerine

Recommended levels of roughness for commonly found contaminants (HSE,2004).

Whilst there is on-going research into the effect of surface roughness on slip resistance it is generally considered that the Rz parameter is a good *indication* of slip risk. Limitations of the Rz measurement are that it does not take into account the density or construction of micro-profile, simply its average height. The stylus measuring peak to valley height may travel around anti-slip particulate or may be too wide to measure the depth of narrow valleys. It is possible for surfaces to have similar Rz values and ultimately differing contaminated slip resistances. Furthermore, Rz does not take into account macro-profiling or the deformation of a softer floor.

National Testing use the relationship between Rz roughness and Pendulum Test Value (PTV) to determine likely thresholds for high, moderate and low slip risk. Where pendulum testing is impossible, such as on stair nosings, Rz measurements married to a similar nearby surface is sometimes the only way to relate a PTV, as recognised by the

UKSRG guidelines. This is based on a linear approximation of the relationship between Rz and PTV, referred to by us at SATRz and is to be considered *as a guide only*.

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4 CONCLUSIONS

4.1 Pendulum tests completed using slider 96 for SHOD pedestrians:

The sample specimen referenced as: **MD-MW Metawalk** demonstrated a low-slip potential when tested in both dry and surface wet conditions. The statistical risk of a slip accident occurring in both dry and surface wet conditions is 1 in 1,000,000 users *(*P.W Pye & H.W Harrison 2003).

4.2 Pendulum tests completed using slider 55 for BAREFOOT pedestrians:

The sample specimen referenced as **MD-MW Metawalk** demonstrated a low-slip potential when tested in dry surface conditions. The statistical risk of a slip accident occurring in these conditions is 1 in 1,000,000 users *(*P.W Pye & H.W Harrison 2003).

However, after the application of a fine mist spray of potable water the sample specimen referenced as: **MD-MW Metawalk** demonstrated a moderate-slip potential when tested under wet surface conditions. The statistical risk of a slip accident occurring in wet conditions is significantly increased to between 1 in 200 and 1 in 10,000 users *(*P.W Pye & H.W Harrison 2003).

IMPORTANT: "When considering the Pendulum Test Value (PTV) and slip potential results, care should be taken when interpreting results that are close to the boundaries of the categories. The slip potential presented by a floor with a PTV of 35 is not significantly different from one with a PTV of 37. However, the slip potential presented by a floor with a PTV of 23 is considerably higher than one with a PTV of 26, when considering the biomechanical data currently available". [- UK Slip Resisitance Group Guidelines 2011,Issue 4].

Also, the risk ratios quoted above are for the basic condition of a reasonably active pedestrian aged between 18 -60 years, walking in a straight line at moderate pace, not turning, carrying, pushing or pulling a load. Moving away from this basic condition will increase the required Pendulum Test Value and additional control measures may need to be formalised by responsible parties in order to adequately manage any identified risks. Similarily, if a sloping surface has to be negotiated then the PTV requirements will be greater and must be increased by:

$$100 \times \text{tangent } \alpha$$

where α is the slope angle.

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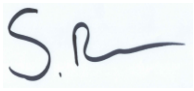
The above assessment was carried out by National Testing Services Limited adhering to the UKSRG, HSE and CIRIA guidelines on pedestrian slip risk assessment, where appropriate. The results given are accurate representations of data acquired on the test date. The results presented only relate to the sample specimen(s) submitted or site measurements recorded at the time of the testing. The results have been interpreted to give slip risk classifications based on parameters recommended by the UKSRG and HSE.

Sample specimen(s) tested by:



Scott Armstrong
Technician
01/11/16

Report authorised for and on behalf of National Testing Services Limited by:

Philip Nolan
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01/11/16

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