DIALux 4 with new improved calculation kernel

New calculation kernel

With DIALux 4 a new calculation has been provided for our customers. This module calculates the light exchange between luminaires and any other surfaces (direct lighting) and also the light exchange between illuminated surfaces (indirect lighting). Direct lighting is not necessarily emitted by luminaires. Lighting from the sky (daylight) or direct sunlight can also be calculated with the new calculation kernel. The method applied for the calculation is the so-called radiosity method. This is where the name of the module comes from. RadiCal derives from radiosity calculator. This name was also the programme used in development. All approaches used so far were analysed and the latest research results and methods were included in the development. Anyone who still thinks that nothing much will have changed in mathematics is wrong. A lot of research and development has taken place precisely in the field of lighting calculation. Especially the games and film industries invest large sums of money to achieve progress in the quality and, in particular, in the calculation speed.

Of course it is possible to buy a calculation kernel "off the peg". A search in the Internet will provide scores of hits straight away. However, for a lighting design tool like DIALux buying something like this is not a viable alternative. For it is not just a question of producing "nice pictures". For the lighting designer the calculation of lighting technology parameters is an essential part of his work. Working with real sources of light is something which only few of the ready-made calculation kernels on the market can do. As well as calculation speed and visualization quality, the accuracy of the calculation is the most important criterion for this software. Many of the usual products fail here completely, meaning that they do not even supply values in figures but provide only pictures.

How RadiCal functions

Radiosity

As the name implies, RadiCal calculates using the radiosity method. The question then arises as to what radiosity actually is. Radiosity[1] [2] is one of a variety of calculation models. Based on the energy conservation principle, the premise is assumed that all light which is projected onto a surface and is not absorbed will be reemitted by this surface. In addition to this, a surface can also be luminous in itself.
The latter of course includes light from the sky or segments thereof. With the radiosity method an equation is made for each surface. This equation defines the light emitted which is a product of light absorbed from other surfaces and, if present, from its own luminance.
Altogether this provides a set of equations whose solution represents the brightness of each individual surface. The advantage of this method is that the calculation takes place independent of location. When one cycle of the progress

bar has been completed, then the user can rotate the 3D scene as he wishes or move through the scene in order to check the lighting effects throughout the whole scene. This benefit is familiar to DIALux users from Version 2.0 onwards. It must however be admitted that the disadvantage is that (at present) the only basis used is ideal diffuse reflectance. An incoming light beam is therefore not mirrored but evenly reflected in all directions. However there are signs that even this deficiency in the radiosity method will be overcome in the near future. While developing RadiCal DIAL has tested the latest technological developments and, if theses tests have been successful, has included the technology in its software. It became clear that not every approach can be used for calculating real lighting scenes.

Adaptive Meshing

How such a calculation is carried out and why is it important for the user to know this? On the one hand it increases the user's confidence in his software if he knows how this works and on the other hand he can see where the difficulties in calculation lie and why some calculations are more complex and take longer than others. After the user has created a geometry for calculations in DIALux (this can be a room or an external scenario) this is passed on to RadiCal and is there divided into surfaces and patches. Why is a subdivision of surfaces necessary? Well, this is because different illuminance values are to be expected all over a surface. In the norms, e.g. in EN 12193 or even in prEN 12464-2 and in many other guidelines, there are parameters for a grid. These parameters provide a maximum patch size which should not be exceeded. The calculation is made using the following formula:

$$p = 0{,}2 \cdot 5^{\log_{10} d}$$

whereby "d" represents the longer dimension of the surface and "p" the maximum patch or grid cell size. However this formula has certain disadvantages. In principle there is no objection to the statement that "p" represents the maximum patch size. Unfortunately there are far too many calculation programmes which use this as an absolute value. So you have a calculation grid of 10 x 10 points on a surface of 10m x 10m or a maximum 1m patch size. For verifying measurements this is certainly a reasonable value but it cannot be seen as anywhere near satisfactory for calculating radiance exchange in a room. In reality the following happens when verifying the measurement: After irradiance has been emitted by the luminaire and has been reflected any number of times by the available surfaces, the receiver measures the illuminance here.
The energy distribution is not however restricted in any way. If a grid is now prescribed for the calculation then the distribution of energy cannot proceed correctly because the irradiance exchange is only defined at discrete supporting points (e.g. at 10 x 10 points).The narrower the beams from the luminaires the greater the errors arising from this method.

In this illustration you can see that wherever the illuminance on a surface significantly changes, the surface is divided into smaller patches. Modern light calculation programmes can no longer do without this so called "adaptive meshing".

The lighting effect of a narrow beam luminaire or even the simple effect of a light beam when a luminaire is mounted close to the illuminated surface cannot be displayed unless such a fine grid is used. On the other hand a very fine grid for all surfaces would exceed the calculation time and memory capacity of any CPU. At this point good software must decide itself when a patch needs to be divided up even more and when not. Of course the calculation time is substantially shorter with less detailed grids. The ratio of calculation time to grid size is not linear but exponential since each surface (patch) can exchange irradiance with any other surface (patch). The grid is not only made finer when calculating direct light, this is also necessary with indirect light.

Combining Grids

It goes without saying that this is not all we need for good and fast lighting calculation. Imagine that you wish to illuminate a large hall. The requirement for this is for example 500lx on a working plane with a good uniformity. You provide this lighting with a field of linear luminaires whose reflectors are positioned in such a way that uniform illuminance is created on the working plane in a defined area under the luminaire (batwing characteristic). In the range of the cut off of the LDC, namely where the luminance begins to decrease, there is suddenly significantly lower illuminance on the working surface. This is where lighting calculation software must subdivide very finely to calculate these effects. However, since in this planning project there are very many luminaries mounted next to each other, the adjacent luminaires in the overlapping areas will also create illuminance. When the calculation of all the luminaires has been completed, an "intelligent" software will be able to decide that it is not necessary to retain this fine grid. The high number of luminaires result in uniform illumination of the illuminated surface and the grids for this illumination can now be combined for the calculation of indirect light. With

these algorithms the calculation time can be shortened significantly while maintaining a high degree of accuracy.

Post Processing Grids

Often the user is obliged to provide illuminance values in a prescribed grid, either because the customer requires this for inspection purposes or because a regulation prescribes such a grid. The DIALux calculation kernel is able to supply these illuminances just as if the measurement had taken place in reality. As described above, the measurement has no, or academically viewed, very little influence on the irradiance exchange in a room. The measuring grid in reality also has no influence on the photon distribution on a surface. This is the same with the procedure in RadiCal. After correct calculation of the irradiance exchange the user can request output in any grid he wishes. Since, during the calculation, consideration was given to where finer measurements were required the correct result can be requested at any position.

Hierarchical Radiosity

The hierarchical process first calculates a link structure which indicates which patches exchange light[3]. Only when this link structure has been created does the actual light exchange take place. The link structure is then refined and the light exchange repeated. This process is reiterated. In this way increasingly better approximations to real lighting conditions are achieved. The link structure can be seen as a compact representation of the form factor matrix.
You can define as form factor that portion of the sender energy which reaches the receiver. The form factor is one when all the energy of one patch is transmitted to another. Because of the size and angle ratios the form factor is always smaller than 1. In addition to the sender – receiver element information about form factors and visibility ratios is also saved. This procedure has one enormous advantage. DIALux is hereby in a position to calculate different energies simultaneously. When the user begins a calculation in DIALux with UGR calculation points, then the UGR calculation must be made with the "new values" of the planned project. Taking the maintenance factor into account is not permissible. When planning according to EN12464 the user must allocate a maintenance factor to each luminaire. This depends on the type of luminaire and type of lamp. It is therefore not possible to simply base the calculation on a global factor (e.g. this used to be 0.8). So when calculating in a planning programme the illuminances and luminances must be defined by calculating with the maintenance value and for UGR calculations with the "new value". Thanks to hierarchical radiosity this can be done in DIALux almost simultaneously while you are working on two calculation processes with different algorithms or you are wrongly referring UGR values to the maintenance value.

Deciding on subdivisions

Both sender and receiver surfaces are divided into smaller partial surfaces. Here it is immaterial whether the sender surface is the light output aperture of a luminaire or an illuminated surface on a wall. In order to decide whether elements of a surface should be subdivided or not the orientation of the two surfaces to each other must first be defined. If the surface elements face each other, the error is estimated which would occur if the light transfer took place

on surface exactly where the subdivision is made. If the surfaces do not face each other then no irradiance exchange takes place. Using the calculation values it is now possible to determine whether the receiver is in front of or behind the sender or whether one part of the receiver surface is in front of and another behind the receiver. This is a decisive step for accurate calculation. Small deviations here can lead to significant deviations in calculation. When calculating direct lighting two different possible errors must be considered.

- The angle from which the receiver surface is seen by the sender is not constant. Therefore the luminance which is emitted from the luminaire in the direction of the receiver is also not constant.
- If the receiver is close to the sender, then the photometric law of distance is not adhered to. How to estimate the error resulting from this can be referred to in Hentschel [4] on page 26.

First the error which results from inconstant luminance is defined. Then the degree of error is estimated according to the photometric law of distance. The total error is the sum of these two individual errors. The decision as to whether to subdivide or not is made by using a special function. After defining the orientation and estimating the error, the maximum permissible error is calculated. This is then applied to the total luminous flux present in the whole lighting scenario. Subsequently a test is carried out to check whether the error estimated is smaller then the maximum permissible error. If this is the case then no further subdivisions are necessary, otherwise a quadripartite division takes place and the test is carried out again.

Subdivision for calculating indirect light

When deciding whether to subdivide a sender surface, it is important to know how uniformly this is illuminated. You obtain a standard for this by comparing the illuminance of a surface element with the illuminance of its patches. Surface elements whose patches show an illuminance which deviates substantially from its own have in this sense substantial errors. The illuminance error is not a calculation error but an indication of lack of uniformity in the illumination of a surface element. The error in illuminance is an important criterion when deciding whether to subdivide a sender surface element or not. The receiver surface must, if necessary, also be subdivided for indirect calculation. This should take place beforehand, after checking whether   the form factor is uniform. After that the test is carried out as already described for direct calculation.

Daylight

From DIALux 4 onwards a new feature is the possibility to calculate daylight. Increasing importance is attached to daylight as a means of saving energy in lighting. The EU guideline about total energy efficiency of buildings which comes into force from 2006 will have a very great effect which has not yet been generally recognized [5] [6]. The two following extracts indicate what kind of planning will be required from designers and particularly from lighting designers in the future.

"Buildings have an effect on long-term energy consumption; therefore new buildings must fulfil certain minimum requirements with regard to total energy efficiency in accordance with the local climatic conditions." and:
" Comprehensive renovation of existing buildings above a certain size are to be considered as an opportunity to apply cost- effective measures to improve total energy efficiency."

A building measure will no longer receive official approval without the required documentation. Our buildings will receive energy certificates similar to those already in use for refrigerators, washing machines and even lamps. So certain boundary values must be observed before approval is even granted. In order to work with correct planning data in the field of lighting, not only is the calculation of artificial lighting required but also of daylight.

Types of sky

The greatest problem when calculating daylight is that you cannot really calculate. Just look out of the window and watch how the appearance of the sky changes within a short time. Clouds move across the sky and the lighting situation in your office changes.
In order to carry out calculations in spite of this it is necessary to refer to defined / normed types of sky. In DIALux three different types of sky from CIE 110-1994 are used.[7] These three types are the overcast sky, the clear sky and the average sky. For the last two it is possible to take direct sunlight into consideration. Each of these types of sky is described through the distribution of its luminance. The zenith luminances are different and different ones may be selected for one model. For overcast skies DIALux applies the zenith luminance of Krochmann. This corresponds to that applied in DIN 5034.[8] This model is applied for calculating daylight quotients. Here there is of course no direct sunlight.

Daylight calculation

The hemisphere of the sky is divided into triangular patches. Like the globe the firmament is divided according to a prescribed number of azimuth and altitude angles. The radius of the firmament is also pre-set. With a clear sky a single patch is highlighted as the sun, if necessary. Daylight calculation is carried out before the calculation of direct light and has the same set up. Depending on the type of sky each sky patch is allocated a luminance L. The calculation of direct light from the sky then proceeds according to the photometric law of distance. The light of each individual sky patch or sun patch is then transferred to the whole scene. Here a subdivision of the illuminated surfaces must also be carried out. A sky patch however need not be subdivided. The process of deciding whether to subdivide or not is not the same as with luminaries. In contrast to direct calculation it is not possible with daylight to come to any conclusion about luminous flux error estimations. Since there is an infinite distance to the sky patch there are no gradients on an illuminated surface but only the two values 0 und E_{sky}. If the light from the sun or the sky falls at a steep angle and the element is then completely visible it is not necessary to subdivide. As soon as surfaces are partially in the shade then a very fine subdivision must be made so that the progression of shadows is taken into consideration.

Accuracy of the calculation

Comparability benchmarking

After explaining in this brief overview how a calculation is carried out we now of course have to examine how accurate a calculation is. One problem when doing this is finding out how accurate the comparative object is. Light calculation programmes have now been on the market for several decades. And during this time comparative tests were carried out again and again to find out how accurate one software or other is. Not least the universities have done a lot of research work to prepare and carry out such tests. These tests showed repeatedly that a simple comparison "Planning with catalogue values versus measurements in reality" led to huge deviations. The reason for this was above all that the data used for the calculation did not correspond to the real data in the installation. Worthy of mention are

- Deviation of real light distribution from the measurements with the prototype
- Deviation of the luminous flux of the lamp from the nominal value
- Operation on mains supply and data documentation in a laboratory (e.g. 230V)
- Deviations in temperature
- Deviations in the definition of degrees of reflectance of certain surfaces
- Errors in measuring instruments of 10%, even with instruments in class B
- …

So if we want to test the quality of a calculation software and not to find out how great the degree of error is in the chain of measurements we must try to keep the parameters which influence the process to a minimum. All data used for the measurement should correspond as closely as possible to the comparative values. The following measuring-calculation comparisons are suitable for this.

Measurement /calculation comparison by testing in DIAL's accredited photometric laboratory

As a manufacturer of lighting calculation software DIAL finds itself in a special situation. It is in fact the only manufacturer of its kind with its own accredited photometric laboratory.[9] In this laboratory luminaries and lamps of different kinds (lamp types, methods of light distribution, mounting methods) were measured.

These combinations of luminaire/lamp were mounted in a testing chamber in exactly the same combination as when they were measured in the goniophotometer.

In the testing chamber the luminaires were operated yet again under laboratory conditions. The room has an L-shaped layout and maximum outer dimensions of 6m x 4.5m. The height of the ceiling is 2.75m. The measuring room was made

from wooden elements assembled to create a flush surface. In this way possible influencing factors which might lead to systematic differences between the calculation and the measurement were kept to a minimum.

The coat of paint was achromatic and approximated closely to degrees of reflectance of 70%, 50% and 20% for ceiling, walls and floor, deviations being below 1%. To carry out qualified measuring technology tests of illuminance distribution a sufficiently fine measuring grid must be selected which is reproducible and can be prepared within a reasonable period of time. Of course the illuminance distribution on all the boundary surfaces of the room must be tested. A quadratic measuring grid with a length of 25 cm was used for the illuminance distribution values which were tested. This provides a reasonable compromise of measuring time and accuracy. Where there are high gradients in the illuminance progression the measuring grid can be freely adapted.

For the measuring-calculation comparison the absolute luminance distribution is used for calculating. Among others the following calculation situations were compared:

- Directly – indirectly illuminating linear suspended luminaires
- Indirectly illuminating linear suspended luminaires
- Directly illuminating linear suspended luminaires in a furnished room
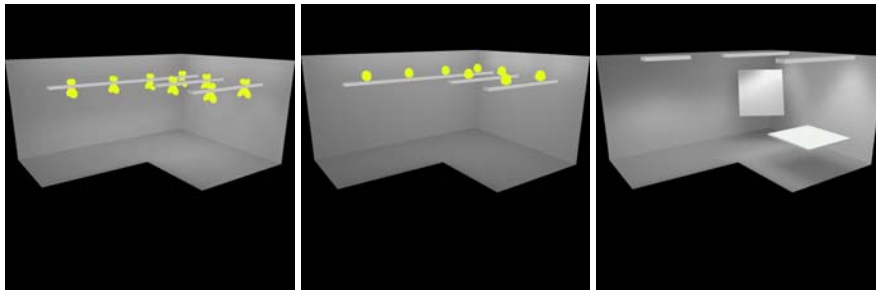
Medium illuminance on the working plane	Directly or indirectly illuminating linear suspended luminaires	Indirectly illuminating linear suspended luminaires	Directly illuminating linear suspended luminaires in a furnished room
Upper value of global error tolerance	763	352	688
Upper value of measurement tolerance	745	344	672
Measured value	718	331	647
Calculated value	691	318	633
Lower value of measurement tolerance	691	318	622
Lower value of global error tolerance	673	298	603

Here the estimation of the value for the measuring tolerance of the medium illuminance amounts to ± 3,8% and for the global error tolerance of the medium illuminance ± 6,3 %.[10] For the error estimation the estimations of CIE TC 3.33 were adopted. The deviations of medium illuminance, the value of most relevance for lighting designers, lie within the measuring instrument tolerance and so it is not possible to state whether the measured value or the calculated value is "more correct". With some individual illuminances there were also more substantial deviations, and higher error tolerances apply for these.

One measuring point always stands for a grid of 0.25m x 0.5m. On such a surface it is certainly possible to calculate with an illuminance progression. Therefore it is likely that the results of the calculation are more accurate than those of the measurement because of the finer subdivision. Minimum and maximum values can be localized exactly with a calculation, whereas with a measurement it is a matter of luck if the measurement grid and the extreme values happen to be the same.

## Comparison of a calculation with any analytically soluble situation

Some years ago many comparative tests of lighting calculation programmes were conducted at the University of Karlsruhe[11]. In one of these tests a lighting situation was prepared in a cubic room. A test room with the dimensions 5m x 5m x 5m and ideally matt reflecting surfaces was simulated. The light source in the centre with a luminous flux of 15,000 lumen has a luminance distribution which creates the same direct illuminance of 100 lux at each point on all the room's surfaces. Even the indirect illuminance on the surfaces is theoretically of the same value for each point of the room's surfaces and with a degree of reflectance of 50% this is also 100 lux.

This calculation can be quite simply checked with the formula:

$$E_{ges} = E_{dir} + E_{ind} = E_{dir} + E_{dir} \cdot \frac{\rho}{1-\rho} = 100lx + 100lx \cdot \frac{0,5}{1-0,5} = 100lx + 100lx = 200lx$$

Deviations from these reference values are easy to identify and help in the testing of the programme. However a weakness in the luminance distribution used in the original test was apparent. The LDC in the step width was defined as C 15 and Gamma 5 degrees. Since this LDC can suddenly bend at certain angles,

namely where it meets a boundary in the geometry of the room, a resolution of 15° or 5° is not sufficient. In order to achieve clear results in the areas at the edge of the room surfaces it is necessary to create the LDC with a 1° step width for C and Gamma.
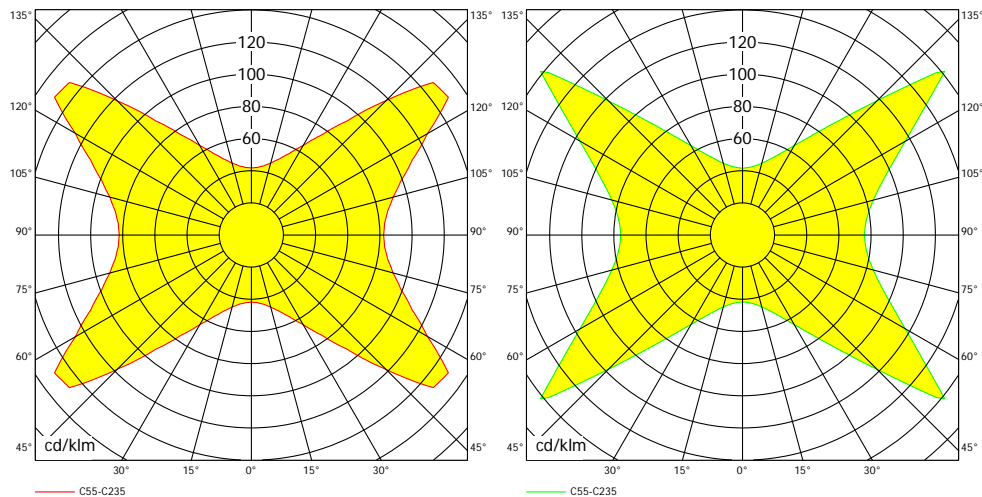
These two diagrams show the LDC tests with a resolution of 15° und 5° and with a resolution of 1° und 1° in the C55-C235 plane. As can be seen clearly, at the peaks a resolution at every 15 and 5 degrees is not sufficient.
While on the right the LDC can be displayed completely into the corners, the left LDC can only interpolate the missing values and so cannot calculate correctly. Missing values, especially within the range of cut offs, can never be interpolated correctly. In order to be able to conduct a calculation correctly, a luminaire must be measured correctly. This means that luminaires with a narrow beam and normal luminaires must be measured within the range of cut offs at a narrower angle than 10 or 5 degrees. This no longer places special demands nowadays on modern measuring technology and data memory capacity.

5.00 m

0.00

0.00   5.00 m

| | 199 | 200 | 201 | lx |
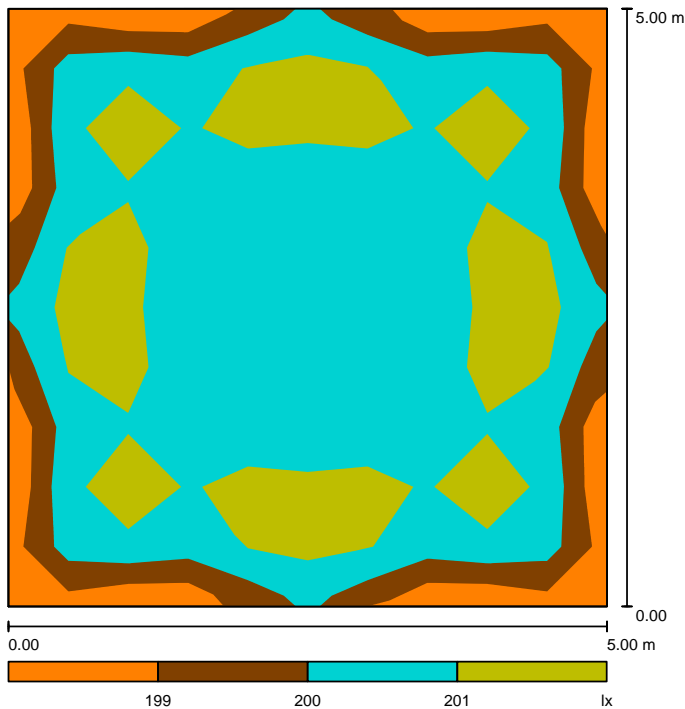
This false colour rendering shows the illuminance distribution calculated on one of the room surfaces of this cubic room.

The results of the calculation are as follows:

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
201	198	202	0.99	0.98

When only calculating direct lighting the results for minimum, medium and maximum values are 100lx as expected. The deviation of the medium value is 1lx or 0.5%. Even the deviation of the minimum and maximum values is only 1%. These results bear witness to the high quality of the calculation.

Comparison with the testing scenarios of CIE TC 3.33

It is the aim of the Technical Comity 3.33 of the CIE to provide developers and users of light calculation programmes with the possibility to assess the accuracy of these calculation programmes. In a technical report (draft from 2004) various test scenarios are defined to serve as a measuring framework for calculation software. As in DIAL's test, here both real and analytical lighting situations are defined. The different test cases each examine different qualities of calculation software. Some of the results of the comparison between DIAL and TCC 3 33 values are listed in the following table.

Test 1 Measurement results for free burning compact fluorescent lamps
In this test free burning ceiling mounted compact fluorescent lamps were mounted in a rectangular field of 2 x 2. Prior to the test a photometric measurement of the lamps was carried out. To check the software the photometric data of the light sources and the measured results are included in the documentation. [10]

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light. building. software.

Position	Sensor						
	1	2	3	4	5	6	7
TE UL	91	107	115	118	116	107	93
MB UL	85	100	108	110	108	100	87
1	**69**	**77**	**84**	**87**	**84**	**77**	**70**
MB LL	65	77	83	85	83	77	67
TE LL	59	70	75	77	76	70	61
Position	**Sensor**						
	1	2	3	4	5	6	7
TE UL	103	124	130	129	129	124	105
MB UL	96	116	122	120	121	116	98
2	**75**	**82**	**91**	**94**	**91**	**81**	**76**
MB LL	74	89	94	93	93	89	75
TE LL	67	81	85	84	84	81	68
Position	**Sensor**						
	1	2	3	4	5	6	7
TE UL	112	132	141	141	141	131	113
MB UL	105	123	132	132	132	122	106
3	**83**	**92**	**101**	**106**	**101**	**92**	**84**
MB LL	81	95	101	102	101	94	81
TE LL	73	86	92	92	92	86	74
Position	**Sensor**						
	1	2	3	4	5	6	7
TE UL	115	133	143	146	143	133	116
MB UL	108	124	133	137	133	124	108
4	**86**	**96**	**107**	**110**	**106**	**96**	**87**
MB LL	83	96	103	105	103	96	83
TE LL	75	87	93	96	93	87	76
Position	**Sensor**						
	1	2	3	4	5	6	7
TE UL	113	132	141	140	141	132	112
MB UL	105	124	131	131	131	123	105
5	**84**	**92**	**101**	**105**	**101**	**91**	**81**
MB LL	81	95	101	101	101	95	81
TE LL	74	86	92	92	92	86	73
Position	**Sensor**						
	1	2	3	4	5	6	7
TE UL	103	124	130	127	130	123	104
MB UL	97	116	121	119	121	115	97
6	**76**	**82**	**91**	**94**	**91**	**81**	**75**
MB LL	74	89	93	92	93	89	75
TE LL	68	81	85	83	85	81	68
Position	**Sensor**						
	1	2	3	4	5	6	7
TE UL	92	108	116	117	115	108	92
MB UL	86	100	108	109	107	100	86
7	**70**	**77**	**85**	**88**	**85**	**77**	**70**
MB LL	66	77	83	84	83	77	66
TE LL	60	70	76	76	75	70	60

Table 1: Upper and lower limits for measurement points illuminance with grey wall-CFL lampTE UL
is the total error band upper limit; TE LL is the lower limit
MB UL is the measurement band upper limit; MB LL is the lower limit

The calculation results from DIALux are entered in lines 1, 2, 3, 4, 5 and 6. To make it easier to evaluate the results all the values within the measuring instrument tolerances are printed in green and all the results within the global tolerances are blue. It is easy to recognize that all the values are within the global tolerances and 75.51 % are even within the measuring instrument tolerances.

A similarly good result can be seen in the second test, the TC 333 test case. Here opaque luminaires were used instead of freely burning lamps .All the values are calculated within the global tolerances, and 67.4 % are within the measuring instrument tolerances.

The result of the calculation of test case 3 „Artificial lighting scenario – Semi Specular Reflector Luminaire, grey wall" is almost perfect. 100% of the measured values are within the measuring instrument tolerances.

In the following test scenarios the reflectance properties of the walls, ceiling and floor were reduced to below 6% +/-1%. Thus it is possible to make a statement about the quality of the calculation of direct lighting. 74%, 98% and 100% respectively were within the measurement tolerances and 100% were within the global tolerances.

The next series of tests (test series 5.2 to 5.7, missing numbers were not omitted but concern chapters without test scenarios) concerns the examination of software, comparing this with analytical methods. Here the results of the calculation were always exactly the same as the values reached analytically.
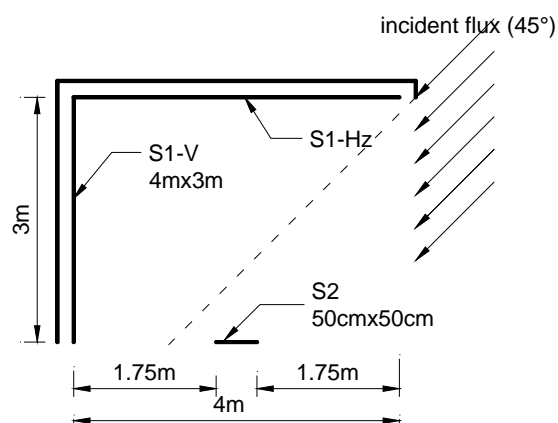
Example: Test scenario 5.6

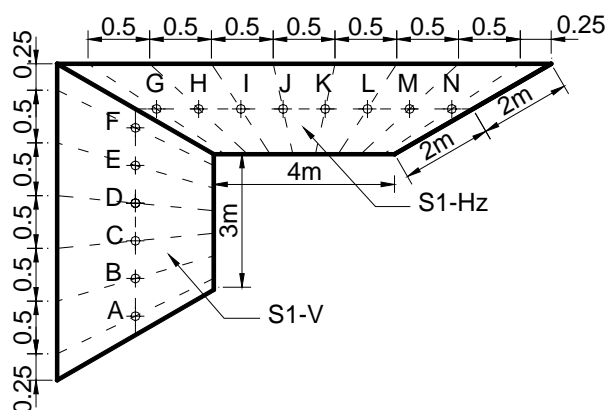Figure 1: Test case description for S_2 of 50cm×50cm

Figure 2: measurement points position

(S$_2$: 50×50cm)

	Points de mesure sur S1-v					
	A	**B**	**C**	**D**	**E**	**F**
E/(Ehz×ρ) (%)	0,246	0,580	0,644	0,556	0,433	0,325
DIALux	0,245	0,577	0,646	0,558	0,431	0,323
Error(%)	0,4	0,52	0,31	0,36	0,46	0,62

	Points de mesure sur S1-hz							
	G	**H**	**I**	**J**	**K**	**L**	**M**	**N**
E/(Ehz×ρ) (%)	0,491	0,639	0,778	0,864	0,864	0,778	0,639	0,491
DIALux	0,489	0,636	0,783	0,861	0,861	0,783	0,636	0,489
Error(%)	0,4	0,47	0,64	0,34	0,34	0,64	0,47	0,4

Table 1: variation of E/(Ehz×ρ) for S2 of 50cm×50cm

The following test cases were of particular interest for DIAL since they deal with the new theme to be found in DIALux, namely daylight calculation. We have gained a lot of experience in the calculation of artificial lighting. But calculating daylight was something quite new. So it is easy to understand why we were so pleased when the results in the CIE comparison were so good first time round.

The following test scenario deals with a rectangular room with an open roof. The task is to define correctly the daylight quotient in the interior of the room.
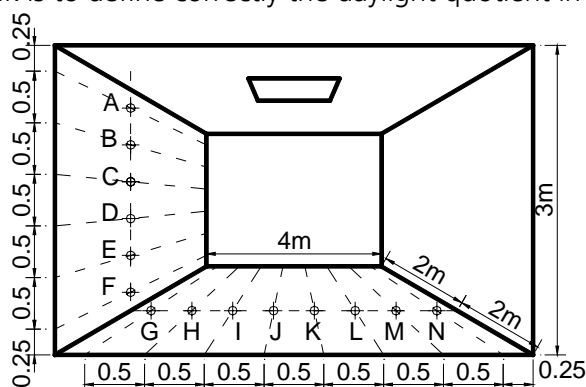
Figure 3: geometry and measurement points description

Daylight quotient on the walls						
	A	B	C	D	E	F
CIE couvert	0.56	1.78	2.32	2.20	1.82	1.43
DIALux	0.56	1.91	2.35	2.09	1.81	1.37
Error(%)	0	6.8	1.28	5	0.55	4.2

Daylight quotient on the floor							
	G	H	I	J	K	L	M	N
CIE couvert	2.29	3.07	3.82	4.29	4.29	3.82	3.07	2.29
DIAlux	2.39	3.19	3.76	4.22	4.35	3.91	2.92	2.31
Error(%)	4.18	3.91	1.57	1.63	1.38	2.3	4.89	0.87

Recapitulation

With these examples we would like to show the user that DIALux is a very accurate aid when calculating lighting situations. Of course we cannot exclude the possibility that under certain conditions there may be larger deviations between the calculated and measured values. Special problems may arise when, in lighting situations, the limitations of photometrical assumptions have been reached. In the area close to the luminaire the LDC no longer applies,
Every assumption on which software is of necessity based is then an estimation and cannot be supported with numerical values according to the laws of physics. The same applies of course if in a comparative lighting scenario mainly highly polished or reflecting materials are used. The method of classical radiosity calculation makes simplified assumptions. In normal cases with indoor and outdoor light planning, the quality of the calculations with DIALux is highly satisfactory.
The intelligent calculation kernel enables optimal solutions with regard to calculation accuracy and calculation speed in full accordance with the requirements made.

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