

Comparative testing of thermal conductivity

Group of experts for establishing European λ_{10} -level

Round 1: 2001

Introduction

During the development of the Specific CEN Keymark Scheme Rules for Thermal Insulation Products, developed 1999-2001 by Scheme Development Group No. 5 (SDG 5), a strong need for reduction of the actual differences in λ_{10} level among the European test institutes was identified.

The coming European product standards specify thermal conductivity (λ_{10}) declared with steps of 1 mW/(m·K). For thermal insulation products with λ_{10} in the range of 35 mW/(m·K) this means steps of 3%, which clearly illustrates the need of a common European λ_{10} level determined ideally down to $\pm 0,5$ to 1%. The European standards for measurement of λ_{10} does not aim at greater accuracy than $\pm 3\%$, therefore the very narrow limit does not seem realistic today. A limitation of $\pm 1,5\%$ has been proposed se below.

Experiences from comparative testing either conducted by manufacturers or the institutes themselves show that a limit of $\pm 1,5\%$ is not generally the situation of today.

Further it has been identified that this λ_{10} problem was not only of interest for affixing the Keymark to products but also in relation to the CE mark. Therefore the efforts for establishing a common European λ_{10} level is conducted in collaboration between Notified Bodies Sector Group No. 19 (SG 19) and SDG 5.

The system for achieving the European λ_{10} level is described in normative Appendix B to the SDG 5 Keymark Internal Rules "Framework for the activities of registered laboratories for thermal conductivity measurements". Quotation from this document:

To ensure conformity with this European λ_{10} level, registered laboratories shall be designated in accordance with the requirements of these scheme rules. These registered laboratories shall be in agreement with the European λ_{10} level to within $\pm 1,5\%$. This value is subject to evaluation by the SDG 5 Implementation Group and will be fixed after the results of the first comparative testing campaign between candidate registered laboratories are available.

In addition to the registered laboratories, a small expert group, whose members are experts in the field of thermal testing and work with an identified reference guarded hot plate equipment, shall be designated so as to define the European λ_{10} level.

NOTE The European λ_{10} level is defined in compliance with EN 1946-2 and the IRMM 440 reference material. This comparative testing is made to confirm the consistency of the involved laboratories with the λ_{10} level.

Further the document determines that measurements carried out by members of the group of expert shall be done with identified reference guarded hot plate equipment at a mean temperature of $10 \pm 0,3^\circ\text{C}$.

In annex 4 of the document: "Example of results of a comparative testing programme set up to establish the European λ_{10} level for the expert group" it is assumed that the results will be within $\pm 1\%$ and the European λ_{10} level is calculated as the average of results within this limitation.

This document report the result of the first comparative testing among laboratories invited to take part in the work even before the SDG 5 Implementation group is established.

The results are collected and the report drafted by M. R. Byberg, VIK, Denmark, member of SDG 5. The final report is edited by the group of experts.

Laboratories

In step 1 of the first comparative testing the following 8 laboratories were invited to take part:

Table 1 - Laboratories participating in step 1

Initials	Laboratory Contact person	Country
BBRI- CSTC- WTCB	Belgian Building Research Institute Gilles Flamant / Piet Vitse	Belgium
CRIR	Centre de Recherche Industrielle de Rantigny Cristian Ciucasu	France
EMPA	Eidgenössische Materialprüfungs- und Forschungsanstalt Hans Simmler	Switzerland
FIW	Forschungsinstitut für Wärmeschutz e.V. München Wolfgang Albrecht	Germany
LNE	Laboratoire National d'Essais Gianni Venuti	France
MPA-NRW	Materialprüfungsamt Nordrhein-Westfalen Thomas Kloos	Germany
NPL	National Physical Laboratory David Salmon	U K
SP	Swedish National Testing and Research Institute Bertil Jonsson	Sweden

In step 2 of the first comparative testing other laboratories are able to test the same specimens as the above listed laboratories. Test results will be reported when they are available. For the moment the following laboratories are foreseen:

Table 2 - Laboratories participating in step 2

OFI	Österreichisches Kunststoffinstitut Günter Jechlinger	Austria
MA39-VFA	MA39 Versuchs- und Forschungsanstalt der Stadt Wien Werner Kuhnert	Austria
BASF	Norbert Krollmann	Germany
CEDEX	Laboratorio Central de Estructuras y Materiales Andrés Arranz	Spain

For the purpose of publishing this report the laboratories by random are allocated the letters A to M. Only members of the expert group will receive the confidential key to these letters.

Apparatuses used in this comparative test

Table 3 - Apparatus survey

Laboratory	GHP sizes				heat-flow
	test specimen mm		metering area mm		
BBRI	600 x 600		300 x 300		vert. symm.
CRIR	610 x 610	single	305 x 305	single	vert. up
EMPA	750 x 750		300 x 300		vert. symm.
FIW	800 x 800		300 x 300		vert. symm.
LNE	610 x 610		305 x 305		vert. symm.
MPA-NRW	770 x 770		503 x 503		vert. symm.
NPL	610 x 610	single	305 x 305	single	vert. up
SP	600 x 600	single	250 x 250	single	vert. down
OFI	750 x 750		500 x 500		vert. symm.
MA39-VFA	800 x 800		500 x 500		vert. symm.
BASF			250 x 250		vert. symm.
CEDEX	600 x 600		300 x 300		vert. symm.

The maximum thickness that can be measured by the laboratories on the used equipment all exceeds test specimen thickness used in this comparative testing.

Test specimens

For the purpose of this comparative campaign test specimens (comprised of two pieces each) of two materials have been prepared:

Expanded polystyrene, EPS	50 mm thickness	Manufacturer BASF, Germany
Mineral wool, MW	100 mm thickness	Manufacturer Isover, France

The specimens were prepared by Erik Rasmussen, chairman of SDG 5, in the size 800 x 800 mm² and transported from laboratory to laboratory in closed metal boxes. Before the first transportation the specimens were conditioned to 23 °C, 50 % RH. No further conditioning was carried out in the laboratories before the measurements.

The specimens are marked:

EPS:	E 01-01A	E 01-01B
MW:	M01-01A	M01-01B

The specimens were first measured by laboratories with equipment 800 x 800 mm², then cut to 750 x 750 mm², 610 x 610 mm² and finally 600 x 600 mm² successively for laboratories with smaller equipment. Every time cutting has taken place the central part of the specimens has been undisturbed. Material cut off was marked and maintained in the boxes.

Contribution to costs

Each laboratory has paid their own costs for participating in meetings (travelling and hours).

Material for test specimens has been prepared and delivered free of charge by BASF, Germany and Saint-Gobain Isover, France.

Metal boxes, preparation of test specimens, transportation from laboratory to laboratory and the measurements is paid by funding mentioned below.

Co-ordination of tests has been done by Erik Rasmussen, Rockwool International A/S, Denmark, and evaluation of test results and draft reporting has been done by M. R. Byberg, Denmark, both free of charge.

The following organisations / companies have provided funding for the comparative tests:

Pittsburgh Corning Europe S.A., Belgium
Österreichische Heraklith GmbH, Austria
EURIMA

Test Plan

A very tight time schedule for the whole campaign was set up and was followed as close as possible by the laboratories. The measurements (step 1) were started in week 23 and finished in week 37, 2001. This means that the laboratories have done the measurements in 14 weeks including transportation and some equipment problems.

Test results

Before presenting any test results it is important to note, that the results consists of only one (two) result from each material from each laboratory and will by no means give statistical evidence of differences between the laboratories involved. On the other hand it is foreseen that the laboratories invited are experts and that the results recorded represent the best of their ability within the accuracy of their equipment.

Test results from laboratories have been reported on the format described in Appendix B to the Keymark rules. The laboratories have been asked to give additional information on the identification no. of the equipment. Further the laboratories were asked to report test results from measurements using the IRMM 440 reference material.

Some laboratories have double plate apparatuses, other laboratories single plate apparatuses. The results are shown in this report with four significant figures even when a laboratory with a double plate apparatus has forwarded the result with three significant figures. The results from the single plate apparatuses are calculated as the average of the results from the individual test pieces and expressed with four significant figures.

NOTE In normal thermal testing only three significant figures are used.

Reported λ_{10} -values

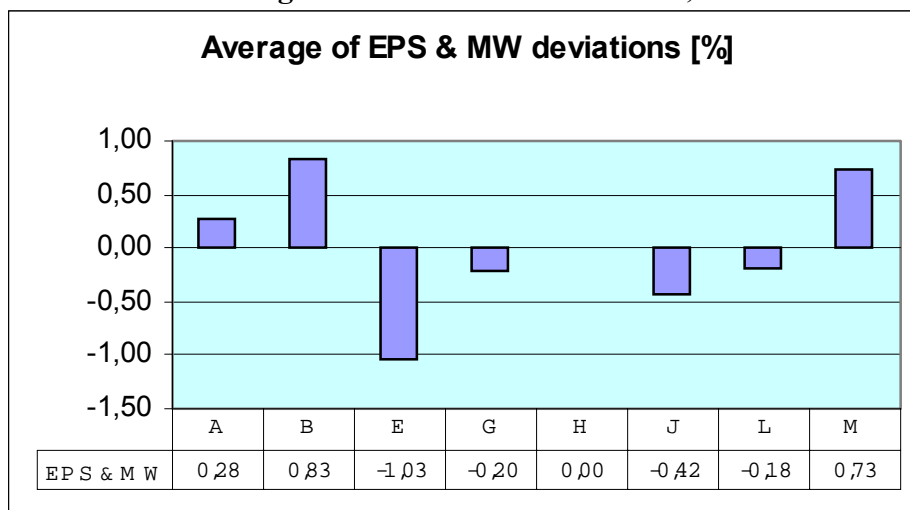
As λ_{10} -measuring related to this comparative testing are still going on no λ_{10} -values will be shown in this version of the report. The individual results from the participating laboratories will be expressed relatively to the established European λ_{10} level.

Evaluation 1

Appendix B of the Keymark rules has foreseen that each of the products EPS and MW should be measured in two thicknesses, 50 and 100 mm. The tests carried out only cover one thickness for each product. Therefore the average of the EPS and MW deviations is used as the “laboratory deviation”.

Calculation of average of EPS- and MW-deviation

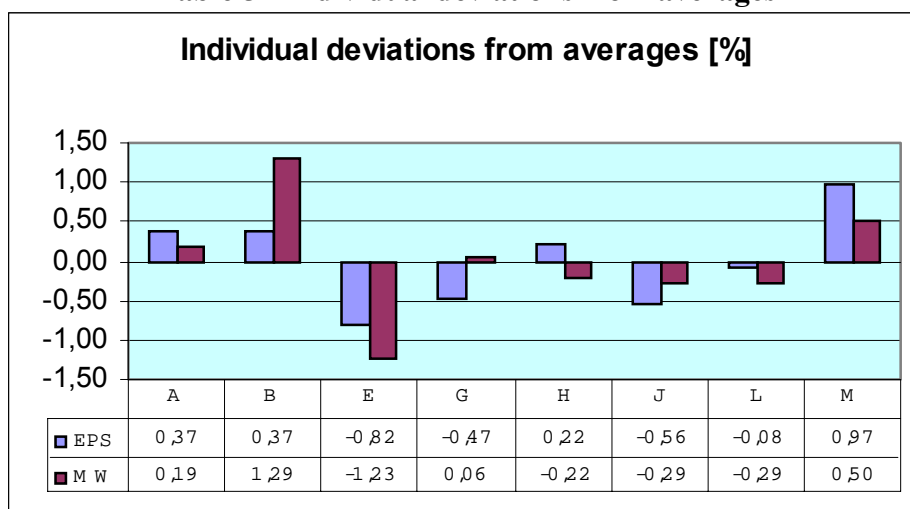
Table 4 - Average of EPS and MW deviations, evaluation 1



Although one of the laboratory deviations is slightly greater than the limit foreseen in Appendix B of the Keymark rules all test results are accepted in step 1 for derivation of the European λ_{10} level.

Individual deviations for EPS and MW

Table 5 - Individual deviations from averages



As shown in Table 5 all EPS deviations are within $\pm 1\%$ of the average. For the MW deviations the max. and min. deviations are both of the magnitude 1,25%. As they are balancing each other, they are accepted.

EU λ_{10} -level

The EU λ_{10} -level is defined as the average of results from the step 1 laboratories on one set of test specimens.

Based on the very few test results, one value for each of two materials from the eight laboratories, it can be concluded that step 1 of the first comparative testing campaign has shown:

Table 6 - EU λ_{10} -level

	max. / min. deviation from EU λ_{10}-level	Standard deviation
EPS, 50 mm	+1,0 % -0,8 %	0,59 %
MW, 100 mm	+1,3 % -1,2 %	0,73 %

Results of IRMM 440 measurements and target value

The laboratories also have reported their latest test results for the IRMM 440-reference material. Table 7 shows the results and Table 8 the deviations from the target value 30,48 mW/(m·K). For the IRMM 440 reference material deviations are all within the $\pm 1\%$ range.

Table 7 - Result of IRMM 440 measurements

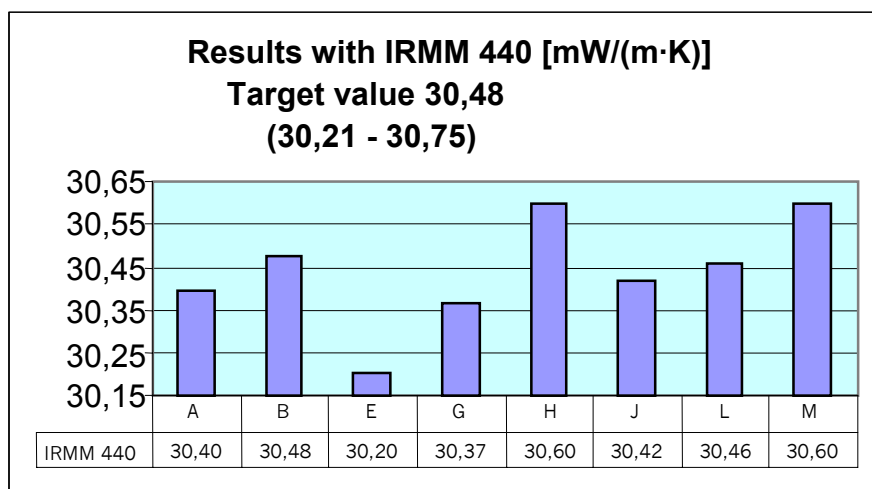
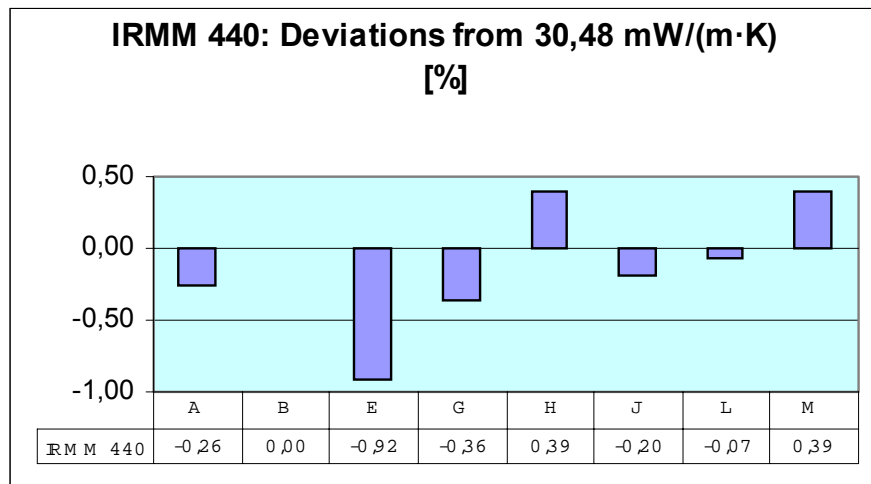
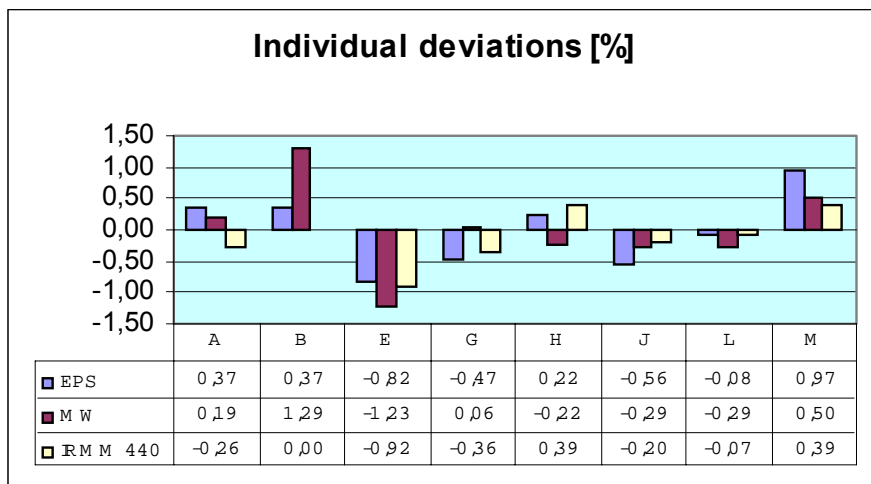


Table 8 - IRMM 440 deviations



Finally Table 9 show the individual deviations for EPS, MW and IRMM 440.

Table 9 - Individual deviations



Comparison between the IRMM 440 results and the results from the campaign

Table 10 – Comparison of test results

	max. / min. deviation from IRMM 440 / EU λ_{10} -level	Standard- deviation
IRMM 440, 35 mm	+0,4 % -0,9 %	0,45 %
EPS, 50 mm	+1,0 % -0,8 %	0,59 %
MW, 100 mm	+1,3 % -1,2 %	0,73 %

Conclusion

Taking into account that this is the first comparative testing campaign in the SDG 5 Keymark Scheme and that only one thickness for each of the two materials have been tested the result show that the agreement between laboratories is better than $\pm 1,5\%$, which is acceptable for this scheme.

The aim of the campaign was also to define the European λ_{10} level and this has been achieved successfully.

The comparative testing has proven useful in showing good agreement between laboratories and it will be repeated in the coming years with more laboratories taking part.

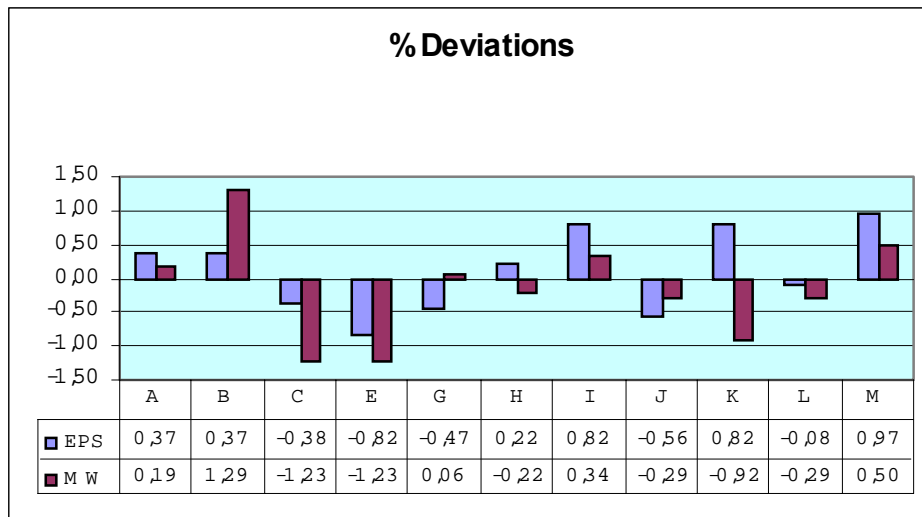
Further it seems useful to test the same material in different thickness.

Annex A

Evaluation of part 1 step 2

In step 2 of the comparative testing campaign four more laboratories have measured the same test specimen as used in step 1. Table A.1 shows the individual deviations related to the average values determined in step 1.

Table A.1 - Deviations from EU λ_{10} level



Conclusion

The results of step 2 of this campaign show that eleven of the twelve laboratories are very well in line based on these very few test results. Further table A.1 shows that the 100 mm MW-results deviate more than the 50 mm EPS-results.

One laboratory has been excluded because the test results are exceeding the required limits.

Also step 2 has shown the relevance of the comparative testing for additional laboratories.