ATLAS
MATERIAL TESTING SOLUTIONS

AMETEK
MEASUREMENT, COMMUNICATIONS & TESTING

Accelerated aging testing of modern automotive materials and products

现代汽车材料和产品的加速老化测试

Dr. Oliver D. Rahäuser, Wuhan, Nov07 2019

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MEASUREMENT, COMMUNICATIONS
& TESTING

"We test everything under the sun."

"我们测试阳光下的一切"

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Content汇报内容

- Modern automotive materials and components
  现代汽车材料和部件
- Accelerated aging testing of materials used in automotives
  汽车材料的加速老化测试
  - *Standard equipment and test methods for weathering and lightfastness testing*
  - *老化和色牢度测试的相关标准仪器和测试方法*
- Accelerated component testing
  零部件加速老化测试
  - *Solar Environmental Chambers*
  - *阳光模拟实验箱*
- Final product testing
- 最终产品测试
  - *Solar Environmental Drive-in chambers / wind tunnels*
  - *阳光模拟步入式环境仓/风洞*
- Summary总结

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Modern Materials and Components
现代产品和零部件

E-mobility, fuel-efficient hybrids, and autonomous driving continue to be major priorities.
电动，混动和自动驾驶持续成为优先的发展方向。
Since the number of components inside a car rather increases than decreases, all future cars are dependant on lean designs made of light weight components - without compromising on quality or safety.
车内的零部件数量不减反增，所有未来的汽车都更依赖于轻量化部件的精细设计 - 质量和安全上不能妥协。

Faurecia: "…reductions of up to 100 kg in the weight of each vehicle comes out to a reduction of 10 g CO_2 emitted/km."
佛吉亚集团："每辆车减重100公斤减少每公里10克的二氧化碳排放。"

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Interior Materials内饰材料

- TPO (Thermoplastic polyolefine elastomers热塑性聚烯烃弹性体)
- TPV (Thermoplastic vulcanizates热塑性硫化橡胶)
- TPU (Thermoplastic polyurethanes热塑性聚氨酯)
- TPE-S (Thermoplastic styrol copolymers热塑性苯乙烯共聚体)
- PVC (Polyvinylchloride聚氯乙烯树脂)
- Leather皮革
- Textiles织物

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Interior Parts内饰件

- Further transformation to modern electronics
- 进一步转变为现代电子产品
  - Diplays and touchscreens
  - 显示屏和触摸屏
  - Head-up displays
  - 平视显示设备

Image by Yanfeng

- Coated / dyed thermoplastics, artificial & real leather, textiles涂层/染色热塑性塑料，人造皮/真皮，织物
  - Trims for doors车门饰件
  - Door panels门板
  - Arm rests休息扶手
  - Dash boards仪表盘

Antolin

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Exterior Materials and Additives
外饰件材料和添加剂

- 1-K PUR (Top Coatings)
- 首层面漆

- Polycarbonates (Glazing, Head/Rear lights)
- 聚碳酸酯（玻璃，头尾灯）

- Polypropylene composites (Fenders, Bumbers, etc…)
- 聚丙烯复合材料（挡泥板，保险杠等）

- Polyurethane composites (Fenders, Bumpers, etc…)
- 聚氨酯复合材料（挡泥板，保险杠等）

- Additives: Pigments and dyes (Coatings, Plastics)
- 添加剂：颜料和染料（涂层，塑料）

- Additives: UV Stabilizers (Coatings, Plastics)
- 添加剂：紫外稳定剂（涂层，塑料）

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Exterior Parts外饰件

- *Further transformation from metal to plastics / -composites*
- *进一步从金属转变为塑料/复合材料）*
  - Polycarbonate glazing up to 50% lighter; PC head lights, back lights聚碳酸酯玻璃可以减重达50%，聚碳酸酯头灯尾灯）
  - Plastic-carbon fibre / Thermoplastic liftgates up to 25-35% lighter
  - 塑料碳纤/热塑性塑料尾门可减重达25-35%
  - Polypropylene- or Polyurethane-carbon fibre composite fenders up to 30% lighter
  - 聚丙烯或聚氨酯碳纤复合挡泥板可减重达30%
  - Extra thin lightweight bumper fascias
  - 超薄轻量化保险杠蒙皮

wall thickness down to 2.5 mm
壁厚减到2.5毫米

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Suitable Light Sources适当的光源

- Filtered Xenon sources (small chambers)
  过滤后的氙灯光源（小型试验箱）
- Filtered Metal Halide sources (large chambers)
  过滤后的金卤灯光源（大型试验箱）

PRODUCTS
产品

COMPONENTS
零部件

MATERIALS
材料

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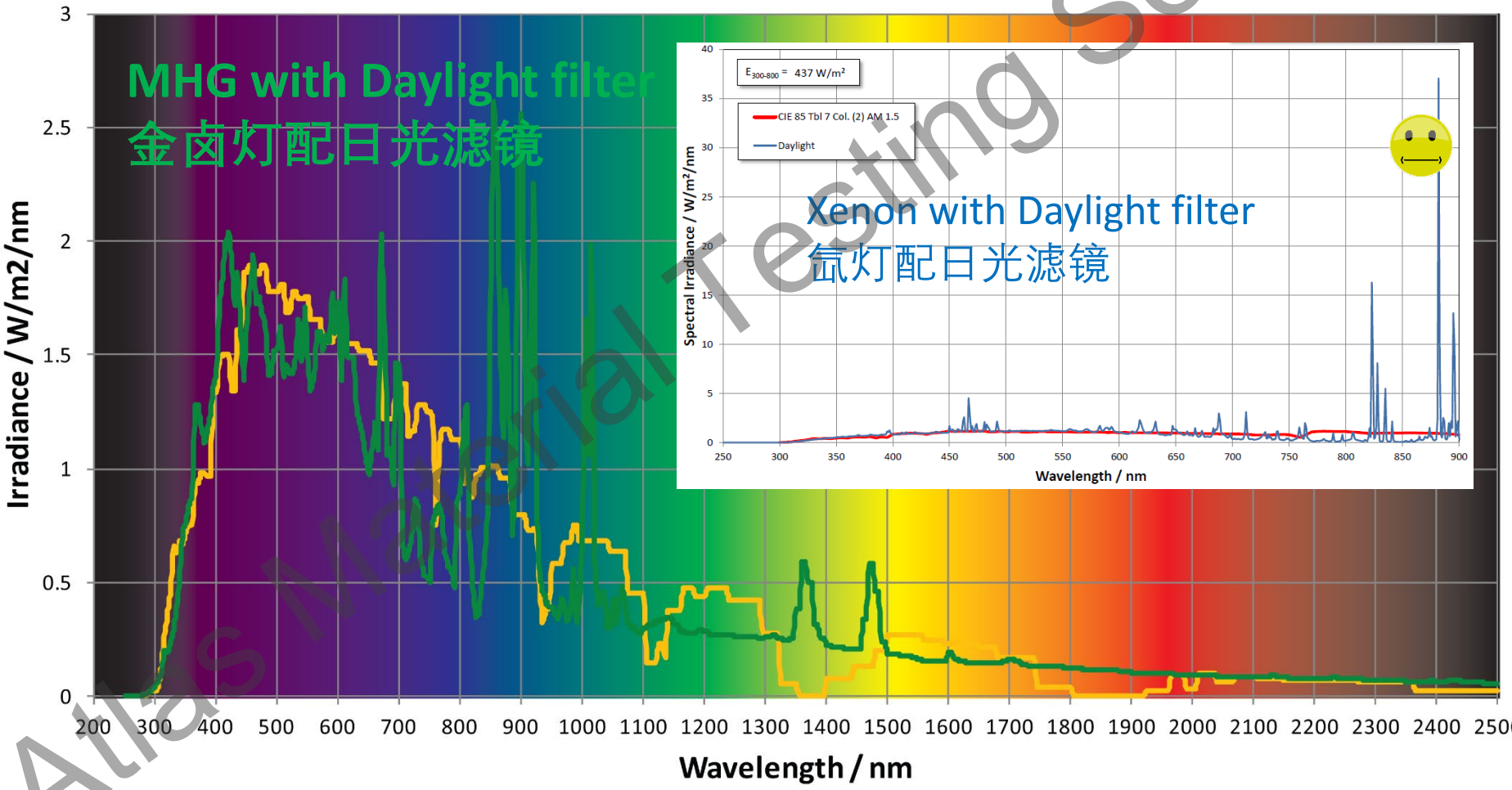
MHG- and Xenon-Technology
金卤灯和氙灯技术

Xenon: **stable UV** during dimming, excess IR, less efficient ➔ small chambers
氙灯：调光过程中合适的紫外，超量的红外，较低效率 – 小型试验箱
MHG: limited dimming possibility, **high efficiency** ➔ large chambers
金卤灯：有限的调光，高效率 – 大型试验箱



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Accelerated aging testing of automotive materials
汽车材料加速老化试验

Standard equipment and test methods for weathering and lightfastness testing
老化和色牢度测试的标准测试仪器和实验方法

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Common Interior / Exterior Standards
常见的内外饰标准

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Standards for Interior materials内饰材料标准

- **GB/T 16991** (Textiles织物: Color fastness and ageing to artificial light at high temperatures: Xenon-arc)
- **ISO 105-B06** (Textiles织物: Colour fastness and ageing to artificial light at high temperatures)
- **ISO 4892-2** (Plastics塑料: Methods of exposure to laboratory light sources - Part 2: Xenon-arc lamps)
- **JASO M346** (Interior内饰: Light-exposure test method by xenon-arc lamp for automotive interior part)
- **SAE J2412** (Interior Trim内饰: Accelerated Exposure of Automotive Interior Trim Components)
- **OEM standards**: VW PV1303 (Non-metallic非金属: Lightfastness test for interior parts); GMW 3414 (Interior Trim: Test Method for Artificial Weathering of Automotive Interior Trim Materials); Toyota TSL1600G

Standards for Exterior materials外饰件标注

- **ASTM D7869** (Coatings涂层: Standard Practice for Xenon Arc Exposure Test with Enhanced Light and Water Exposure for Transportation Coatings)
- **GB/T 32088** (Non-metallic非金属: Accelerated weathering test methods of automotive nonmetallic components and materials: Xenon-arc)
- **ISO 4892-2** (Plastics塑料: Methods of exposure to laboratory light sources - Part 2: Xenon-arc)
- **ISO 16474-2** (Coatings涂层: Paints and varnishes - Methods of exposure to laboratory light sources: Xenon-arc)
- **JASO M351** (Automotive parts汽车部件 - Accelerated weathering testing method by xenon-arc lamp)
- **SAE J2527** (Exterior Materials外饰件材料: Accelerated Exposure of Automotive Exterior Materials: Xenon-Arc)
- **OEM standards**: PV3929 (Kalahari test), PV3930 (Florida test), DBL55555-5 (non-metallic materials: Weathering Test)

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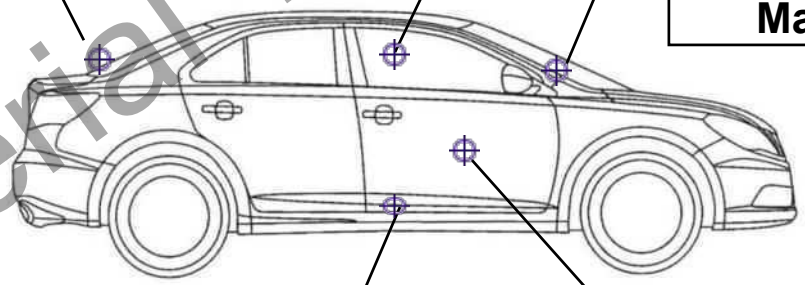
Interior Surface Temperatures
内饰件表面温度

Xenon Test: SAE J2412	**Xenon Test**: ISO 105-B06	**Xenon Test**: ISO 4892-2	**Xenon Test**: GMW 3414
CHT: 62 °C; BPT: **89** °C	CHT: 65 °C; BST: **100** °C	CHT: 65 °C; BST: **100** °C	CHT: 65 °C; BST: **105** °C

Measured Surface Temperatures:
表面温度测量



Body Cloth
88 - 93 °C
Max 110 °C

Rear Shelf
后窗台板
81 - 107 °C
Max 130 °C

Instrument Panel
仪表盘
93 - 100 °C
Max 122 °C

Ambient air
环境温度
27 - 33 °C
Max. 52 °C

Carpet地毯
50 - 54 °C
Max 75 °C

Lower Door Panel
门板下部
51 - 56 °C
Max 75 °C

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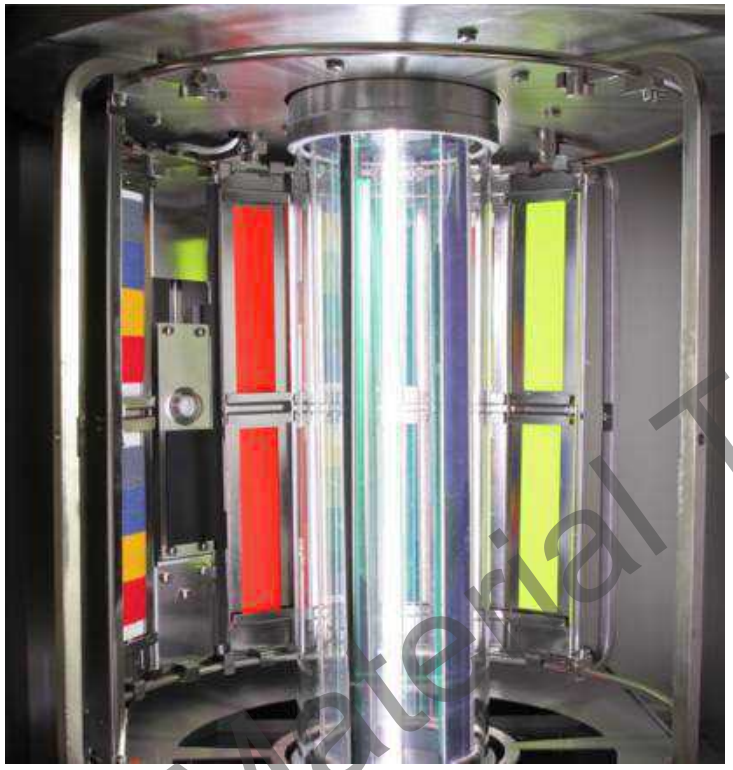
Interior Material Testing (Xenon)
内饰件测试（氙灯）

Xenon Test: ISO 105-B06
CHT: 65 °C; BST: **100** °C; E: 60 W/m^2 (300-400 nm) behind Window glass



Analytical View

- **Color change变色**
- **Gloss loss失光**
- **Haptics change触觉变化**

Material aging driven by导致材料老化

- Continuously high temperatures持续高温
- Continuously high irradiance持续高辐照

Focus on photo-oxidation reactions!
着重于光氧化反应

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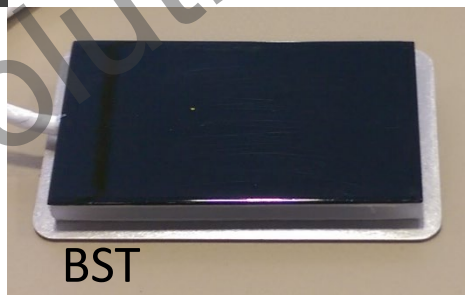
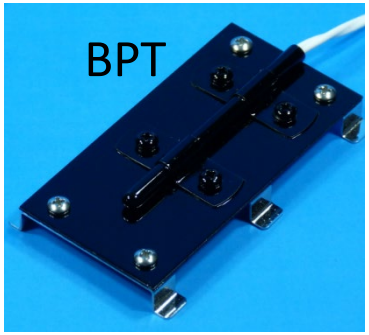
Exterior Surface Temperatures
外饰件表面温度

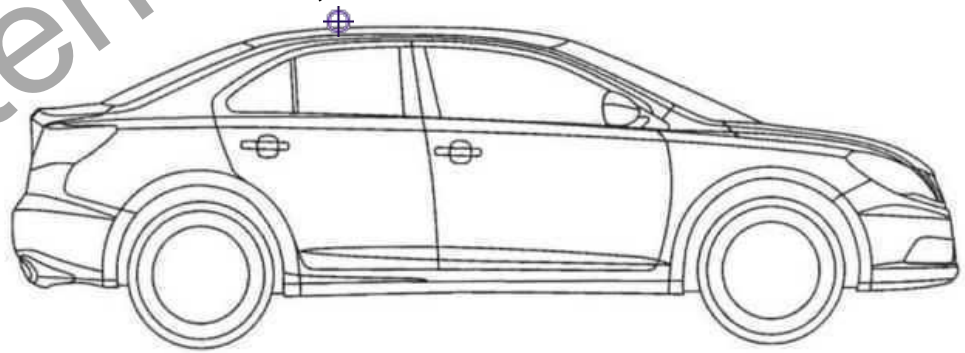
Xenon Test: SAE J2527	**Xenon Test**: ASTM D7869	**Xenon Test**: ISO 4892-2
CHT: 47 °C; BPT: **70** °C	CHT: 50 °C; BPT: **70** °C	CHT: 38 °C; BST: **65** °C

Measured Surface Temperatures:
表面温度测量





Coating System
涂层系统
70 - 75 °C
Max 90 °C



Ambient环境
27 - 33 °C
Max. 52 °C

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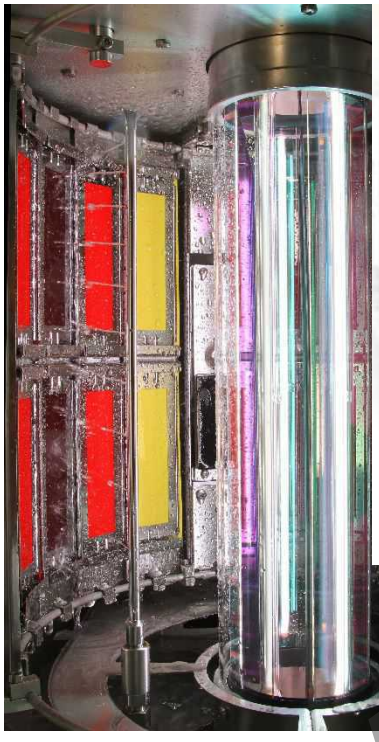
Exterior Material Testing (Xenon)
外饰件测试（氙灯）

Xenon Test氙灯测试: ISO 4892-2
CHT: 38 °C; BST: **65** °C; E: 60 W/m^2 (300-400 nm) Daylight; Dry-Wet cycles 102min – 18min



Analytical View

- **Color change变色**
- **Gloss loss失光**
- **Cracking开裂**
- **Loss of strength 强度丧失**

Material aging driven by导致材料老化

- Continuously high temperatures持续高温
- Continuously high irradiance持续高辐照
- Water spray喷水

Focus on photo-oxidations and secondary reactions!
着重与光氧化和次级反应

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Accelerated component testing
零部件加速测试

Solar Environmental Test Chambers
日光模拟环境试验箱

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Component and Products零部件和产品

- **DIN 75220** (Ageing of automotive components in solar simulation units)
- **VDA 230-219** (Ageing of automotive components in solar simulation units)
- **IEC 60068-2-5** (Electronics: Simulated solar radiation at ground level and guidance for solar radiation testing and weathering)
- **OEM standards**: Daimler DBL 5471(Interior parts: Trim and molded padded parts for vehicle interiors (composite parts); Accelerated aging of assembly components; BMW PR 306.5 (Solar simulation) *;

- **Note: Before solar simulation testing, confirm positive test of (xenon) hot lightfastness test**
- **阳光模拟测试前，确认氙灯热光色牢度测试合格**

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Component test chambers (MHG based)
基于金卤灯的零部件测试箱

S

Small-size Component testing小尺寸零部件测试
(Test area: ~45 x 40 cm)

M

Medium-size Component testing中尺寸零部件测试
(Test area: ~65 x 60 cm)

L

Medium-size Component testing中尺寸零部件测试
(Test area: ~90 x 80 cm)

multiple specimens M

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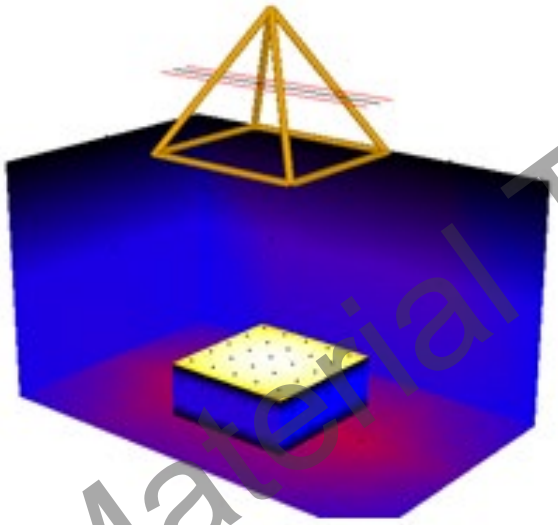
Component test chamber uniformity
零部件测试箱的均匀性

- SolarSim Computer Simulation Atlas独有的计算机模拟技术:
  - *Irradiance 辐照强度(1000 W/m² ±5 % uniformity)*
  - *Target plane 目标平面(~30-40 cm above chamber floor)*



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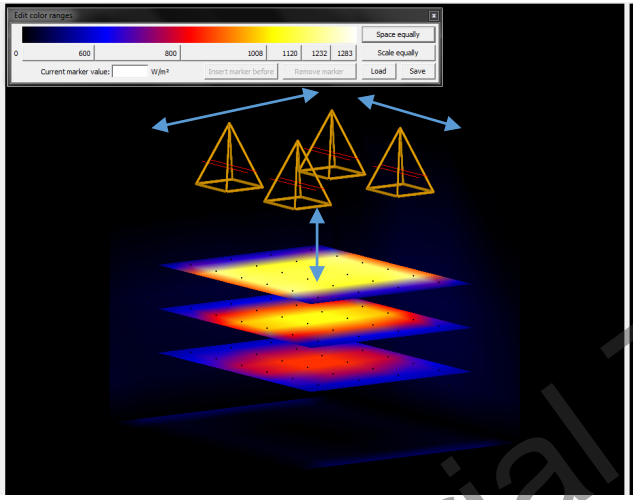
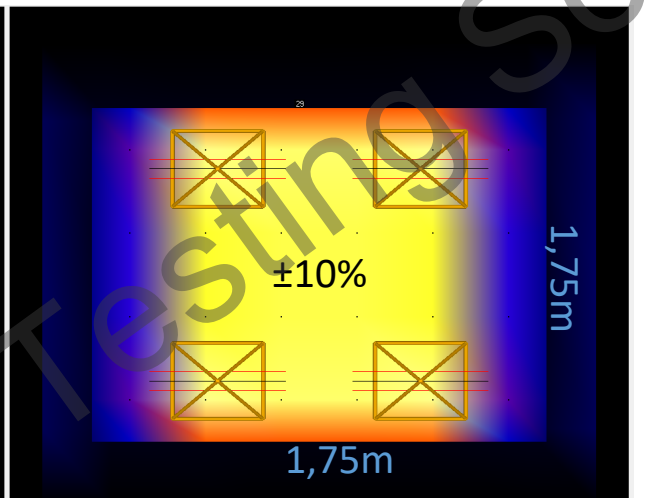
Uniformity of larger test chambers
更大测试箱体的均匀性

- SolarSim Computer Simulation Atlas独有计算机模拟技术:
  - *Irradiance辐照强度 (1000 W/m² ±10%)*
  - *Target plane 目标平面(~40-50 cm above chamber floor)*





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IP/DP® Box Testing 门板仪表盘测试箱

Test specifications测试规范: GMW3417, GMW14444, GM9538P, 7454M, 7455M, 2617M, Ford DVM 0020, ASTM G201

- Instrument panel / Door panel仪表盘和门板
- Temperature limits programmable 程序化温度控制
- Can install different automotive glass types 可安装不同类型的汽车玻璃

➔Correlation check to laboratory test
➔与实验室测试进行相关性检验

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Exterior Component Testing (MHG)
金卤灯外饰零部件测试

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DIN 75220 / VDA 230-219

Outdoor / Dry climate	Z-OUT-T	8,0	2	42°C +/- 3°C	< 30%	1.000 +/- 100 W/m²
		3,5	5	10°C +/- 3°C	> 55%	
15 cycles / 360 hours		8,0	2	42°C +/- 3°C	< 30%	1.000 +/- 100 W/m²
		3,5	5	10°C +/- 3°C	> 55%	
		1,0	Service	Room conditions (ca. 23°C / 50% rH)		
Outdoor / Humid climate	Z-OUT-F	5,0	5	-10 +/- 3°C	Condensation permissible	
10 cycles / 240 hours		12,0	2	42°C +/- 3°C	> 60%	1.000 +/- 100 W/m²
		6,0	8	-10°C +/- 3°C	Condensation permissible	
		1,0	Service	Room conditions (ca. 23°C / 50% rH)		

Analytical View

- Force fit 压入配合度
- Tension cracks拉伸开裂
- Appearance外观
- Function功能

Component/Product aging driven by
导致零部件和产品老化

- Thermal cycling热循环 (ΔT = 32K or 52K)
- Humidity cycling湿度循环 (ΔRH = 30%)
- High ambient temperature 高温(42 °C)
- Typical BST典型BST温度 (65-70°C)

Focus high mechanical stress combined with radiation effect!
着重于高机械应力和高辐照作用相结合

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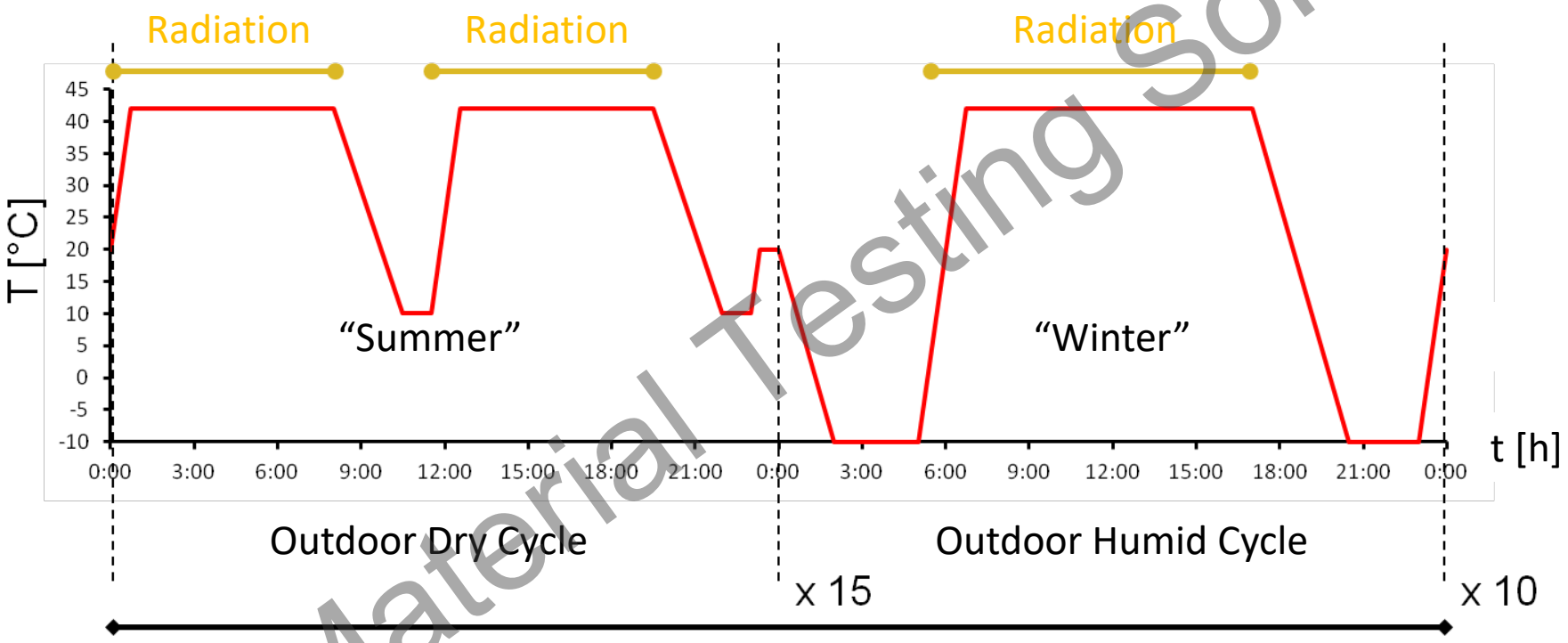
Makro Cycle: Exterior Components
Makro 循环: 外饰零部件

Summer / Winter Cycles夏季冬季循环: DIN 75220 / VDA 230-219



Makro Cycle 25 Days

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Full Car Natural Aging Testing
整车自然老化测试

➔ Correlation check to laboratory test

➔ 与实验室测试进行相关性检验

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Final product testing
终端产品测试

Solar Environmental Drive-in chambers and climatic wind tunnels
步入式日光模拟试验舱和气候风洞

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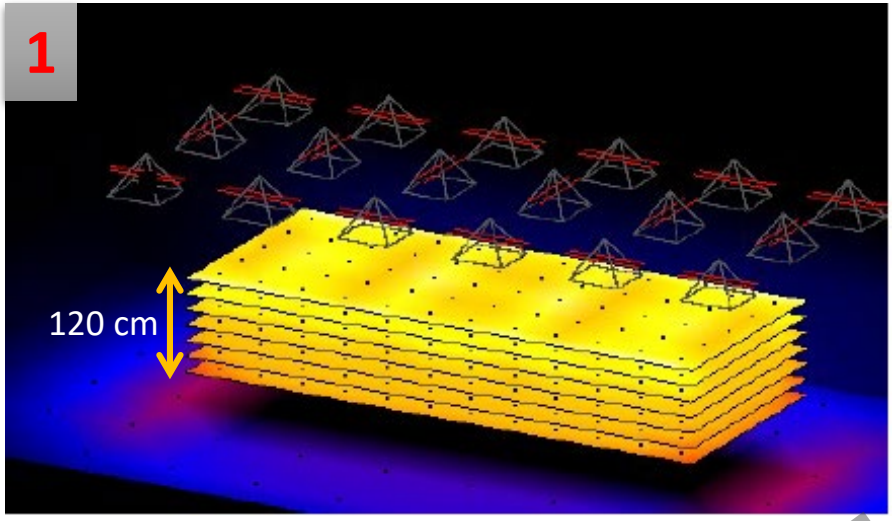
Climatic Drive-in Chamber Concept 1
步入式气候环境舱 概念1



Although the solar simulator is fix and planar, the irradiance uniformity is good for a relatively large volume

尽管日光模拟器是固定位置和二维的，辐照强度均匀性仍然在相对较大空间范围内都不错。

➔ can test a range of differently sized/high cars可以测试一系列不同尺寸和高度的汽车

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Climatic Drive-in Chamber Concept 2/3
步入式气候环境舱 概念2/3

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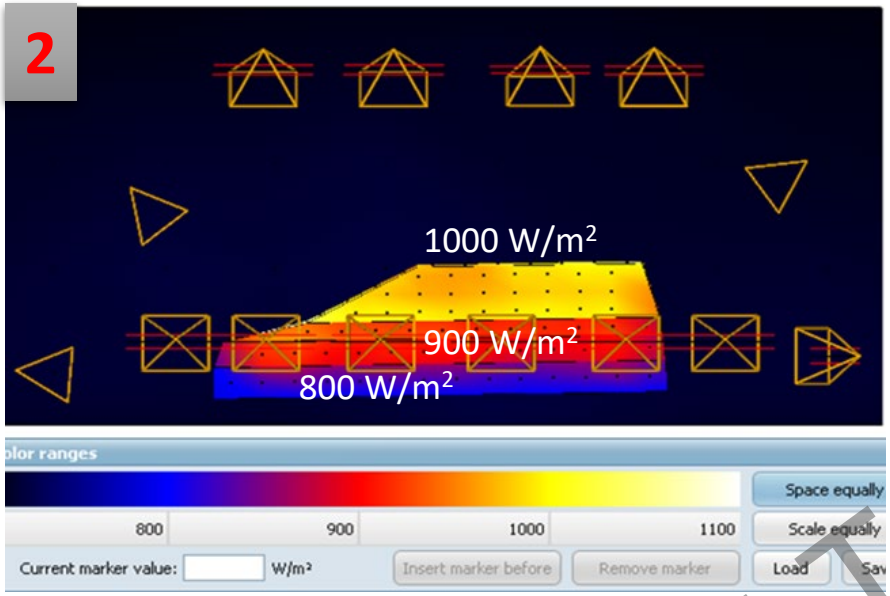
2



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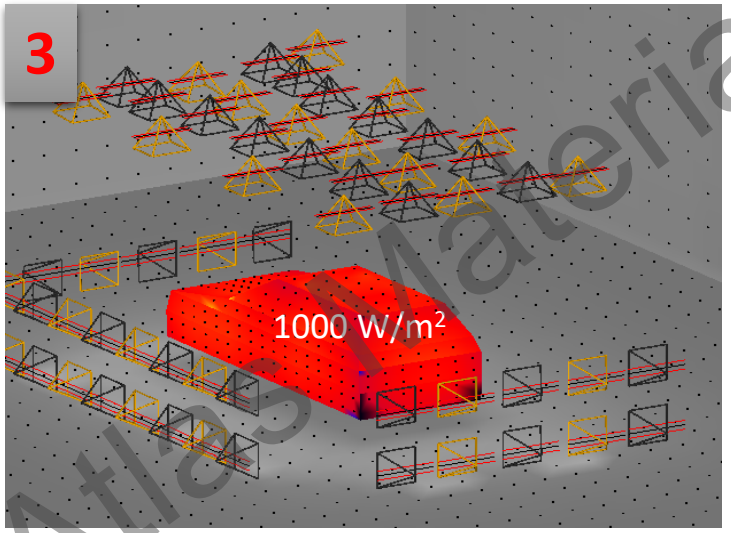

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Drive-in Chamber Concept 4
步入式气候环境舱 概念4

Solar environmental chamber combined with refrigeration for -20-40°C.
日光模拟环境舱与制冷系统结合，模拟零下20-零下40度。
Advanced solar simulator with motor frames for automatic positioning
带有移动灯架和自动定位功能的先进日光模拟系统

➔ can test full range of models: cars / vans / trucks
➔ 可测试全系列的车系:

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Analytical View分析检查

- Performance性能
- Function功能
- Force fit压入配合
- Color颜色
- Appearance外观
- Smell气味

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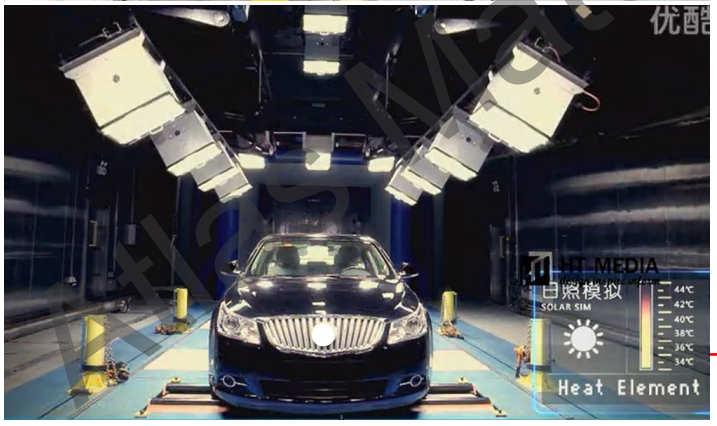
Climatic Wind Tunnel Performance
气候风洞的性能



Irradiance辐照:
600-1200 W/m²
(diurnal cycling)

Temperatures温度
-40°C up to +60°C

Wind Speed风速:
Up to 250 km/h

Dynamometer功率计:
Driving max 250 km/h

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Analytical View分析检查

- Aerodynamics空气动力学
- Performance性能
- Function功能
- Emissions排放

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Summary总结

- We better understand xenon testing and metal halide testing concepts更好地理解氙灯测试和金属卤化物灯测试的概念
- For xenon testing of automotive materials there are ~5 commonly used test methods for interior and another ~5 test methods covering exterior materials. Latest ASTM test emphasizes on high water uptake汽车材料氙灯测试常用的测试方法有~5种内饰测试方法和~5种外饰测试方法。最新的ASTM测试强调高水分摄取。
- We saw the need for various sized component test chambers due to different specimen sizes. 由于试样尺寸的不同，需要不同尺寸的试验箱。
- The analytical view of component and product testing is much different to the view of material testing零件和产品测试的分析着眼点与材料测试的分析着眼点有很大的不同。

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Summary总结

- Interior component testing can be demanding and the use of indoor test boxes critical for realistic testing内饰零部件测试可能是苛刻的，使用额外室内测试箱对实际测试很重要
- We saw 3 different solar simulator concepts for solar environmental Drive-in chambers (peak sun from top / peak sun from multiple directions / multiple directions and automatic positioning) 我们看到了3种不同的日光模拟器概念用于日光模拟环境试验舱(从顶部的峰值日光/从多个方向峰值日光/多个方向自动定位峰值日光)
- Climatic wind tunnels typically install solar simulators suitable to test small up to large vehicles. Simulation of every global climate possible气候风洞通常安装日光模拟器，适用于测试小型到大型车辆。模拟所有可能的全球气候。

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Questions and Answers问答

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Thank You!谢谢!

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