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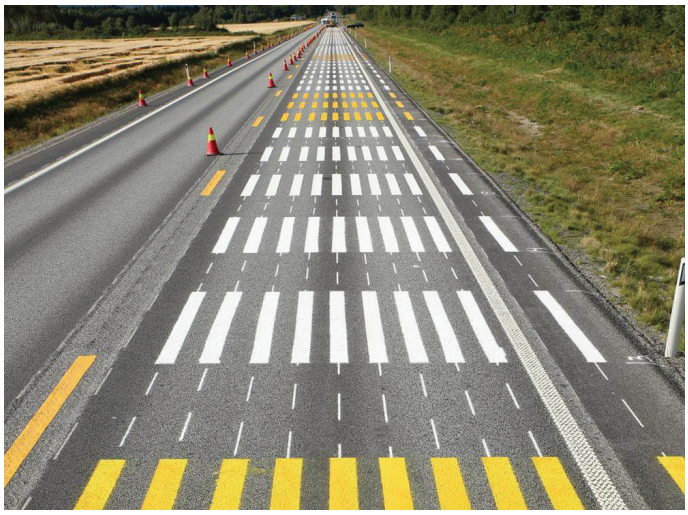

Nordic certification of road marking materials in Norway and Sweden 2015–2017

Trond Cato Johansen
Carina Fors
Erik Kjellman

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Abstract

A Nordic certification system for road marking materials was introduced in 2015. In the first stage, the certification system applies to the countries of Denmark, Norway and Sweden. In these countries, a documented product approval will be required in order to use a road marking material on roads managed by the national road authorities. Product approval will be based on monitored and documented performance measurements of material samples applied on test fields on public roads.

The first round of material tests in Sweden started in May 2015. In all, 81 materials, out of which 78 were for certification and 3 for manufacturer's internal test, were applied at the Swedish test site north of Sunne, in the west of Sweden. In 2016, another 72 materials were applied for certification at the Swedish test site.

The present report documents the follow-up performance measurements that were carried out in 2017, i.e. one-year follow-up measurements for materials applied in 2016 and two years follow-up measurements for materials applied in 2015. The performance parameters include the coefficient of retroreflected luminance (R_L) under dry and wet conditions, the luminance coefficient under diffuse illumination (Qd), the friction, the chromaticity in daylight, and the chromaticity of retroreflected light (yellow materials, only).

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Referat

En nordisk certifiering av vägmarkeringsmaterial introducerades 2015 och avser i ett första steg Danmark, Norge och Sverige. I dessa länder kommer det att krävas ett dokumenterat godkännande av vägmarkeringsmaterial som används på vägar som administreras av den statliga väghållaren. Detta godkännande baseras på funktionsmätningar på vägmarkeringar som har applicerats i provfält.

En första testomgång i Sverige påbörjades i maj 2015. Totalt 81 material, varav 78 för certifiering och tre för tillverkarnas interna test, applicerades på det svenska provfältet norr om Sunne. År 2016 applicerades ytterligare 72 material på det svenska provfältet.

Föreliggande rapport dokumenterar resultaten från de uppföljande funktionsmätningar som gjordes 2017, det vill säga ettårsuppföljning av material som lades ut 2016 och tvåårsuppföljning av material som lades ut 2015. Funktionsmätningarna omfattar retroreflexion (R_L) i torrt och vått tillstånd, luminanskoefficient (*Qd*), friktion, färg i dagsljus och färg i fordonsbelysning (för gula material).

Titel:	Nordisk certifiering av vägmarkeringsmaterial i Norge och Sverige 2015–2017
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Preface

A Nordic certification system for road marking materials was introduced in 2015. Certification of products is based on documented performance measurements of material samples applied on test field on public roads. This report compiles and presents the results of the performance measurements carried out in 2017 on road marking materials applied for certification at the Swedish test site in 2015–2016.

Performance measurements of retroreflection, luminance coefficient, friction and chromaticity coordinates were carried out by operators from Ramböll, supervised by staff from VTI.

The road trials are administered as a joint project between Ramböll AB and the Swedish National Road and Transport Research Institute (VTI). Trond Cato Johansen at Ramböll is the project manager and Carina Fors is the project leader at VTI. Kenneth Kjemtrup, the Danish Road Directorate, Bjørn Skaar, the Norwegian Public Roads Administration and Ulf Söderberg, the Swedish Transport Administration constitute a steering committee for the Nordic certification system.

Drøbak, November 2017

Trond Cato Johansen
Project Manager

Quality review

Internal peer review was performed on 18 December 2017 by Thomas Lundberg. Carina Fors has made alterations to the final manuscript of the report. The research director Anna Anund examined and approved the report for publication on 23 January 2018. The conclusions and recommendations expressed are the author's/authors' and do not necessarily reflect VTI's opinion as an authority.

Kvalitetsgranskning

Intern peer review har genomförts 18 december 2017 av Thomas Lundberg. Carina Fors har genomfört justeringar av slutligt rapportmanus. Forskningschef Anna Anund har därefter granskat och godkänt publikationen för publicering 23 januari 2018. De slutsatser och rekommendationer som uttrycks är författarens/författarnas egna och speglar inte nödvändigtvis myndigheten VTI:s uppfattning.

Contents

Summary

Nordic certification of road marking materials in Norway and Sweden 2015–2017

by Trond Cato Johansen (Ramböll), Carina Fors (VTI) and Erik Kjellman (VTI)

A Nordic certification system for road marking materials was introduced in 2015. In the first stage, the certification system applies to the countries of Denmark, Norway and Sweden. In these countries, a documented product approval will be required in order to use a road marking material on roads managed by the national road authorities. Product approval will be based on monitored and documented performance measurements of material samples applied on test fields on public roads. Certification in Norway and Sweden will be based on the results from a test site in Norway or in Sweden and certification in Denmark will be based on the results from a test site in Denmark.

The first round of material tests in Sweden started in May 2015. In all, 81 materials, out of which 78 were for certification and 3 for manufacturer's internal test, were applied at the Swedish test site in Sunne. In 2016, another 72 materials were applied for certification at the Swedish test site.

Approximately two weeks after application, the initial performance of the coefficient of retroreflected luminance R_L under dry and wet conditions, the luminance coefficient under diffuse illumination *Qd*, the friction, the chromaticity in daylight, and the chromaticity of retroreflected light (yellow materials, only) are determined.

Follow-up measurements of the performance parameters mentioned above are carried out one and two years after application. The present report documents the follow-up measurements that were carried out in 2017, i.e. one-year follow-up measurements for materials applied in 2016 and two years follow-up measurements for materials applied in 2015.

Materials are certified in relation to the number of wheel passages they will stand. Depending on the traffic flow, the position in the lane and the exposure time, different roll-over classes (P0–P6, defined by EN 1824) will be reached. For materials applied in 2016, roll-over classes P1–P4 were reached in 2017 and for materials applied in 2015, roll-over class P5 was reached in 2017.

Out of the 72 materials applied in 2016, 58 (40 white, 18 yellow) were approved at the initial measurements and did thus qualify for follow-up measurements. Out of the 40 white materials, 7 fulfilled the requirement for roll-over class P4, 11 for class P3, 24 for class P2, and 25 for class P1. 14 white materials did not fulfil the requirements for any roll-over class and one of the white materials was disqualified due to missing documentation. The corresponding figures for the 18 yellow materials show that no material fulfilled the requirement for roll-over classes P4 and P3. 4 fulfilled the requirement for class P2 and 7 for class P1. 11 yellow materials did not fulfil the requirements for any roll-over class.

Two materials applied in 2015 fulfilled the requirement for class P4 in 2016. The follow-up measurements carried out in 2017 showed that none of these materials fulfilled the requirement for class P5. Thus, the final result for the 78 materials applied in 2015 is as follows:

No P-class: 24 white, 23 yellow

P0 & P1: 25 white, 6 yellow

P2: 19 white, 5 yellow

P3: 10 white, 3 yellow

P4: 2 white, 0 yellow

P5: 0 white, 0 yellow

Sammanfattning

Nordisk certifiering av vägmarkeringsmaterial i Norge och Sverige 2015–2017

av Trond Cato Johansen (Ramböll), Carina Fors (VTI) och Erik Kjellman (VTI)

En nordisk certifiering av vägmarkeringsmaterial introducerades 2015 och avser i ett första steg Danmark, Norge och Sverige. I dessa länder kommer det att krävas ett dokumenterat godkännande av vägmarkeringsmaterial som används på vägar som administreras av den statliga väghållaren. Detta godkännande baseras på funktionsmätningar på vägmarkeringar som har applicerats i provfält. Certifiering i Norge och Sverige kommer att baseras på resultat från provfält i Norge eller i Sverige, medan certifiering i Danmark kommer att baseras på resultat från provfält i Danmark.

En första testomgång i Sverige påbörjades i maj 2015. Totalt 81 material, varav 78 för certifiering och tre för tillverkarnas interna test, applicerades på det svenska provfältet norr om Sunne. År 2016 applicerades ytterligare 72 material på det svenska provfältet.

Cirka två veckor efter utläggningen görs fysikaliska mätningar av vägmarkeringarnas retroreflexion, R_L i torrt och vått tillstånd, luminanskoefficient, *Qd*, friktion, färg i dagsljus och färg i fordonsbelysning (för gula material).

Uppföljande mätningar av ovan nämnda funktionsparametrar görs ett respektive två år efter utläggning. Föreliggande rapport dokumenterar resultaten från de uppföljande mätningar som gjordes 2017, det vill säga ettårsuppföljning av material som lades ut 2016 och tvåårsuppföljning av material som lades ut 2015.

Materialen certifieras i relation till antalet hjulpassager de tål. Beroende på trafikflöde, position i körfältet och exponeringstid, uppnås olika hjulpassageklasser (P0–P6) som definieras av europastandarden EN 1824. På provfältet som lades ut 2016 uppnåddes klasserna P1–P4 under 2017 och på provfältet som lades ut 2015 uppnåddes klassen P5 under 2017.

Av de 72 material som lades ut 2016 godkändes 58 (40 vita, 18 gula) vid de initiala mätningarna och de kvalificerade sig därmed för uppföljande mätningar. Av de 40 vita materialen uppfyllde 7 kraven för hjulpassageklass P4, 11 för klass P3, 24 för klass P2 och 25 för klass P1. 14 vita material uppfyllde inte kraven i någon hjulpassageklass och ett av de vita materialen har diskvalificerats på grund av saknad dokumentation. Motsvarande siffror för de 18 gula materialen visade att inga material uppfyllde kraven för klasserna P4 och P3. 4 material uppfyllde kraven för klass P2 och 7 för klass P1. 11 gula material uppfyllde inte kraven i någon hjulpassageklass.

Två material som lades ut 2015 uppfyllde kraven för klass P4 under 2016. De uppföljande mätningarna som gjordes 2017 visade att inga av dessa material uppfyllde kraven för klass P5. De slutgiltiga resultaten för de 78 material som lades ut 2015 är således:

Ingen P-klass: 24 vita, 23 gula

P0 & P1: 25 vita, 6 gula

P2: 19 vita, 5 gula

P3: 10 vita, 3 gula

P4: 2 vita, 0 gula

P5: 0 vita, 0 gula

1. Introduction

A Nordic certification system for road marking materials was introduced in 2015. In the first stage, the certification system applies to the countries of Denmark, Norway and Sweden. In these countries, a documented product approval will be required in order to use a road marking material on roads managed by the national road authorities. Product approval will be based on monitored and documented performance measurements of material samples applied on test fields on public roads. Certification in Norway and Sweden will be based on the results from a test site in Norway or in Sweden and certification in Denmark will be based on the results from a test site in Denmark. The results from the Danish test site are presented in a separate report (Johansen, Fors and Kjellman, 2018).

The first round of material tests in Sweden started in May 2015, when 81 materials were applied at the Swedish test site in Sunne. 78 materials – 49 white and 29 yellow – were applied for certification and 3 for manufacturer's internal test. In 2016, another 72 materials were applied for certification at the Swedish test site – 48 white and 24 yellow.

Follow-up measurements of the performance parameters coefficient of retroreflected luminance R_L under dry and wet conditions, luminance coefficient under diffuse illumination *Qd*, chromaticity in daylight, chromaticity of retroreflected light (yellow materials only) and friction are carried out one year and two years after application. Thus, in 2016 one-year follow-up measurements for materials applied in 2015 were carried out. In 2017, two-years follow-up measurements for materials applied in 2015 and one-year follow-up measurements for materials applied in 2016 were carried out.

Materials are certified in relation to the number of wheel passages they will stand. Measurements of the transversal distribution of wheel passages have been carried out at the test sites, and roll-over classes (P-classes) have been determined for each of the six lines of road marking materials that were applied in the lane (see also Section 2.2). For materials applied at the Swedish test site in 2015, the P-classes P0, P1, P2, P3 and P4 were reached in 2016 and P-class P5 was reached in 2017. For materials applied at the Swedish test site in 2016, the P-classes P1, P2, P3 and P4 were reached in 2017.

The certification system is further described in the document *Nordic certification system for road marking materials – Version 4:2017* (Fors, Johansen, Lundkvist and Nygårdhs, 2017) which is a public report available at www.vti.se/en/publications. The document is referred to as *NCSRM-4:2017* in the present report.

1.1. Aim

The aim of this report is to compile and present the results of the follow-up performance measurements carried out in 2017 on the materials applied at the Swedish test site in 2015 and in 2016, i.e. the report presents which materials have been certified for use in Norway and Sweden, for the P-classes mentioned above. Results for higher P-classes for materials applied in 2016 will be published in 2018.

The report includes results of materials registered as *certification materials*. Results of materials registered as *test materials* will be available only to the specific manufacturer.

2. Test site

2.1. General

The road used for the test site is a two-lane rural road located at European road E45, approximately 10 km north of Sunne, Sweden, 130 km east of Oslo, Norway. The road is relatively straight and flat and without any major junctions and has an AADT of around 3 900 vehicles/day in two directions, with a posted speed limit of 90 km/h. The width of the road is 9.0 m and each lane is 3.75 m wide. Figure 1 shows the test site at the time of application in 2015.

Figure 1. The test site in Sweden at the time of application in 2015. Photo: Trond Cato Johansen.

The road surface consists of a thin asphalt overlay which was laid in 2012. The roughness class is RG3, i.e. the averaged measured texture depth is in the range 0.90 – 1.20 mm.

The Köppen (climatic) classification of the test site is Dfb, close to the boundary of the Dfc climate zone, based on data for the period 1951–2000 (Kottek, Grieser, Beck, Rudolf and Rubel, 2006). The climatic class of the Swedish test site according to EN 1824 is C3. The extent of winter maintenance may vary a lot between years.

Studded tyres are permitted in Sweden from 1 October to 15 April. In 2014, the percentage of cars using studded tyres in Karlstad, 70 km south of the test site, was 80 % (Trafikverket, 2014).

Further details can be found in *NCSRM-4:2016.*

2.2. Material application

Each marking material was applied as a row of seven longitudinal lines in the direction of the traffic, Figure 1. The length of the lines were 2.5 m and the width was 0.3 m. The distance between two

adjacent rows of lines was at least 2 m. The lines are numbered from right to left in the driving direction, i.e. line 1 is the one on the shoulder and line 7 is the one next to the centre line.

2.3. Traffic volume and wheel passages

Measurements of wheel passages were carried out in the end of September 2016, both on the test field established in 2015 and the test field established in 2016. The number and type of vehicles and their lateral position were registered by a portable traffic analyser based on coaxial cable technique, developed at VTI. The measurement equipment was placed in an empty position (i.e. were no material was applied) in the middle of the respective test field. Wheel passages were registered for one week.

2.3.1. Test field 2015

At the test field established in 2015, on average, 1 696 vehicles, corresponding to 3 848 wheel pairs, were registered per day (in one direction). 87.7 % were passenger cars, 11.9 % were heavy vehicles (trucks and buses) and 0.4 % were other vehicles (two wheelers, working vehicles). The traffic flow was the highest on Friday (1 927 vehicles) and the lowest on Sunday (1 313 vehicles).

The registered traffic flow was compared to AADT information provided by the Swedish Transport Administration (STA), and it was found that the latter was 18.2 % higher. STA has a measurement point 1 km south of the test site, and for this point there is a theoretical model of traffic flow variations over the year available. This model confirms that our measurements were carried out when the traffic flow is relatively low (traffic flow peaks during the winter and summer holidays) and thus, our data was adjusted according to the STA data (i.e. increased by 18.2 %).

The transversal distribution of wheel passages tends to move to the centre line in darkness compared to daylight. In darkness, passenger vehicles were positioned 8 cm more to the left and heavy vehicles were positioned 17 cm more to the left. This was adjusted for by calculating normalized wheel passage curves for daylight and darkness, and multiplying them by the amount of traffic that passes in daylight and darkness, for each week during the year. Daylight was defined to start when morning civil twilight begins, and to end when evening civil twilight ends. Darkness was defined to start when daylight ended and to end when daylight began.

Figure 2 shows the distribution of wheel passages for the average week, adjusted for STA’s AADT data and for variations in distribution due to the light conditions.

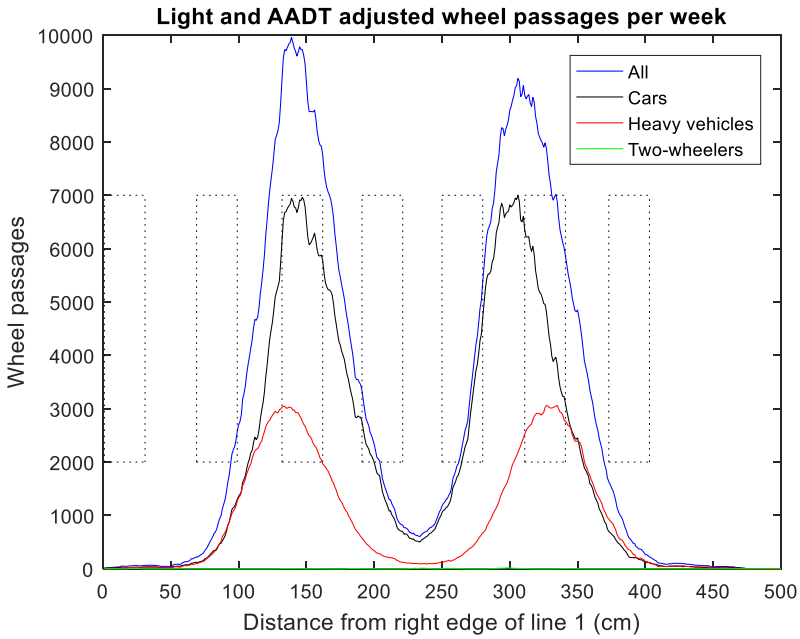

Figure 2. Wheel passages per week at the Swedish test field established in 2015, adjusted for AADT and light conditions. The dashed areas correspond to the seven lines (line 1 to the left, line 7 to the right). Please note that the shoulder is to the left in the figure.

Table 1 shows the number of wheel passages per line and week, as an average for the 15 cm wide area in the centre of the line (corresponding to the measurement area, see Figure 4–Figure 6).

Table 1. Number of wheel passages per line and week, at the Swedish test field established in 2015.

Line	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7
Number of wheel passages per week	763	9460	1 849	2 269	7 849	693

2.3.2. Test field 2016

At the test field established in 2016, on average, 1 758 vehicles, corresponding to 3 988 wheel pairs, were registered per day (in one direction). 87.9 % were passenger cars, 11.7 % were heavy vehicles, and 0.3 % were other vehicles (two wheelers, working vehicles). The traffic flow was the highest on Friday (2 009 vehicles) and the lowest on Sunday (1 341 vehicles).

The registered traffic flow was compared to AADT information provided by the Swedish Transport Administration (STA), and it was found that the latter was 14.0 % higher. STA has a measurement point 1 km south of the test site, and for this point there is a theoretical model of traffic flow variations over the year available. This model confirms that our measurements were carried out when the traffic flow is relatively low (traffic flow peaks during the winter and summer holidays) and thus, our data was adjusted according to the STA data (i.e. increased by 14.0 %).

The transversal distribution of wheel passages tends to move to the centre line in darkness compared to daylight. In darkness, passenger vehicles were positioned 4 cm more to the left and heavy vehicles were positioned 13 cm more to the left. This was adjusted for by calculating normalized wheel passage curves for daylight and darkness, and multiplying them by the amount of traffic that passes in daylight and darkness, for each week during the year. Daylight was defined to start when morning civil twilight begins, and to end when evening civil twilight ends. Darkness was defined to start when daylight ended and to end when daylight began.

Figure 3 shows the distribution of wheel passages for the average week, adjusted for STA's AADT data and for variations in distribution due to the light conditions.

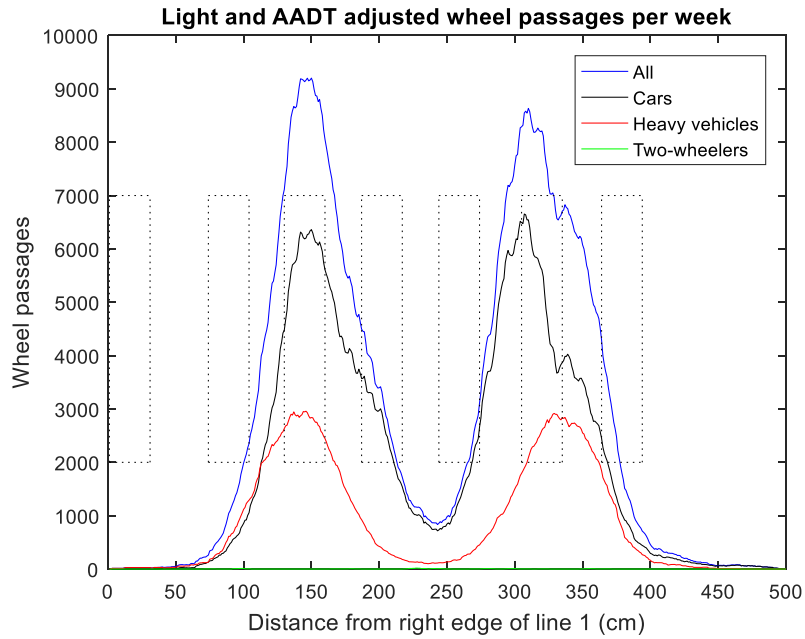

Figure 3. Wheel passages per week at the Swedish test field established in 2016, adjusted for AADT and light conditions. The dashed areas correspond to the seven lines (line 1 to the left, line 7 to the right). Please note that the shoulder is to the left in the figure.

Table 2 shows the number of wheel passages per line and week, as an average for the 15 cm wide area in the centre of the line (corresponding to the measurement area, see Figure 4–Figure 6).

Table 2. Number of wheel passages per line and week, at the Swedish test field established in 2016.

Line	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7
Number of wheel passages per week	939	9 035	3 261	1 425	7 959	2 038

2.4. Weather conditions 2016–2017

The weather conditions from August 2016, when the materials were applied, to August 2017, when the follow-up measurements were carried out are shown in Table 3.

Table 3. Weather conditions at the Swedish test site, from August 2016 to August 2017.

Weather parameter	Value
Annual average temperature	6.3 °C
Average summer temperature (Apr-Sep)	12.0 °C
Average winter temperature (Oct-Mar)	0.6 °C
Annual precipitation	499 mm
Number of sun hours per month (Karlstad)	154 h
Number of weeks with snow	9
Number of times the snow plough has operated	34
Number of times the road has been salted	108

Weather data was retrieved from *the Swedish Meteorological and Hydrological Institute* (SMHI) open data service[1]. Data on temperature, precipitation and snow are from weather stations located less than 15 km from the test site.

Information about snow plough operations and salting was obtained from the Swedish Transport Administration.

[1] http://opendata-download-metobs.smhi.se/explore/

3. Performance measurements

3.1. General

Measurements of all performance parameters were carried out by operators from Ramböll, supervised by an observer from VTI. All measurement equipment were calibrated according procedures recommended by the respective manufacturer.

Performance measurements were carried out in August 2017 (week 33).

3.2. Methods and measuring instruments

3.2.1. Coefficient of retroreflected luminance R_L and luminance coefficient under diffuse illumination *Qd*

The coefficient of retroreflected luminance, R_L, and the luminance coefficient under diffuse illumination, *Qd*, were measured using an *LTL-XL* (Delta, Denmark). Measurements were taken at three points diagonally within the measurement area of 0.15 x 1.5 m, defined by EN 1824, Figure 4. The result of an individual line was calculated as the average of the three measurements.

The coefficient of retroreflected luminance, R_L, under wet conditions was measured on type II markings (i.e. road markings with special properties intended to enhance the retroreflection in wet or rainy conditions), with the same instrument and measurement points as described above. Approximately 3 litres of clean water was poured over the measurement area, and measurements were carried out 60 seconds afterwards.

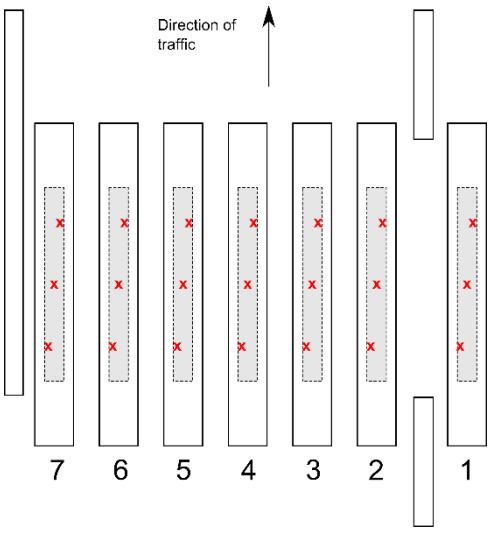

Figure 4. The measurement points (red crosses) for R_L and Qd were placed diagonally within the measurement area (grey) defined by EN 1824.

The markings were not cleaned before the measurements, but in case a substantial part of the measurement area was abnormally dirty (e.g. oil stain), the instrument was moved in the longitudinal direction to the closest area not affected by abnormal dirt.

Some marking lines were too worn to be measured, e.g. this is sometimes the case for lines in position 3 and 6. If the measurement area of the marking lines were worn in a way that made representative measurements impossible, these single lines were not measured. However, other marking lines of the same product, that were not equally worn, were measured.

3.2.2. Chromaticity coordinates

Chromaticity coordinates were measured in one point on each line, located at the centre of the line, Figure 5. A *Spectrophotometer CM-2500c* (Konica Minolta, Japan) was used to measure the colour coordinates. The chromaticity coordinates of yellow materials in retroreflected light (night-time colour) were measured by an *LTL 2000Y* (Delta, Denmark).

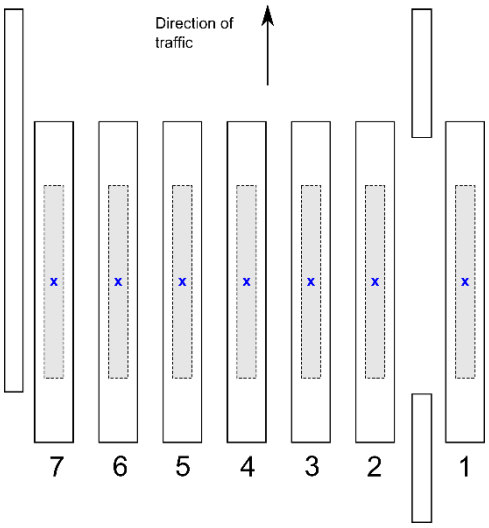

Figure 5. The measurement points (blue crosses) for chromaticity coordinates were placed in the centre of the lines.

For materials with a high degree of wear, the measurement was taken at an area where the material was intact, if possible. For materials that had a very non-homogenous surface (due to unevenly distributed drop-on), an area that appeared to represent the average surface of the material was selected as measurement point. In some cases, several measurement points were selected, to ensure correct chromaticity coordinates. These points had to be located within the grey area in Figure 4.

The markings were not cleaned before the measurements, but in case a substantial part of the measurement area was abnormally dirty (e.g. oil stain), the instrument was moved to the closest area not affected by abnormal dirt.

3.2.3. Friction

Friction measurements were carried out using a *Portable Friction Tester version 4*, PFT (Coralba, Sweden), along the centre of each line, Figure 6. The PFT takes a sample approximately every 1.9 cm and thus, about 70 samples are taken on each line. The result of an individual line is calculated as the average of all samples from that line.

In case there were any notches, joints or other abnormalities on the marking surface, the measurement area/line was either reduced or moved somewhat, so that no samples were taken from the abnormality.

Friction was measured on wetted markings. The friction measurements were always carried out after the measurements of the coefficient of retroreflected luminance, R_L, the luminance coefficient under diffuse illumination, *Qd*, and chromaticity coordinates.

The PFT instrument is further described in Wälivaara (2007).

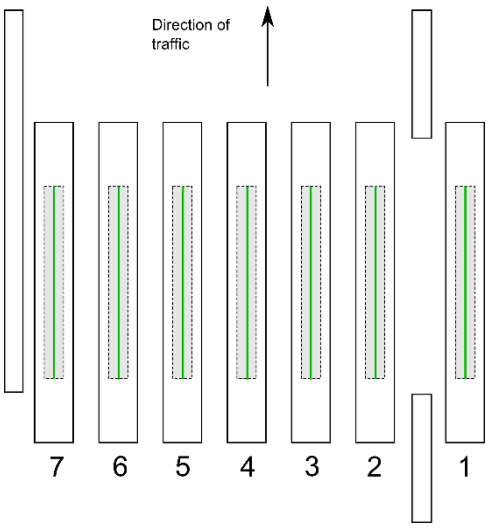

Figure 6. The measurement areas (green lines) for friction.

3.3. Weather conditions

During the measurements in 2017, the weather changed between sunny and cloudy. The air temperature was 16–24 ˚C. The road surface had a temperature of 18–26 ˚C and it was completely dry. The road markings had a temperature of 17–24 ˚C.

4. Performance requirements

4.1. Performance parameters

The performance requirements include four parameters for type I markings[2] and five parameters for type II markings, which are given in Table 4.

Table 4. Performance requirements.

Performance parameter	**White markings**	**Yellow markings**	**Applies to marking type**
Coefficient of retroreflected luminance, R_L, dry [mcd/m^2/lx]	≥ 150	≥ 100	I, II
Coefficient of retroreflected luminance, R_L, wet [mcd/m^2/lx]	≥ 35	≥ 35	II
Luminance coefficient under diffuse illumination, *Qd* [mcd/m^2/lx]	≥ 130	≥ 100	I, II
Friction, [PFT units]	≥ 0.52	≥ 0.52	I, II
Chromaticity coordinates, x, y	*	**	I, II

*) According to EN 1436
**) Includes both daytime and night-time colour. Daytime colour: according to class Y1 in EN 1436. Night-time colour: according to ASTM D6628.

4.1.1. Special considerations regarding friction

A PFT value of 0.52 corresponds to a *Skid Resistance Tester* (SRT) value of 50. The translation from PFT units into SRT units and vice versa results in an uncertainty of approximately 10 % (Wälivaara, 2007). Consequently, there is a risk that a reading of a value just below 0.52 PFT units, in fact has 50 SRT units and therefore should fulfil the requirement.

In order to minimize the risk that materials are rejected because of the uncertainty when translating PFT units into SRT units, the required limit for approval was lowered by approximately 10 % or 0.05 PFT units, from 0.52 to 0.47.

4.2. Certification in relation to P-classes

Materials are certified in relation to the number of wheel passages they will stand. The six lines within the driving lane are exposed to different numbers of wheel passages, which means that different roll-over classes are reached on different lines at different times.

Roll-over classes according to EN 1824 are determined from the measurements of wheel passages for each of the six lines, Table 5.

Materials are thus certified for a certain roll-over class (P-class). In order to be certified, all four (type I markings) or five (type II markings) performance requirements must be fulfilled for that particular class.

Certification is given based on the follow-up measurements one and two years after application. No certification is given based on the initial measurements that are carried out a few weeks after application.

[2] Type I refers to flat markings. Type II refers to markings with special properties intended to enhance the retroreflection in wet or rainy conditions.

At the follow-up measurements, the performance parameters are defined as the registered value of the line which is closest to the centre of a certain P-class (see section 4.2.1).

The materials have to fulfil the requirements for all classes lower than that it is certified for, provided that the lower classes exist on the test field. Example: In order for a material to be certified as a P3 material, the performance requirements have to be fulfilled also for classes P0, P1 and P2.

If a material has been certified for a certain P-class after one year (i.e. at the one-year follow-up measurement), this certification is valid irrespective of the results of the measurements after two years. The two year follow-up measurements are merely used to evaluate whether the material fulfils the requirement for a higher P-class than what it is already certified for.

Table 5. Roll-over classes, EN 1824.

Roll-over class	Number of wheel passages
P0	≤ 50 000
P1	Between 50 000 and 60 000
P2	100 000 ± 20 %
P3	200 000 ± 20 %
P4	500 000 ± 20 %
P5	1 000 000 ± 20 %
P5.5	1 500 000 ± 20 %
P6	2 000 000 ± 20 %

4.2.1. P-classes at the Swedish test site 2016–2017

For materials applied at the Swedish test site in 2015, P-classes P0–P4 were reached in 2016, and P-class P5 was reached in 2017. For materials applied in 2016, classes P1–P4 were reached in 2017 and P-class P5 is expected to be reached in 2018. The dates for the follow-up measurement were selected so that all P-classes were represented by one line, Table 6 and Table 7.

Table 6. P-classes at the Swedish test site, materials applied in 2015.

Roll-over class	Lines	Measured
P0	Line 2	August 2016
P1	Line 2	August 2016
P2	Line 7	August 2016
P3	Line 4	August 2016
P4	Line 6	August 2016
P5	Line 6	August 2017

Table 7. P-classes at the Swedish test site, materials applied in 2016.

Roll-over class	Lines	Measured
P0	-	-
P1	Line 2	August 2017
P2	Line 7	August 2017
P3	Line 4	August 2017
P4	Line 3	August 2017
P5	-	Summer 2018 (expected)

5. Certification of materials applied in 2015

Table 8–Table 13 show the certification of road marking materials in P-classes P0–P5 for materials applied at the Swedish test site in 2015. **A** means approved and **NA** not approved material.

Only materials that were approved at the initial measurements and that participate as *certification materials* with two years follow-up are included in the tables below.

Measurement data per material and P-class can be found in Appendix 1.

5.1. White road markings

5.1.1. Type I

5.1.1.1. Material thickness 0.4 mm

Table 8. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P0–P5. White type I materials, 0.4 mm, applied in 2015.

Manufacturer *Material*	**P0**	**P1**	**P2**	**P3**	**P4**	**P5**
Plastiroute GmbH AquaRoute BST-NO	**NA**					
Plastiroute GmbH AquaRoute HD BST	**NA**					

5.1.1.2. Material thickness 1.5 mm

Table 9. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P0–P5. White type I materials, 1.5 mm, applied in 2015.

Manufacturer *Material*	**P0**	**P1**	**P2**	**P3**	**P4**	**P5**
Cleanosol AB, A/S, LKF A/S 45 S30 N	**NA**					
Ennis Flint Sprayplastic W2015.1	**NA**					
LKF Materials A/S Viatherm SK25	**A**	**A**	**A**	**A**	**NA**	
Swarco Vestglas Gmbh Swarcotherm SRP 15 white	**NA**					
Svevia X204	**A**	**A**	**NA**			
Svevia X205	**A**	**A**	**NA**			
Svevia X206	**NA**					

5.1.1.3. Material thickness 3 mm

Table 10. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P0–P5. White type I materials, 3 mm, applied in 2015.

Manufacturer *Material*	**P0**	**P1**	**P2**	**P3**	**P4**	**P5**
Cleanosol AB, A/S CL 35E1 R3	A	A	A	A	NA	
Cleanosol AB, A/S CL 35E2 R3	A	A	A	A	NA	
Cleanosol AB, A/S CL 71E1 R3	A	A	NA			
Cleanosol AB, A/S, LKF A/S 31 E35	A	A	A	NA		
Cleanosol AB, A/S, LKF A/S 31 E35 NO	A	A	A	NA		
Cleanosol AB, A/S, LKF A/S 50 EP40 Agglo	A	A	A	A	NA	
Ennis Flint Crystalex W2015.5	NA					
Ennis Flint Crystalex W2015.6	NA					
Hermseal A/S MeltMark ESP	NA					
Hitex HiBrite WR EXTR	NA					
Hot Mix Oy Hot Mix 1A white	A	A	A	NA		
LKF Materials A/S Premark SK151	A	A	A	A	NA	
LKF Materials A/S Premark SK152	A	A	A	A	A	NA
LKF Materials A/S Premark SK153	A	A	A	NA		
LKF Materials A/S Viatherm SK20	A	A	A	A	NA	
LKF Materials A/S Viatherm SK60	A	A	A	A	NA	
LKF Materials A/S Viatherm Viking	A	A	A	A	A	NA
Promax Industries ApS Promax white prime	NA*					
Swarco Vestglas Gmbh Swarcotherm ERP 15 white	A	A	A	A	NA	
Svevia X201	A	A	NA			
Svevia X202	NA					

Manufacturer *Material*	**P0**	**P1**	**P2**	**P3**	**P4**	**P5**
Trafikmarkering TTP 30	NA*					
Veluvine Thermolit Gaula	A	A	NA			
Veluvine Thermolit Nausta	A	A	A	NA		

*) Disqualified due to missing documentation. In the result report published in 2016, the material was wrongly approved in lower P-classes.

5.2. Yellow road markings

5.2.1. Type I

5.2.1.1. Material thickness 0.4 mm

Table 11. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P0–P5. Yellow type I materials, 0.4 mm, applied in 2015.

Manufacturer *Material*	**P0**	**P1**	**P2**	**P3**	**P4**	**P5**
Plastiroute GmbH AquaRoute HD BST Yellow	NA					

5.2.1.2. Material thickness 1.5 mm

Table 12. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P0–P5. Yellow type I materials, 1.5 mm, applied in 2015.

Manufacturer *Material*	**P0**	**P1**	**P2**	**P3**	**P4**	**P5**
Cleanosol AB, A/S CL 29S2 R2 Yellow	NA					
Cleanosol AB, A/S CL 71S1 R2 Yellow	A	A	A	A	NA	
Cleanosol AB, A/S, LKF A/S NTY 29S Yellow	NA					
Ennis Flint Sprayplastic Y2015.3	NA					
Ennis Flint Sprayplastic Y2015.4	NA					
LKF Materials A/S Viatherm SK55 yellow	A	A	A	A	NA	
Svevia Y313	NA					
Svevia Y314	NA					

5.2.1.3. Material thickness 3 mm

Table 13. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P0–P5. Yellow type I materials, 3 mm, applied in 2015.

Manufacturer *Material*	P0	P1	P2	P3	P4	P5
Cleanosol AB, A/S CL 27EP2 R2 Yellow	NA					
Cleanosol AB, A/S CL 29E2 R2 Yellow	NA					
Cleanosol AB, A/S CL 71E1 R2 Yellow	NA					
Cleanosol AB, A/S, LKF A/S NTY 27 Agglo Yellow	NA					
Cleanosol AB, A/S, LKF A/S NTY 29E Yellow	NA					
Hitex HiBrite Yellow EXTR 1	NA					
Hot Mix Oy Hot Mix 1A yellow	A	A	NA			
Hot Mix Oy Hot Mix 3000 M (yellow)	A	A	A	NA		
LKF Materials A/S Viatherm SK50 yellow	A	A	A	A	NA	
Svevia Y311	NA					

5.3. Summary of the results

Out of the 78 materials applied for certification at the Swedish test site in 2015, 31 have received certification in one or more P-classes. Two materials applied in 2015 fulfilled the requirement for class P4 in 2016. The follow-up measurements carried out in 2017 showed that none of these materials fulfilled the requirement for class P5. Thus, the final result for the 78 materials applied in 2015 is as follows (including materials with one and two years follow-up):

No P-class: 24 white, 23 yellow

P0 & P1: 25 white, 6 yellow

P2: 19 white, 5 yellow

P3: 10 white, 3 yellow

P4: 2 white, 0 yellow

P5: 0 white, 0 yellow

Detailed results for P-classes P0–P4 can be found in the report *Nordic certification of road marking materials in Sweden 2015–2016* (Johansen, Fors, Nygårdhs and Lundkvist, 2016).

6. Certification of materials applied in 2016

Table 14–Table 21 show the certification of road marking materials in P-classes P1–P4 for materials applied at the Swedish test site in 2016. **A** means approved and **NA** not approved material.

Only materials that were approved at the initial measurements and that participate as *certification materials* with one or two years follow-up are included in the tables below.

Measurement data per material and P-class can be found in Appendix 1.

6.1. White road markings

6.1.1. Type I

6.1.1.1. Material thickness 0.4 mm

Table 14. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P1–P4. White type I materials, 0.4 mm, applied in 2016.

Manufacturer *Material*	**P1**	**P2**	**P3**	**P4**
SAR WP201 (type I)	**NA**			
SAR WP203 (type I)	**NA**			
Visafo VIT VISA 16	**NA**			
Visafo VIT VISA 17	**NA**			

6.1.1.2. Material thickness 1.5 mm

Table 15. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P1–P4. White type I materials, 1.5 mm, applied in 2016.

Manufacturer *Material*	**P1**	**P2**	**P3**	**P4**
Ennis Flint Spray W2016.10	**NA**			
Ennis Flint Spray W2016.11	**NA**			
Ennis Flint Spray W2016.9	**NA**			
Geveko Viatherm 45 S30N	**A**	**A**	**A**	**A**
Geveko Viatherm 71 S	**A**	**A**	**A**	**A**
Kelly Bros White Spray Briteline 150	**A**	**A**	**NA**	
Kestrel Eurolux SC White Spr. IGSO03	**A**	**A**	**NA**	
Kestrel Eurolux SC White Spr. IGSO04	**A**	**A**	**NA**	
Svevia AB X1653	**A**	**A**	**A**	**NA**
Svevia AB X1654	**A**	**A**	**A**	**NA**

6.1.1.3. Material thickness 3 mm

Table 16. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P1–P4. White type I materials, 3 mm, applied in 2016.

Manufacturer *Material*	**P1**	**P2**	**P3**	**P4**
Ennis Flint Screed/extr. W2016.1	NA			
Geveko Markings PREMARK RETRO 161	A	A	NA	
Geveko Markings PREMARK RETRO 162	A	A	NA	
Geveko Viatherm 31 E35NO	A	A	A	A
Geveko Viatherm 35 E40	A	A	A	A
Geveko Viatherm 71 E	A	A	A	A
Kelly Bros White Extr./Scr. Briteline 150	A	A	A	NA
Kelly Bros White Extr./Scr. Briteline 150 S	A	A	A	A
Kestrel Eurolux SC White Extr. IGSO01	A	A	NA	
Kestrel Eurolux SC White Extr. IGSO02	A	A	NA	
Kestrel Eurolux SC White Extr. IGSO09	A	A	NA	
SAR CP301	NA			
Swarco Vestglas Gmbh Swarcotherm ERP 16 white	A	NA		
Svevia AB X1601	A	A	A	NA
Svevia AB X1602	A	A	A	A
Trafikmarkering TTP 30.2	NA*			
Veluvine Thermolit Fabiola	A	A	NA	

*) Disqualified due to missing documentation.

6.1.2. Type II

6.1.2.1. Material thickness 0.6 mm

Table 17. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P1–P4. White type II materials, 0.6 mm, applied in 2016.

Manufacturer *Material*	**P1**	**P2**	**P3**	**P4**
SAR WP201 (type II)	**NA**			
SAR WP203 (type II)	**NA**			
Swarco Limburger Lackf. Gmbh Limboroute W13N	**NA**			

6.1.2.2. Material thickness 3 mm

Table 18. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P1–P4. White type II materials, 3 mm, applied in 2016.

Manufacturer *Material*	**P1**	**P2**	**P3**	**P4**
Ennis Flint Screed/extr. W2016.4 *Profile/pattern:* Flat	**NA**			
Geveko Markings Viatherm 50 EP40 *Profile/pattern:* Drop, agglo	**A**	**A**	**NA**	
Promax Promax White prime profile 2016 *Profile/pattern:* Combi drop	**NA**			
Svevia AB X1622 *Profile/pattern:* Drop DoL	**A**	**A**	**NA**	
Svevia AB X1631 *Profile/pattern:* Combi drop	**A**	**A**	**NA**	
Svevia AB X1632 *Profile/pattern:* Combi drop	**A**	**A**	**NA**	

6.2. Yellow road markings

6.2.1. Type I

6.2.1.1. Material thickness 1.5 mm

Table 19. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P1–P4. Yellow type I materials, 1.5 mm, applied in 2016.

Manufacturer *Material*	**P1**	**P2**	**P3**	**P4**
Ennis Flint Spray Y2016.12	NA			
Ennis Flint Spray Y2016.13	NA			
Ennis Flint Spray Y2016.14	NA			
Kelly Bros Yellow Spray Briteline 100	NA			
Kestrel Eurolux SC Yellow IGSO 08	A	A	NA	

6.2.1.2. Material thickness 3 mm

Table 20. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P1–P4. Yellow type I materials, 3 mm, applied in 2016.

Manufacturer *Material*	**P1**	**P2**	**P3**	**P4**
Ennis Flint Screed/extr. Y2016.5	NA			
Ennis Flint Screed/extr. Y2016.7	NA			
Geveko Viatherm NTY 29E	A	NA		
Geveko Viatherm NTY 71E	NA			
Kelly Bros Yellow Extr./Scr. Briteline 100	NA			
Kestrel Eurolux SC Yellow IGSO 05	A	A	NA	
Kestrel Eurolux SC Yellow IGSO 06	A	A	NA	
Kestrel Eurolux SC Yellow IGSO 07	A	NA		
Promax Promax Yellow prime 2016	NA			
Swarco Vestglas Gmbh Swarcotherm ERP 16 yellow	A	NA		
Svevia AB Y1605	A	A	NA	

6.2.2. Type II

6.2.2.1. Material thickness 3 mm

Table 21. Certification of road marking materials for use on Norwegian and Swedish roads, roll-over classes P1–P4. Yellow type II materials, 3 mm, applied in 2016.

Manufacturer *Material*	**P1**	**P2**	**P3**	**P4**
Ennis Flint Screed/extr. Y2016.8 *Profile/pattern:* Flat	**NA**			
Svevia AB Y1615 *Profile/pattern:* Rullad	**NA**			

6.3. Summary of the results

Out of the 72 materials applied for certification at the Swedish test site in 2016, 58 (40 white, 18 yellow) were approved at the initial measurements and did thus qualify for follow-up measurements. Out of the 40 white materials, 7 fulfilled the requirement for roll-over class P4, 11 for class P3, 24 for class P2, and 25 for class P1. 14 white materials did not fulfil the requirements for any roll-over class and one of the white materials was disqualified due to missing documentation. The corresponding figures for the 18 yellow materials show that no material fulfilled the requirement for roll-over classes P4 and P3. 4 fulfilled the requirement for class P2 and 7 for class P1. 11 yellow materials did not fulfil the requirements for any roll-over class.

The 7 materials that fulfilled the requirement for roll-over class P4 have the opportunity to receive certification in roll-over class P5, which is expected to be reached in 2019.

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Appendix 1 – Results of the performance measurements

Explanation of the denotations in the result tables	
Parameters	
$R_{L,dry}$	Mean value of the coefficient of retroreflected luminance for dry road marking, $R_{L,dry}$ [mcd/m^2/lx]
$R_{L,wet}$	Mean value of the coefficient of retroreflected luminance for wet road marking, $R_{L,wet}$ [mcd/m^2/lx]
Qd	Mean value of luminance coefficient under diffuse illumination, *Qd* [mcd/m^2/lx]
Frict.	Mean value of friction [PFT units]
Colour	"OK", when colour coordinates are inside the colour box (daylight colour)
NTY	"OK", when colour coordinates are inside the colour box (night-time colour)
Appr.	Approved (**A**) or Not Approved (**NA**) in the P-class referred to
Comments and annotations	
worn	No measurements could be carried out, because the material was too worn.
n.m.	If $R_{L,dry}$ did not fulfil the requirement, $R_{L,wet}$ was not measured (n.m.).
d	Disqualified due to missing documentation.
-	The parameter does not apply to the material.

Values that do not fulfil the performance requirements are indicated in orange.

Rows marked in grey indicate that the material has not fulfilled the requirements in a lower P-class. It can thus not be approved in the present P-class.

Materials applied in 2015

Roll-over class P5

Table 22. The performance of materials applied at the Swedish test site in 2015 after two years. Roll-over class P5. White materials, per type and thickness. Alphabetical order by manufacturer.

Manufacturer *Material*	***$R_{L,dry}$***	***Qd***	***Frict.***	***Colour***	***Appr.***
Type I, 0.4 mm					
Plastiroute GmbH AquaRoute BST-NO	worn	worn	worn	worn	**NA**
Plastiroute GmbH AquaRoute HD BST	worn	worn	worn	worn	**NA**
Type I, 1.5 mm					
Cleanosol AB, A/S, LKF A/S 45 S30 N	120	238	0.79	OK	**NA**
Ennis Flint Sprayplastic W2015.1	worn	worn	worn	worn	**NA**
LKF Materials A/S Viatherm SK25	100	185	0.80	OK	**NA**
Swarco Vestglas Gmbh Swarcotherm SRP 15 white	worn	worn	worn	worn	**NA**
Svevia X204	worn	worn	worn	worn	**NA**
Svevia X205	worn	worn	worn	worn	**NA**
Svevia X206	worn	worn	worn	worn	**NA**
Type I, 3 mm					
Cleanosol AB, A/S CL 35E1 R3	155	220	0.73	OK	**NA**
Cleanosol AB, A/S CL 35E2 R3	117	202	0.75	OK	**NA**
Cleanosol AB, A/S CL 71E1 R3	150	231	0.78	OK	**NA**
Cleanosol AB, A/S, LKF A/S 31 E35	117	214	0.75	OK	**NA**
Cleanosol AB, A/S, LKF A/S 31 E35 NO	137	235	0.75	OK	**NA**
Cleanosol AB, A/S, LKF A/S 50 EP40 Agglo	159	218	0.76	OK	**NA**
Ennis Flint Crystalex W2015.5	worn	worn	worn	worn	**NA**
Ennis Flint Crystalex W2015.6	worn	worn	worn	worn	**NA**
Hermseal A/S MeltMark ESP	99	225	0.83	OK	**NA**

Hitex HiBrite WR EXTR	worn	worn	worn	worn	**NA**
Hot Mix Oy Hot Mix 1A white	104	197	0.80	OK	**NA**
LKF Materials A/S Premark SK151	worn	worn	worn	worn	**NA**
LKF Materials A/S Premark SK152	worn	worn	worn	worn	**NA**
LKF Materials A/S Premark SK153	worn	worn	worn	worn	**NA**
LKF Materials A/S Viatherm SK20	worn	worn	worn	worn	**NA**
LKF Materials A/S Viatherm SK60	worn	worn	worn	worn	**NA**
LKF Materials A/S Viatherm Viking	worn	worn	worn	worn	**NA**
Promax Industries ApS Promax white prime	d	d	d	d	**NA**
Swarco Vestglas Gmbh Swarcotherm ERP 15 white	115	194	0.76	OK	**NA**
Svevia X201	104	136	0.76	OK	**NA**
Svevia X202	125	173	0.78	OK	**NA**
Trafikmarkering TTP 30	d	d	d	d	**NA**
Veluvine Thermolit Gaula	worn	worn	worn	worn	**NA**
Veluvine Thermolit Nausta	worn	worn	worn	worn	**NA**

Table 23. The performance of materials applied at the Swedish test site in 2015 after two years. Roll-over class P5. Yellow materials, per type and thickness. Alphabetical order by manufacturer.

Manufacturer *Material*	$R_{L,dry}$	*Qd*	*Frict.*	*Colour*	*NTY*	*Appr.*
Type I, 0.4 mm						
Plastiroute GmbH AquaRoute HD BST Yellow	worn	worn	worn	worn	worn	NA
Type I, 1.5 mm						
Cleanosol AB, A/S CL 29S2 R2 Yellow	79	178	0.74	OK	outside	NA
Cleanosol AB, A/S CL 71S1 R2 Yellow	108	194	0.76	OK	OK	NA
Cleanosol AB, A/S, LKF A/S NTY 29S Yellow	102	185	0.76	OK	outside	NA
Ennis Flint Sprayplastic Y2015.3	worn	worn	worn	worn	worn	NA
Ennis Flint Sprayplastic Y2015.4	worn	worn	worn	worn	worn	NA
LKF Materials A/S Viatherm SK55 yellow	worn	worn	worn	worn	worn	NA
Svevia Y313	worn	worn	worn	worn	worn	NA
Svevia Y314	59	127	0.73	OK	OK	NA
Type I, 3 mm						
Cleanosol AB, A/S CL 27EP2 R2 Yellow	86	182	0.73	OK	OK	NA
Cleanosol AB, A/S CL 29E2 R2 Yellow	92	191	0.76	OK	outside	NA
Cleanosol AB, A/S CL 71E1 R2 Yellow	108	174	0.78	OK	OK	NA
Cleanosol AB, A/S, LKF A/S NTY 27 Agglo Yellow	85	174	0.74	OK	OK	NA
Cleanosol AB, A/S, LKF A/S NTY 29E Yellow	83	171	0.77	OK	OK	NA
Hitex HiBrite Yellow EXTR 1	69	143	0.77	OK	outside	NA
Hot Mix Oy Hot Mix 1A yellow	85	194	0.77	OK	OK	NA
Hot Mix Oy Hot Mix 3000 M (yellow)	71	175	0.78	OK	OK	NA
LKF Materials A/S Viatherm SK50 yellow	worn	worn	worn	worn	worn	NA
Svevia Y311	worn	worn	worn	worn	worn	NA

Materials applied in 2016

Table 24–Table 31 show the results for roll-over classes P1, P2, P3 and P4, respectively, for materials applied at the Swedish test site in 2016.

Roll-over class P1

Table 24. The performance of materials applied at the Swedish test site in 2016 after one year. Roll-over class P1. White materials, per type and thickness. Alphabetical order by manufacturer.

Manufacturer *Material*	$R_{L,dry}$	$R_{L,wet}$	*Qd*	*Frict.*	*Colour*	*Appr.*
Type I, 0.4 mm						
SAR WP201 (type I)	43	-	88	0.85	outside	NA
SAR WP203 (type I)	43	-	89	0.80	outside	NA
Visafo VIT VISA 16	103	-	123	0.80	OK	NA
Visafo VIT VISA 17	128	-	122	0.83	OK	NA
Type I, 1.5 mm						
Ennis Flint Spray W2016.10	117	-	193	0.83	OK	NA
Ennis Flint Spray W2016.11	109	-	227	0.78	OK	NA
Ennis Flint Spray W2016.9	115	-	205	0.82	OK	NA
Geveko Viatherm 45 S30N	225	-	224	0.77	OK	A
Geveko Viatherm 71 S	347	-	232	0.69	OK	A
Kelly Bros White Spray Briteline 150	164	-	202	0.74	OK	A
Kestrel Eurolux SC White Spr. IGSO03	225	-	193	0.58	OK	A
Kestrel Eurolux SC White Spr. IGSO04	215	-	193	0.65	OK	A
Svevia AB X1653	186	-	184	0.64	OK	A
Svevia AB X1654	185	-	203	0.69	OK	A
Type I, 3 mm						
Ennis Flint Screed/extr. W2016.1	136	-	206	0.71	OK	NA
Geveko Markings PREMARK RETRO 161	180	-	178	0.81	OK	A
Geveko Markings PREMARK RETRO 162	191	-	185	0.73	OK	A

Geveko Viatherm 31 E35NO	249	-	220	0.59	OK	A
Geveko Viatherm 35 E40	323	-	218	0.59	OK	A
Geveko Viatherm 71 E	513	-	236	0.58	OK	A
Kelly Bros White Extr./Scr. Briteline 150	177	-	201	0.70	OK	A
Kelly Bros White Extr./Scr. Briteline 150 S	215	-	206	0.63	OK	A
Kestrel Eurolux SC White Extr. IGSO01	179	-	185	0.69	OK	A
Kestrel Eurolux SC White Extr. IGSO02	212	-	186	0.66	OK	A
Kestrel Eurolux SC White Extr. IGSO09	205	-	193	0.65	OK	A
SAR CP301	115	-	195	0.71	OK	NA
Swarco Vestglas Gmbh Swarcotherm ERP 16 white	150	-	187	0.82	OK	A
Svevia AB X1601	169	-	179	0.77	OK	A
Svevia AB X1602	190	-	183	0.71	OK	A
Trafikmarkering TTP 30.2	d	-	d	d	d	NA
Veluvine Thermolit Fabiola	176	-	218	0.77	OK	A
Type II, 0.6 mm						
SAR WP201 (type II)	45	n.m.	95	0.83	OK	NA
SAR WP203 (type II)	46	n.m.	100	0.87	OK	NA
Swarco Limburger Lackf. Gmbh Limboroute W13N	32	n.m.	94	0.87	OK	NA
Type II, 3 mm						
Ennis Flint Screed/extr. W2016.4	108	n.m.	219	0.76	OK	NA
Geveko Markings Viatherm 50 EP40	155	49	140	0.85	OK	A
Promax Promax White prime profile 2016	worn	worn	worn	worn	outside	NA
Svevia AB X1622	171	57	161	0.75	OK	A
Svevia AB X1631	173	41	170	0.79	OK	A
Svevia AB X1632	185	44	175	0.80	OK	A

Table 25. The performance of materials applied at the Swedish test site in 2016 after one year. Roll-over class P1. Yellow materials, per type and thickness. Alphabetical order by manufacturer.

Manufacturer *Material*	$R_{L,dry}$	$R_{L,wet}$	*Qd*	*Frict.*	*Colour*	*NTY*	*Appr.*
Type I, 1.5 mm							
Ennis Flint Spray Y2016.12	66	-	154	0.81	OK	OK	NA
Ennis Flint Spray Y2016.13	77	-	158	0.77	OK	outside	NA
Ennis Flint Spray Y2016.14	76	-	159	0.77	OK	OK	NA
Kelly Bros Yellow Spray Briteline 100	103	-	165	0.79	outside	outside	NA
Kestrel Eurolux SC Yellow IGSO 08	117	-	142	0.63	OK	OK	A
Type I, 3 mm							
Ennis Flint Screed/extr. Y2016.5	84	-	156	0.73	OK	outside	NA
Ennis Flint Screed/extr. Y2016.7	75	-	161	0.79	OK	outside	NA
Geveko Viatherm NTY 29E	105	-	157	0.77	OK	OK	A
Geveko Viatherm NTY 71E	101	-	180	0.89	OK	outside	NA
Kelly Bros Yellow Extr./Scr. Briteline 100	114	-	157	0.78	OK	outside	NA
Kestrel Eurolux SC Yellow IGSO 05	116	-	133	0.63	OK	OK	A
Kestrel Eurolux SC Yellow IGSO 06	117	-	149	0.66	OK	OK	A
Kestrel Eurolux SC Yellow IGSO 07	112	-	147	0.66	OK	OK	A
Promax Promax Yellow prime 2016	125	-	171	0.58	OK	outside	NA
Swarco Vestglas Gmbh Swarcotherm ERP 16 yellow	103	-	156	0.68	OK	OK	A
Svevia AB Y1605	118	-	157	0.75	OK	OK	A
Type II, 3 mm							
Ennis Flint Screed/extr. Y2016.8	77	n.m.	166	0.70	OK	OK	NA
Svevia AB Y1615	110	31	143	0.82	OK	OK	NA

Roll-over class P2

Table 26. The performance of materials applied at the Swedish test site in 2016 after one year. Roll-over class P2. White materials, per type and thickness. Alphabetical order by manufacturer.

Manufacturer *Material*	$R_{L,dry}$	$R_{L,wet}$	*Qd*	*Frict.*	*Colour*	*Appr.*
Type I, 0.4 mm						
SAR WP201 (type I)	35	-	95	0.91	outside	NA
SAR WP203 (type I)	38	-	98	0.80	OK	NA
Visafo VIT VISA 16	29	-	96	0.80	OK	NA
Visafo VIT VISA 17	32	-	102	0.85	OK	NA
Type I, 1.5 mm						
Ennis Flint Spray W2016.10	133	-	205	0.85	OK	NA
Ennis Flint Spray W2016.11	125	-	245	0.83	OK	NA
Ennis Flint Spray W2016.9	122	-	211	0.84	OK	NA
Geveko Viatherm 45 S30N	183	-	224	0.72	OK	A
Geveko Viatherm 71 S	294	-	232	0.62	OK	A
Kelly Bros White Spray Briteline 150	177	-	220	0.77	OK	A
Kestrel Eurolux SC White Spr. IGSO03	190	-	203	0.62	OK	A
Kestrel Eurolux SC White Spr. IGSO04	157	-	188	0.77	OK	A
Svevia AB X1653	193	-	211	0.70	OK	A
Svevia AB X1654	219	-	226	0.64	OK	A
Type I, 3 mm						
Ennis Flint Screed/extr. W2016.1	139	-	217	0.76	OK	NA
Geveko Markings PREMARK RETRO 161	151	-	204	0.87	OK	A
Geveko Markings PREMARK RETRO 162	154	-	209	0.85	OK	A
Geveko Viatherm 31 E35NO	223	-	216	0.58	OK	A
Geveko Viatherm 35 E40	249	-	209	0.57	OK	A

Geveko Viatherm 71 E	321	-	212	0.60	OK	A
Kelly Bros White Extr./Scr. Briteline 150	185	-	212	0.75	OK	A
Kelly Bros White Extr./Scr. Briteline 150 S	216	-	218	0.67	OK	A
Kestrel Eurolux SC White Extr. IGSO01	158	-	192	0.70	OK	A
Kestrel Eurolux SC White Extr. IGSO02	192	-	196	0.67	OK	A
Kestrel Eurolux SC White Extr. IGSO09	201	-	197	0.62	OK	A
SAR CP301	98	-	204	0.80	OK	NA
Swarco Vestglas Gmbh Swarcotherm ERP 16 white	102	-	215	0.89	OK	NA
Svevia AB X1601	209	-	200	0.68	OK	A
Svevia AB X1602	197	-	206	0.75	OK	A
Trafikmarkering TTP 30.2	d	-	d	d	d	NA
Veluvine Thermolit Fabiola	206	-	236	0.76	OK	A
Type II, 0.6 mm						
SAR WP201 (type II)	34	n.m.	102	0.90	OK	NA
SAR WP203 (type II)	36	n.m.	104	0.91	OK	NA
Swarco Limburger Lackf. Gmbh Limboroute W13N	worn	worn	worn	worn	outside	NA
Type II, 3 mm						
Ennis Flint Screed/extr. W2016.4	120	n.m.	233	0.80	OK	NA
Geveko Markings Viatherm 50 EP40	150	44	141	0.86	OK	A
Promax Promax White prime profile 2016	249	43	190	0.70	OK	NA
Svevia AB X1622	169	53	156	0.77	OK	A
Svevia AB X1631	212	49	193	0.75	OK	A
Svevia AB X1632	226	41	196	0.74	OK	A

Table 27. The performance of materials applied at the Swedish test site in 2016 after one year. Roll-over class P2. Yellow materials, per type and thickness. Alphabetical order by manufacturer.

Manufacturer *Material*	$R_{L,dry}$	$R_{L,wet}$	*Qd*	*Frict.*	*Colour*	*NTY*	*Appr.*
Type I, 1.5 mm							
Ennis Flint Spray Y2016.12	71	-	168	0.85	OK	outside	NA
Ennis Flint Spray Y2016.13	73	-	164	0.84	OK	outside	NA
Ennis Flint Spray Y2016.14	73	-	176	0.85	OK	outside	NA
Kelly Bros Yellow Spray Briteline 100	114	-	172	0.85	OK	OK	NA
Kestrel Eurolux SC Yellow IGSO 08	100	-	154	0.67	OK	OK	A
Type I, 3 mm							
Ennis Flint Screed/extr. Y2016.5	93	-	161	0.78	OK	OK	NA
Ennis Flint Screed/extr. Y2016.7	75	-	156	0.83	OK	OK	NA
Geveko Viatherm NTY 29E	90	-	177	0.67	OK	OK	NA
Geveko Viatherm NTY 71E	86	-	191	0.75	OK	outside	NA
Kelly Bros Yellow Extr./Scr. Briteline 100	123	-	162	0.84	OK	OK	NA
Kestrel Eurolux SC Yellow IGSO 05	100	-	155	0.68	OK	OK	A
Kestrel Eurolux SC Yellow IGSO 06	101	-	163	0.70	OK	OK	A
Kestrel Eurolux SC Yellow IGSO 07	93	-	168	0.70	OK	OK	NA
Promax Promax Yellow prime 2016	146	-	172	0.62	OK	outside	NA
Swarco Vestglas Gmbh Swarcotherm ERP 16 yellow	56	-	170	0.77	OK	OK	NA
Svevia AB Y1605	118	-	172	0.72	OK	OK	A
Type II, 3 mm							
Ennis Flint Screed/extr. Y2016.8	80	n.m.	174	0.83	OK	OK	NA
Svevia AB Y1615	129	31	149	0.83	OK	OK	NA

Roll-over class P3

Table 28. The performance of materials applied at the Swedish test site in 2016 after one year. Roll-over class P3. White materials, per type and thickness. Alphabetical order by manufacturer.

Manufacturer *Material*	$R_{L,dry}$	$R_{L,wet}$	*Qd*	*Frict.*	*Colour*	*Appr.*
Type I, 0.4 mm						
SAR WP201 (type I)	worn	-	worn	worn	worn	NA
SAR WP203 (type I)	worn	-	worn	worn	worn	NA
Visafo VIT VISA 16	worn	-	worn	worn	worn	NA
Visafo VIT VISA 17	worn	-	worn	worn	worn	NA
Type I, 1.5 mm						
Ennis Flint Spray W2016.10	113	-	214	0.82	OK	NA
Ennis Flint Spray W2016.11	97	-	248	0.76	OK	NA
Ennis Flint Spray W2016.9	97	-	218	0.80	OK	NA
Geveko Viatherm 45 S30N	151	-	193	0.72	OK	A
Geveko Viatherm 71 S	271	-	217	0.67	OK	A
Kelly Bros White Spray Briteline 150	118	-	191	0.81	OK	NA
Kestrel Eurolux SC White Spr. IGSO03	75	-	139	0.78	OK	NA
Kestrel Eurolux SC White Spr. IGSO04	worn	-	worn	worn	worn	NA
Svevia AB X1653	174	-	195	0.70	OK	A
Svevia AB X1654	209	-	230	0.68	OK	A
Type I, 3 mm						
Ennis Flint Screed/extr. W2016.1	111	-	238	0.72	OK	NA
Geveko Markings PREMARK RETRO 161	111	-	185	0.83	OK	NA
Geveko Markings PREMARK RETRO 162	81	-	165	0.83	OK	NA
Geveko Viatherm 31 E35NO	195	-	224	0.61	OK	A
Geveko Viatherm 35 E40	226	-	219	0.62	OK	A

Geveko Viatherm 71 E	379	-	237	0.56	OK	A
Kelly Bros White Extr./Scr. Briteline 150	157	-	217	0.78	OK	A
Kelly Bros White Extr./Scr. Briteline 150 S	179	-	223	0.71	OK	A
Kestrel Eurolux SC White Extr. IGSO01	worn	-	worn	worn	worn	NA
Kestrel Eurolux SC White Extr. IGSO02	worn	-	worn	worn	worn	NA
Kestrel Eurolux SC White Extr. IGSO09	134	-	171	0.74	OK	NA
SAR CP301	46	-	238	0.96	OK	NA
Swarco Vestglas Gmbh Swarcotherm ERP 16 white	106	-	213	0.82	OK	NA
Svevia AB X1601	172	-	201	0.72	OK	A
Svevia AB X1602	170	-	206	0.75	OK	A
Trafikmarkering TTP 30.2	d	-	d	d	d	NA
Veluvine Thermolit Fabiola	141	-	222	0.85	OK	NA
Type II, 0.6 mm						
SAR WP201 (type II)	worn	worn	worn	worn	worn	NA
SAR WP203 (type II)	worn	worn	worn	worn	worn	NA
Swarco Limburger Lackf. Gmbh Limboroute W13N	worn	worn	worn	worn	worn	NA
Type II, 3 mm						
Ennis Flint Screed/extr. W2016.4	100	n.m.	239	0.80	OK	NA
Geveko Markings Viatherm 50 EP40	48	9	96	0.90	OK	NA
Promax Promax White prime profile 2016	197	41	186	0.73	OK	NA
Svevia AB X1622	115	35	140	0.79	OK	NA
Svevia AB X1631	77	25	121	0.82	OK	NA
Svevia AB X1632	176	31	189	0.79	OK	NA

Table 29. The performance of materials applied at the Swedish test site in 2016 after one year. Roll-over class P3. Yellow materials, per type and thickness. Alphabetical order by manufacturer.

Manufacturer *Material*	$R_{L,dry}$	$R_{L,wet}$	*Qd*	*Frict.*	*Colour*	*NTY*	*Appr.*
Type I, 1.5 mm							
Ennis Flint Spray Y2016.12	55	-	177	0.82	OK	OK	NA
Ennis Flint Spray Y2016.13	57	-	164	0.83	OK	outside	NA
Ennis Flint Spray Y2016.14	58	-	185	0.79	OK	OK	NA
Kelly Bros Yellow Spray Briteline 100	92	-	185	0.84	OK	OK	NA
Kestrel Eurolux SC Yellow IGSO 08	worn	-	worn	worn	worn	worn	NA
Type I, 3 mm							
Ennis Flint Screed/extr. Y2016.5	65	-	183	0.76	OK	OK	NA
Ennis Flint Screed/extr. Y2016.7	58	-	176	0.80	OK	OK	NA
Geveko Viatherm NTY 29E	82	-	184	0.72	OK	OK	NA
Geveko Viatherm NTY 71E	81	-	199	0.77	OK	outside	NA
Kelly Bros Yellow Extr./Scr. Briteline 100	95	-	186	0.84	OK	outside	NA
Kestrel Eurolux SC Yellow IGSO 05	worn	-	worn	worn	worn	worn	NA
Kestrel Eurolux SC Yellow IGSO 06	worn	-	worn	worn	worn	worn	NA
Kestrel Eurolux SC Yellow IGSO 07	68	-	151	0.74	OK	OK	NA
Promax Promax Yellow prime 2016	106	-	187	0.72	OK	outside	NA
Swarco Vestglas Gmbh Swarcotherm ERP 16 yellow	42	-	168	0.75	OK	OK	NA
Svevia AB Y1605	88	-	169	0.77	OK	OK	NA
Type II, 3 mm							
Ennis Flint Screed/extr. Y2016.8	56	n.m.	191	0.78	OK	OK	NA
Svevia AB Y1615	97	23	157	0.83	OK	OK	NA

Roll-over class P4

Table 30. The performance of materials applied at the Swedish test site in 2016 after one year. Roll-over class P4. White materials, per type and thickness. Alphabetical order by manufacturer.

Manufacturer *Material*	$R_{L,dry}$	$R_{L,wet}$	*Qd*	*Frict.*	*Colour*	*Appr.*
Type I, 0.4 mm						
SAR WP201 (type I)	worn	-	worn	worn	worn	NA
SAR WP203 (type I)	worn	-	worn	worn	worn	NA
Visafo VIT VISA 16	worn	-	worn	worn	worn	NA
Visafo VIT VISA 17	worn	-	worn	worn	worn	NA
Type I, 1.5 mm						
Ennis Flint Spray W2016.10	worn	-	worn	worn	worn	NA
Ennis Flint Spray W2016.11	76	-	244	0.76	OK	NA
Ennis Flint Spray W2016.9	57	-	200	0.79	OK	NA
Geveko Viatherm 45 S30N	154	-	220	0.72	OK	A
Geveko Viatherm 71 S	218	-	203	0.65	OK	A
Kelly Bros White Spray Briteline 150	133	-	221	0.76	OK	NA
Kestrel Eurolux SC White Spr. IGSO03	80	-	148	0.82	OK	NA
Kestrel Eurolux SC White Spr. IGSO04	worn	-	worn	worn	worn	NA
Svevia AB X1653	worn	-	worn	worn	worn	NA
Svevia AB X1654	145	-	200	0.73	OK	NA
Type I, 3 mm						
Ennis Flint Screed/extr. W2016.1	worn	-	worn	worn	worn	NA
Geveko Markings PREMARK RETRO 161	82	-	162	0.81	OK	NA
Geveko Markings PREMARK RETRO 162	62	-	150	0.82	OK	NA
Geveko Viatherm 31 E35NO	190	-	223	0.63	OK	A
Geveko Viatherm 35 E40	227	-	218	0.61	OK	A

Geveko Viatherm 71 E	367	-	233	0.58	OK	**A**
Kelly Bros White Extr./Scr. Briteline 150	143	-	220	0.75	OK	**NA**
Kelly Bros White Extr./Scr. Briteline 150 S	179	-	225	0.69	OK	**A**
Kestrel Eurolux SC White Extr. IGSO01	worn	-	worn	worn	worn	**NA**
Kestrel Eurolux SC White Extr. IGSO02	worn	-	worn	worn	worn	**NA**
Kestrel Eurolux SC White Extr. IGSO09	96	-	147	0.82	OK	**NA**
SAR CP301	38	-	243	0.94	OK	**NA**
Swarco Vestglas Gmbh Swarcotherm ERP 16 white	117	-	208	0.74	OK	**NA**
Svevia AB X1601	worn	-	worn	worn	worn	**NA**
Svevia AB X1602	155	-	207	0.69	OK	**A**
Trafikmarkering TTP 30.2	d	-	d	d	d	**NA**
Veluvine Thermolit Fabiola	110	-	236	0.83	OK	**NA**
Type II, 0.6 mm						
SAR WP201 (type II)	worn	worn	worn	worn	worn	**NA**
SAR WP203 (type II)	worn	worn	worn	worn	worn	**NA**
Swarco Limburger Lackf. Gmbh Limboroute W13N	worn	worn	worn	worn	worn	**NA**
Type II, 3 mm						
Ennis Flint Screed/extr. W2016.4	75	n.m.	271	0.81	OK	**NA**
Geveko Markings Viatherm 50 EP40	worn	worn	worn	worn	worn	**NA**
Promax Promax White prime profile 2016	worn	worn	worn	worn	worn	**NA**
Svevia AB X1622	worn	worn	worn	worn	worn	**NA**
Svevia AB X1631	worn	worn	worn	worn	worn	**NA**
Svevia AB X1632	worn	worn	worn	worn	worn	**NA**

Table 31. The performance of materials applied at the Swedish test site in 2016 after one year. Roll-over class P4. Yellow materials, per type and thickness. Alphabetical order by manufacturer.

Manufacturer *Material*	$R_{L,dry}$	$R_{L,wet}$	*Qd*	*Frict.*	*Colour*	*NTY*	*Appr.*
Type I, 1.5 mm							
Ennis Flint Spray Y2016.12	37	-	180	0.79	OK	OK	NA
Ennis Flint Spray Y2016.13	worn	-	worn	worn	worn	worn	NA
Ennis Flint Spray Y2016.14	39	-	170	0.77	OK	outside	NA
Kelly Bros Yellow Spray Briteline 100	77	-	195	0.83	OK	outside	NA
Kestrel Eurolux SC Yellow IGSO 08	worn	-	worn	worn	worn	worn	NA
Type I, 3 mm							
Ennis Flint Screed/extr. Y2016.5	worn	-	worn	worn	worn	worn	NA
Ennis Flint Screed/extr. Y2016.7	48	-	210	0.80	OK	outside	NA
Geveko Viatherm NTY 29E	85	-	187	0.71	OK	OK	NA
Geveko Viatherm NTY 71E	81	-	204	0.76	OK	outside	NA
Kelly Bros Yellow Extr./Scr. Briteline 100	80	-	201	0.82	OK	outside	NA
Kestrel Eurolux SC Yellow IGSO 05	worn	-	worn	worn	worn	worn	NA
Kestrel Eurolux SC Yellow IGSO 06	worn	-	worn	worn	worn	worn	NA
Kestrel Eurolux SC Yellow IGSO 07	87	-	172	0.72	OK	OK	NA
Promax Promax Yellow prime 2016	108	-	187	0.62	OK	outside	NA
Swarco Vestglas Gmbh Swarcotherm ERP 16 yellow	44	-	176	0.71	OK	OK	NA
Svevia AB Y1605	80	-	181	0.73	OK	OK	NA
Type II, 3 mm							
Ennis Flint Screed/extr. Y2016.8	44	n.m.	224	0.76	OK	outside	NA
Svevia AB Y1615	82	n.m.	161	0.77	OK	OK	NA

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