LABORATORY PROFILE

2021 Edition

Optical & Thermal Testing Laboratory

OTM Solutions Pte Ltd

ilac-MRA

Accredited Laboratory
SAC-SINGLAS
LA-2016-0610-G

SINGAPORE GREEN BUILDING COUNCIL MEMBER

OTM

Choose OTM.

Work with the expert in

Optical & Thermal Measurement solutions.

Table of contents

Laboratory overview ····· 2

- Accreditation and qualifications ····· 3
- Instruments ····· 6
- Quanlity control & assurance ····· 9
- Branding ····· 10
- Customer satisfaction ····· 12
- Customer base ····· 14
- Publications and presentations ····· 15

Testing services ····· 17

- Glass solar/luminous/thermal properties ····· 18
- IGDB & CGDB submission ····· 26
- Frame U-value & SHGC ····· 28
- Solar reflectance index ····· 32
- Daylight reflectance ····· 36
- Thermal conductivity ····· 40
- Emittance/emissivity ····· 44
- Colour & colour difference ····· 46
- Luminance contrast ····· 48
- On-site monitoring ····· 50

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Optical & thermal testing is our primary focus

OTM Solutions Pte Ltd was incorporated in 2013, with the vision of being Singapore's best optical & thermal testing laboratory.

We have dedicated personnel, equipment, quality system and expertise available to deliver accurate and reliable optical & thermal testing services to our clients.

2021 is the 8th year of operation of our laboratory. We look forward to working with you in 2021.

Key milestones

- 2013 Incorporated as OTM Solutions Pte Ltd
- 2014 Qualified for IGDB data submission
- 2016 Accredited by SAC-SINGLAS
- 2017 Joined as SGBC corporate member
- 2018 Qualified for CGDB data submission

We are competent in optical & thermal testing

ilac-MRA Accredited Laboratory SAC-SINGLAS LA-2016-0610-G

SAC-SINGLAS accreditation according to ISO 17025
Accredited in 2016

SINGAPORE GREEN BUILDING COUNCIL

SGBC lab partner for SGBP certification
Qualified in 2017

NFRC National Fenestration Rating Council®

NFRC/LBNL IGDB submission
Qualified in 2014

Attachments Energy Rating Council AERC

AERC/LBNL CGDB submission
Qualified in 2018

SAC-SINGLAS accreditation: the Singapore Laboratory Accreditation Scheme (SINGLAS) managed by Singapore Accreditation Council (SAC).
SGBC lab partner: lab partner of Singapore Green Building Council (SGBC) for Singapore Green Building Product (SGBP) certification.
IGDB submission: submission of glass product optical data to the International Glazing Database (IGDB) managed by National Fenestration Rating Council (NFRC) and Lawrence Berkeley National Laboratory (LBNL).
CGDB submission: submission of window attachment product optical data to the Complex Glazing Database (CGDB) managed by Attachments Energy Rating Council (AERC) and LBNL.

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

SAC-SINGLAS accredited
Internationally recognized

Insulation Material Steady-State Thermal Transmission Property Test Report

Report number: OTM2101001

Client:

Company name
Address line 1
Address line 2
Attention: Name

Laboratory:

Optical & Thermal Testing Laboratory
OTM Solutions Pte Ltd
21 Woodlands Close
#07-05 Primz Bizhub
Singapore 737854

Tel: (+65) 6908 0126
WhatsApp: (+65) 8838 1374
Email: info@otm.sg
Web: www.otm.sg

View laboratory profile

The Optical & Thermal Testing Laboratory of OTM Solutions Pte Ltd is accredited to ISO/IEC 17025 under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme (SAC-SINGLAS, Certificate No: LA-2016-0610-G).

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council.

What is SAC-SINGLAS accreditation?

We always highlight that our lab is SAC-SINGLAS accredited. The rationale is explained here.

No laboratory license

Operating a lab, including a third-party lab, does not require a license in Singapore (and in most parts of the world).

Voluntary SAC-SINGLAS accreditation

The Singapore Laboratory Accreditation Scheme (SINGLAS) managed by Singapore Accreditation Council (SAC) is a voluntary lab accreditation scheme based on ISO 17025.

The accreditation criteria are comprehensive and cover all essential parts of lab operation.

SAC audits the lab every year, to verify the compliance of the lab quality system to ISO 17025.

SAC accredited reports

An SAC-SINGLAS accredited lab is allowed to issue SAC accredited reports with the “ilac-MRA” and “SAC-SINGLAS” marks, for testing services conducted under the terms of accreditation.

SAC accredited reports are internationally recognized, thanks to the Mutual Recognition Arrangements (MRAs) signed by SAC.

Benefits of engaging an SAC-SINGLAS accredited lab

The annual audit by SAC verifies that the instruments are well maintained and calibrated, the personnel are qualified, the test accuracy is satisfying, and more other things.

A general lab customer usually does not have the knowledge and resources to thoroughly check a lab’s quality system. It is effortless and risk-free to select an SAC-SINGLAS accredited laboratory.

For decision makers, e.g. government or buyers, SAC accredited reports are more trustworthy.

Laboratory instruments

UV/VIS/NIR spectrophotometer

FTIR spectrometer

Emissometer

Heat flow meter

Hot wire thermal conductivity meter

Digital multimeter

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

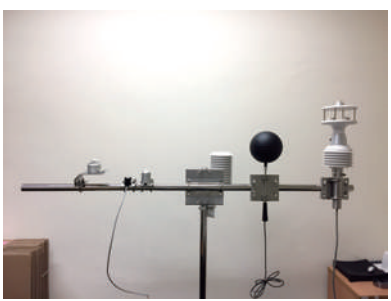
Handheld & on-site instruments

Portable spectrophotometers

Roller wave gauge

Standard colour tiles

Data loggers and sensors



Micro-climate station

Weather station

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Focus on one thing.
Do it well.

Focus on optical & thermal testing.

Be Singapore's best
optical & thermal testing laboratory.

We compare our results with external labs regularly

Testing quality is critical to both our customers and ourselves. At OTM, we've implemented a robust laboratory quality system based on ISO 17025 and are improving it continually.

Quality control measures

In the lab, ISO 17025 is closely adhered to, with the following important practices:

- Impartiality in laboratory operation
- Regular instrument calibration & maintenance
- Detailed work instructions
- Competent personnel
- Traceable measurement results
- Minimized measurement uncertainties
- Regular performance verifications
- Regular quality assurance tests

Quality assurance tests

In order to ensure test result validity, the laboratory performs the following:

- Daily instrument performance verification with retained samples
- Quarterly internal quality assurance tests with retained samples
- Participation of proficiency tests (PT) programs or inter-laboratory comparisons (ILCs)

Listed below are the proficiency tests or inter-laboratory comparisons participated by the lab:

- 2014: ILC on glass testing, organized by LBNL
- 2015: ILC on glass testing, organized by LBNL
- 2017: ILC on complex glazing testing, organized by LBNL
- 2018: ILC with NMC on spectral reflectance testing
- 2019: PT on thermal conductivity testing
- 2020: ILC on glass testing, organized by LBNL

Advertisement and newsletters

Advertisement on SG Green

Quarterly newsletter

OTM Insights newsletter

We release our OTM Insights newsletter quarterly since Q3/2019.

In each OTM Insights newsletter, we provide a detailed technical insights article and also various news on OTM operation.

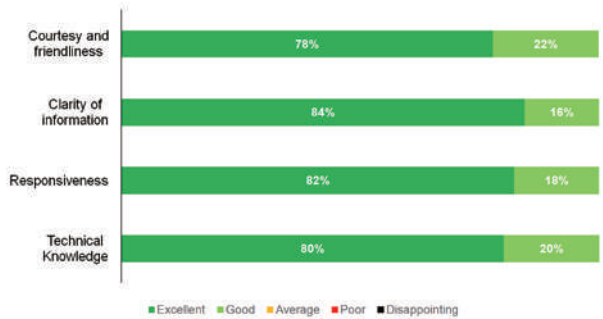
Past issues

Listed below are the past issues of OTM Insights:

- Issue 6 (Q4/2020): What are the differences between the NFRC, EN, and ISO glass optical & thermal test methods?
- Issue 5 (Q3/2020): How accurate are glass optical & thermal test results?
- Issue 4 (Q2/2020): How to test optical & thermal properties of glasses from existing buildings?
- Issue 3 (Q1/2020): Partially fritted glazing optical & thermal property testing procedures
- Issue 2 (Q4/2019): Double glazing optical & thermal property testing procedures
- Issue 1 (Q3/2019): Single glazing optical & thermal property testing procedures

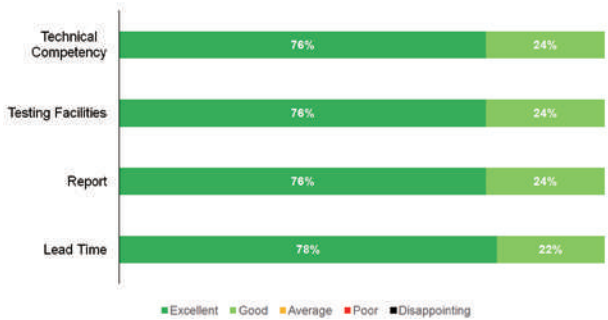
We do our best to achieve high customer satisfaction

100% customers are satisfied with our customer services



Rating on customer services

100% customers are satisfied with our testing services

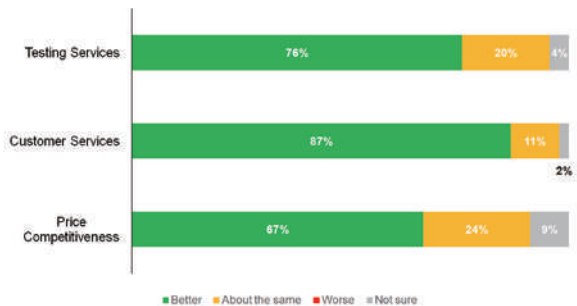


Rating on testing services

Source of data: customer satisfaction survey conducted between 01/2020 and 09/2020. 45 customers participated the survey.

We do our best to achieve high customer satisfaction

Most customers rated us better than other labs.
We worked hard to improve our price competitiveness in 2020.
Most customers rated that our prices are better than other labs.



Comparison with other labs

100% customers are willing to work with OTM again and recommend OTM to others.

Work with OTM
again in the future

Recommend
OTM to others

Source of data: customer satisfaction survey conducted between 01/2020 and 09/2020. 45 customers participated the survey.

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

We serve regional and international customers

The main customer base of OTM is the building and construction industry, from material manufacturers to construction companies. Our customers are from in total 20 countries, as of 2019.

Global distribution of OTM customers

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

We understand the physics in optical & thermal testing

Publications

Chen, F. and Wittkopf, S. K. (2012) Summer condition fenestration thermal transmittance measurement using calorimetric hot box. 53, Energy and Buildings.

Chen, F. and Wittkopf, S. K. (2012) Solar heat gain coefficient measurement with indoor calorimetric hot box and solar simulator. 53, Energy and Buildings.

Chen, F., Choo, T. S. and Ouyang, J. (2013) The effects of fenestration systems on occupant thermal and visual comfort in the tropics. SB13 Singapore Conference.

Chen, F. (2013) Annual equivalent shading coefficient (AESC) index for thermal performance rating of fenestration in Singapore. SB13 Singapore Conference.

Presentations

Chen. F. (2012) SERIS' approach towards a standard calorimetric method for solar heat gain coefficient (SHGC) measurement. 2012 International Collaboration Seminar: Development of Evaluation Method for G-value, Korea.

Chen. F. (2012) SERIS' experience on calorimetric G-value measurement. The 2nd International Seminar Regarding G-value Measurement Method, China.

Chen, F. (2013) The ABCs of fenestration system U-value and G-value. Seminar on Energy Efficient Facades and Fenestrations in the Tropics, Singapore.

Chen, F. (2013) Fenestration: the New Focal Point of Tropical Green Building Innovations. SGBC and SIBL Joint Seminar: Holistic Approach to Sustainable Development, Singapore.

Chen, F. (2013) The ABCs of Facades in the Tropical Climate. 2nd Seminar on High Performance Façades in the Tropics, Singapore.

Chen, F. (2013) Fenestration System Thermal Performance Rating for Summer Condition. APEC Policy Workshop for Energy Efficient Envelopes, Thailand.

Chen, F. (2015) New Perspectives on Energy Efficient Fenestrations in Tropical Climate. Fenestration Days China, China.

Chen, F. (2017) Accurate Measurement of Transmittance and Reflectance for Engineering Applications. PerkinElmer INTour Seminar 2017, Singapore.

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Your premium optical & thermal testing laboratory:

- Broadest scope
- Best accuracy
- Fastest delivery
- Friendliest price

We are a full services optical & thermal testing laboratory

Glass properties

IGDB & CGDB submission

Frame U-value & SHGC

Solar reflectance index

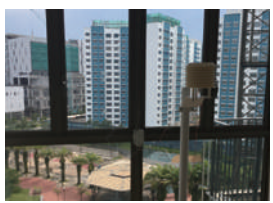
Daylight reflectance

Thermal conductivity

Emissivity

Colour

Luminance contrast



On-site monitoring

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Verify your glass specifications with the greatest transparency

Test methods

There are 3 major glass test methods. It is important to select an appropriate test method for fair comparison:

- NFRC method: NFRC 100/200/300/301
- EN method: EN 410/673
- ISO method: ISO 9050/10292

We support all 3 methods, with the NFRC method as the default.

Sample types

All general glass types: laminated glass, glass with window film, insulating glazing unit and partially fritted glass.

Instruments

- PerkinElmer Lambda 950 spectrophotometer
- PerkinElmer Spectrum Two spectrometer

Standard result set

- Visible light transmittance
- Visible light reflectance (front & back)
- Solar energy transmittance
- Solar energy reflectance (front & back)
- Solar heat gain coefficient (SHGC)
- Shading coefficient
- U-value (winter & summer)

Scan me for instant quote

Interested? Scan the QR code above to get price and procedures instantly

We are the expert in glass optical & thermal property testing

Extended results

Upon customer's request, we can report additional sets of results favoured by the industry, particularly the window film sector:

- UV transmittance & rejection
- Infrared transmittance & rejection
- Total solar energy rejection
- Light-to-solar gain (LSG) ratio
- Luminous efficacy
- Colour (transmitted & reflected)
- Colour rendering index (CRI)
- CIE damage factor
- Skin damage factor

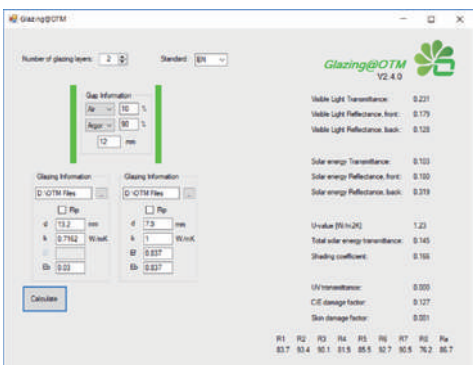
Advanced calculations

Upon customer's request, we can perform the following advanced calculations

- Extract low-e layer optical properties and construct new low-e glass
- Extract PVB/SGP interlayer optical properties and construct new glass laminate
- Extract window film optical properties and attach it to a different glass

Home-made calculation software

We coded our own glass calculation software from scratch, for the best capabilities and flexibilities.



Glazing@OTM Software

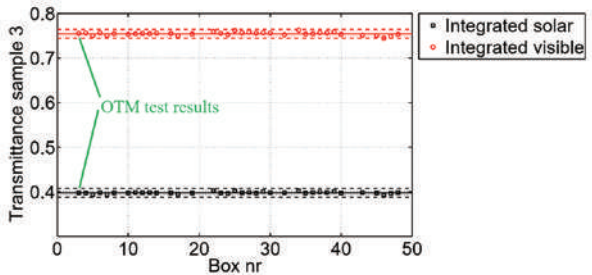
Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Our results are as accurate as the world's best laboratories

We participate the inter-laboratory comparison (ILC) organized by Lawrence Berkeley National Laboratory (LBNL) regularly.

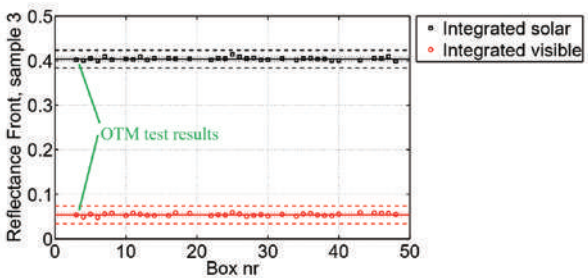
Shown below are the result comparisons of the ILC conducted in 2015. The results measured by OTM are accurate, among the 36 participating labs.

a)



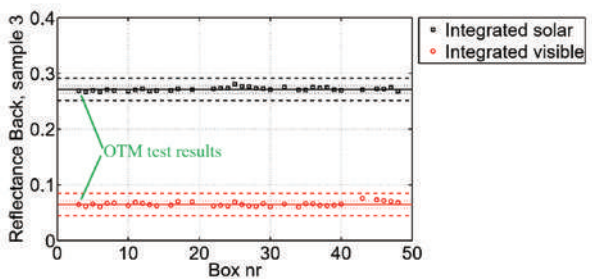
Comparison of transmitance results

b)



Comparison of reflectance results (front side)

c)



Comparison of reflectance results (back side)

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Our results are accepted by the world's largest glass optical property database

OTM is qualified to submit data to the IGDB, the world's largest glass optical property database, managed by NFRC and LBNL.

When you are using the famous LBNL WINDOW software, the optical data were probably tested by OTM.

Furthermore, OTM is also qualified to submit data to the CGDB managed by AERC and LBNL.

National Fenestration Rating Council®

Attachments Energy Rating Council AERC

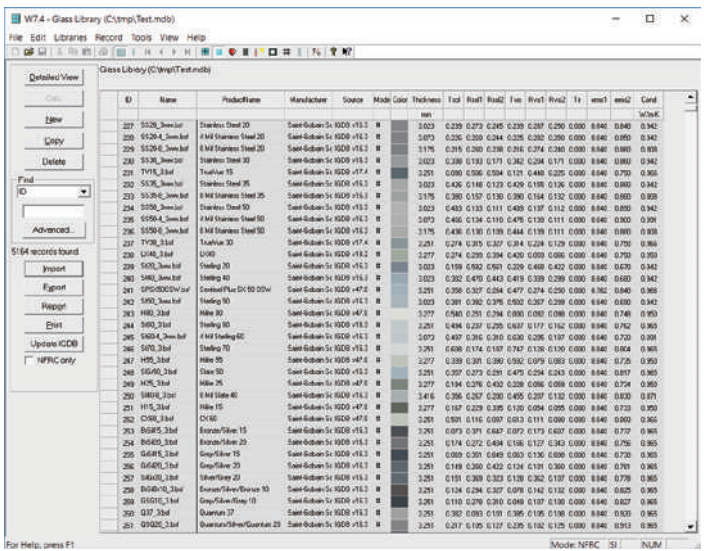
IGDB: International Glazing Database

CGDB: Complex Glazing Database

NFRC: National Fenestration Rating Council

AERC: Attachments Energy Rating Council

LBNL: Lawrence Berkeley National Laboratory



LBNL WINDOW software

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

How are glass optical & thermal properties tested in the laboratory?

Curious about the glass testing procedures? The important concepts are explained here.

No direct measurement

In contrast to the common assumptions, the U-value & SHGC of a glass are not directly measured in an instrument with controlled temperature difference and solar radiation.

Only spectral optical properties are physically tested

In the lab, we only test the spectral transmittance/reflectance in the 300 nm – 2500 nm range (ultraviolet, visible light and near infrared) and the spectral reflectance in the 5 μm – 25 μm range (infrared).

Broadband optical properties are calculated

Weighted averaging is performed, with the standard AM1.5 solar spectrum or the standard room temperature blackbody emission spectrum as the weights, to get the following broadband optical properties:

- Visible light transmittance/reflectance
- Solar energy transmittance/reflectance
- Emittance

Thermal properties are calculated

According to the standard environmental conditions and mathematical models defined in the standards, the following thermal properties are calculated:

- U-value
- SHGC and shading coefficient

Detailed testing procedures

Please scan the QR code on the left for the step-by-step procedures on the following

- Single glazing testing procedures
- Double glazing unit (DGU) testing procedures
- Partially fritted glazing testing procedures

What are U-value, SHGC and shading coefficient?

U-value, SHGC and shading coefficient are the 3 important thermal results influencing building envelope energy efficiency. The basic concepts are explained here.

U-value

$$U\ [W/(m^2\ K)] = \frac{\text{Heat transmitted through a glass [W]}}{\text{Area [m}^2\text{]} \times \text{Temperature difference [K]}}$$

U-value represents the insulation performance of a glass under an indoor/outdoor temperature difference. Smaller U-value means better thermal insulation.

U-value is dependent on the environmental conditions, e.g. indoor/outdoor wind speed. Therefore, the summer condition and winter condition U-values are different.

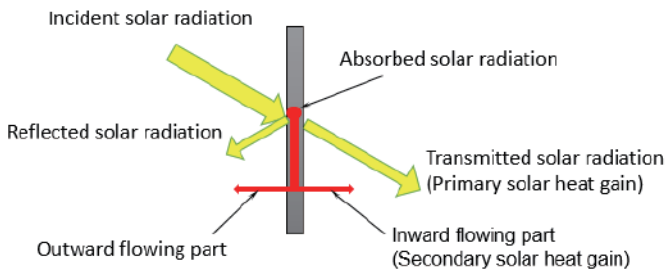
Among the physically tested results, U-value is only dependent on the emittance, but independent of the solar energy transmittance/reflectance.

Solar heat gain coefficient（SHGC）

$$SHGC[\ -\ ] = \frac{\text{Solar heat transmitted through a glass [W]}}{\text{Solar heat incident onto a glass [W]}}$$

SHGC represents the solar heat gain performance of a glass. Smaller SHGC means better solar heat gain control.

As shown below, SHGC consists of two components, the primary and secondary solar heat gains.



SHGC is dependent on all physically tested results.

Shading coefficient

$$\text{Shading coeffient}\ [\ -\ ] = SHGC\ [\ -\ ] / 0.87$$

Shading coefficient is identical to SHGC in physical meaning. Shading coefficient is the SHGC scaled by 0.87 (the nominal SHGC of a clear glass).

What are the differences between NFRC, EN and ISO methods?

The NFRC, EN and ISO methods are the three widely adopted glass test methods:

- NFRC: NFRC 100/200/300/301
- EN: EN 410/673
- ISO: ISO 9050/10292

The differences between them are explained here.

Identical in measurement principles

The measurement principles in the 3 methods are identical. The same set of instruments can be used for all 3 methods.

Testing: NFRC method is more detailed

The requirements in the NFRC method on the testing procedures are detailed and specific, whereas the EN/ISO methods are brief in the testing part.

The test results obtained according to the NFRC methods can be directly used for the EN/ISO calculations, but not vice versa.

Calculation: different solvers and conditions

The differences in the calculation parts are substantial.

- Solver: the NFRC method uses a numerical solver, whereas the EN/ISO method uses an analytical solver.
- Environmental conditions: different solar spectrum, temperature and wind speed etc.

Results: large difference in SHGC

The visible light transmittance/reflectance results are identical.

The winter condition U-value results are close, but there is no summer condition U-value in the EN/ISO method.

The difference in the SHGC results could be large (e.g. 0.02), due to the differences in the environmental conditions.

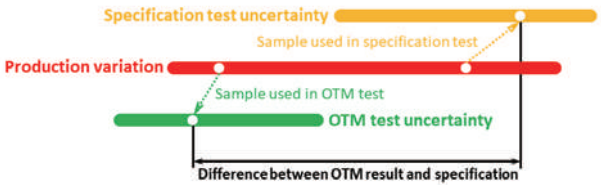
Which method is recommended?

It depends on your project requirements.

If it is not explicitly specified, the NFRC methods are recom -mended, due to the more detailed requirements and the wide adoption by the industry.

Why are lab test results different from manufacturer's specifications?

It is impossible for our test results to be the same as the manufacturer's specifications. Some explanations are provided here.



It is normal and inevitable

As depicted above, there are 3 factors causing the difference:

- Specification test uncertainty
- Production variation
- OTM test uncertainty

It is impossible to eliminate all uncertainties and variations. Therefore, there are always certain differences.

Production variation

Two different samples are used in the specification test and in OTM test.

The two samples cannot be identical, especially when they are produced in different lots, different years or different plants.

Specification test uncertainty

The specifications are with certain uncertainty. It is also important to know the test methods used for the specifications.

OTM test uncertainty

Our results are with certain uncertainty, as specified in the test report. We will be fully responsible to our result accuracy. We will re-test for free or refund the full price if our results are not accurate.

Project suggestions

- Understand your project requirements
- Check with your glass supplier for their typical production variation and specification accuracy
- Check with OTM for the measurement uncertainty

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Laboratory testing for IGDB & CGDB submission

IGDB test methods

- NFRC 300
- NFRC 301

IGDB sample types

All sample types in the scope of IGDB submission, e.g. glasses or window films.

Instruments for IGDB testing

- PerkinElmer Lambda 950 spectrophotometer
- PerkinElmer Spectrum Two spectrometer

Results for IGDB submission

- A text file in the IGDB data format.

Refer to pages 18-25 for more information on our glass testing services.

CGDB test methods

- AERC 1.1

CGDB sample types

All samples types in the scope of CGDB submission, e.g. fabrics.

Instruments for CGDB testing

- PerkinElmer Lambda 950 spectrophotometer
- Devices and Services AE1 RD1 emissometer

Results for CGDB submission

- A homogeneity report
- A text file in the CGDB data format

For both IGDB & CGDB submissions, the submission will be performedby the customer.

What are the procedures for CGDB submission testing?

If you are new to CGDB submission, the testing procedures are explained here.

Homogeneity test

The purpose of the homogeneity test is to understand the consistency of a product and select a representative sample.

18 samples need to be sampled from different lots and different positions. The visible light transmittances or reflectances of the 18 samples are measured for the calculation of material product homogeneity.

Based on the homogeneity test results, a representative sample is selected for more detailed optical property test.

Optical property test

In the optical property test, the following properties of the representative sample are tested:

- Direct-hemispherical and diffuse spectral transmittance in the 300 nm – 2500 nm range
- Direct-hemispherical and diffuse spectral reflectance in the 300 nm – 2500 nm range
- Thermal emissivity and infrared (IR) transmittance

Result compilation

Based on the test results, two sets of result files are compiled:

- A homogeneity test report in the MS Excel format
- A text file in the CGDB data format containing the optical property test results

The two files shall be submitted together by the customer.

Know your frame U-value and SHGC

Calculation methods

- NFRC 100/200
- NFRC Simulation Manual

Solar reflectance test method

- ASTM E903

Frame and fenestration types

All general frame types: aluminium frame, aluminium frame with thermal break, and uPVC frame.

All general fenestration types: window and curtain wall system.

Calculation tools

- LBNL WINDOW/THERM

Solar reflectance test instrument

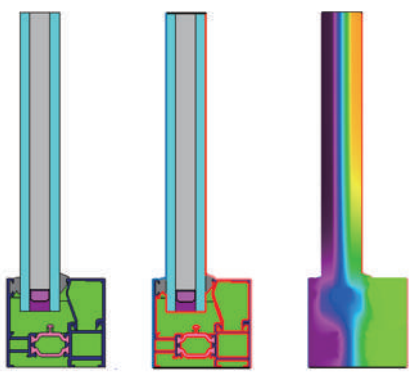
- PerkinElmer Lambda 950 spectrophotometer

Standard calculation result set

- Frame U-value and SHGC
- Edge-of-glazing U-value and SHGC
- Centre-of-glazing U-value and SHGC
- Fenestration system U-value and SHGC

Standard solar reflectance test results

- Solar reflectance and absorptance



Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Why are frame U-value and SHGC important?

The importance of frame U-value and SHGC in the tropical climate is being more recognized by the industry recently. The background information is explained here.

Frame U-value is important in winter conditions

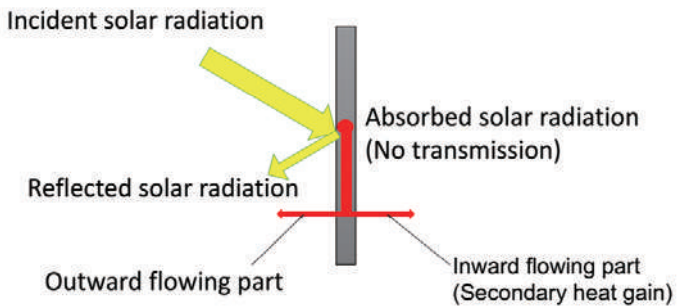
Due to the large indoor/outdoor temperature difference, the overall fenestration U-value is important in winter conditions.

As the U-value of frames, particularly aluminium frames, are typically greater than the U-value of low-e insulating glazing units, frame U-value is important in winter conditions.

Frame SHGC is important in summer conditions

Due to the large solar heat gain, the overall fenestration SHGC is important in summer conditions.

The solar heat gain through a frame could be large. Shown below is the heat transfer mechanism.



Frame U-value influences SHGC

The secondary heat gain through a frame is dependent on the solar absorptance and the U-value of the frame.

Frames with lower solar absorptance and U-value are with lower SHGC.

4 reasons to engage OTM for your frame U-value & SHGC assessment

- We are a neutral and independent third-party lab
- We are technically competent
- We use the NFRC methods consistently
- We offer special bundle price if both frame and glass are evaluated by OTM

How are frame U-value and SHGC calculated?

Curious about the frame U-value and SHGC calculation procedures? The important concepts are explained here.

Physical property testing not required

Thermal conductivity and emissivity of common frame materials are provided in a standard material database.

It is not required to conduct thermal conductivity and emissivity test, unless your material is not available in the database.

Optional solar reflectance testing

The default solar reflectance of all materials is 0.3. It is optional to test your material solar reflectance for better accuracy.

Frame cross-section drawing needed

Frame cross-section drawing in CAD format is needed. The bill of materials (BOM) of the fenestration is needed.

2D model in LBNL THERM

A 2D model is built in the LBNL THERM software, with the standard environmental conditions applied. The frame and edge-of-glazing U-values and SHGCs are calculated.

Area-weighted averaging in LBNL WINDOW

In the LBNL WINDOW software, the overall fenestration system U-value and SHGC are calculated based on area-weighted averaging of frame, edge-of-glazing and centre-of-glazing U-values and SHGCs.

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Solar reflectance index (SRI) test, internationally recognized

Test methods

- ASTM E903
- ASTM C1371 (with TN 11-2)
- ASTM E1980

Sample types

All general materials with flat surface: roof materials, pavement materials and façade cladding materials.

Instruments

- PerkinElmer Lambda 950 spectrophotometer
- Devices and Services AE1 RD1 emissometer

Standard result set

- Solar reflectance & absorptance
- Emittance
- SRI at 3 wind conditions

For non-roof materials, it is possible to test the solar reflectance only.

Scan me for instant quote

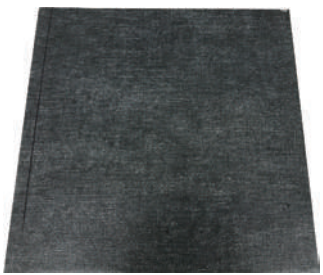
Interested? Scan the QR code above to get price and procedures instantly

We are familiar with all sample types

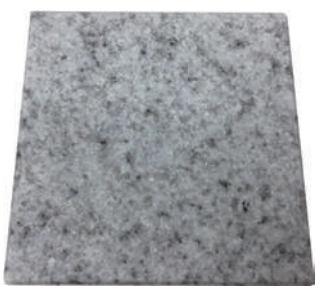
PVDF coated metal plate

Waterproofing membrane

Concrete

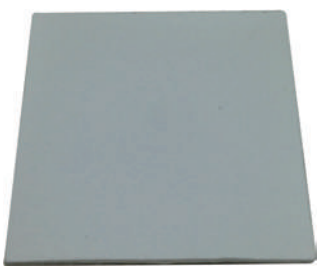


Ceramic tile



Granite

Wood



Paint

Roof tile

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

What is solar reflectance index (SRI)?

SRI is an important parameter for urban heat island mitigation. Materials with higher SRI are with lower surface temperature under solar radiation. The basic concepts are explained here.

Surface temperature under solar radiation

The temperature of a surface under solar radiation is dependent on both the surface properties and the environment conditions.

Solar reflectance and emittance are the two properties affecting surface temperature.

Under the standard environmental conditions, the surface temperatures at three wind speeds can be calculated.

Reference white and black surfaces

A surface with solar reflectance = 0.80 and emittance = 0.9 is defined as the reference white surface.

A surface with solar reflectance = 0.05 and emittance = 0.9 is defined as the reference black surface.

Solar reflectance index (SRI)

The surface temperatures of the reference white surface (T_{white}), of the reference black surface (T_{black}), and of a sample (T_{sample}) can be calculated. An SRI can then be calculated from the 3 temperature results.

$$SRI = \frac{T_{black} - T_{sample}}{T_{black} - T_{white}} \times 100$$

As there are three standard wind speeds, there are 3 SRIs at different wind speeds.

It is possible for SRI to be greater than 100 or less than 0.

SRI is for horizontal or low-sloped surfaces only

Strictly speaking, the concept of SRI is not applicable to façades, as the temperature calculation model is for horizontal and low-sloped surfaces only.

In LEED, only solar reflectance is required for non-roof areas.

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

How is solar reflectance index tested in the lab?

Curious about the SRI testing procedures? The important concepts are explained here.

SRI is calculated

SRI is calculated from tested solar reflectance and emittance, according to ASTM E1980.

Solar reflectance and emittance are tested separately, with two different instruments.

Emittance is directly measured

Emittance is directly measured with the instrument emissometer, according to ASTM C1371.

Three methods for solar reflectance testing

There are 3 solar reflectance measurement methods:

- ASTM E903
- ASTM C1549
- ASTM E1918

The 3 methods are equivalent essentially. The differences are mainly on the solar radiation source, detector and optical geometry.

ASTM E903 is the most accurate one, as it uses spectrophoto -meter.

At OTM, ASTM E903 is employed. The spectral reflectance of a sample in the solar spectrum range (300 nm – 2500 nm) is measured. Weighted averaging, with the standard AM1.5 spectrum as the weights, is performed to get the solar reflectance.

Initial and aged SRI

Due to soiling and weathering, the SRI becomes lower when a material is aged. The aged SRI is a more realistic representation than the initial SRI in the lifetime of a building.

At this moment, we can test the initial SRI only.

Fulfil BCA daylight reflectance requirements with ease

Test methods for non-glass materials

- ASTM E903
- ASTM E971
- CIE 130

Test methods for glass materials

- ASTM E903
- NFRC 300

Sample types

All general façade and roof materials with flat surface: aluminium cladding, concrete, roof tile and glass.

Instrument

- PerkinElmer Lambda 950 spectrophotometer

Standard result set for non-glass materials

- Total daylight reflectance
- Diffuse daylight reflectance
- Specular daylight reflectance

Standard result set for glass materials

- Daylight reflectance

Glass materials are with specular reflection only. The concept of total/diffuse/specular reflection is not applicable to glasses.

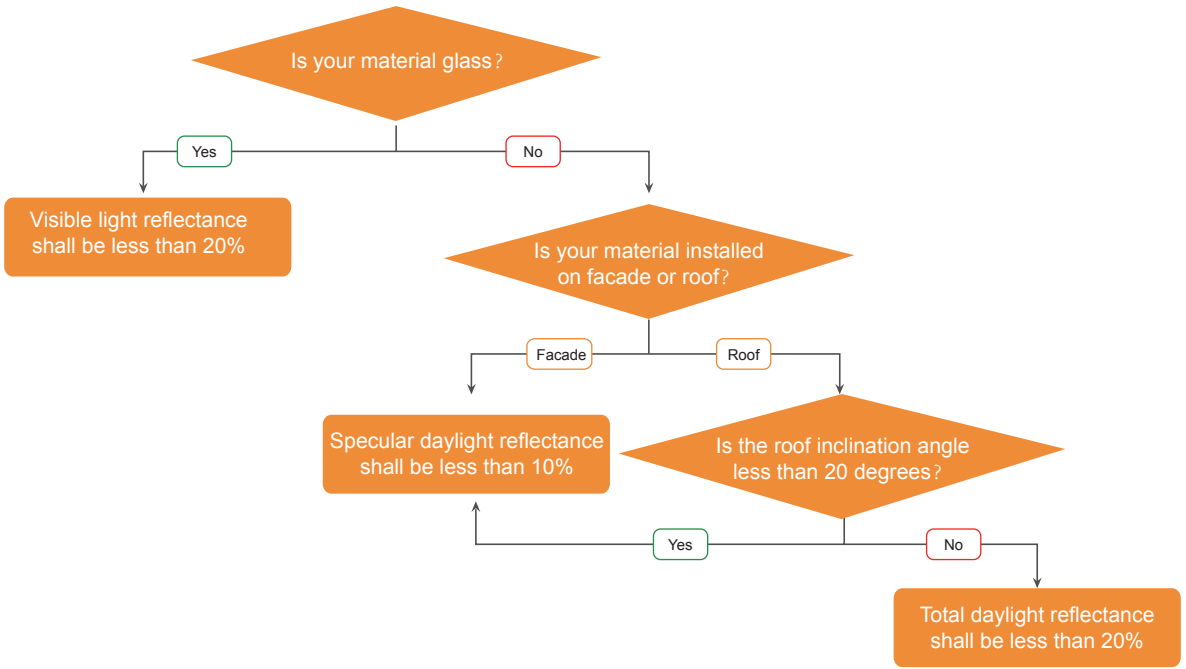
Glasses with ceramic frit are considered as non-glass materials

Scan me for instant quote

Interested？ Scan the QR code above to get price and procedures instantly

Can a material meet BCA daylight reflectance requirements?

Use the flow chart below to check if your material can meet the BCA daylight reflectance requirements.



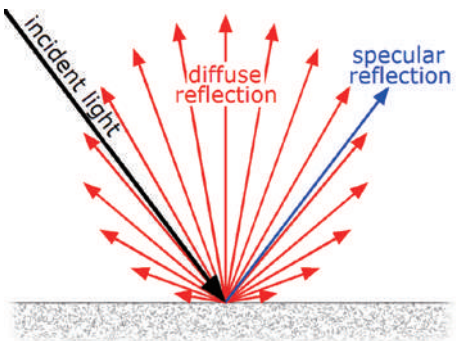
Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Is daylight reflectance correlated to colour and gloss?

Instruments for colour and gloss measurement are available in many companies. The relationship between daylight reflectance, colour and gloss is explained here.

What is daylight reflectance?

Daylight reflectance is the fraction of natural daylight reflected by a surface.



The specularly reflected portion is called the specular daylight reflectance

The diffusely reflected portion is called the diffuse daylight reflectance.

The sum of the specular and diffuse daylight reflectances is the total daylight reflectance.

Daylight reflectance and colour

For colour measurement instruments with integrating spheres, the Y results in the Yxy colour space (with D65 illuminant and 10 degree observer) is close to the daylight reflectance results.

- The Y result in the SCI mode is equivalent to the total daylight reflectance.
- The Y result in the SCE mode is equivalent to the diffuse daylight reflectance.
- The difference between them is equivalent to the specular daylight reflectance.

Daylight reflectance and gloss

The gloss result is proportional to the specular daylight, though they are not equivalent.

How is daylight reflectance tested in the lab?

Curious about the daylight reflectance testing procedures? The important concepts are explained here.

No simple handheld device

BCA requires the measurements to be performed according to the ASTM E903 method with 150 mm integrating sphere.

Most handheld devices cannot meet this requirement.

Instrument measured spectral reflectance

The instrument (UV/VIS/NIR spectrophotometer) measures the spectral reflectance in the visible light range (380 nm – 780 nm).

When the instrument is in the specular-component-included (SCI) mode, the total spectral reflectance is measured.

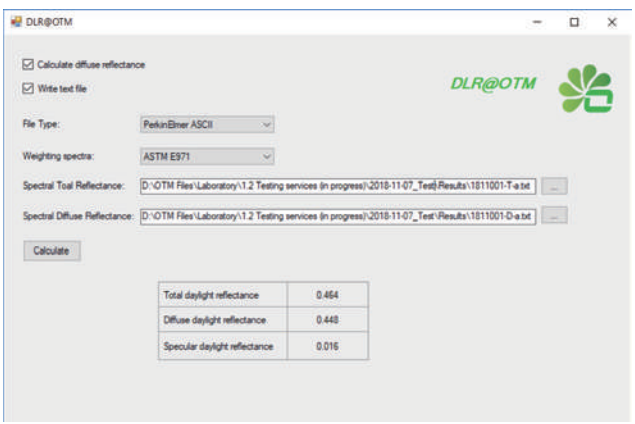
When the instrument is in the specular-component-excluded (SCE) mode, the diffuse spectral reflectance is measured.

The specular spectral reflectance is the difference between the above two.

Calculation of broadband results

The broadband results (total/diffuse/specular daylight reflectance) are calculated from the spectral results (total/diffuse/specular spectral reflectance), by weighted averaging, with the standard daylight spectrum and human vision sensivity as the weights.

At OTM, a home-made software is used for the calculation.



DLR@OTM software

Thermal conductivity of solid, powder, liquid & paste

Unlike other tests, the selection of test method for thermal conductivity testing is highly dependent on the sample type.

For thick solid samples with two flat surfaces

- Test method: ASTM C518
  - Up to 2.5 W/(m·K)
  - With external thermocouple kit for materials with large thermal conductivity
- Sample types: insulation materials, concrete panels, composite panels
- Instrument: Thermtest HFM100 heat flow meter

For homogeneous solid, powder, paste and liquid samples

- Test method: ASTM C1113, D5930 or D7896 with manufacturer's instructions
  - Up to 10 W/(m·K)
- Sample types: general solid, powder, paste and liquid samples
- Instrument: Xiatech TC3000E hot wire thermal conductivity meter

Standard result set

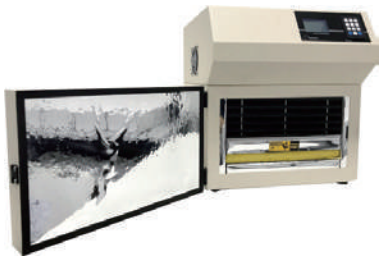
- Thermal conductivity

Upon request, results of thermal resistance and U-value can be included.

Scan me for instant quote

Interested? Scan the QR code above to get price and procedures instantly

Two instruments, more capabilities



Heat flow meter

Hot wire thermal conductivity meter

Feature comparison

Instrument	Heat flow meter	Hot wire thermal conductivity meter
Method	ASTM C518	ASTM C1113, D5930 or D7896 with manufacturer's instructions
Measurement principle	Steady-state measurement • Typical measurement time 1 h • Calibration required	Transient measurement • Typical measurement time: 1 min • Calibration not required
Sample type	Both homogeneous materials and layer-by-layer composite materials, solid only	Homogeneous materials only Solid, powder, paste and liquid
Solid sample size	Typically: 300 mm x 300 mm with maximum 100 mm thickness Both sides should be flat and parallel	For solid samples, typically 50 mm x 50 mm x 5 mm Two samples are needed, at least one side shall be flat

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

What are the differences between thermal conductivity, thermal resistance and U-value?

They are different parameters to describing material insulation performance. The differences are explained here.

Thermal conductivity

Thermal conductivity represents the ability of a material to conduct heat.

Its unit is W/(m·K) and it is indepdent of material thickness. Typically, thermal conductivity is used for homogeneous materials only.

Thermal resistance

$$\text{Thermal resistance} = \frac{\text{Thickness}}{\text{Thermal conductivity}}$$

Thermal resistance is calculated from thickness and thermal conductivity. It is dependent on thickness and its unit is (m²K)/W.

A typical wall system consists of multiple wall layers, the total thermal resistance is simply the sum of the thermal resistance of all layers.

Typically, thermal resistance is used for materials with known thickness or with multiple layers.

U-value

$$U = \frac{1}{\text{Sum of thermal resistance of all solid and air layers}}$$

U-value is the reciprocal of the sum of the thermal resistance of all solid and air layers in a wall system. Its unit is W/(m²K).

Typically, U-value is used for a complete wall system. If only a few layers of a wall is considered, the concept of U-value is not applicable

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

How is thermal conductivity tested in the laboratory?

Curious about the thermal conductivity testing procedures? The important concepts are explained here.

With heat flow meter

A steady state temperature difference is maintained on the two sides of a sample (e.g. 20°C). The heat flux through the sample is measured with heat flux transducers. The thermal conductivity is calculated as the ratio of the heat flux to the temperature difference.

As it is challenging to measure heat flux accurately, a comparison method is used. A reference material with known thermal conductivity is measured to get a correction factor. The correction factor is used to correct the sample measurement result.

Calibration is always required for the heat flow meter method.

With hot wire thermal conductivity meter

The hot wire is heated up by a short pulse of current. The heat from the hot wire is dissipated to the sample. The dissipation speed is correlated to the material thermal conductivity.

The temperature variation history is analysed to get the thermal conductivity.

For solid samples, it is important to maintain good thermal contact between the sample surfaces and the hot wire probe.

Calibration is not required for the hot wire method. The method is also much fast, as it is not required to attain a steady state.

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Material emittance / emissivity testing

The words emittance and emissivity are used inter-changeably.
Emittance is the standard term used in the standards.

Test methods

- ASTM C1371 (with TN 11-2)

Sample types

All general materials with flat surface, excluding glasses.

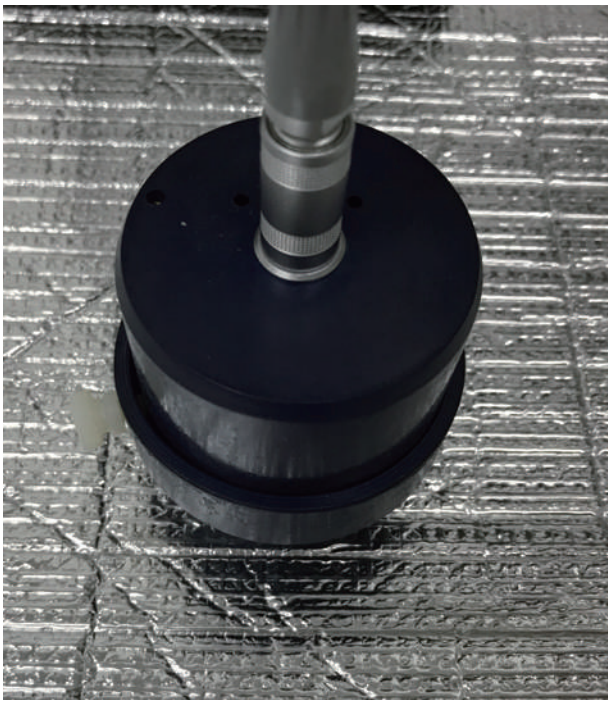
For glass materials, the NFRC 301 method is recommended

Instrument

- Devices and Services AE1 RD1 emissometer

Standard result set

- Emittance



Why is emittance important to insulation performance?

Emittance is an important property in material insulation performance. The basic concepts are explained here.

Three heat transfer modes

There are three heat transfer modes, namely conduction, convection and radiation.

To reduce conduction, materials with low thermal conductivity should be used.

To reduce convection, air cavities with appropriate thickness should be used.

To reduce radiation, materials with low emittance should be used.

Emittance and radiative heat transfer

All surfaces emit infrared radiation. They also reflect and absorb infrared radiation emitted by the surrounding surfaces.

The emittance of most natural surfaces is around 0.9. For a surface with 0.9 of emittance, the infrared heat emitted by it is 90% of that by a perfect black body. It also absorbs 90% of incident infrared heat and only reflects 10% back.

For some low-emittance surfaces, the emittance is around 0.05. For a surface with 0.05 of emittance, the infrared heat emitted by it is only 5% of that by a perfect black body. It also only absorbs 5% of incident infrared heat and reflects 95% back.

Low-emittance surfaces can effectively reduce the radiative heat transfer and improve the insulation performance. They are typically applied on the indoor side topmost layer of a wall or on the surface facing an air cavity.

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Colour & colour difference testing in laboratory or on-site

Test methods

There are numerous test methods for colour & colour difference testing. We can support almost all of them. Typically:

- ASTM E1331
- ASTM D2244

Sample types

All general materials; it is possible to measure samples in powder or granular form

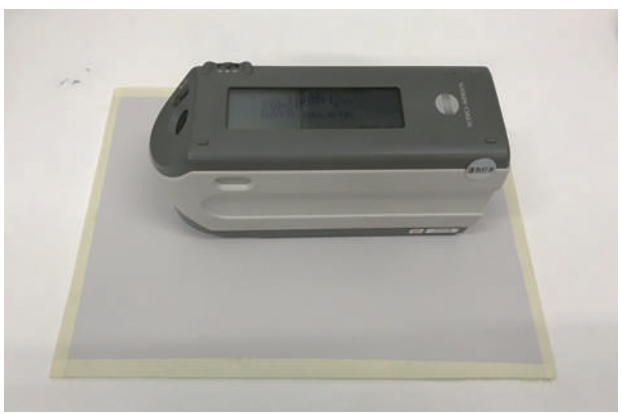
Instruments

- PerkinElmer Lambda 950 spectrophotometer
- Konica Minolta CM-2500d spectrophotometer

Standard result set

Depending on the test methods used. Typically:

- Color in CIELAB colour space
- Colour difference in CIELAB colour space



Can colour results be used for colour matching?

Though colour can be instrumentally measured, it is advised to use physical colour standards to transfer colour. The reasons are explained here.

Absolute colour and relative colour measurement

CIELAB colour space is the most commonly used colour space in the building and construction sector.

The colour measurement results, i.e. L*ab, can be considered as the absolute colour, as it is not compared with any other reference colours.

The colour difference measurement results, i.e. ΔE*ab, can be considered as the relative colour, as it is compared with a reference colour.

Higher accuracy in relative colour measurement

In relative colour measurements, as both the reference colour and the test colour are measured by the same instrument (many uncertainty sources are cancelled out), the accuracy is very high (e.g. accuracy of ΔE*ab is better than ±0.05).

Lower accuracy in absolute colour measurement

In absolute colour measurement, the test colour is not compared to a reference colour (many uncertainty sources are applicable), the accuracy is lower (accuracy of ΔE*ab is around ±1.5).

Use physical colour standards for colour matching

When different instruments are used in colour matching, it is preferred to use a physical colour standard to transfer colour.

There are multiple relative colour measurements with respect to the same physical colour standard. The overall uncertainty is much smaller than using different instruments to perform independent absolute colour measurements

Luminance contrast & luminous reflectance testing

Test methods

- AS 1428.1
- AS/NZS 1428.4.1

Sample types

- All general materials: flooring tiles, pavement materials, Tactile Ground Surface Indicators (TGSIs)

Instruments

- Konica Minolta CM-2500d spectrophotometer

Standard result set

- Luminous reflectance
- Luminance contrast

Example applications

- To determine if there is sufficient luminance contrast between adjacent building elements for the safety of building users

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

What are luminous reflectance and luminance contrast?

Sufficient luminance contrast is critical in the selection of tactile Ground Surface Indicators (TGSIs). The luminance contrast between two surfaces is calculated from the luminous reflectances of them.

The basic concepts of the two properties are explained here.

Luminous reflectance

Luminous reflectance is the reflectance of a surface to visible light.

It is equivalent to visible light reflectance and daylight reflectance. The luminous reflectance of a perfect white surface is 100 (100% reflectance) of a perfect black surface is 0 (0% reflectance).

The luminous reflectance can be measured by a portable or benchtop spectrophotometer.

Luminance contrast

Luminance contrast is a measure of the difference between two luminous reflectances.

Below is the calculation equation:

$$\text{Lumiance contrast} = \frac{125 \times (LR_1 - LR_2)}{LR_1 + LR_2 + 25}$$

Here, LR_1 and LR_2 are the luminous reflectances of surface 1 and surface 2, respectively.

Luminance contrast is a calculated quantity and it is always in terms of two surfaces.

Luminance contrast is different from colour contrast. Surface pairs with large colour contrast may be with small luminance contrast.

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

On-site testing & monitoring of building façade performance

Standard on-site testing methods

- Glass colour uniformity: ASTM C1376
- Glass roller wave: ASTM C1651
- Glass edge lift：EN 1863-1
- Wall U-value: ISO 9869 -1

Custom methods for on-site monitoring

Proposals will be prepared based on the project requirements. We can monitor the following for your decision making:

- Weather: wind speed/direction, solar irradiance, air temperature/humidity
- Façade performance: surface temperature, heat flux, transmitted solar irradiance & visible light
- Thermal comfort: indoor air speed, temperature & humidity, globe temperature

Instruments

We have a wide collection of instruments for on-site testing & monitoring. New instruments can be added when there are special needs.

Reference projects

A number of on-site testing & monitoring projects have been performed by us:

- Glass colour uniformity measurements
- Façade cladding colour matching
- Thermochromic glass performance monitoring in 3 HDB flats
- Low-e glass performance comparison in 4 EC flats
- Thermal micro-climate monitoring in 5 sites of a commercial building
- Frame thermal performance monitoring at the BCA Skylab

Reference projects

Cladding colour uniformity

Glass colour uniformity

Monitoring at BCA Skylab

Thermochromic glass monitoring

Low-e glass comparison

Micro-climate monitoring

Choose OTM. Work with the expert in Optical & Thermal Measurement solutions.

Choose OTM.

Work with the expert in

Optical & Thermal Measurement solutions.

OTM Solutions Pte Ltd

21 Woodlands Close
#07-05 Primz Bizhub
Singapore 737854

Email: info@otm.sg
Tel: (+65) 6908 0126
WhatsApp: (+65) 8838 1374
Web: www.otm.sg

www.otm.sg