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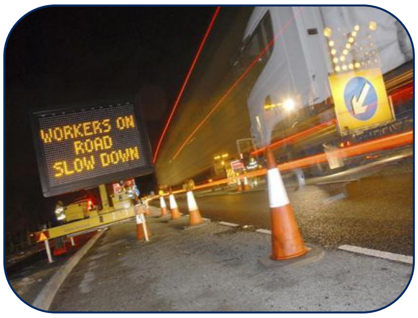


PUBLISHED PROJECT REPORT PPR603

Establishing a new supply of UK PSV control stone

Including results of supplementary experiments

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Executive Summary

The stock of control stone used for calibration in the polished stone value (PSV) test, which determines the suitability of aggregate for use in the road surface course, ran out in 2008. The plan conceived for a straightforward introduction of a new, replacement, PSV control stone, by thorough testing of aggregate from a quarry chosen for its proximity to the source of the existing control stone, did not come to fruition. Further progress with alternative aggregates, proposed by industry, was also hampered by commercial sensitivity.

An alternative aggregate was eventually procured and initial testing confirmed its suitability for use as PSV control stone. Subsequent use by UK laboratories revealed that the mean PSV of the new source had been overestimated and a revised value was introduced. Extensive round-robin testing of the aggregate confirmed its revised PSV. The round-robin testing also demonstrated the suitability of a proposed alternative control stone, sourced in Germany.

The 2011 UK PSV control stone has a mean PSV of 49.0 and is available for use in the PSV test. The PSV of the German control stone was confirmed as 54.5 or 55.0.

1 Introduction

Aggregates used in the surface course on UK roads are required to meet a pre-defined specification in terms of their resistance to polishing under the action of traffic. The current method of testing this polishing resistance is via the 'Polished Stone Value' (PSV) test, in which the skid resistance of small samples of aggregate is tested after they have been subjected to controlled polishing in the laboratory. The PSV test makes it possible to specify aggregates for a given location based on required performance and this is essential for sustainable road construction and maintenance.

Calibration and national correlation of the PSV test is permitted by simultaneous testing of a control sample of aggregate: "PSV control stone". Stocks of the control stone are kept at TRL and they ran out in 2008. This report describes the work carried out for Highways Agency, who have a vested interest in the accurate specification of surface course aggregates, to source and store new PSV control stone to create a managed stockpile at TRL.

2 Background

In the 1950s, in unpublished work at TRL (then the Road Research Laboratory), Maclean and Shergold designed an accelerated polishing machine to assess the properties of different aggregates. This was developed later to provide what is now a standardised method of assessing the polishing resistance of aggregates, the Polished Stone Value test. In this test, samples of aggregate are set in resin to form specimens which are mounted on the circumference of a wheel. Fourteen specimens are mounted onto each wheel, two specimens made using each of six test aggregates and two specimens made using the PSV control stone. The wheel is rotated for a period of time while a rubber tyre is loaded onto the aggregate surface and a polishing medium trickled into the interface. The full PSV test is complete when two wheels of aggregate have been polished. Figure 2.1 shows a diagram of the polishing machine, taken from the current European Standard (British Standards, 2009). At the end of the polishing process, the skid resistance is measured on each specimen. To calculate the polished stone value (PSV), the mean skid resistance of the four specimens prepared for each aggregate is compared with the mean skid measured for the four control stone specimens.

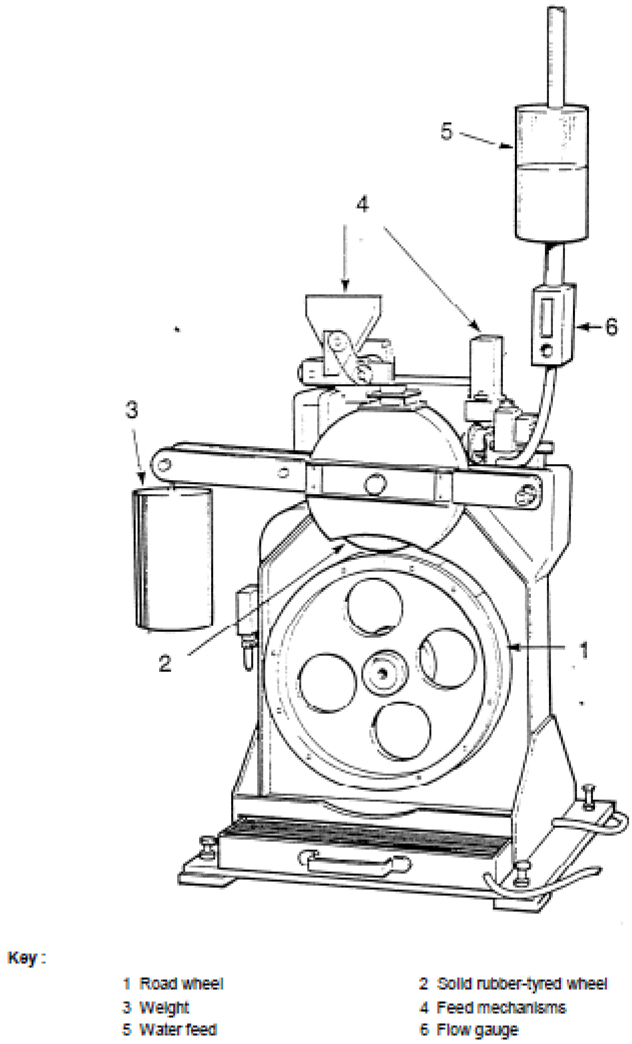

Figure 2.1 Typical accelerated polishing machine (British Standards, 2009)

The last publically available information about the PSV control stone itself was published in 1983(Hosking & Tubey). This report details a change to the PSV test (a pneumatic tyre was replaced with a pair of solid rubber tyres) and a change in control stone from aggregate from Enderby quarry to an anonymous aggregate called "PSV control stone (1982)". This is probably the control stone that was in use, and was running out, at the start of this project.

Prior to the modification to the test, the control adjustment was made by reference to a table of values calculated using the following formula. The mean PSV expected from the control stone (Enderby) when polished correctly was 51.

$$\text{PSV reported} = \frac{51 \times \text{PSV recorded}}{\text{PSV recorded for control stone}}$$

The new PSV control stone (1982) was chosen on the basis of its similar PSV, as measured by the equipment before modification, of 52. However, it was initially found that, when the new solid tyres were used in place of the pneumatic tyre in the polishing machine, the PSV measured for the new control stone was 55. To account for this apparent reduction in polishing severity caused by the change in polishing tyre, the control stone value was adjusted so that PSV results from modified tests would fall in line with PSV results from the unmodified version. Consequently, the formula proposed for correction to the new control stone was:

$$\begin{aligned}\text{PSV reported} &= \frac{55}{\text{PSV recorded for control stone (1982)}} \times \frac{52}{55} \times \text{PSV recorded} \\ &= \frac{52 \times \text{PSV recorded}}{\text{PSV recorded for control stone (1982)}}\end{aligned}$$

Between 1983 to the present, the details of research carried out to improve the test or review the role of the control stone are scarce. The version of the British Standard amended at that time (British Standards, 1983) includes a foreword about the modified test and new control stone and includes instructions for both methods and for both control stones. Two correction tables are included and the new one corrects to a value of 52 but has its results centred about 54 rather than about 55 as would be expected given the new correction formula (Hosking & Tubey, 1983).

However, unpublished work, also by Hosking (1985), demonstrated that the initial estimate of 55 for the new control stone (1982) was an overestimate as a result of testing with brand new wheels (as per the modified test). Furthermore, suspect results were obtained for some stones, particularly the high-PSV gritstones, when the control stone gave high values. Under those circumstances the measured values are over-corrected and consequently reported PSVs were too low. The results from the 1983 study (Hosking & Tubey) were re-analysed and it was shown that correction using multiplication biases results at both ends of the measureable range (high values are underestimated and low values overestimated). A closer correlation to pre-modification test results was found by using a simple additive correction formula and a control stone value of 52.5. This is the form in use in the current Standard (British Standards, 2009). The permitted range for control stone values (49.5 to 55.5) was also set at this time.

PSV reported = PSV recorded + 52.5 – PSV recorded for control stone (1982)

The stockpile of PSV control stone (1982) procured for use when the stock of aggregate from Enderby had been depleted was estimated to be sufficient for approximately ten years. It is assumed therefore, that a further change to the control stone, or a second batch of the same control stone, has been commissioned in the intervening years.

When the stock of control stone ran out in 2008 the present project, let in November 2008, conceived a simple process whereby a number of candidate aggregate sources would be selected on the basis of similarity to the existing control stone. Those candidates would undergo laboratory testing to determine their polish resistance and yield after preparation for the test before a single source could be selected and procured. The stockpile would then be subjected to checks on homogeneity and a final round-robin test to establish its mean polish resistance so that it could be used for correction in future PSV testing.

The remainder of this report describes the activities carried out under the project, including the commissioning of a new UK control stone in 2011 and participation in trials to secure an alternative control stone sourced from a quarry in Germany.

3 UK control stone replacement

3.1 Sourcing

The quarry in which the existing quartz dolerite PSV control stone was extracted ceased operations in 1998, although the site was used for related activities for some time afterwards. A geological map of the region was inspected and cross-referenced with a list of operating quarries (British Geological Survey; Natural Environment Research Council, 2007) (Thompson, Burrows, Flavin, & Walsh, 2004). At the start of this project there were apparently three quarries producing similar aggregate for use in road surface courses within five miles of the control stone quarry.

The owners of those three quarries were contacted directly to request a sample of current aggregate production to compare against the existing control stone. The intention was that, if the aggregate appeared suitable, its yield after sieving and sorting would be calculated and indicative PSV testing would be carried out. One of the quarry owners did respond to the request but a sample of aggregate could not be obtained.

Advice on obtaining suitable aggregate was sought through the Mineral Products Association (MPA). After discussion amongst their members, three alternative sources were proposed: a dolerite and two granite quarries all with reported PSV between 50 and 55. Samples of aggregate from these three candidate quarries were delivered to TRL in early 2009. They will be referred to as Sample 1, Sample 2 and Sample 3.

In an attempt to select a new PSV control stone that was as similar as possible to the existing source, given that the ideal sources were not available, the three proposed alternative aggregates were tested in a staged fashion, starting with the dolerite offered.

3.2 Testing on Sample 1

"Sample 1" was olivine dolerite and, of the three proposed aggregates, it was assumed to be the most similar to the existing control stone.

It was determined by sieving (passing 10 mm) and flaking (retained on a 14/10 flakey sieve) that, from the standard 4/10 mm output of the quarry, a yield of approximately 15 % by mass could be obtained. This is an estimate of the percentage of aggregate that would be useable for PSV testing if no other grading operation was carried out at the quarry. It is an important consideration not least because users of the control stone expressed a desire for increased yield so that preparation of control stone samples could be more efficient. Yield from the existing control stone was approximately 30 % so further grading at the quarry would be required before the source of "Sample 1" could be used as PSV control stone.

The bulk sample was reduced to nine sub-samples by fractional shovelling(British Standards, 1997). Three sub-samples were sent to each of three PSV test laboratories accredited by the United Kingdom Accreditation Service (UKAS), along with three samples of the existing control stone. The results are shown in Table 3.1. The average PSV of the proposed control stone "Sample 1" is 48. This is lower than the expected PSV, which should have been between 50 and 55. There is also a clear disparity between the three laboratories with lab A returning results approximately 6 points higher (the limit of reproducibility for the test) than the other two labs.

Table 3.1 PSV results for proposed control stone "Sample 1" and existing control stone

	Specimen	Laboratory A	Laboratory B	Laboratory C
Proposed control	1	52	46	47
	2	52	46	46
	3	52	47	46
Existing control	1	54	52	52
	2	54	53	52
	3	55	51	52

These results were discussed with representatives from the British Standards committee responsible for the Standard documentation in the UK (B/502/6 Test methods). Further testing was proposed but the quarry owner withdrew the aggregate as a potential control stone citing unacceptable commercial risk.

3.3 Testing on Sample 2

In order to minimise costs and delay, it was decided that extensive testing would be carried out on a larger stockpile of aggregate, once its use had been approved by the supplier, rather than on the initial sample. One sub-sample of "Sample 2" was sent to each of three UKAS accredited laboratories in July 2009. The results returned were 51, 48 and 50 from laboratories A, B and C respectively. The yield after sieving and flaking was approximately 20 %.

On average, the measured PSV was again lower than the expected PSV (between 50 and 55). Although further testing was proposed on a larger batch of the aggregate, after some discussion, "Sample 2" was withdrawn as a potential source of control stone aggregate for commercial reasons.

3.4 Testing on Sample 3

At a meeting with the BSi technical committee in November 2009, an alternative strategy was drawn up so that a new control stone could be issued as soon as possible.

No testing was carried out on the small amount of "Sample 3" already delivered and instead, with the agreement of the quarry owner, a stock of 50 tonnes of the same aggregate was ordered from the quarry. The aggregate was delivered to TRL where it was moved into fifty flexible intermediate bulk containers (FIBC) each containing approximately one tonne. During the process of moving the aggregate into the containers, samples were taken at five discrete points; 200 kg of aggregate was placed in a wooden storage box each time. The filled FIBCs were placed into a purpose built, covered, storage bay.

20 kg of aggregate was removed from each of the five retained boxes and set aside. The five boxes were then combined into a single stockpile and the aggregate was thoroughly mixed. From this stockpile twelve sub-samples, each approximately 20 kg, were selected by fractional shovelling.

One sub-sample was sent to each of six UKAS accredited laboratories for PSV testing. The results are shown in Table 3.2. The five sub-samples that were retained to test the homogeneity of the stockpile were sent to laboratory A and these PSV measurements are also shown in Table 3.2. It was noted by the laboratory that four of these five sub-samples were re-tested due to some anomalous readings and only the re-test values are shown.

Table 3.2 PSV for proposed control stone "Sample 3" round-robin (left) and homogeneity tests (right)

Laboratory	PSV
A	54
B	52
C	52
D	56
E	52
F	49
Mean	**52.5**

Homogeneity sample	PSV
1	52
2	51
3	52
4	51
5	50
Mean	**51**

Additional information was requested from the laboratories so that anomalous results could be investigated if the need arose. The additional information requested should be recorded by the laboratories as part of their quality assurance processes and it comprised:

- Temperature recorded at the time of testing
- Friction tester reference stone values
- Number of runs since replacing test tyres
- Corn emery and flour emery flow rates.

Three of the six laboratories provided this information, which demonstrated that tests were carried out according to the required Standard. No further investigation was carried out because the range of test values reported was similar to the expected reproducibility of the test.

According to the Standard (British Standards, 2009), a new control stone should be tested against the existing control stone in at least ten laboratories. At the time of testing, no further UKAS accredited laboratories were available to participate in the round-robin experiment (December 2009). To mitigate this, the strategy drawn up with the BSi committee included an interim period where "Sample 3" aggregate would be released for use as a control stone in April 2010, with PSV 52.5, as had been measured. UKAS directly requested that laboratories send ongoing test results, by email to a dedicated address, for monitoring and review of the mean PSV of the new control stone if required.

The yield of "Sample 3" aggregate is 12 %.

4 Verification of PSV through ongoing testing

A batch number was assigned to each FIBC of the new control stone aggregate. The batch numbers have the format yymmddhh according to the date and time at which it leaves TRL. The aggregate was distributed, as had been the case for the old control stone, by Wessex Engineering (now Cooper Wessex) who also make PSV test equipment. The batch number from the one-tonne FIBC was passed on to individual laboratories and thereby reported back with ongoing test results.

Shortly after the new control stone was released reports were received from laboratories who had difficulty obtaining test results within the required range encompassing the average PSV calculated from round-robin testing (49.5 to 55.5).

Despite repeated requests from UKAS, ongoing test results were only received after direct communication with each individual laboratory, which was undertaken on two occasions. Consequently, the results were delivered in two sets. The first set of results received is shown, underlined, in Table 4.1. Two of the six laboratories that participated in the initial round-robin had ceased operation by this time (May 2010). The results are the mean pendulum test value on the four control stone specimens used in each PSV test run, not corrected to any other control stone. They are therefore not polished stone values.

It was assumed that, although these values had not been corrected against the existing control stone, the average pendulum test value and the average PSV would be the same - the main purpose of the control stone being to reduce inter-laboratory variability.

Based on the first set of ongoing results, the mean PSV of the new UK PSV control stone was 48.7 and the correction value to be used by laboratories using this control stone was amended to 49.0 (+/- 3). The laboratories were informed by UKAS and BSi accordingly (October 2010).

If the second set of ongoing test results received (shown in italics in Table 4.1) is included in a calculation of the mean PSV for the control stone, its PSV is altered to 49.3. No further change was made to the recommended correction value.

The reason for the discrepancy between the results obtained during round-robin testing of the new UK PSV control stone and the extensive ongoing test results shown below is not clear. At the time of writing it is understood that the amended correction value of 49.0 has been adopted by all UK laboratories and no further disruption to their services has occurred.

Table 4.1 Ongoing test results for new UK PSV control stone

Laboratory								
A	B	C	D	E		F	G	H
46.0	-	-	46.7	53.0	*51.2*	48.7	*45.3*	*53.3*
47.0			45.3	52.3	*51.6*	51.0	*45.7*	*52.7*
50.3			47.3	52.3	*53.0*	47.0	*46.0*	*50.0*
50.3			46.3	53.4	*52.8*	49.7	*45.3*	*53.0*
51.0			49.0	52.7	*51.4*			
50.3			48.7	53.5	*51.6*			
			46.3	53.7	*51.5*			
			46.1	52.0	*51.5*			
			48.1	51.5	*52.2*			
			49.8	52.0	*51.5*			
			49.5	52.2	*52.5*			
			47.1	51.7	*52.5*			
			49.4	51.7	*50.8*			
				52.2	*50.8*			
				51.3	*50.7*			
				52.2	*51.7*			
				51.7	*50.7*			
				51.0	*50.7*			
				53.0	*50.8*			
					50.7			

5 Second alternative European control stone

Although the new UK PSV control stone is available and the correction value of 49.0 has been adopted, it does not strictly meet the requirements of the Standard. A suitable alternative control stone should have a "mean PSV in the range 50 to 60" (Section 6.4 in EN 1097-8:2009). Its yield, at 12 % by mass, is not particularly desirable either. The consequence of low yield is less efficient preparation of control specimens, and presumably therefore additional costs which will be passed back to quarry owners.

Researchers in Germany proposed an alternative control stone, sourced from a well known granite-producing quarry in Southeast Germany. If approved, a reserved stockpile of control stone would be stored separately at the quarry and its distribution would be controlled by the Technical University of Munich.

A sample of the proposed German control stone was sent to the UK for testing. At this time, twelve UKAS accredited laboratories volunteered to carry out PSV testing as part of a complete round-robin test. Samples of three different control stones were sent to twelve PSV test laboratories. The three aggregates were:

- HhG-CS1: proposed German control stone
- SwD-CS2: old UK control stone (the last of the stock held at TRL)
- SbG-CS3: new UK control stone.

The laboratories were asked to perform a standard PSV test on the aggregate samples, testing them all on the same pair of wheels. Further information was also requested about the equipment used and parameters recorded during the tests, as before, including test temperatures, polishing tyre age, emery flow rates and friction tester reference stone values. Eleven laboratories returned PSV results, one of which used different wheels for each sample, and eight laboratories returned the additional information requested.

The PSV results, as delivered by the 11 laboratories, are shown in Table 5.1. Note that some laboratories were still using the old UK control stone and some were using the new UK control stone. The mean PSV, standard deviation and an estimate of reproducibility for each aggregate are also shown in the table. PSVs are rounded up to the nearest integer (as reported) before calculation of the mean PSV, which is shown to one decimal place. The labels assigned to the laboratories were assigned according to the order in which results were returned.

The value reported for reproducibility, the difference expected between tests on the same material in different laboratories in 95% of cases, is an estimate, equal to 2.8 times the between-laboratory standard deviation. A proper calculation of reproducibility requires the inclusion of between-sample standard deviation, not available in this case because only one sample was sent to each laboratory. Furthermore, the range of PSVs tested does not sufficiently sample the range of results that can be measured by the test. However, it is encouraging that the reproducibility estimate for each aggregate is of the same order as that published in the Standard (R=5, Annex E in EN 1097-8:2009).

Table 5.1 PSV reported by participating laboratory

Laboratory	HhG-CS1	SwD-CS2	SbG-CS3
a	53.0	53.0	49.0
b	56.0	52.0	50.0
c	55.0	51.0	48.0
d	53.0	52.0	49.0
e	50.0	48.0	47.0
f	58.0	49.0	49.0
g	55.0	52.0	49.0
h	55.0	53.0	46.0
j	56.0	52.0	47.0
k	57.0	54.0	49.0
l	52.0	50.0	47.0
Mean	54.5	51.5	48.2
Standard Deviation	2.3	1.8	1.3
~R	6.6	5.1	3.5

Where all three aggregate samples were tested on the same pair of wheels (ten laboratories), it is possible to cross-correct each aggregate against the two known UK control stones. Table 5.2 shows the PSV for each aggregate sample. The first two columns have been corrected against the old UK control stone (52.5) and the second two columns have been corrected against the new UK control stone (49.0). An outlying value was identified using Grubb's Test (British Standards, 1994), and this has not been included when calculating the mean PSV for the proposed German control stone – the value is highlighted with an asterisk.

The round-robin test has shown that:

- The PSV of the new UK control stone (SbG-CS3), 49.0, is correct. It will henceforth to be referred to as 2011 UK PSV control stone
- The PSV of the proposed German control stone (HhG-CS1) should be set at either 54.5 or 55, depending on results from further testing in Europe.

The yield from the proposed German control stone is approximately 40 %, which is higher than both old and the new UK control stones, although it is not clear whether the sample delivered was subjected to additional grading before it left the quarry.

Table 5.2 PSV calculated using currently available UK controls

Laboratory	Corrected to SwD (52.5)		Corrected to SbG (49.0)	
	HhG-CS1	**SbG-CS3**	**HhG-CS1**	**SwD-CS2**
a	52.3	48.6	52.7	52.9
b	56.0	50.5	54.5	51.1
c	56.3	49.6	55.7	51.9
d	53.0	49.1	52.9	52.4
e	53.9	50.8	52.1	50.8
f	60.8*	51.9	57.9	49.6
g	55.0	49.6	54.4	51.9
h	54.4	45.8	57.6	55.8
j	56.0	46.6	58.4	54.9
l	55.3	49.9	54.4	51.6
Mean	54.7	49.2	55.1	52.3
Standard Deviation	1.4	1.9	2.3	1.9
~R	3.9	5.2	6.3	5.2

6 Conclusion

A new PSV control stone has been commissioned. The 2011 UK PSV control stone has a PSV of 49.0. This value is to be used for correction calculations when the new control stone is used as part of the PSV test.

An alternative control stone is likely to be commissioned, using aggregate from a granite quarry in Germany. It has been demonstrated that the yield (useable aggregate after preparation for testing) is likely to be better than the 2011 UK PSV control stone and that, subject to further testing in European PSV test laboratories, the PSV of this aggregate is 54.5 or 55.0.

European Standards documentation needs to be updated to reflect the change to the available PSV control stone. Laboratories must identify the control stone in use and details of the correction applied to test results. Recommended amendments to the existing Standard are summarised in Appendix A.

Initial progress towards introduction of a new PSV control stone was slow. After a suitable candidate was selected and approved, its release for use in PSV test laboratories, and subsequent amendment of its PSV, also took longer than expected. It is recommended that, if a new source of PSV control stone is required in the future, the process of commissioning should be started at least three years before the existing source has been depleted.

The possible use of an alternative mechanism for calibration of the PSV test or of an easily reproducible synthetic material instead of a finite and intrinsically variable natural resource, should be revisited. The need for calibration of the polishing process in emerging laboratory test equipment such as the Wehner-Schulze machine (Woodbridge, Dunford, & Roe, 2006) may increase demand for such a mechanism. Research in this area, carried out by TRL for Highways Agency, will be reported elsewhere in due course.

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Appendix A Suggested amendments to EN 1097-8:2009 relating to change of PSV control stone

The outlined text in black is copied directly from the current Standard (British Standards, 2009). Immediately below each section, the text in red represents a suggested alteration, to be discussed and ratified by European committee.

6.4 *PSV control stone*, from a recognized source, with a mean PSV value in the range 50 to 60.

NOTE 1 At present the only recognized source of PSV control stone is a stock of quartz dolerite aggregate controlled by Transport Research Laboratory (TRL), Old Wokingham Road, Crowthorne, Berkshire RG11 6AU, United Kingdom.

NOTE 2 An alternative source of PSV control stone with a mean PSV value in the range 50 to 60 can be used provided the PSV value has been established in a controlled experiment carried out in at least 10 laboratories, by cross testing against the TRL type control stone. In case of dispute, the TRL type control stone should be used.

6.4 PSV control stone, from a recognized source, with a mean PSV in the range 49 to 60.

NOTE 1 A suitable source of PSV control stone has a mean PSV in the range 49 to 60, established in a controlled experiment carried out in at least 10 laboratories, by cross testing against an existing recognised PSV control stone.

At present the recognized sources of PSV control stone are:

1) SwD - UK PSV control stone with specified mean PSV 52.5;

2) SbG - 2011 UK PSV control stone with specified mean PSV 49.0;

3) HhG - German PSV control stone with specified mean PSV 54.5.

List of current suppliers to be added, text for example:

1) SwD – no longer available to purchase. Some laboratories may have residual stock.

2) SbG – Stockpile stored at TRL, Crowthorne House, Nine Mile Ride, RG40 3GA. Available to purchase in quantities of one tonne directly through TRL, or in smaller quantities through Wessex Engineering, ABC, ABC, ABC etc.

3) HhG – Stockpile stored at ABC. Available to purchase through ABC, ABC, ABC etc.

If a suitable alternative control stone is used, the three letter source code 'ALT' shall be clearly indicated along with the mean PSV, X, for the source. Details of the controlled experiment used to determine the mean PSV for that source (6.4) shall be available on request. In case of dispute, the HhG type German PSV control stone shall be used.

6.5 *Friction tester reference stone*, from a recognized source, for conditioning new sliders and checking the friction tester (11.3), with a mean PSV value in the range 60 to 65.

NOTE 1 At present the only recognized source of friction tester reference stone is a stock of olivine basalt aggregate controlled by the Transport Research Laboratory (TRL), Old Wokingham Road, Crowthorne, Berkshire, RG11 6AU, United Kingdom.

NOTE 2 An alternative source of friction tester reference stone with a mean PSV value in the range 60 to 65 can be used provided the PSV value has been established in a controlled experiment carried out in at least 10 laboratories, by cross testing against the TRL type friction tester reference stone. In case of dispute, the TRL type friction tester reference stone should be used.

6.5 *Friction tester reference stone*, from a recognized source, for conditioning new sliders and checking the friction tester (11.3), with a mean PSV in the range 60 to 65.

NOTE 1 At present the only recognized source of friction tester reference stone is an olivine basalt aggregate called the TRL type friction reference stone.

[List of current suppliers to be added]

An alternative source of friction tester reference stone with a mean PSV value in the range 60 to 65 can be used provided the PSV value has been established in a controlled experiment carried out in at least 10 laboratories, by cross testing against the TRL type friction tester reference stone. In case of dispute, the TRL type friction tester reference stone shall be used.

12.2 The results of the whole test shall be rejected if the difference between the two test results obtained from 12.1 is more than 5.0 units, or if at least one of the two test results lies outside the specified range for the PSV control stone used. If the results are rejected, the whole test shall be repeated.

The specified range for the TRL type PSV control stone is (49,5 to 55,5).

12.2 The results of the whole test shall be rejected if the difference between the two test results obtained from 12.1 is more than 5.0 units, or if at least one of the two test results lies outside the specified range for the PSV control stone used. If the results are rejected, the whole test shall be repeated.

The specified range for a PSV control stone with mean PSV X is (X ± 3).

12.3.3 Calculate the PSV to the nearest whole number, from the following equation:

$$PSV = S + (52.5) - C$$

where

S is the mean value for the four aggregate test specimens;

C is the mean value for the four PSV control stone specimens.

NOTE An indication of the precision of the PSV test is given in Annex E.

12.3.3 Calculate the PSV to the nearest whole number, from the following equation:

PSV = S + X - C

where

S is the mean value for the four aggregate test specimens;

X is the mean PSV specified for the source of control stone used;

C is the mean value for the four PSV control stone specimens.

NOTE An indication of the precision of the PSV test is given in Annex E.

13 Test report

The test report shall state that the PSV value was determined in accordance with this European Standard and whether or not a certificate of sampling is available. If available, a copy of the certificate of sampling shall be provided with the test report.

The test report shall also contain at least the following additional information:

a) reference to this European Standard;

b) sampling report (if available);

c) sampling identification and description (in accordance with EN 933-3);

d) PSV value for the aggregate;

e) overall mean value recorded for the PSV control stone (12.3);

f) individual values and the mean values for each test run for the four aggregate test specimens and the four PSV control stone specimens, clearly indicating which values relate to which test run.

13 Test report

The test report shall state that the PSV value was determined in accordance with this European Standard and whether or not a certificate of sampling is available. If available, a copy of the certificate of sampling shall be provided with the test report.

The test report shall also contain at least the following additional information:

a) reference to this European Standard;

b) sampling report (if available);

c) sampling identification and description (in accordance with EN 933-3);

d) PSV for the aggregate;

e) three letter source code for the PSV control stone used and batch number if available;

f) overall mean value recorded for the PSV control stone (12.3) and the specified mean PSV, X, for the source of control stone used;

g) individual values and the mean values for each test run for the four aggregate test specimens and the four PSV control stone specimens, clearly indicating which values relate to which test run.