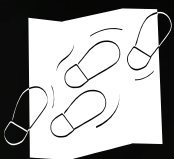
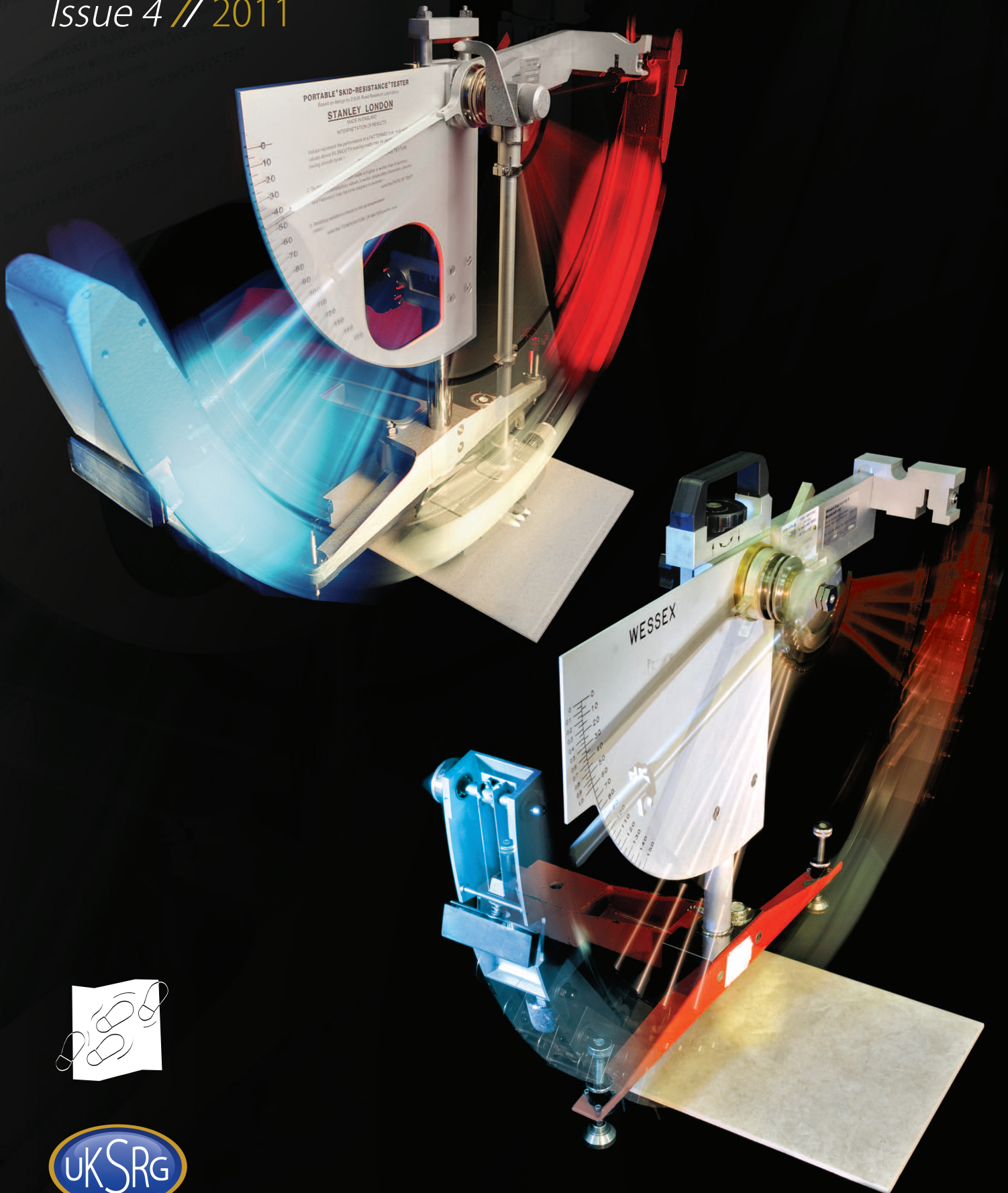


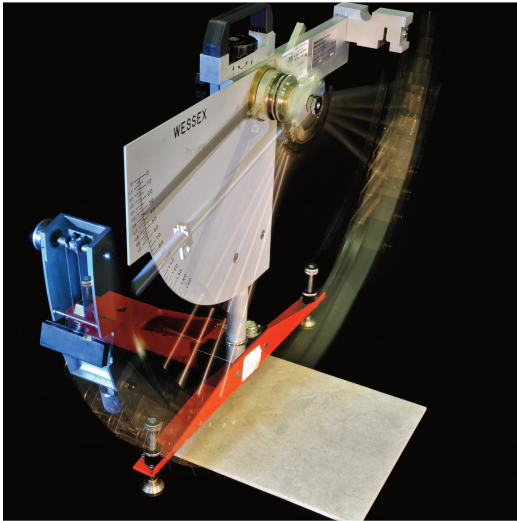
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The Assessment of Floor Slip Resistance

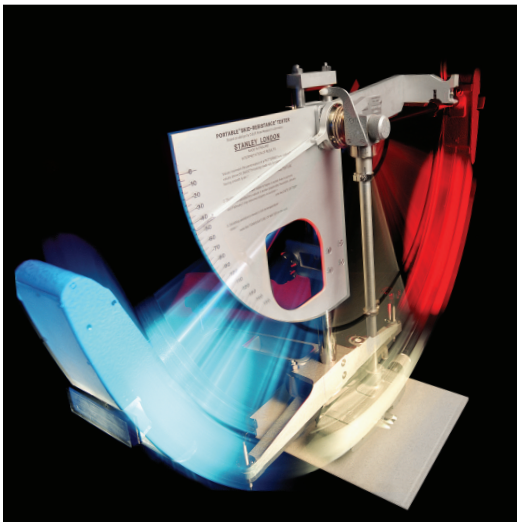
The UK Slip Resistance Group Guidelines

Issue 4 // 2011





The UK Slip Resistance Group (UKSRG) was formed more than 20 years ago by a small group of people interested in pedestrian slipping. The UKSRG aims to further the understanding of pedestrian slipping throughout the UK and elsewhere. It promotes methods of test that have been shown to reliably demonstrate the slip potential of floor surfaces.



The revisions included in issue 4 of the UKSRG guidelines improve the reliability and precision of the Pendulum test method. A new validation surface has been introduced which provides a useful check at an important point on the Pendulum scale and makes the verification process more robust.

THE ASSESSMENT OF FLOOR SLIP RESISTANCE

The UK Slip Resistance Group Guidelines Issue 4.0, September 2011

The UK Slip Resistance Group

This influential body was set up by Rapra Technology Ltd in 1986. In 2001 the UK Slip Resistance Group (UKSRG) became fully independent of Rapra who remain an active member. Group members are drawn from flooring manufacturers, health and safety organisations, engineering consultants, testing & research organisations and slip test equipment manufacturers.

These guidelines contain standard procedures for the assessment of the slip resistance of flooring materials. An accurate assessment of the slip resistance of flooring leads to an understanding of the pedestrian slip risk at the specification stage or in assessing the built environment.

Advice on slip related problems can be obtained by using the 'contact us' facility on the UKSRG website at www.ukslipresistance.org.uk

IMPORTANT NOTE

Understanding the potential for slipping accidents to occur requires not simply obtaining a particular value from an instrument, but also an assessment of other factors, for example, the type of contaminant involved, the cleaning method, type of footwear, etc.

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1 General Principles

The United Kingdom Slip Resistance Group (UKSRG) and the Health & Safety Executive (HSE) currently recommend the use of two instruments for the assessment of slip resistance, the Transport Road Laboratory (TRL) Pendulum and an appropriate roughness meter, including non-contact types, which measures the Rz parameter. Research has shown that, combined with the Pendulum, a roughness meter can provide useful supplementary information.

Interpretation of data obtained by measurement is not always straightforward, and the instruments involved, in particular the Pendulum, are very dependent on being set up correctly, being used in the correct manner and being used with the correct protocol.

In August 2002, the British Standards Institute (BSI) published BS 7976: 1-3, Part 2 of which gives a method of Pendulum operation. These Guidelines are a further development of the methodology detailed in the British Standard, but include additional information, and are written in more accessible terms than the rigid structure used in the British Standard document.

Evaluations using these Guidelines can be made either on site (on installed materials) or in the laboratory (on uninstalled samples). Tests may also be undertaken in the laboratory on samples that have been finished to a similar state as they would be during installation. It should be noted that values obtained on uninstalled materials may, for a variety of reasons, change when that material is used in service.

This document is based on present knowledge, and will be updated or replaced as new information becomes available. Details of any amendments and of subsequent issues are available at www.ukslipresistance.org.uk

2 Background Information

2.1 Why the Pendulum?

The Pendulum has been chosen by the UKSRG and the HSE for two main reasons. Firstly, unlike most other available instruments, it reproduces the same hydrodynamic uplift characteristics that occur when a person slips in liquid-contaminated conditions. Secondly, good correlation between the readings given by the instrument and the incidence of pedestrian slipping accidents has been observed since the 1940s.

For many years the Pendulum has been the only instrument for the purpose of floor surface slip resistance measurement described in British Standards. Such was the confidence of the members of BS Committee B/556 that a new British Standard was drafted around this instrument (BS 7976:2002).

2.2 Why Surface Roughness?

Surface microroughness is integrally linked to the formation of a hydrodynamic lubricating film, also known as a 'squeeze film', and its uplift effect on a particular surface. It is the roughness of a surface that provides a means of solid-to-solid contact through the squeeze film when a contaminant is introduced. Over a particular surface, or generic types of surface, there is a relationship between roughness readings and Pendulum values. This relationship can be used to characterise and compare particular locations, where it might be impossible or impracticable to set up the Pendulum, for instance on some flights of stairs or in confined spaces.

2.3 Health & Safety Reminder...

As a result of the mass of the Pendulum and the stabilising weight, it is the responsibility of the user to ensure that a suitable risk assessment has been compiled concerning their transportation and movement. For those working in the UK, any assessment should be in accordance with the Manual Handling Operations Regulations, 1992. For other locations, the local requirements and standards for risk assessment should be considered.

3 Using the Pendulum

3.1 Scope

This section is intended to cover the essential procedures for measuring the Pendulum Test Value (PTV) in a straightforward on-site situation. Later sections describe how to modify the procedure when measuring in the laboratory or on profiled surfaces, on ramps or on some flights of stairs.

The procedures relate to both dry and wet situations.

3.2 Equipment

1. Pendulum conforming to BS 7976-1 (e.g. Munro-Stanley or Wessex types). N.B. There are slight operational differences between the setting up procedures of the two types. The instructions given in the document will highlight these differences as appropriate. Users are advised to familiarise themselves with the instrument specific instructions provided by the manufacturer.
2. 75mm x 25mm x 6mm Slider 96 rubber, formerly known as Four S rubber, (specification given in Table 3.1) should be used for assessing slip potential in all areas used by shod pedestrians.
3. 75mm x 25mm x 6mm Slider 55 rubber, formerly known as TRRL rubber, (specification given in Table 3.1) should be used for assessing slip potential in areas used by barefoot pedestrians.

NOTE: On profiled surfaces, undertaking measurements with both slider 96 and slider 55 will help the user to understand the range of behaviour that may be seen with different footwear (sections 8.1 & 9.3).

4. Gauge to set the sliding length, 124mm +/- 1mm, with a thickness of 8mm (this differs from that required by Issue 3 of these guidelines).
5. Thermometer.
6. Float glass sheet 150mm x 100mm or larger for Pendulum verification. There should be no visible scratches on, or damage to the glass surface.
7. 3M™ Lapping Film Aluminium Oxide 261X 3µm (also known as pink lapping film) for preparation of slider 96 and Pendulum verification.

NOTE: The matt surface shall be used.

8. 3M™ Lapping Film Aluminium Oxide 261X 30µm (also known as green lapping film) for preparation of slider 55 and Pendulum verification.

NOTE: The matt surface shall be used.

9. A certified Pavigrés tile for verification purposes, 150mm x 100mm or larger for Pendulum verification. There should be no visible scratches on, or damage to the tile surface.
10. P400 grade resin bonded silicon carbide abrasive paper for preparation of sliders.
11. Spray bottle containing potable water. Use of distilled or deionised water is not necessary.
12. A minimum of 6kg weight to be placed on the back foot of the Stanley Pendulum to ensure stability during testing (this is not necessary with the Wessex Pendulum).
13. An appropriate detergent solution for removing contamination from the floor surface.
14. Surface microroughness meter capable of measuring the Rz parameter.
15. Disposable paper towels.
16. An inclinometer or angle gauge to measure slope of flooring under test.
17. Suitable test proforma (an example is provided in Appendix A) or notebook.
18. If the troubleshooting guide is used (see section 11), you will also need a small spirit level or angle gauge to check Pendulum setup.

Users may find a sample holder useful for verification and the testing of sample flooring materials. The sample holder must hold the sample or verification surfaces firmly without rocking and should also resist the force applied by the pendulum swing. Example sample holders are shown on the UKSRG website.

Suppliers of all of the specialist materials detailed above are listed under the *UKSRG Guidelines* heading at www.ukslipresistance.org.uk.

Slider storage and life

Slider rubbers have a 12 month shelf life from the date of manufacture. Sliders are stamped with a batch number, and will be supplied with a certificate indicating the date beyond which they should not be used. This certificate should be retained, and the batch number noted with test results. When not in use, sliders should be stored in the dark to avoid UV radiation, between 5°C and 23°C.

Note. It is important that all sliders are properly prepared before use. Preparation of slider 96 is detailed in section 4, preparation of slider 55 is detailed in section 5. Use of other slider materials is not recommended due to difficulties with slider preparation and validation of test results. Use of a specific shoe sole material does not necessarily give an indication of the slip resistance that a pedestrian would experience whilst wearing shoes soled with that material (see section 9.3).

Table 3.1. Selected Properties of the Slider Materials

Material	Temperature, °C	Resilience ^a , %	Hardness ^b , IRHD
Slider 96 rubber	5	19 to 23	96 ± 2
	23	22 to 26	
	40	26 to 30	
Slider 55 rubber	0	43 to 49	55 ± 5
	10	58 to 65	
	20	66 to 73	
	30	71 to 77	
	40	74 to 79	

^a Lüpke rebound test in accordance with BS 903-A8:1990.
^b International Rubber Hardness Degrees in accordance with BS 903-A26:1995.

3.3 Setting Up the Stanley Pendulum

(See 3.4 for the Wessex Pendulum)

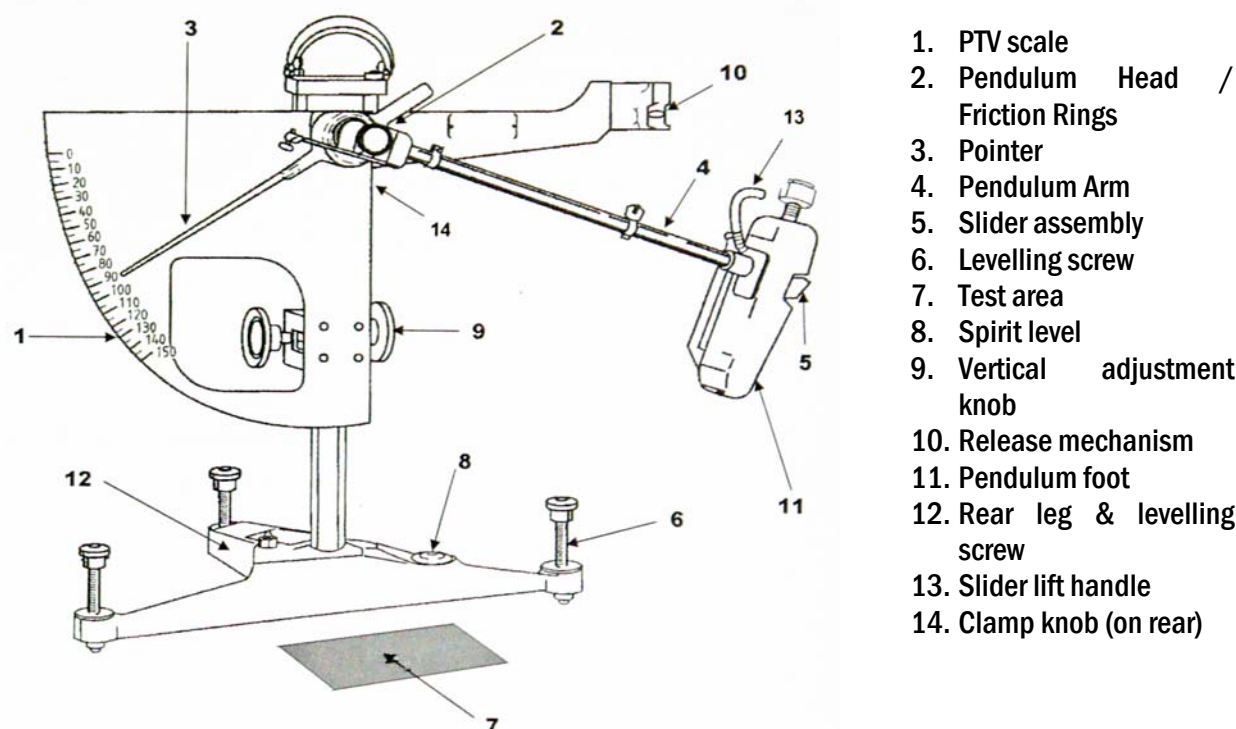


Figure 3.2 The Stanley Pendulum

The Pendulum tester is a relatively simple device, which is manufactured to very fine tolerances. The Pendulum should be treated with care in order to avoid damage. Good reproducibility and repeatability between instruments, including between Stanley and Wessex instruments is possible. However, this is known to be critically dependent on precise setting up, and attention to detail is required.

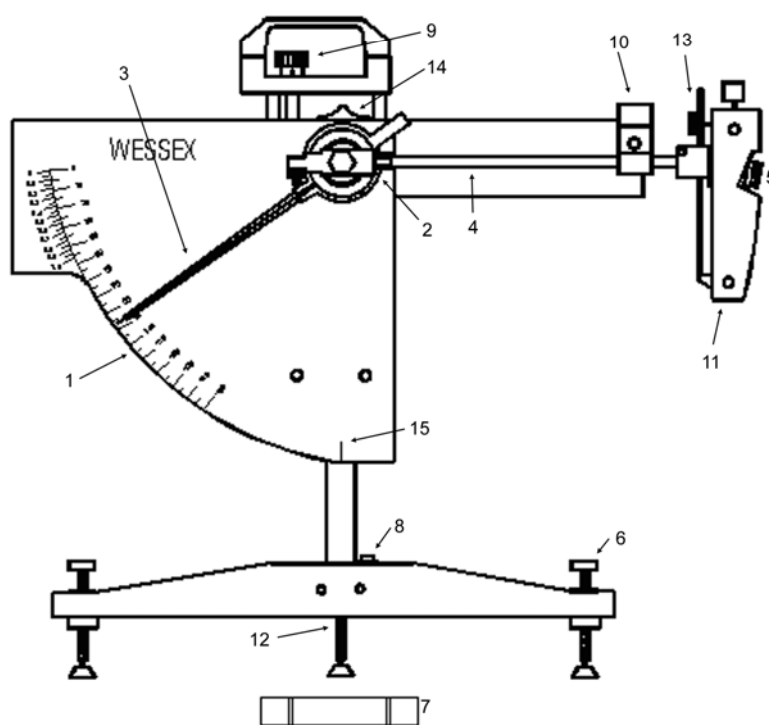
The numbers in parenthesis given in this section refer to the key in Figure 3.2.

1. Unfold the rear leg (12), place the washer over the threaded stud and secure with the retaining nut; using the spanner provided to ensure that the retaining nut is tight.
2. Attach the Pendulum arm (4) to the Pendulum head (2). Latch the Pendulum arm into the release mechanism (10). Fully tighten the retaining nut using a C-spanner.
3. Place the weight on the back foot.
4. In the interest of stability, the Pendulum base is levelled at the minimum height that gives clearance over the floor, rather than using the full range of the levelling screws. The full range of adjustment is only needed on slopes, uneven surfaces or thick flooring samples in the laboratory.
5. The Pendulum base is levelled with the levelling screws at the end of each leg (6) in conjunction with the built-in spirit level (8). The bubble should lie in the centre of the inner circle when viewed from above. Take care to avoid parallax error when looking onto the spirit level. Once level, ensure the levelling screw lock-nuts are tight (if the Pendulum does not have lock-nuts, they should be retrofitted before further use).
6. Whilst firmly holding the vertical adjustment knob (9) release the Pendulum head clamp knob (14), then using the vertical adjustment knob (9), raise the head of the Pendulum to its full extent. Firmly re-clamp the head.
7. Check there is no visible damage to the instrument, e.g. the Pendulum arm is not bent, the pointer (3) is not deformed, etc.
8. Whilst holding the Slider lift handle (13) press the release button (10) to release the Pendulum arm. Using the Slider lift handle, manually swing the arm through a full arc to ensure clearance of the foot over the floor surface, and ensure it does not strike any nearby objects. Check that the pointer (3) does not catch on the frame at any point, and that the foot (11) swings parallel to the Pendulum base. Clip the arm back into the release mechanism.
9. To operate the release mechanism, the index finger should be positioned behind the vertical upstand immediately above the button, and the button squeezed between the thumb and finger.
10. Press the release button to release the arm, which should swing clear over the surface to be tested. The arm should release cleanly from the mechanism. Catch the arm on the return swing and return it to the release mechanism.
11. If while the arm is swinging there is any tendency for the base of the Pendulum to move relative to the surface, non-slip pads under the levelling screws (6) should be used. Always re-level the instrument after inserting non-slip pads.

3.4 Setting Up the Wessex Pendulum

(See 3.3 for the Stanley Pendulum)

The Pendulum tester is a relatively simple device, which is manufactured to very fine tolerances. The Pendulum should be treated with care in order to avoid damage. Good reproducibility and repeatability between instruments, including between Wessex and Stanley instruments is possible. However, this is known to be critically dependent on precise setting up, and attention to detail is required.



1. PTV scale
2. Pendulum Head / Friction Rings
3. Pointer
4. Pendulum Arm
5. Slider assembly
6. Levelling screw
7. Footprint ruler
8. Spirit level
9. Vertical adjustment knob
10. Release mechanism
11. Pendulum foot
12. Rear leg & levelling screw
13. Slider lift handle
14. Clamp knob (on rear)
15. Pointer alignment mark

Figure 3.3 The Wessex Pendulum

The numbers in parenthesis given in this section refer to the key in Figure 3.3.

1. Slot the removable rear leg (12) into position over the threaded stud, slide on the washer and secure with the retaining nut; using the spanner provided to ensure that the retaining nut is tight.
2. Attach the Pendulum arm (4) to the Pendulum head (2). Latch the Pendulum arm into the release mechanism (10). Fully tighten the retaining nut.
3. Stand Pendulum on the non-slip plates provided.
4. In the interest of stability, the Pendulum base is levelled at the minimum height that gives clearance over the floor, rather than using the full range of the levelling screws. The full range of adjustment is only needed on slopes, uneven surfaces or thick flooring samples in the laboratory.
5. The Pendulum base is levelled with the levelling screws at the end of each leg (6) in conjunction with the built-in spirit level (8). The bubble should lie in the centre of the inner circle when viewed from above. Take care to avoid parallax error when looking onto the spirit level. Once level, ensure the levelling screw lock-nuts are tight (if the Pendulum does not have lock-nuts, they should be retrofitted before further use).
6. Release the Pendulum head clamp knob, then using the vertical adjustment knob (9) raise the head of the Pendulum to its full extent. Firmly re-clamp the head.
7. Check there is no visible damage to the instrument, e.g. the Pendulum arm is not bent, the pointer (3) is not deformed, etc.

8. Whilst holding the Slider lift handle (13) press the release button (10) to release the Pendulum arm. Using the Slider lift handle, manually swing the arm through a full arc to ensure clearance of the foot over the floor surface, and ensure it does not strike any nearby objects. Check that the pointer (3) does not catch on the frame at any point, and that the foot (11) swings parallel to the Pendulum base. Clip the arm back into the release mechanism.
9. To operate the release mechanism, the index finger should be positioned behind the vertical upstand immediately above the button, and the button squeezed between the thumb and finger.
10. Press the release button to release the arm, which should swing clear over the surface to be tested. The arm should release cleanly from the mechanism. Catch the arm on the return swing and return it to the release mechanism.

3.5 Setting the Zero

1. Check that the Pendulum head assembly is raised to its fully raised position so that the foot (with the slider assembly attached) can swing over the test surface without contacting it.
2. Secure the arm in the release mechanism.
3. Bring the pointer round to its stop, i.e. fully anticlockwise, using the pointer counterweight. Avoid using the pointer itself, which is easily damaged.
4. Release the arm by pressing the button as described in 3.3.9 / 3.4.9. Allow the arm to swing through its full arc and then catch it on its return swing before it reaches the vertical position.

It is suggested that this is done with the same hand, whilst keeping your other hand out of the way, in order to avoid striking your arm with the Pendulum arm. This also reduces the tendency of inexperienced operators to catch the arm during the upswing, rather than as it falls back. It is important that in pressing the release catch you do not inadvertently apply forces to the frame of the instrument, i.e. check you are not using the instrument to support yourself.
5. Mentally note the pointer reading.
6. Return the Pendulum arm to its release mechanism. If the reading was exactly zero, repeat steps 3 – 6 twice more and then make a note that the zero is correctly adjusted.
7. If the reading was not exactly zero, the pointer friction rings need to be adjusted as follows. Unscrew the outer locking ring; only a fraction of a turn will be necessary. Rotate the inner friction ring, either clockwise if the pointer gave a negative reading, or anticlockwise if the pointer gave a positive reading. Generally only a movement of 10° – 30° will be required. Lock the setting by rotating the outer locking ring clockwise.
8. Repeat steps 3 – 7 until three consecutive zero readings are obtained and then make a note that the zero is correctly adjusted. If three consistent reading are not possible, consult the Troubleshooting Guide (section 11).
9. Check that the friction rings adequately damp the movement of the pointer. The pointer should not continue to move when the force causing the movement is removed. Inadequate damping often shows up as scatter in results during testing.

Setting or checking the zero should always be carried out:

- a. Immediately after setting up the instruments in a new location;
- b. After changing a slider;
- c. At any stage during a series of tests at a particular location where readings do not appear to be consistent with one another;
- d. At the end of a test or series of tests before repositioning the instrument. This is to check that the zero has not shifted for some reason during the test and might thus invalidate the readings.

3.6 Conducting the Test

Floor surfaces should be assessed in relation to their use or intended use and particularly the nature of any contaminant likely to be found on their surface. Floors that will only ever be used in a clean and dry condition only need to offer low slip potential when clean and dry. Cleaning processes on such floors need careful management to ensure this is the case in use.

The test sequence on an area / sample of flooring should consist of:

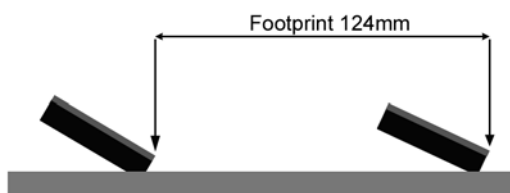
1. Slider preparation / re-preparation
2. Dry test in direction 1
3. Dry test in direction 2 (90° to direction 1)
4. Dry test in direction 3 (45° to direction 2)
5. Wet test in direction 1
6. Wet test in direction 2 (90° to direction 1)
7. Wet test in direction 3 (45° to direction 2)

In some cases, the dry tests may not be of interest to the user. However, it should be noted that the wet PTV might be reduced slightly if the dry testing is not undertaken, as the slider is conditioned by the flooring material in the course of the dry tests. When testing in the wet condition, the exact area used for dry testing should be avoided, as the surface may be contaminated with deposits of rubber from the test slider.

Check that the instrument reads zero (see section 3.5), that the slider fitted has been prepared (see section 4.1 & 5.1) and that the Pendulum is correctly set up (see section 3.3 or 3.4).

1. Setting the correct slider contact length

In this operation the Pendulum head is adjusted in height so that the distance across which the slider contacts the surface to be tested is adjusted. The footprint should be 124 +/- 1mm, measured on the trailing edge of the backing plate (see diagram).



This is normally accomplished in a series of small steps using the appropriate gauge as follows:

- a) With the arm hanging freely, raise or lower the Pendulum head so that the slider is just clear of the surface.
- b) Position the centre of the gauge approximately level with the rear edge of the slider backing plate.
- c) Move the Pendulum foot to the right and lower the head so that the slider starts to contact the test surface with its rear corner level with the right outermost mark on the gauge. Either clamp or manually hold the head in that position.
- d) Raise the slider with the slider lifting handle and move the Pendulum foot to left hand side sufficiently to ensure the slider is clear of the surface when the slider is lowered.
- e) Gently lower the Pendulum foot so that the slider contacts the test surface.
- f) The rear edge of the slider should lie in between the two left hand gauge marks. If not, then raise or lower the Pendulum head so that the slider is moved about 50% of the distance towards the correct setting.

- g) Reclamp the head, reposition the gauge so that the corner of the slider is level with the left hand outermost gauge mark and then move the Pendulum foot over to the right hand side and check it lines up with the either of the two right hand gauge marks. If not, repeat the process, backwards and forwards until the Pendulum head is set at the correct height to give a 124 +/- 1 mm footprint.

2. Secure the arm in its release mechanism.

3. Prepare the test area.

Unless the test is to determine the 'as found' condition, the test area should be thoroughly cleaned in order to eliminate (or indeed to demonstrate in conjunction with an 'as found' test) any effect due to deficiencies of the normal cleaning of the floor. Ensure the floor surface is well rinsed with clean water and dried before testing.

4. Apply any test contaminant.

- a) If the test is to be carried out in the dry state – check that both the floor and the slider are fully dry as even small amounts of residual moisture can affect the results.
- b) If the test is to be carried out in the water-wet state, spray a film of water to uniformly wet the full test area.
- c) If some other contaminant, for example dust or oil, is to be used, this should be evenly distributed over the test area.

5. Bring the pointer round to its stop, i.e. fully anticlockwise, using the pointer counterweight. Avoid using the pointer itself, which is easily damaged.

6. Release the Pendulum arm as described in 3.3.9 / 3.4.9. Take care not to jerk or lean on the instrument while doing so.

7. Catch the Pendulum arm on its return swing before the slider comes in contact again with the test surface.

8. Read and record the value indicated by the pointer on the scale. A typical result form is provided in Appendix A. Judgement must be used in order to evaluate the reading to the nearest whole number as the scale is only marked every five units. Care should be taken to avoid parallax, looking along the axis of the pointer towards the scale can be useful.

9. Record the reading and repeat steps (4) to (8) to give a total of eight readings.

10. The Pendulum Test Value (PTV) is the median of the last 5 readings.

11. After the test wipe the slider with a dry paper towel.

12. If testing on site, wipe up all water/contaminant from the floor so as not to leave it in a potentially dangerous state.

4 Slider 96

Slider 96 rubber, formerly known as Four S rubber, should be used for assessing pedestrian slip potential in all areas used by shod pedestrians. Slider 96 is a standard test rubber that simulates a shoe heel of moderate slip resistance. This enables a consistent measure of the floors contribution to the slip potential. Understanding how the floor behaves helps to identify other control measures including cleaning, footwear and behavioural aspects.

4.1 Preparing Slider 96

Slider preparation is critical to achieving good reproducibility. New sliders should be prepared in order to start each test with the slider in the same condition; the procedure can also be used to re-prepare a slider that has already been used. Slider preparation is required for both Slider 96 and Slider 55 rubber, but the procedures differ. For preparation and verification of Slider 55 see section 5. Standard sliders should be 76mm wide, as described in Figure 12.2.

New Slider 96:

1. Fit the new slider to the Pendulum.
2. Clean the float glass with an unused clean paper towel.
3. Ensure the glass plate is restrained (ideally clamped or braced) to prevent movement.
NB Blue tack has been shown to be inadequate, strong tape can be effective.
4. Fix an unused, flat piece of P400 paper to the float glass, with the adhered edge to the right. Fixing only the right edge allows the paper to sit flat under the slider without a tendency to crease.
5. Set the Pendulum to test the surface, i.e. with 124mm footprint measured on the trailing edge of the backing as described in 3.6.
6. Carry out 10 swings of the Pendulum arm, locking the arm into the raised position and releasing for each swing.
7. Re-adjust the footprint and repeat step 6, to give a total of 20 swings on the P400 surface.
8. You do not need to record the values obtained.
9. The chamfered edge of the slider should now measure a minimum of 1mm. If this is not the case, repeat steps 5 & 6.
10. Replace the P400 paper with an unused piece of Pink Lapping Film, with the matt side facing up and adhered to the right.
11. Set the Pendulum to test the surface.
12. Spray the surface of the lapping film with potable water.
13. Carry out 20 swings of the Pendulum arm, locking the arm into the raised position and releasing for each swing. Keep the surface wet by applying water between each swing. You do not need to record the values from this stage.
14. Wipe slider with paper towel to ensure it is clean and dry.

Re-preparation of worn slider

1. Clean the slider using paper towel to ensure no cross-contamination of test areas.
2. Carry out a minimum of 3 swings on the P400 paper mounted on float glass, as per new slider preparation to remove any grooves. N.B. after testing a rough surface, more than 3 swings may be required to remove any grooves from the working edge of the slider. The footprint should be checked between sets of 3 swings in order to avoid incorrectly shaping the working edge.
3. Repeat steps 10 – 14 of the new slider preparation procedure.

The working edge of the slider should be in the range 1 – 4mm. Both edges of the slider can be used.

4.2 Verification Using Slider 96

Verification of the Pendulum was introduced into the British Standard as a regular means of ensuring that the instrument has not developed defects, which could result in erroneous readings. These guidelines take this a stage further in order to make the verification more robust.

Verification using Slider 96 is achieved by testing a piece of float glass, an unused sample of Pink Lapping Film and a certified sample of Pavigrés tile, all of which provide consistent surfaces for this purpose. All of these tests are undertaken in line with section 3.6, though only in the water-wet condition. The float glass and Pavigrés tile must be clean and free from scratches or other defects. The pink lapping film can vary slightly from batch to batch, which is reflected in the PTV range below. The certified Pavigrés tile is expected to last a full Pendulum calibration period of one year.

The verification PTVs should be as shown in Table 3. The surfaces should be tested in the order shown in Table 3. The slider does not need to be reconditioned between the verification tests. Verification should be undertaken prior to each day's usage of the Pendulum and following re-assembly of the Pendulum following transportation. The verification results should be recorded.

Table 3. Verification PTVs

Verification Surface		Slider 96 Rubber
1	Pink Lapping Film (wet)	59 – 64
2	Float Glass (wet)	5 – 10
3	Pavigrés Tile (wet)	32 – 36

The slider footprint should be set on the Pavigrés tile in the same position each time, with the tile in the same orientation. The supplier of the certified tile will mark the footprint and direction of use, as illustrated below:

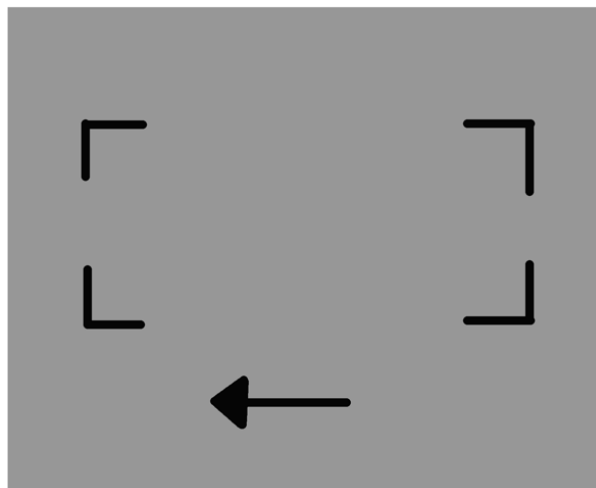


Figure 4.1 Markings to indicate Pavigrés tile test position and direction.

Should the verification values not be obtained, the user should re-visit the set-up procedure, including replacing or re-preparing the slider. A troubleshooting guide (section 11) is provided for less common problems with the Pendulum. If the verification values are still not obtained, the Pendulum may need repair and / or re-calibration.

5 Slider 55

Slider 55 rubber, formerly known as TRRL rubber, should be used for assessing pedestrian slip potential in areas used by barefoot pedestrians. Laboratory tests comparing Slider 55 Pendulum test data with barefoot ramp test data shows reasonable agreement between the tests. It has also been found to help to explain wet barefoot slipping accidents, which is one of the most important criteria for assessing the validity of a particular method. The use of Slider 55 has not been as widespread as the use of Slider 96, and as such further validation work is ongoing at several institutions to further the understanding of this test protocol.

Slider 55 is also useful in understanding the range of behaviour that may be experienced with different footwear on profiled surface (i.e. with a raised geometric pattern), as detailed in Section 8.1.

Preparation of the Slider 55 rubber follows the same process as for Slider 96, but the pink lapping film is substituted with green lapping film. Testing on pink lapping film has shown the Slider 55 rubber to be sensitive to the width of the working edge (slider length), which suggests that the variation in squeeze film thickness due to working edge is significant on this surface. The Green Lapping Film has a higher level of roughness, and therefore does not show this sensitivity. The squeeze film equation used to calculate the thickness of the squeeze film uses the assumption that neither of the surfaces deform, which may be a good approximation for Slider 96, but Slider 55 certainly does deform as it hits the surface of the material under test.

5.1 Preparing Slider 55

Slider preparation is critical in achieving good reproducibility. New sliders should be prepared in order to start each test with the slider in the same condition; the procedure can also be used to re-prepare a slider that has already been used. Slider preparation is required for both Slider 96 and Slider 55 rubber, but the procedures differ. Slider 55 is prepared with green lapping film. Standard sliders should be 76mm wide.

New Slider 55:

1. Fit the new slider to the Pendulum.
2. Clean the float glass with a new paper towel.
3. Ensure the glass plate is restrained (ideally clamped or braced) to prevent movement.
N.B. Blue tack has been shown to be inadequate, strong tape can be effective.
4. Fix an unused, flat piece of P400 paper to the float glass, with the adhered edge to the right. Fixing only the right edge allows the paper to sit flat under the slider without a tendency to crease.
5. Set the Pendulum to test the surface, i.e. with 124mm footprint measured on the trailing edge of the backing.
6. Carry out 10 swings of the Pendulum arm, locking the arm into the raised position and releasing for each swing.
7. Re-adjust the footprint and repeat step 6, to give a total of 20 swings on the P400 surface.
8. You do not need to record the values obtained.
9. The chamfered edge of the slider should now measure a minimum of 1mm. If this is not the case, repeat steps 5 & 6.
10. When preparing slider 55 rubber, some burring of the working edge can occur, and this needs to be removed by rubbing with paper towel before proceeding with the final stages of preparation.
11. Replace the P400 paper with an unused piece of Green Lapping Film, with the matt side facing up and adhered to the right.
12. Set the Pendulum to test the surface.

13. Spray the surface of the lapping film with potable water.
14. Carry out 20 swings of the Pendulum arm, locking the arm into the raised position and releasing for each swing. Keep the surface wet by applying water between each swing.
15. Wipe slider with paper towel.

Re-preparation of worn slider

1. Clean the slider to ensure no cross-contamination occurs from one test area to the next.
 2. Carry out a minimum of 3 swings on the P400 paper mounted on float glass, as per new slider preparation to remove any grooves. N.B. after testing a rough surface, more than 3 swings may be required in order to remove any grooves from the working edge. The footprint should be checked between sets of 3 swings in order to avoid incorrectly shaping the working edge.
 3. Repeat steps 10 – 15 of the new slider preparation procedure.
- The working edge of the slider should be in the range 1 – 4mm. Both edges of the slider can be used.

5.2 Verification Using Slider 55

Verification of the Pendulum was introduced into the British Standard as a regular means of ensuring that the instrument has not developed defects, which could result in erroneous readings. These guidelines take this a stage further in order to make the verification more robust.

Verification using Slider 55 is achieved by testing a piece of float glass, an unused sample of Green Lapping Film and a certified sample of Pavigrés tile, all of which provide consistent surfaces for this purpose. All of these tests are undertaken in line with section 3.6, though only in the water-wet condition. The float glass and Pavigrés tile must be clean and free from scratches or other defects. The pink lapping film can vary slightly from batch to batch, which is reflected in the PTV range below. The certified Pavigrés tile is expected to last a full Pendulum calibration period of one year.

The verification PTVs should be as shown in Table 4. The surfaces should be tested in the order shown in Table 4. The slider does not need to be reconditioned between the verification tests. Verification should be undertaken prior to each day's usage of the Pendulum and following re-assembly of the Pendulum following transportation. The verification results should be recorded.

Table 4. Verification PTVs

Verification Surface		Slider 55 Rubber
1	Green Lapping Film (wet)	60 – 66
2	Float Glass (wet)	5 – 10
3	Pavigrés Tile (wet)	13 – 19

The slider footprint should be set on the Pavigrés tile in the same position each time, with the tile in the same orientation. The supplier of the certified tile will mark the footprint and direction of use, as illustrated in Figure 4.1.

Should the verification values not be obtained, the user should re-visit the set-up procedure, including replacing or re-preparing the slider. A troubleshooting guide (section 11) is provided for less common problems with the Pendulum. If the verification values are still not obtained, the Pendulum may need repair and / or re-calibration.

6 Using the Pendulum for Laboratory Tests

Tests carried out on flooring samples in the laboratory follow the same protocols as those on site, with the following additional requirements and considerations:

1. Ensure that the bench on which the tests are carried out is firm in all directions. Ensure that the Pendulum swing does not cause the bench to move.
2. When working on a bench, parallax error when viewing the level bubble is more likely, so care is required to ensure the Pendulum is levelled accurately.
3. The sample to be tested should be restrained to resist the force applied by the pendulum during testing, a sample holder may be useful, details of which are available under the *UKSRG Guidelines* heading at www.ukslipresistance.org.uk.
4. The sample should sit evenly on the bench without rocking. Flexible samples should be mounted securely on a plywood or similar backing sheet.
5. Samples should be large enough to allow the 6 tests to be undertaken on the sample without the footprints overlapping.

Wet tests should not be carried out over the same area as dry tests unless the sample size dictates, in which case the sample should be cleaned to ensure that there are no rubber deposits left on the surface from the dry tests.

7 Using the Roughness Meter

Microroughness does three things that increase slip resistance, which are easy to understand;

- it helps liquid to move out from the contact patch so the foot / shoe sole contacts flooring material
- it provides space when the residual liquid has less volume than the volume of texture, so that the sole is partially in contact with the flooring
- it provides a hysteresis effect, as the points distort the skin / shoe sole

Microroughness measurements can be useful to quickly identify locations where differences in wet slip resistance might exist. They can be useful in identifying possible directionality, and for monitoring wear that might also cause a change in wet slip resistance. In some situations, for example on the edge of a stair nosing or on the curved surface of a bath or shower tray, a measurement of roughness might be the only measurement it is possible to make. This is especially true when making on-site measurements.

Microroughness measurements should be used in conjunction with Pendulum test values wherever possible. One should not confuse roughness measurements with slip resistance measurements. It is impossible to explain what gives a surface slip resistance in wet conditions without referring to the roughness of the surface. However, the interpretation of microroughness measurements is based on comparison with slip resistance measurements, and so on this basis, it cannot be considered as reliable as Pendulum Test Values. Neither can it be considered an independent test of slip resistance. It can, however, be used as complementary information which alerts the user to unusual properties or conditions of a floor surface. In understanding the subtleties of the test, the user gains a much more robust understanding of the floor surface than by simply relying on one piece of information. In essence, if the Pendulum test and the roughness meter indicate different levels of slip potential, further investigation is required.

The Rz roughness parameter is measured, which can be thought of as the total roughness of a surface, from the deepest valley to the highest peak. Any instrument capable of measuring this can be used, including optical meters. The filter should be set to the DIN standard, and the cut-off length set to 5 x 0.8mm. The roughness meter should be placed on the clean dry floor surface to be measured, and operated in accordance with manufacturers instructions. Generally, roughness meters are simple to use, and data can be generated quickly.

Ten readings should be taken over an area of about 75mm x 75mm, with the meter oriented in three directions, as per the Pendulum tester, to obtain an average roughness reading. In some situations it may be interesting to compare directions, in which case 10 readings in each direction should be used. Table 4 gives an indication of expected slip potential in water-wet conditions.

Table 4. Slip potential classifications for Rz Surface Microroughness

Slip Potential	Rz Microroughness
High	Less than 10 μm
Moderate	10 – 20 μm
Low	Greater than 20 μm

The Rz roughness parameter does not consider the shape of the roughness profile. If the difference between an angular texture and a rounded texture are considered, it is easy to visualise how the wet slip resistance is developed. The angular texture may become rounded with wear and yet result in very little change in Rz despite a significant change in slip resistance.

At the time of writing, instruments capable of measuring the roughness of a surface using an optical scanning technology are available for laboratory assessments, and are expected to be available in a

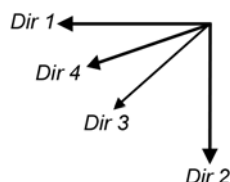
portable form in the near future. These instruments would overcome some of the limitations of a mechanical stylus instrument such as the tendency to deflect around discrete particles in some safety floors.

Roughness meters are calibrated by taking a measurement on a specimen surface of known roughness, which is supplied with the instrument. The calibrated roughness specimen should be independently checked or replaced annually.

8 Profiled Surfaces, Slopes & Stairs

8.1 *Using the Pendulum on Profiled Surfaces*

Profiled surfaces have a raised geometric pattern and can be evaluated using the Pendulum. Measurements will be required in various directions to determine the minimum PTV. A roughness measurement taken on the tops of the profile, that is the part of the profile normally in contact with the shoe, can also provide useful information.



It is recommended that profiled surfaces be 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. Whilst this is also true of many flat surfaces, the effect is exaggerated by profiling, and is therefore considered to warrant further investigation as described. Using the two verified sliders gives an indication of the range of behaviour that may be experienced on profiled surfaces.

The interaction of the Pendulum slider with a profiled surface is greatly exaggerated compared with the interaction of the foot with the same profiled surface. The Pendulum gives the correct thickness of lubricating squeeze film between the slider and the surface, but the Pendulum foot does not have the same momentum as a person's foot. Furthermore, people walk at different angles across floor surfaces, and the heel strike angle may vary even during walking in a particular direction. It is therefore suggested that the reading obtained in the direction that gives the lowest readings using the Pendulum is likely to indicate the lowest slip resistance that a pedestrian would experience, and so should be considered when assessing the slip potential for profiled surfaces.

8.2 *Using the Pendulum on Stairs*

The slip resistance of stairs can only be estimated from the Pendulum test values obtained at the landings. A comparison of the surface roughness of individual treads and the landings allows the slip resistance to be estimated for the treads assuming the material is the same and the surface roughness is similar. In order to measure the slip resistance of the landing and nosing, in the direction of travel, the Pendulum will need to be supported using some method to extend the landing over the first step. On ribbed nosings it may be preferable to treat the surface as profiled, following the advice in section 8.1.

Where it is difficult to test in situ, laboratory testing may be useful. The test sample may be prepared using several strips of the nosing material. Roughness readings can be helpful in evaluating directional properties. Again, reference to section 8.1, which deals with profiled surfaces, may be useful.

Slip resistance is only one of many contributors to the risk of accidents on stairs. Expert advice should be sought. Guidance on the effect of dimensions can be obtained from BRE IP 15/03.

8.3 Using the Pendulum on Slopes

The slip resistance of slopes can be measured using the Pendulum test. The setup of the Pendulum differs slightly in so much as the footprint shifts relative to the frame. The Pendulum frame is set up as it would be on the level surface, using the levelling screws to ensure the frame is level, with reference to the spirit bubble. When the Pendulum is set to swing up the slope, the footprint will be shifted to the left of the normal position, though the footprint length is set in the normal way, using the footprint gauge. When testing down the slope, the footprint will be shifted to the right. It is suggested that the slip resistance of slopes be measured in three orientations, up the slope, across the slope and down the slope. Where directional features in the surface may be missed by this approach, additional test directions should be included.

As a general rule, pedestrian surfaces in the built environment should not exceed a slope of 5° , which is within the range of slopes that can be tested with the Pendulum. In some situations, steeper slopes may be encountered. The levelling screws on the Pendulum allow tests to be undertaken at up to 6.5° , and the slider mounting allows for slopes up to 10° .

Treatment of results for sloping surfaces is covered in section 9.2.

9 Assessing the Results

Points to consider:

1. Is the slip resistance of the floor directional?
2. Has localised wear affected the slip resistance?
3. Are contaminants being deposited on the floor? Water is the most common contaminant; oil, grease, and dry contaminants (such as flour, sand, dust, talc, fibres, etc) may also increase slip potential.
4. Is the cleaning of the floor effective?
5. What are the sources of floor surface contamination? Some commonly observed examples are spillages, water from cleaning processes, condensation, overspray of polish and dust from building work.
6. Can contaminants be seen on the floor? On some floors, contaminants may be difficult to see. This may change according to lighting conditions.
7. Does the floor surface slope?
8. Is the surface profiled?
9. Is the floor uniform with respect to slip resistance? Consider areas subjected to high levels of wear. Surface roughness measurements in several locations will help to identify this.

9.1 Testing in 'as found' state

When testing in dry or as found situations, the slider can change the 'as found' state by removing traces of contamination as it sweeps across the surface. If there is significant variation through the 8 readings, it may be necessary to draw attention to the first reading when considering the slip potential.

It should be recognised that the 'as found' state is simply a measure of the state of the floor at the time of the test and may or may not be representative of the state of the floor at the time of an accident or necessarily represent the worst state of the floor. It can however give an indication of the effectiveness of the current cleaning regime.

9.2 Using the Results

The criteria for judging the results of slip resistance tests are based on the work of the Building Research Station in the 1960's, supported by the experience of investigators and bodies such as the former GLC over the last 40 years. This work suggested that for unencumbered, able bodied, working aged people a PTV level of 36 or above represented an acceptably low risk of slipping when walking in a straight line on a level surface. This table below is based on these results, and is used for readings with both Slider 96 and Slider 55:

Table 5. Slip potential classifications for PTV

Slip Potential	PTV
High	0-24
Moderate	25-35
Low	36+

The friction required for other situations may be higher, for example, on slopes, when pushing loads, changing direction and moving more quickly.

When walking on a slope, a higher level of slip resistance is required than on the level to achieve the same degree of safety. The target PTV on a slope compared to a level walkway needs to be increased by:

$$100 \times \tan \alpha \quad (\alpha \text{ is the slope angle})$$

Calculating the required slip resistance for slopes will show that steeper angles ($>10^\circ$) give rise to requirements that are not commonly achieved by flooring materials in wet conditions. Where slopes are introduced to aid manual handling the additional friction required by the activity should be considered too.

Consideration should also be given to the effect of installation, wear and subsequent cleaning of the flooring. Slip resistance is likely to change throughout the life of a product, and floor specifiers should consider these factors. Some surfaces will tend to polish with foot traffic, whereas others may become rougher, as such, the effect of wear is difficult to predict. Floor surfaces should be assessed in relation to the particular nature of any contaminant likely to be found on their surface. Floors that are foreseeably dry need only offer low slip potential when dry, however cleaning processes on such floors need careful management to ensure this is the case in use.

When considering the slip potential, care should be taken when interpreting results 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 available.

Slider 96 is a standard test rubber which simulates a shoe heel of moderate slip resistance. This enables a consistent measure of the floors contribution to the slip potential. Understanding how the floor behaves helps to identify other control measures including cleaning, footwear and behavioural aspects.

9.3 The Role of Footwear

In order to understand the likelihood of a slipping accident occurring, or in order to understand how a specific slipping accident has occurred, it is necessary to consider the role of footwear. The slip resistance properties of footwear vary widely, in both dry and wet conditions.

In the dry condition, the slip resistance is primarily related to the properties of the heel material. Footwear manufacturers have to balance the contact area and the wear resistance of the heel, particularly with ladies heels that may have a small surface area. Such heels are often made from a hard material to give good wear characteristics, but they may offer less slip resistance than the Slider 96 rubber used for flooring assessment. When considering Pendulum test results, you should consider whether the dry slip resistance experienced by the pedestrian would have been a factor in the accident. Further consideration needs to be given to the change of gait required to walk in footwear with increased heel height.

In the wet condition, the slip resistance of footwear is related to both the material and the cleating pattern. Laboratory testing is required to quantify the role of the footwear in dry or wet conditions.

The laboratory method chosen will largely depend on whether the footwear is an ordinary everyday type - used by the general public at large in a variety of circumstances - or an occupational/industrial type worn in the workplace as 'personal protective equipment' (PPE) with slippery floors.

For everyday shoes (including the ladies fashion shoes mentioned above) UK footwear suppliers mainly use a mechanical method developed by SATRA, which measures coefficient of friction of whole shoes or

sole/heel components against dry and wet reference surfaces. Product acceptance is based on shoe industry guidelines, as the best currently available means of showing compliance with the General Product Safety Directive and the Sale of Consumer Goods and Associated Guarantees Directive.

PPE footwear is covered by the PPE directive and is CE marked after the product has been certified by regulated testing bodies. They generally use a set of specifications for Safety, Protective and Occupational Footwear (BS EN ISO 20345, 6 & 7 respectively) which draw upon a mechanical whole shoe slip method BS EN ISO 13287. This uses one or both of two particular lubricated surfaces and has associated pass levels. These are minimum requirements but do not limit the amount of testing that manufacturers may carry out. A great deal of test data is also available based on an adaptation of the German ramp test. This uses human subjects wearing a pair of the footwear on any surface that can be laid on the ramp. Such surfaces can also be characterised by the Pendulum test. There is some debate about whether the EN 13287 mechanical method and friction pass levels are yet adequate and work is ongoing to further develop it.

10 Care and Maintenance of the Pendulum

The Pendulum is vulnerable to damage due to its ungainly shape and weight. It should be treated as a scientific instrument with care and respect; if handled properly it can be expected to give several decades of useful service.

The Pendulum should be kept in a clean, dry state. A polythene protective cover is a worthwhile investment if the instrument is to be used outside. Any contamination should be removed at the earliest opportunity. The manufacturer or their representatives should carry out maintenance of the Pendulum.

10.1 Calibration

The Pendulum should be calibrated at least once every 12 months and in accordance with BS 7976 Part 3. In the intervening months the verification procedure is carried out to ensure the Pendulum is serviceable. If the verification can not be achieved, the instrument may need service or recalibration within the 12 month period.

11 Troubleshooting

Pavigrés Tile

If verification values on the Pavigrés tile are consistently low, particularly when tile has been in use for some time, the surface may be worn to such an extent that a replacement certified tile is required.

Level

The main supporting upright can be checked in both planes using a spirit level / inclinometer, to ensure the frame is level when the bubble is centred.

Arm Alignment

Once the frame is level, with the Pendulum arm in the raised position, the arm should be horizontal, which can be checked with a spirit level / inclinometer.

Foot Alignment

Using a small spirit level, check that the front face of the Pendulum foot (11) is vertical.

1. Play can sometimes be found in the joint between the Pendulum Arm (4) and the Pendulum head (2) – loosen the retaining nut using the C-spanner, adjust the alignment and re-tighten the retaining nut of the Pendulum arm (4) at the Pendulum head (2) using the C-spanner provided.
2. The Pendulum foot can rotate on the Pendulum arm, the clamping nut can be loosened and the foot rotated to the vertical position. Take care not to loosen the foot too much, as this may result in an adjustment to the arm length.

Having checked the vertical alignment in the raised position, release the foot and allow the arm to hang freely. Measure the distance between the foot and the frame at each end of the foot. If the measurements are different, then the catch plate may be misaligned.

Head Alignment

To ensure the Pendulum head assembly is aligned with the frame, hold the Pendulum foot, release and move through the arc, checking the clearance of the foot and the frame is constant through the full swing.

Pointer Alignment

Release the arm from the release mechanism and allow it to hang freely in the vertical position. Gently move the pointer until it rests against the stop of the Pendulum head. The pointer should now be vertical, in line with the check mark on the Pendulum frame (15). Using a spirit level, check that the pointer counterweight is also vertical. If the pointer and pointer counterweight are not in alignment, the pointer must be damaged and needs to be replaced. If they are in alignment but are not vertical, the stop screw requires adjustment.

Friction Rings / Thrust Washer / Felts

The locking rings act on a thrust washer, which applies pressure to the pointer via felt washers. The thrust washer should not rotate with the pointer, it has a lug which locates into a groove on the shaft. The pointer should have a little resistance to its movement, and should be adequately damped to stop movement when the applied force is removed. If the pointer has too little friction, scatter is often seen in the Pendulum Test Values obtained.

Level Screw Locking Nuts

The level screws should each have locking nuts fitted to aid stability. The Pendulum frame should be levelled at the minimum height that allows clearance over the test surface. The full range of adjustment is only required when testing on slopes, particularly uneven surfaces or for thick flooring samples.

12 Squeeze Film Theory

The theory of squeeze-film formation, with respect to the Pendulum, was developed from the hydrodynamic theory of a tapered wedge described by Fuller (1956). In hydrodynamic lubrication, the two surfaces, between which the fluid film forms, are not parallel, i.e. they converge (see Figure 12.1). If the inclined surface moves relative to the stationary surface, which is covered with a lubricating fluid, the liquid is drawn into the converging gap between the surfaces. If the relative velocity of the two surfaces is sufficient, the hydrodynamic pressure generated within the fluid supports the load of the upper surface, reducing the contact between the two surfaces, and therefore reducing the friction between them. When the relative velocity is high enough, the thickness of the fluid film is enough to separate the two surfaces completely. This principle is essentially that involved in a 'hydroplane' or 'aquaplane'.

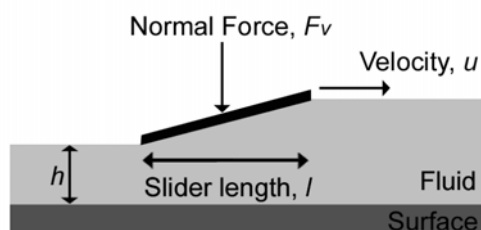
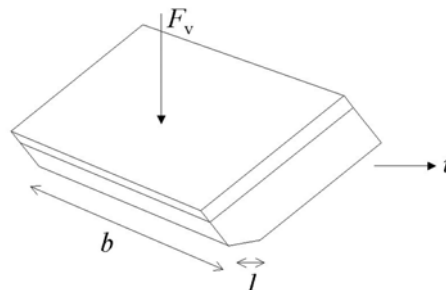


Figure 12.1 Squeeze-film formation

When applied to the action of the Pendulum, the conditioned edge of the slider forms a very small converging gap with the test surface. As the slider passes over the test surface, the fluid film partially reduces the contact between the slider and the asperities of the test surface, thus reducing the dynamic friction measured.

This is the model Proctor and Coleman (1988) used for predicting how the fluid film is affected by changes to the surfaces, relative velocity and lubricating fluid. In this simplified model, it has been assumed that there is no deformation of the slider during the formation of the fluid film.

Figure 12.2 Schematic showing slider dimensions, vertical force and velocity terms



The thickness of the fluid film produced, h , is described below;

$$h^2 = \frac{6u\eta l^2 b K_E}{F_v} K_p$$

where; h = thickness of the fluid film at the exit of the converging surfaces
 u = relative velocity of the slider
 η = viscosity of the fluid
 l = slider length
 b = slider width
 K_E = correction factor dependant upon the ratio of the slider width to the slider length
 K_p = correction factor to allow for the pressure variation
 F_v = vertical force of the fluid

In applying the model to the Pendulum, with water as the lubricating fluid, the following values are used: $b = 0.075$ m, $u = 2.7$ ms⁻¹, $\eta = 1 \times 10^{-3}$ Nm⁻², $K_E = 1$, $K_p = 0.025$, and $F_v = 24.5$ N. l will be 0.01 m to 0.04 m depending on slider wear. The squeeze-film thickness is relatively sensitive to the changes in slider length. It should be considered that the practical implications of this are only significant on floor surfaces where the roughness of the floor is comparable with the thickness of the fluid film. Even then, an effect can only be shown empirically with lapping films, which have very narrow roughness distribution, and as such are quite unlike most flooring materials which have a much wider roughness distribution. The equation can also be used to quantify the effect of contaminant viscosity.

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Appendix A – Slip Resistance Test Record Sheet

This can be used as a checklist to ensure that nothing is forgotten.

Job or Identification Number _____ Date _____

Location / Sample designation _____ Page _____ of _____

Operator _____

Temperature _____

Rz Surface Microroughness Readings

1	2	3	4	5	6	7	8	9	10	Mean

Pendulum Serial Number _____ Calibration due date _____

Slider Rubber used (choose one): Slider 96 Slider 55 Batch Number: _____

Slider preparation, P400 & lapping film: Pink Green Level ☐ Zero ☐

Verification
readings (PTV)

Lapping Film

Float Glass

Pavigrés Tile

, , / , , , , ,
, , / , , , , ,
, , / , , , , ,

Median

Floor description _____

Floor condition _____ Slope (°) _____

Pendulum Readings

Direction	Condition e.g. As Found	Contamination e.g. Wet	Readings	Median
1		Dry	, , / , , , , ,	
2		Dry	, , / , , , , ,	
3		Dry	, , / , , , , ,	
1		Wet	, , / , , , , ,	
2		Wet	, , / , , , , ,	
3		Wet	, , / , , , , ,	
			, , / , , , , ,	
			, , / , , , , ,	
			, , / , , , , ,	

