

Natural Outdoor Weathering Testing

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녹음하기

Administrative Notes

You'll receive a follow-up email from info@email.q-lab.com with links to a survey, registration for future webinars, and to download the slides

Use the Q&A feature in Zoom to ask us questions today!



We make testing simple.



Thank you for attending our webinar!

We hope you found our webinar on *Natural Outdoor Weathering Testing* to be helpful and insightful. The link below will give you access to the slides and recorded webinar.

Q-Lab Corporation

- 1956 창업
- 내후/내광성/부식 시험 전문 기업



Westlake, Ohio
Headquarters &
Instrument Division



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내후성 시험 Weathering Testing

- **촉진시험 Accelerated tests**
 - 시험실에 설치된 시험 챔버에 폭로함
Exposure in test chambers in the laboratory
 - 광/온습도 등 환경 제어 Controlled conditions
 - 인공 빛과 이슬효과/강우 재현
Artificially-created light and simulated condensation/rain

- **옥외폭로시험 Outdoor Tests**
 - 옥외 폭로 시험장에 설치된 거치대에 폭로
Exposure on outdoor test racks in large fields
 - 환경 제어 없음 Uncontrolled conditions
 - 자연 태양빛과 실제 날씨 환경
Natural sunlight and real weather conditions

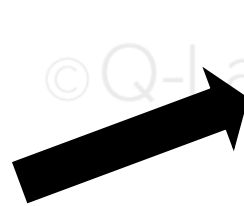


Forces of Weathering

Accelerated

- Light
- Heat
- Condensation
- Humidity
- Spray

Outdoor testing adds other weathering factors



Outdoor

- Sunlight
- Temperature
- Condensation
- Humidity
- Rain
- Biological
- Acid Deposit
- Dirt Pickup

옥외폭로시험에 대한 근거 없는 믿음. Outdoor Weathering Myths

- 촉진 시험은 100% 반복적이다. Accelerated tests are 100% repeatable
 - 모든 시험은 가변적. All tests (outdoor and accelerated) have variability
- 어떤 품질저하 현상도 좋다. Any degradation is good
 - 잘못된 품질저하 모드는 오해를 일으킨다. The wrong degradation mode can be misleading
- 옥외폭로시험 결과를 얻는데 5년이 걸린다. It takes 5 years to obtain outdoor test results
 - 옥외폭로시험은 12개월 내로 유용한 데이터를 얻을 수 있다. Outdoor testing can yield useful data in 12 months
- 내후성 시험의 데이터는 절대적이다. Weathering test data is absolute
 - 단일 테스트로는 완벽한 상관관계를 얻을 수 없다. A single test will not yield a perfect correlation
- Rank 데이터는 약하다. Ranked data is weak data
 - Rank 데이터는 올바르게 적용하면 강력해질 수 있다. Ranked data can be powerful if correctly applied
- 옥외폭로시험은 비싸다. Outdoor testing is too expensive...

옥외폭로시험의 중요성 Why Outdoor Testing Is Important

옥외폭로시험은 촉진시험에 대한 중요한 보완책이며 합리적 가격으로 진행.

Outdoor testing is an important and inexpensive complement to accelerated testing

- 품질저하 모드가 의도치 않게 변경되지 않았음을 확신시켜 줌. Gives confidence that degradation modes are not unintentionally changed
- 테스트의 신뢰성이나 실험의 실수(인적오류)를 식별할 수 있다. Test reliability issues or experimental mistakes (human errors) can be identified
- 신속하고, 현실적인 결과 제공 Can give rapid, realistic results
- 적용할 수 있는 상관 인자를 구해낼 수 있다. Establishes a working Correlation Factor

불행하게도, 오해 때문에 옥외폭로 시험은 종종 무시됩니다.

Unfortunately, outdoor testing is often ignored due to misconceptions

옥외폭로 시험 비용 Outdoor Testing Costs

- 시험 비용 Cost of Testing
 - 1년에 \$500~1,000\$ Only \$500 - \$1,000 per test per year
 - 지속적인 테스트를 통해 저렴한 비용으로 매우 가치 있는 데이터 라이브러리를 구축. Ongoing tests build a library of highly valuable data, at low cost
- 시험하지 않았을 경우 비용 Cost of *Not* Testing
 - 제품의 리콜? 행복하지 않은 고객? Product recalls? Unhappy customers?
 - 결과에 대한 자신감 낮음. Less confidence in results

Global Benchmark Outdoor Exposure Locations

Florida Subtropical

Arizona Desert Sunshine

Q-Lab 사 옥외폭로장 Q-Lab Outdoor Weathering Sites

Florida



Arizona



Ohio



Q-TRAC



Test sites available in many different climate types



Exciting
News!

Q-Lab is excited
to announce the
acquisition of

Arizona Desert Testing, LLC!

We make testing simple. |



Why Florida?

- High UV irradiance
- High temperatures
- High time of wetness (TOW)
- High humidity
- No **extreme** conditions



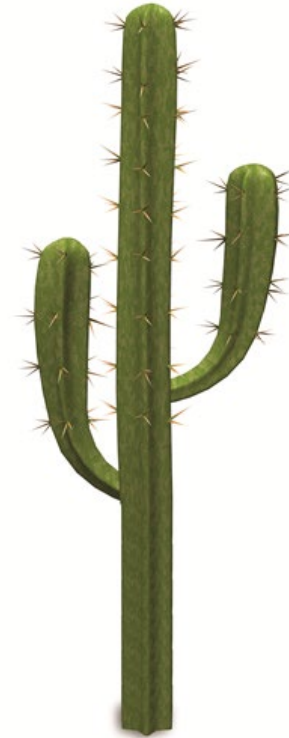
Florida Is Accelerated But Not Extreme

- Same noon summer sun spectrum as temperate regions, but present in Florida for more of the year.
- Consistently hot, but max temperatures are not extreme (no 38 °C days)
- Florida's **summer** is just like summer in temperate regions
- Florida's **winter** is ... also like summer in temperate regions
- *The same weather as the rest of the world, just "more of it"*



Why Arizona?

- Higher UV irradiance
- Hot, Hot, Hot!
- High temperature swings – thermal cycling
- Low moisture



Florida & Arizona Comparison

Force	Parameter		Florida	Arizona
Sunlight	Annual Solar Energy (MJ/m ²)	TUV (295-385 nm)	320	350
		Total	6588	8004
	% sunlight (from sunrise to sunset)		69	85
Heat	Summer avg. Max Temp (°C)		32	40
	Thermal Cycling		Thermal shock from daytime thunderstorms	Large day/night temperature swings
Water	Humidity		High	Low
	Rainfall		High	Low
	Time of Wetness		High	Low

Natural Outdoor Exposure Variations

- Exposure Angle
- Backing
- Under-glass
- Black Box
- Mildew-enhanced
- Salt-accelerated
- Whole product

Exposure Angles

	45° South	90° South	5° South	0°
Graphic				
Orientation	Faces Equator (north in southern hemisphere)			Horizontal
Materials commonly tested	<ul style="list-style-type: none"> • Powder/coil coatings • Corrosion tests • Outdoor plastics • Vinyl siding 	<ul style="list-style-type: none"> • Window profiles • Wood siding • Architectural coatings 	<ul style="list-style-type: none"> • Automotive coatings • Roofing materials 	<ul style="list-style-type: none"> • 3D parts • Roofing • Outdoor flooring
Comment	Most commonly used outdoor exposure	Reduced solar exposure Vertical end-use	Increased wet time	Highest time of wetness

45° South Exposure Angle



90° South Exposure Angle



5° South Exposure Angle



0° Exposure Angle



Backing Techniques

- **Open-Backed**
 - Used for rigid specimens
 - Painted metal
 - Plastic lenses
- **Mesh-Backed**
 - Flexible specimens
 - Typically for 0° exposures
- **Plywood-Backed**
 - Vinyl siding
 - Roofing

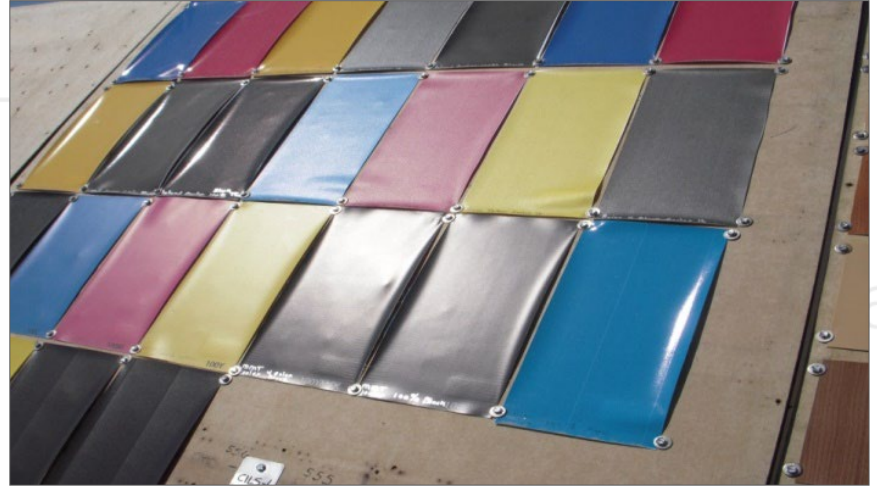
Open-Backed



Mesh-Backed



Plywood-Backed



Under-Glass Exposure



Automotive Interior Testing: Under-Glass Exposures



Automotive Exterior Testing

Black Box



Enhanced Testing

Mildew



- 90° or 45° North facing
- Mildew-enhanced area of field
- Longest time of wetness

Salt (SCAB)



- ASTM D6675 / ISO 11474
- 5% Salt Solution
- Synergistic corrosion + weathering

Whole Product

- Entire vehicle, house, etc.
- Best simulation of the end use
- All parts, materials and components interact during the weathering process
- Thermal radiation studies commonly performed



Automotive Interior Materials Boxes

AIM Box



Automotive Interior Materials Boxes

AIM Box

- 자동차 실내의 극한의 열(heat) 재현(up to **110°C**) Reproduces extreme heat from automotive interior
- **IP Module** 시험 가능 Can test entire instrument panel
- 다양한 내장 부품의 서로 다른 열팽창 경험
Different plastics experience different thermal expansion
- 다양한 인테리어 부품 간의 서로 다른
스트레스(stress) 유발 Generates differential stresses
between different interior plastics



TRUE-AIM Box

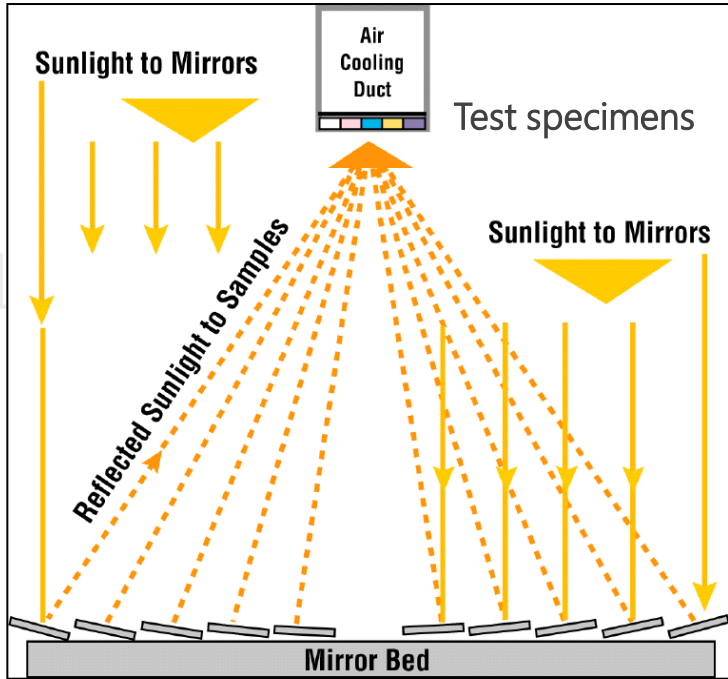
- TRUE AIM Box 는 총 광량을 증가시킴
TRUE (Tracking Reflecting Ultra Exposure) AIM box increases total solar radiation exposure
- 높은 반사율의 거울과 태양을 이중의 축(방위각과 고도)으로 추적하는 시스템을 사용하여 태양을 box 안쪽으로 더 집중화 함
Highly reflective mirrors and dual-axis tracking (azimuth and elevation) to focus more sunlight into the box interior.
- 글라스 타입과 온도 제한은 일반 AIM Box 와 동일함. Glass types and temperature limits are same as regular AIM Box
- **시편이 받는 광량을 약 두배 증가시킴**
Approximately doubles total sunlight received by specimens.



Q-Trac



태양 집중 장치 Sunlight Concentrating Mirrors



햇빛을 반사하여 시편으로 집중 Mirrors Reflect Sunlight onto Specimens



평균적으로 80%의 UV가 반사 된다

Mirrors on average reflect 80% of solar UV radiation



Tracking the Sun



Outdoor Weathering Testing Programs

Best Practices for Outdoor Weathering Testing

- **벤치마크 사이트에서 시험** Test at benchmark sites
 - 가혹한 환경으로 인해 품질저하 가속화 Harsh environments accelerate degradation
 - 이 사이트의 데이터는 국제적으로 인정되고 비교 가능 Data form these sites is internationally accepted and comparable
- **매년(또는 더 자주) 새로운 옥외폭로시험을 시작** Start new outdoor tests every year (or more frequently)
 - 데이터 라이브러리 개발 Develop library of data
 - 기존 포مول레이션과 새 포مول레이션 비교. 경쟁사 소재와 비교 Compare old formulations to new; compare to competitors' materials
 - 테스트 데이터의 가치는 복리와 마찬가지로 시간이 지남에 따라 증가 Value of test data increases over time – like compound interest
- **실험실 촉진 시험 검증** Qualify/validate your accelerated lab testing
 - 더 나은 실험실 테스트 개발 Develop better laboratory tests
 - 실제 데이터 기준으로 랩 테스트 Test the lab test against real data

옥외폭로시험 모범 사례

Best Practices for Outdoor Weathering Testing

- 가능한 빠르게 시험 시작 Begin testing as soon as possible
- 다양한 시편 사용 Use a balanced mix of specimens
- 적어도 3개 이상의 replicate 사용 Use at least 3 replicates
- 정기적으로 평가 Evaluate regularly and often
 - 시험당 적어도 5번 At least 5 intervals per test
- 노출하지 않은 비교시편 사용
Use control or reference specimens
- 일반적으로 12개월 혹은 24개월이면 기본적 결과 획득
Typically 12 to 24 months sufficient for baseline results
- 반복시험을 수행, Fail 이 될 때까지 시험.
Perform repeat testing and test to failure



Experimental Design for Outdoor Testing

- Every specimen type should be in every test
- Use equal number of specimens in each test
- Use regular exposure periods
 - Except it is OK to schedule more evaluations in early periods (to catch early failures)
- Use the same evaluation techniques throughout

Replicates

- More specimens lead to better data analysis, & adding them is inexpensive
 - There is unlimited “chamber capacity” for outdoor testing
- At least three replicates allows mean and standard deviation calculation
- More specimens give higher confidence that small differences in test results are truly meaningful

Reference Materials

A reference (i.e. control) material is one with known performance

- Always expose one good and one bad “control”
- Use the reference material to compare different tests or different exposures
- The results from the reference materials can be used to “normalize” the results
- This “reference” material is often not a standard polystyrene chip - it is your own material

Repeat the Tests

- The first step in writing a standard test is to prove it can be repeated
- Prove the test method is correct by doing the tests again
- Determine and measure the unknown factors that will appear when testing

테스트 기간 Test Duration

- 내구성 있는 소재는 수년 동안 옥외에 노출되어야 함. 아마도 1년, 10년, 50년이 될 수도 있다. Durable materials need to be exposed outdoor for years – maybe 1, maybe 10, maybe 50!
 - Paint
 - Signage
 - PV modules
 - Sealants
 - Roofing materials
- 일부 소재는 더 짧은 옥외폭로가 필요 Some materials require shorter outdoor exposures:
 - Food and beverages
 - Cosmetics and personal care
 - Optical lenses

Always test to failure!

Evaluation and Correlation

품질저하 모드 Degradation Modes

- 품질저하 모드를 아는 것은 매우 중요
Knowing the degradation modes is critical
- 품질저하 모드는 모든 테스트에서 동일해야 함. 그렇지 않으면 테스트가 유효하지 않을 수 있음. The degradation mode must be the same in all tests or the test may be invalid
- 알려지 모든 품질저하 모드를 평가해야 함. You must evaluate for all known degradation modes

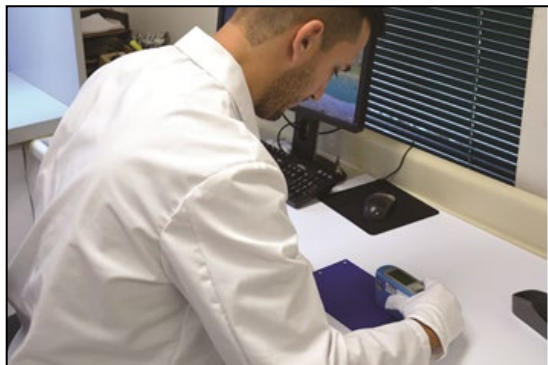


측정 기술 Measurement Techniques

비파괴 Non-Destructive

Surface Properties

- Gloss and Color
- Visual Appearance
- Surface Oxidation



파괴 Destructive

Bulk Properties

- Tensile
- Impact
- Bend
- Hardness
- Abrasion

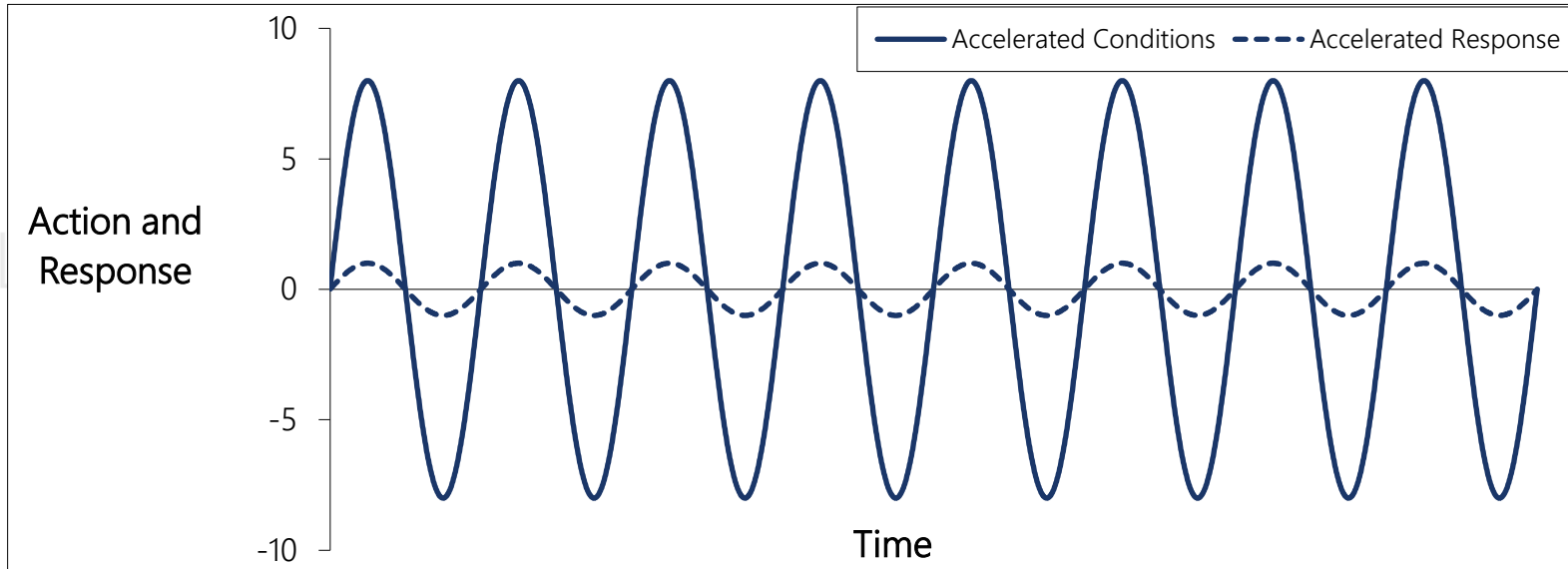
*파괴 측정은 더 많은 시편이 필요하며
가변적일 수 있음. Destructive testing requires
more specimens and can be highly variable*

촉진과 옥외폭로 시험 사이클 비교 Accelerated and Outdoor Cycles Compared

	촉진시험 Accelerated Tests	옥외폭로시험 Outdoor Tests
평균 사이클 시간 Average Cycle Time	2-4 hours	24 hours
하루 사이클 수 Cycles per day	6-10	1 (!)
다크 Dark period?	Maybe	Always
사이클 변화 Cycle variation	Same every time	Different every day

Cyclic Conditions

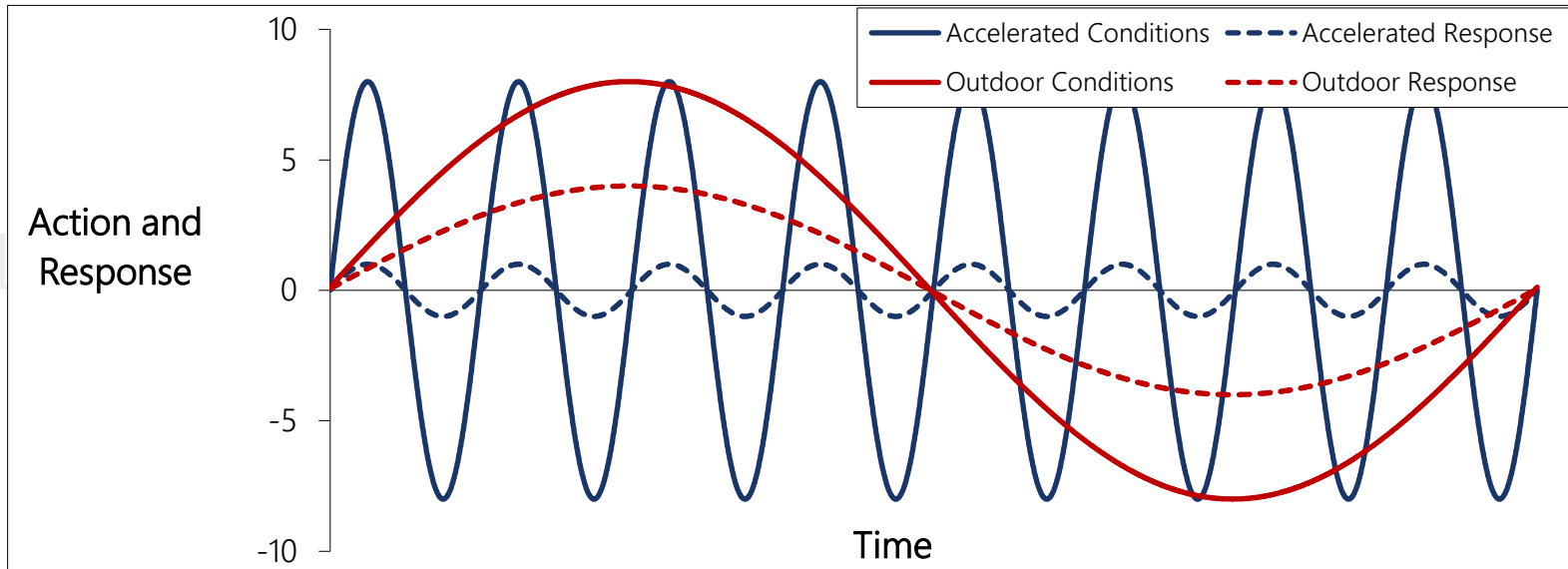
Accelerated Testing



As the environment changes, the material under test will attempt to equilibrate to it – but there is a delay in the material's response

Cyclic Conditions

Accelerated and Outdoor Testing



Different cycle times in Outdoor vs. Accelerated tests may result in different material equilibrium responses

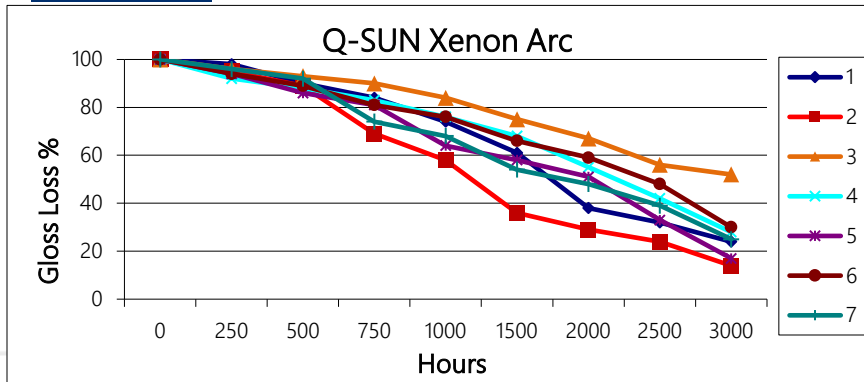
성능 데이터 상관관계 Correlating Performance Data

- 측정 가능한 목표 사용 Use measurable targets
 - 시간에 따른 50% 광택율 Time to 50% gloss
 - 가장 큰 차별화 포인트 Point of greatest differentiation
 - 시험의 종료 End of test
- 랭크오더 상관관계 계산 Calculate rank order correlation
 - Spearman correlation
 - Pearson correlation
- 랭크오더 상관 관계는 가속 테스트가 실시간 예측에 적합한지 확인하는 데 도움이 될 수 있습니다. Rank order correlation can help determine if an accelerated test is a good predictor of real time

촉진 인자 Acceleration Factor

- Use Time vs. Degradation curves
- 촉진시험과 옥외폭로시험 비교 Compare the accelerated and outdoor
- 동일한 품질저하 모드에 도달한 시간 확인 Check for time to reach same amount of failure mode
- 순위지정 혹은 비교 수단으로 확인 Verify by ranking or compare means
- 결과도 같을 경우 촉진요소 계산 If results are same, calculate acceleration factor (AF)
- $AF = \text{Time Outdoor} / \text{Time in Accelerated}$
- **상관관계의 핵심은 옥외폭로 시험! *The Key to Correlation is the Outdoor Test!***

품질저하 곡선 Time Degradation Curves



제논아크 시험 Xenon Arc Exposure

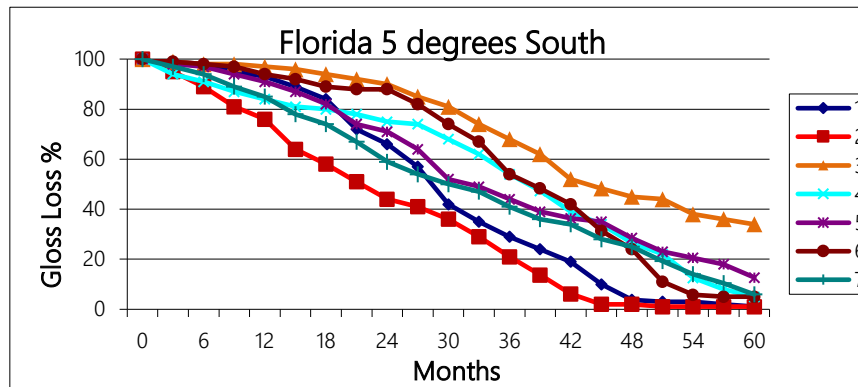
50% 광택을 저하 50% Gloss Loss

- 1 = 1800 hours, Rank 2
- 2 = 1250 hours, Rank 1
- 3 = 3000 hours, Rank 7
- 4 = 2250 hours, Rank 5
- 5 = 2100 hours, Rank 4
- 6 = 2500 hours, Rank 6
- 7 = 1900 hours, Rank 3

플로리다 옥외폭로시험 Outdoor Florida Exposures

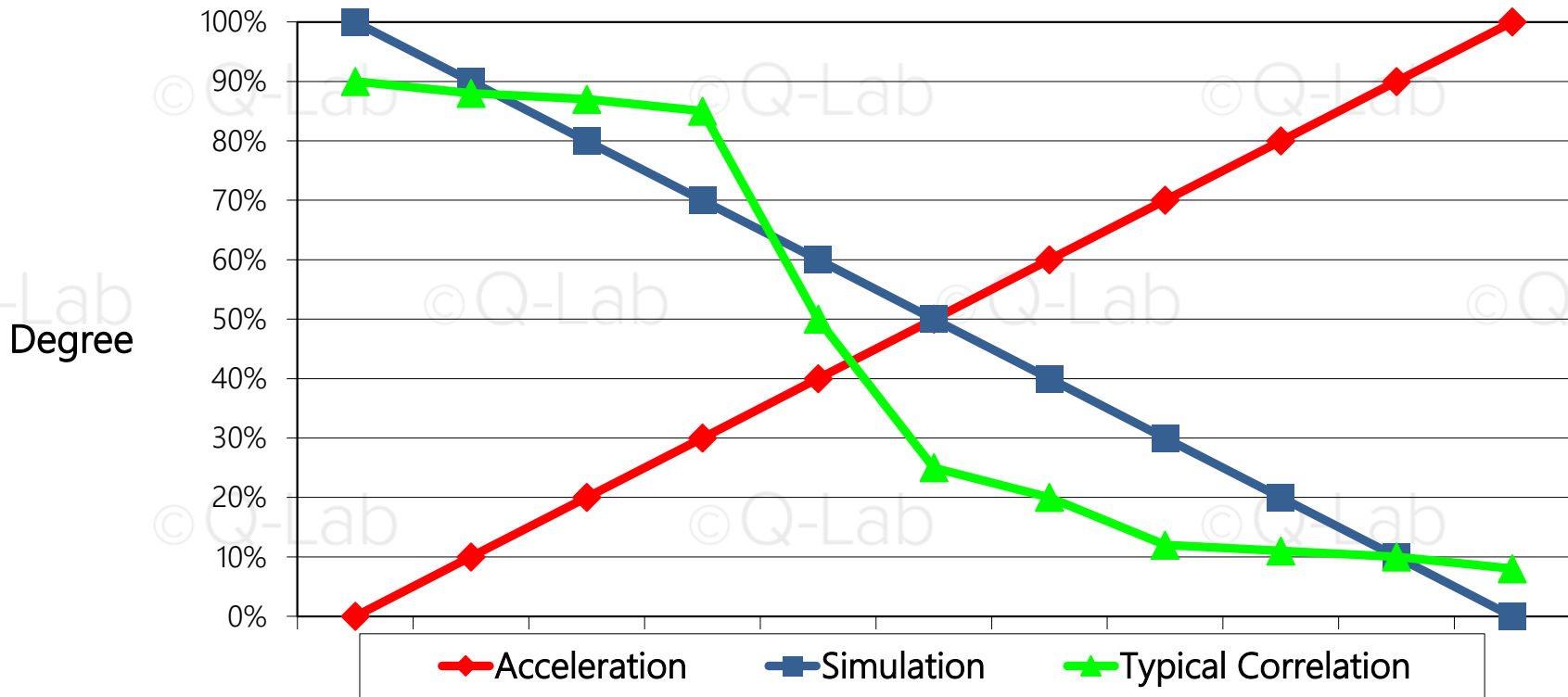
50% 광택을 저하 50% Gloss Loss

- 1 = 30 months, Rank 2, AF 12:1
- 2 = 24 months, Rank 1, AF 14:1
- 3 = 45 months, Rank 7, AF 11:1
- 4 = 40 months, Rank 5, AF 13:1
- 5 = 36 months, Rank 4, AF 13:1
- 6 = 42 months, Rank 6, AF 12:1
- 7 = 33 months, Rank 3, AF 13:1



All data fictitious. Acceleration factors cannot be transferred

촉진과 상관관계 Acceleration and Correlation



Summary

시험 프로그램의 예시 Example Test Program

옥외폭로시험 Outdoor

1. Florida
2. 5° South
3. 60 months duration
4. Measure at 3 months
5. Color, Gloss, Visual
6. 300 × 150 mm panels

촉진 내후성 시험 Accelerated

1. Xenon Arc
2. Daylight Filters
3. 3,000 hours
4. Measure at 250 hrs
5. Color, Gloss, Visual
6. 75 × 50 mm panels

각 테스트에서 참조용 시편을 노출하고, 품질저하 유형 및 속도를 참조 시편과 비교하고, 촉진시험이 올바른 결과를 제공하는지 확인

Expose reference panels in each test, compare the type & rate of degradation to the reference panel, and ensure the accelerated test is providing the correct results

Putting it All Together



+



+



결론 Conclusions

- 촉진시험은 내후성 결과를 빠르게 얻을 수 있는 아주 좋은 방법. Accelerated testing is a great way to get fast weathering results
- 옥외폭로시험은 촉진시험을 보완하고 검증함. Outdoor testing complements and verifies accelerated testing
 - 저렴하고, 빠르고, 쉽게 구현이 가능함에도 때로는 간과되기도 함. It is often overlooked, despite being inexpensive, fast, and easy to implement
 - 자신감을 높이고 결과를 실제 경험과 연관시키는 데 도움이 됩니다. It helps increase confidence and correlate results to real world experience



Thank you for your time.

Questions?

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We make testing simple. |

