Comparison of Traditional Methods for Testing Paint Adhesion and Service Life with New Methods for Service Life Prediction

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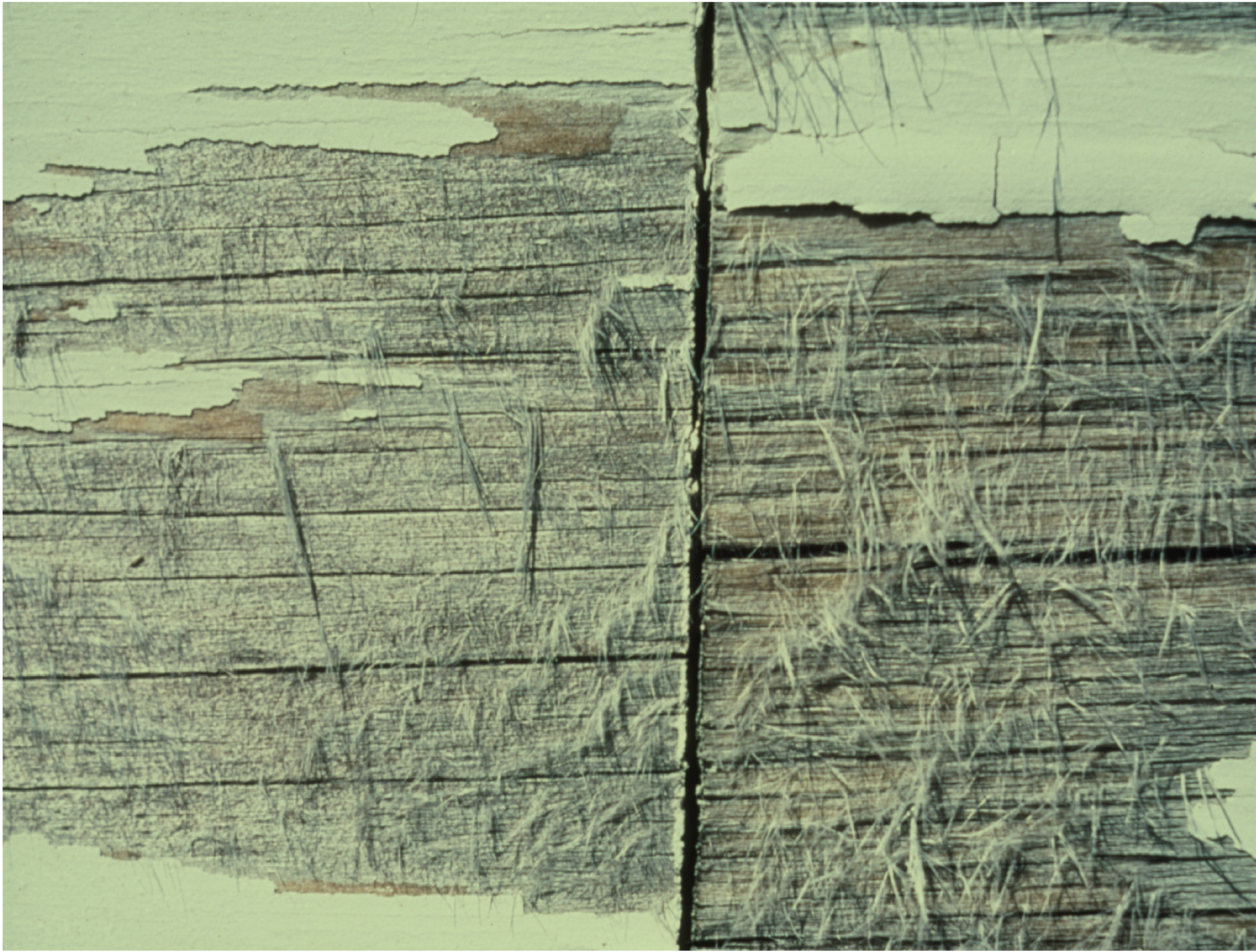
USDA - U.S. Forest Service


The problem!



Effects of short-term weathering of wood before painting (1-16 weeks)

On long-term paint performance (10-20 years)

Western redcedar during preweathering

Following the preweathering

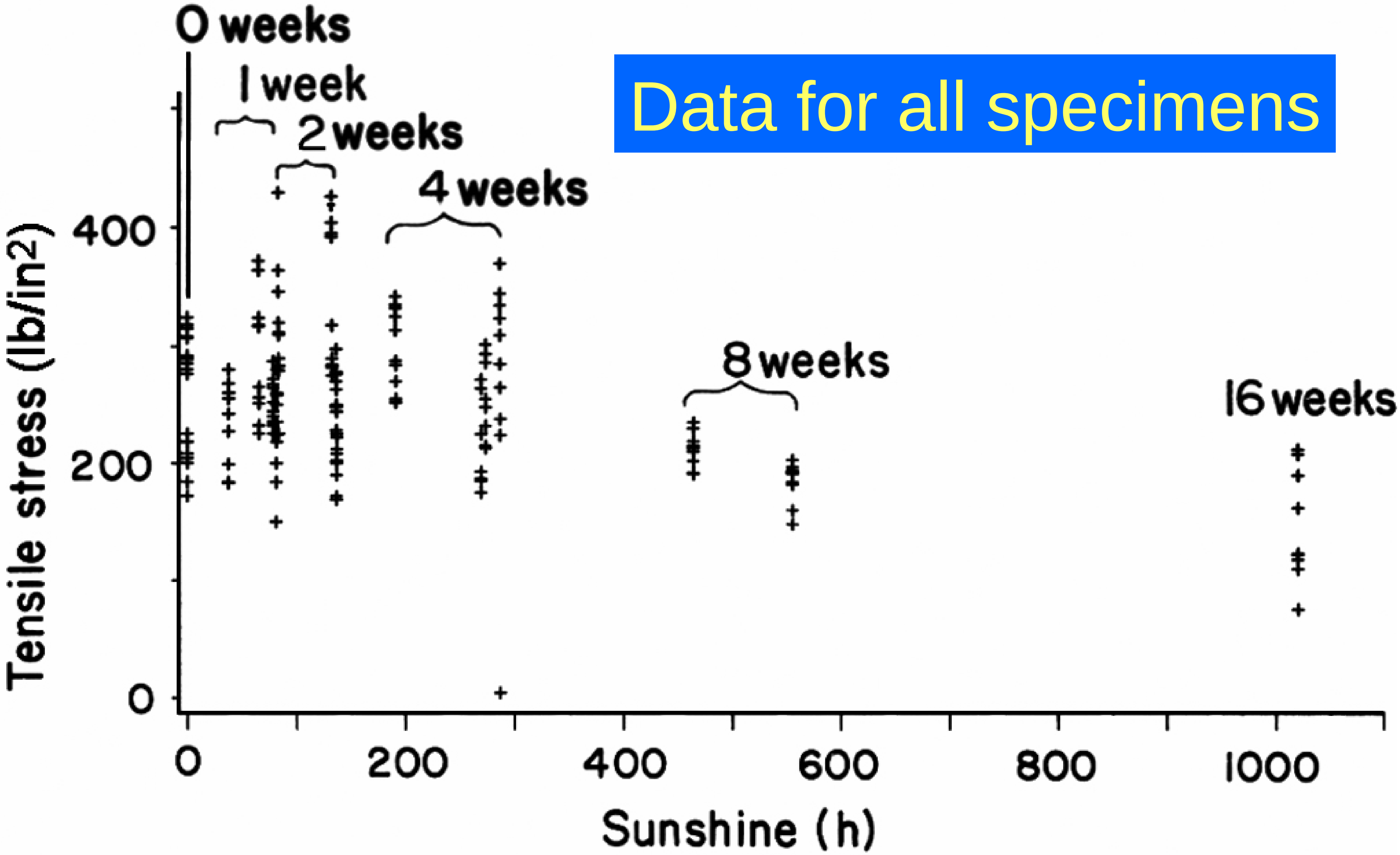
Boards were removed from fence and painted,

then divided into 2 groups.

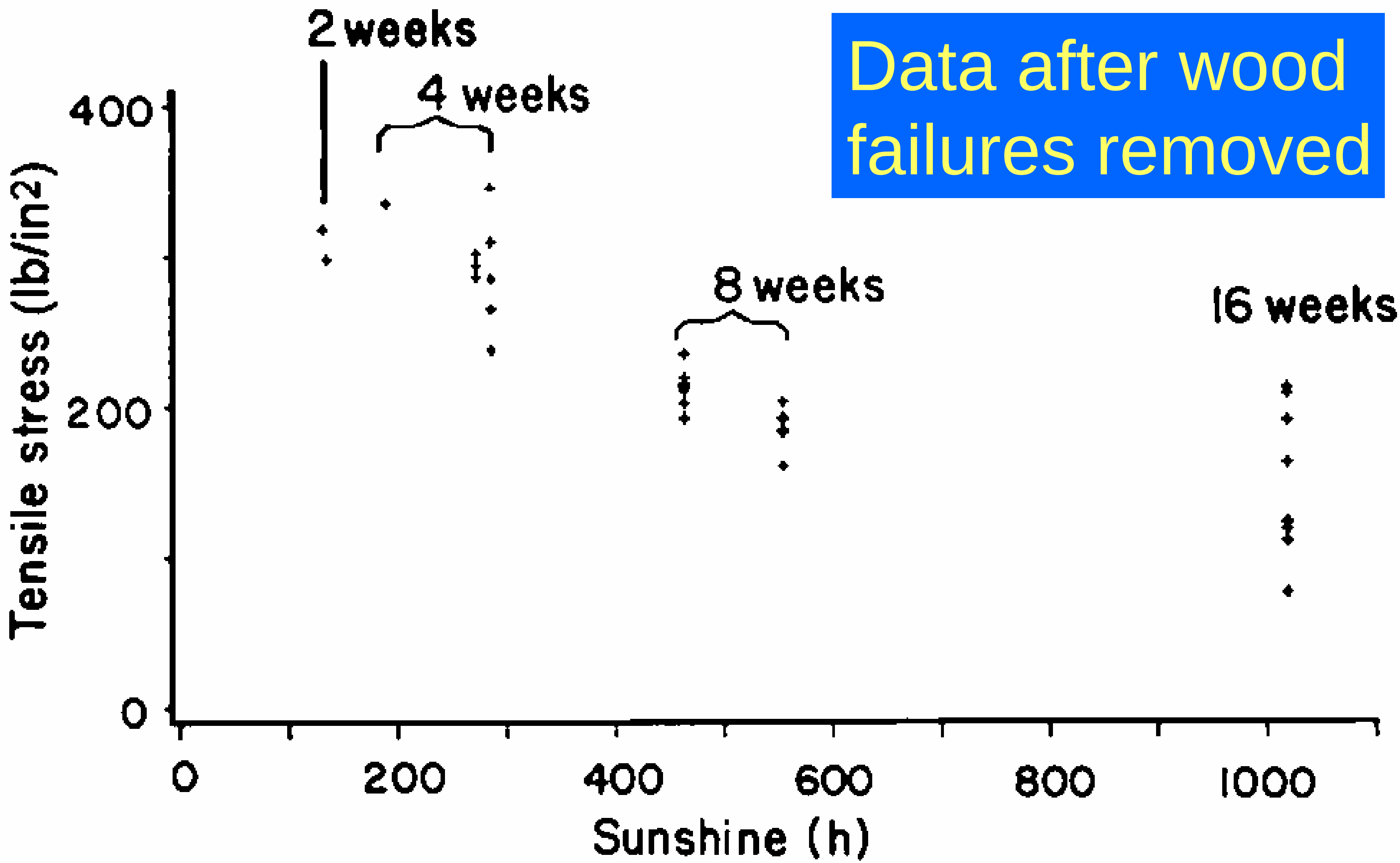
One group was tested for paint adhesion

Second group was placed back on the fence

Data for all specimens



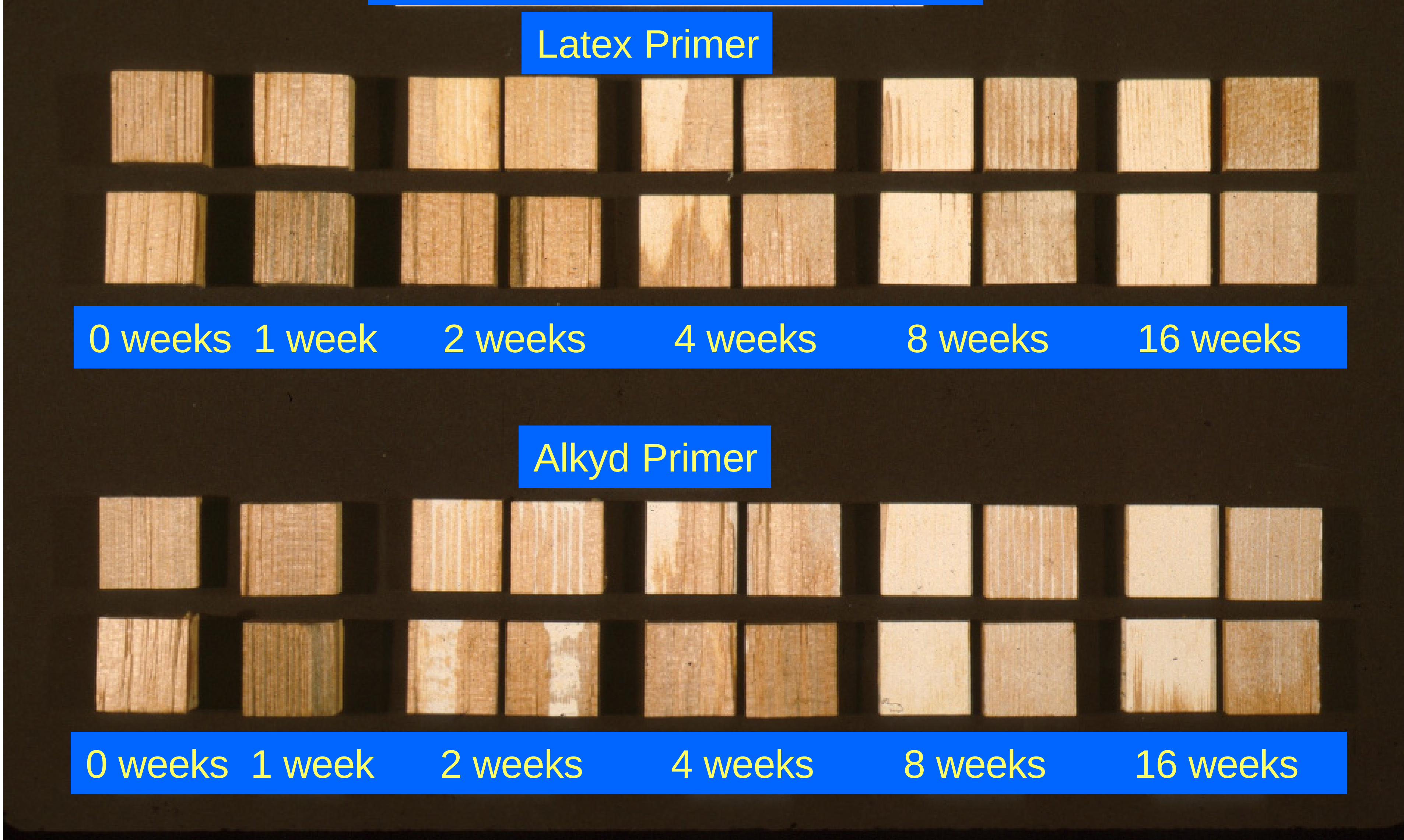
Tensile test: Alkyd primer adhesion to smooth-planed western redcedar



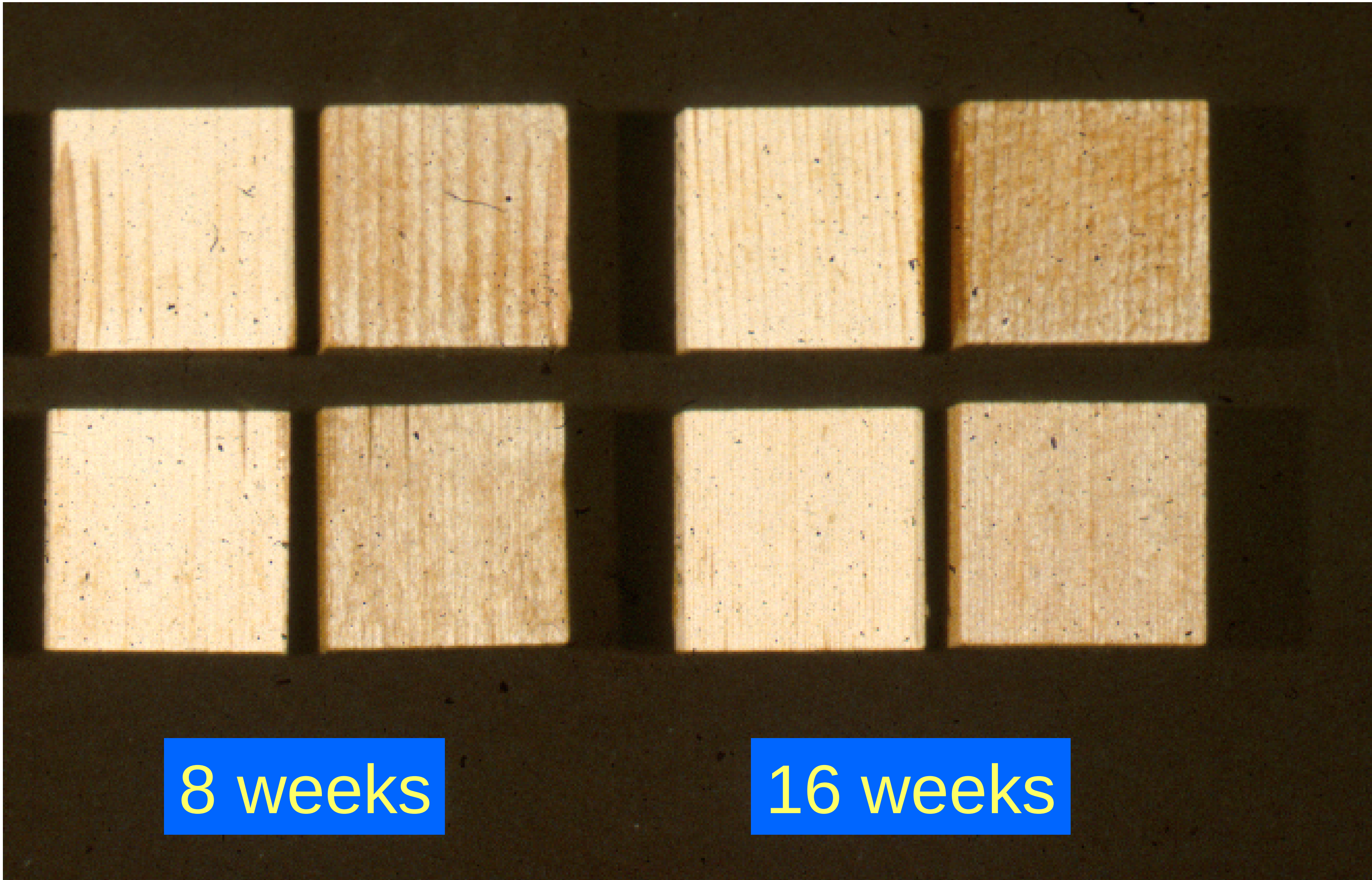
Data after wood failures removed

Tensile test: Alkyd primer adhesion to smooth-planed western redcedar

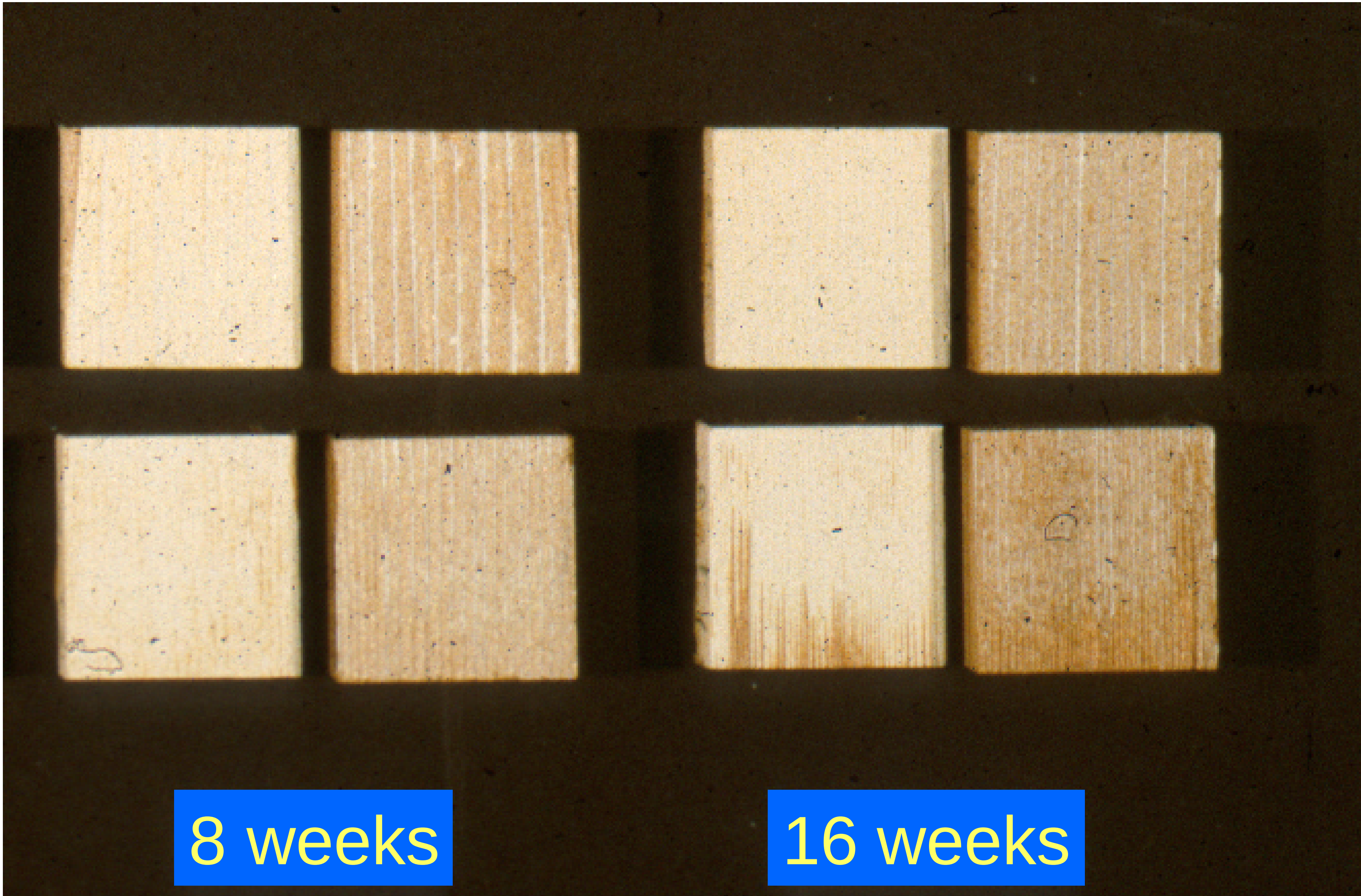
Tensile specimens



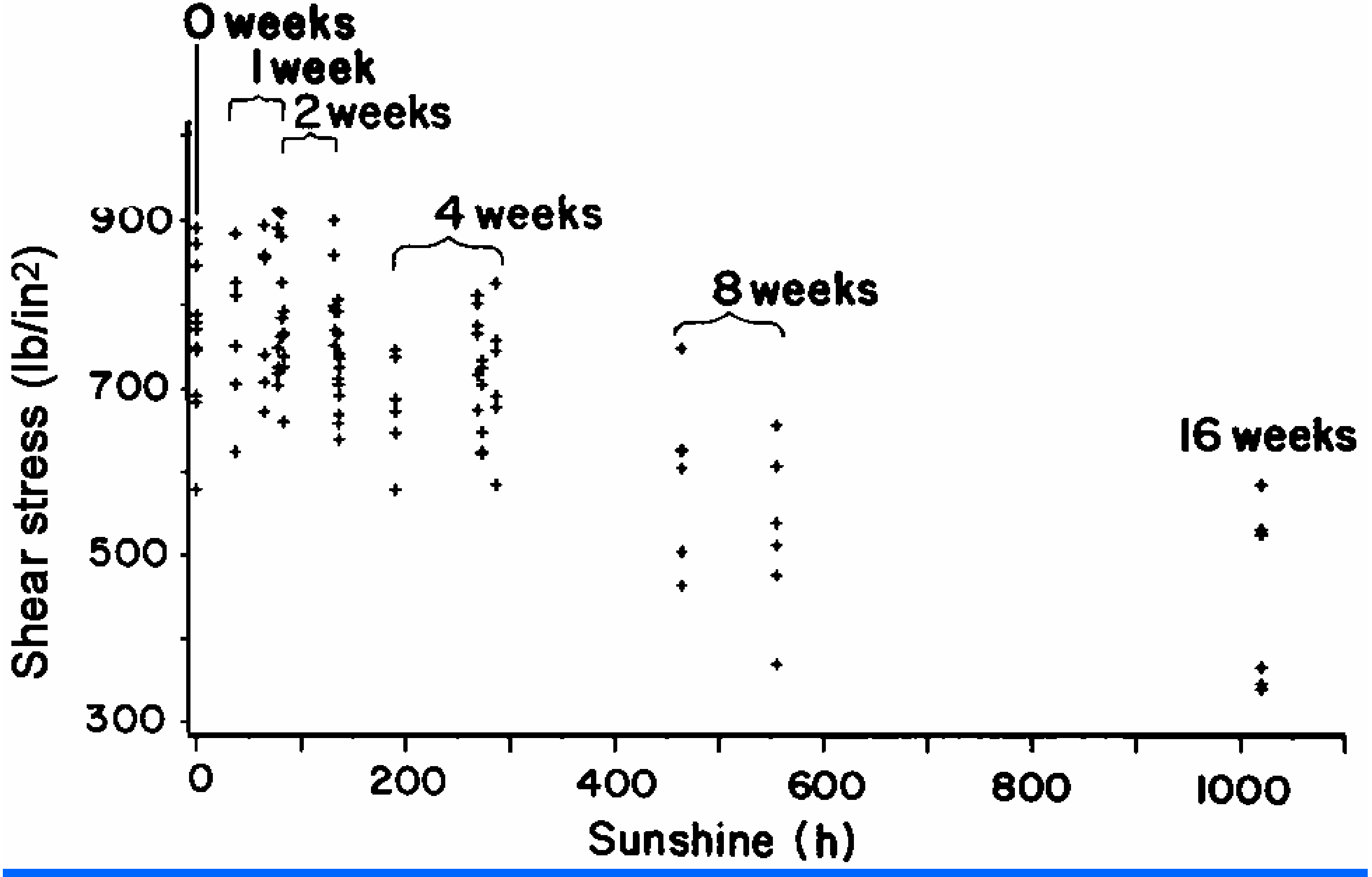
Failed interphases: Tension test



Adhesion failure, latex primer: Tension test



Adhesion failure, alkyd primer: Tension test



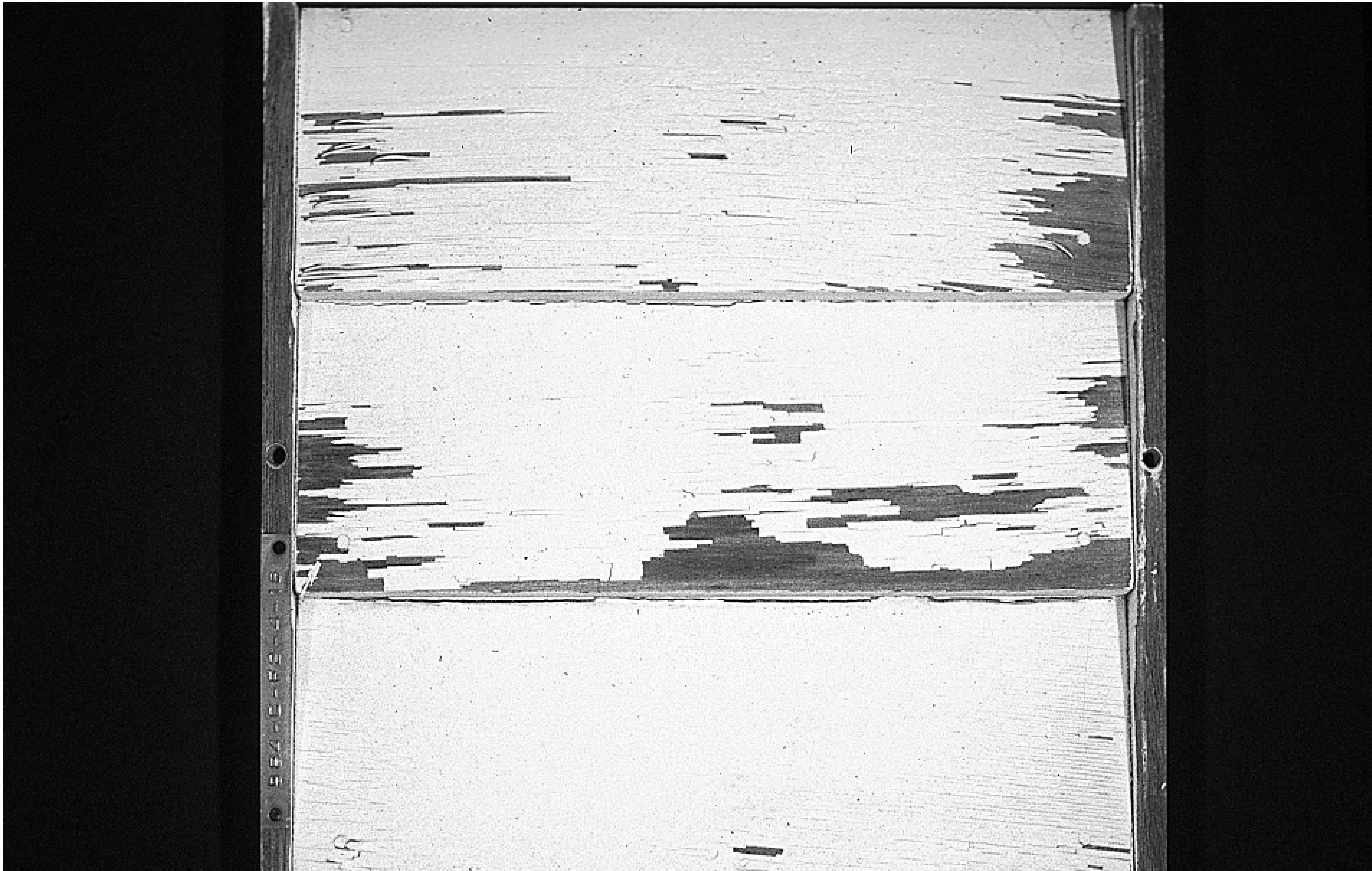
Block shear test: Acrylic latex primer

Painted boards after 17 years

outdoor exposure near

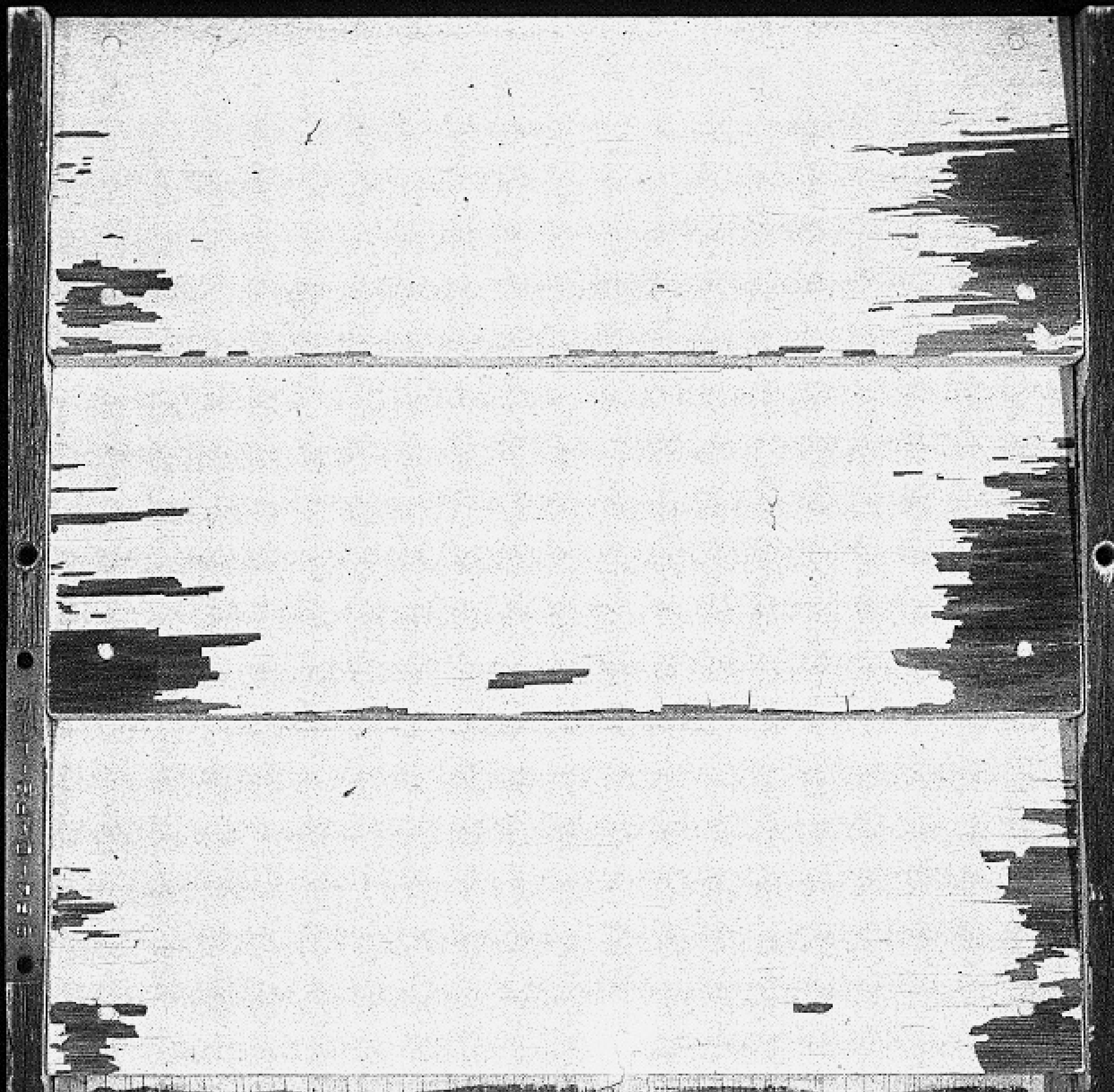
Madison, Wisconsin

Painted panels on test fence near Madison Wisconsin after 17 years



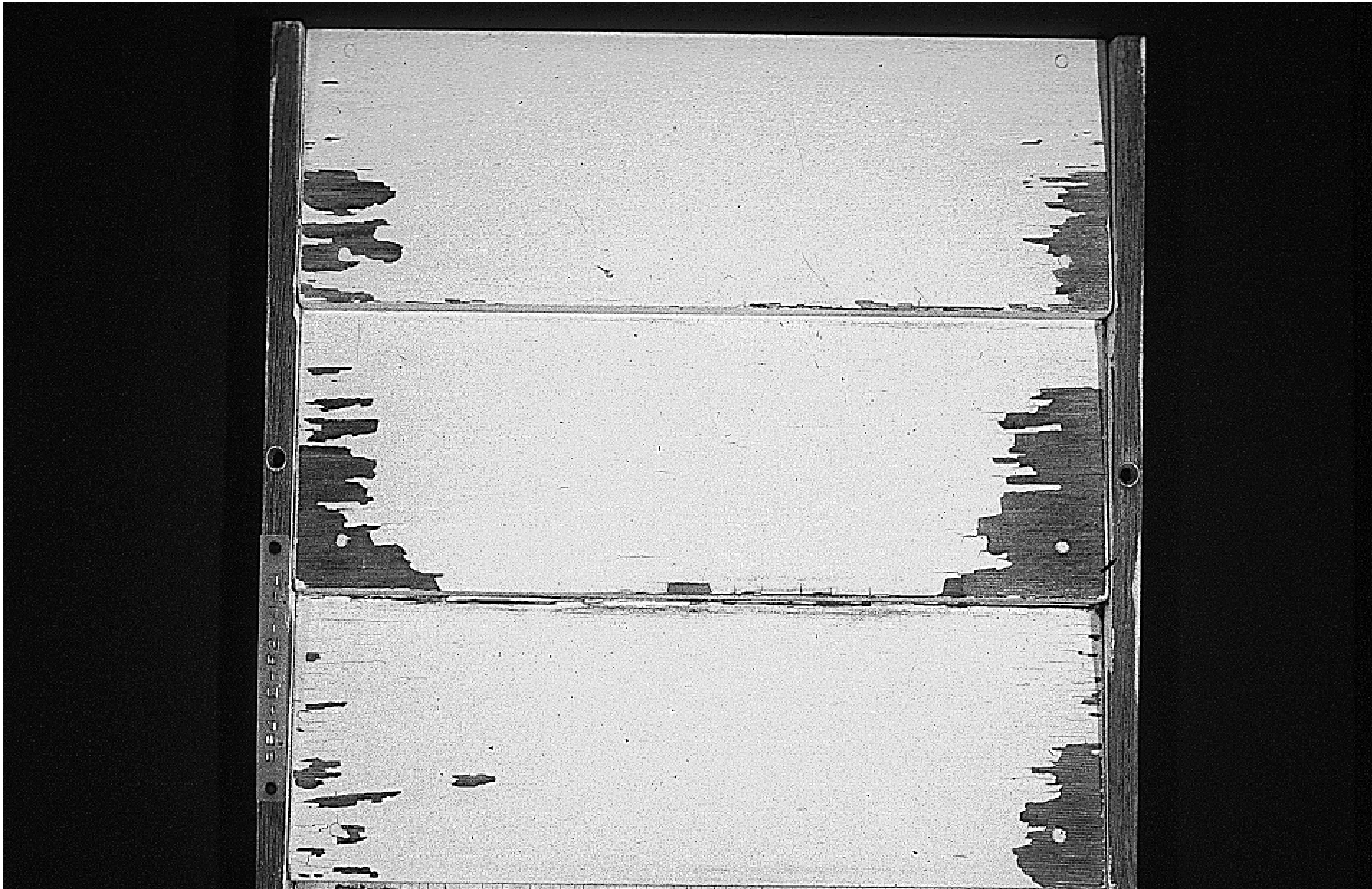
16 weeks preweathering prior to painting

WRP, Alkyd primer, Acrylic latex top coat



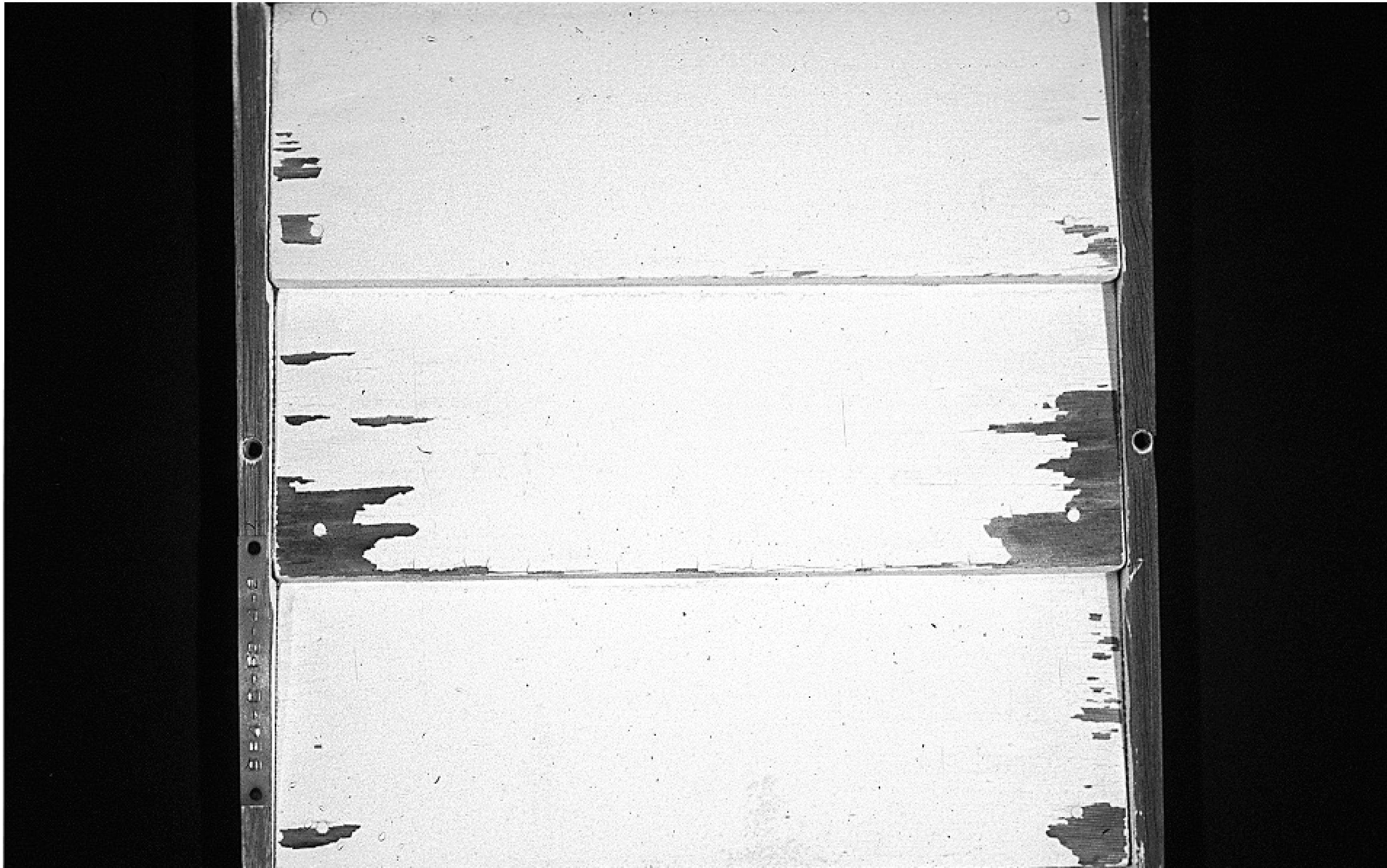
8 weeks preweathering prior to painting

WRP, Alkyd primer, Acrylic latex top coat



4 weeks preweathering prior to painting

WRP, Alkyd primer, Acrylic latex top coat



2 weeks preweathering prior to painting

WRP, Alkyd primer, Acrylic latex top coat

1 week preweathering prior to painting

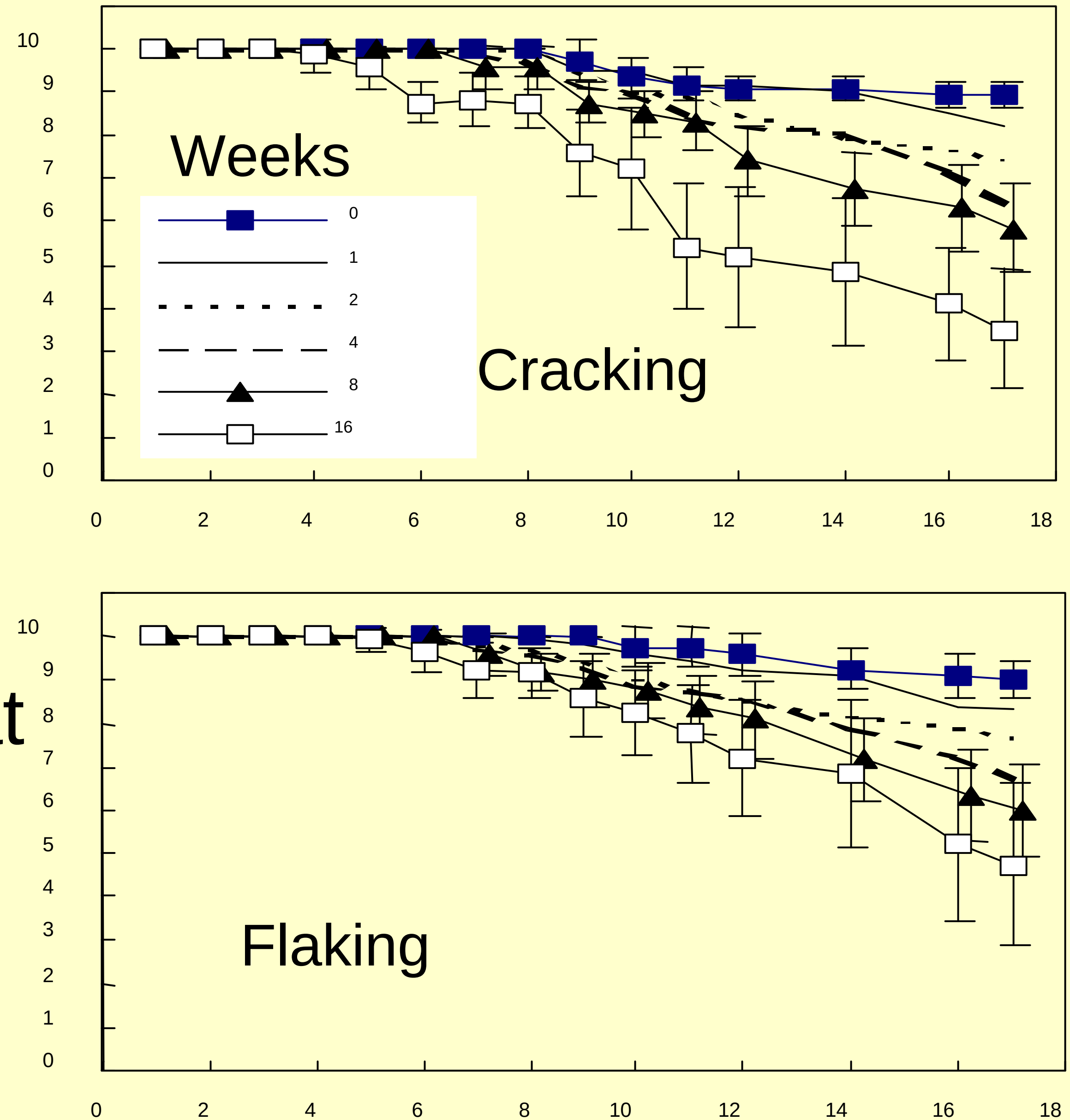
WRP, Alkyd primer, Acrylic latex top coat

0 weeks preweathering prior to painting

WRP, Alkyd primer, Acrylic latex top coat

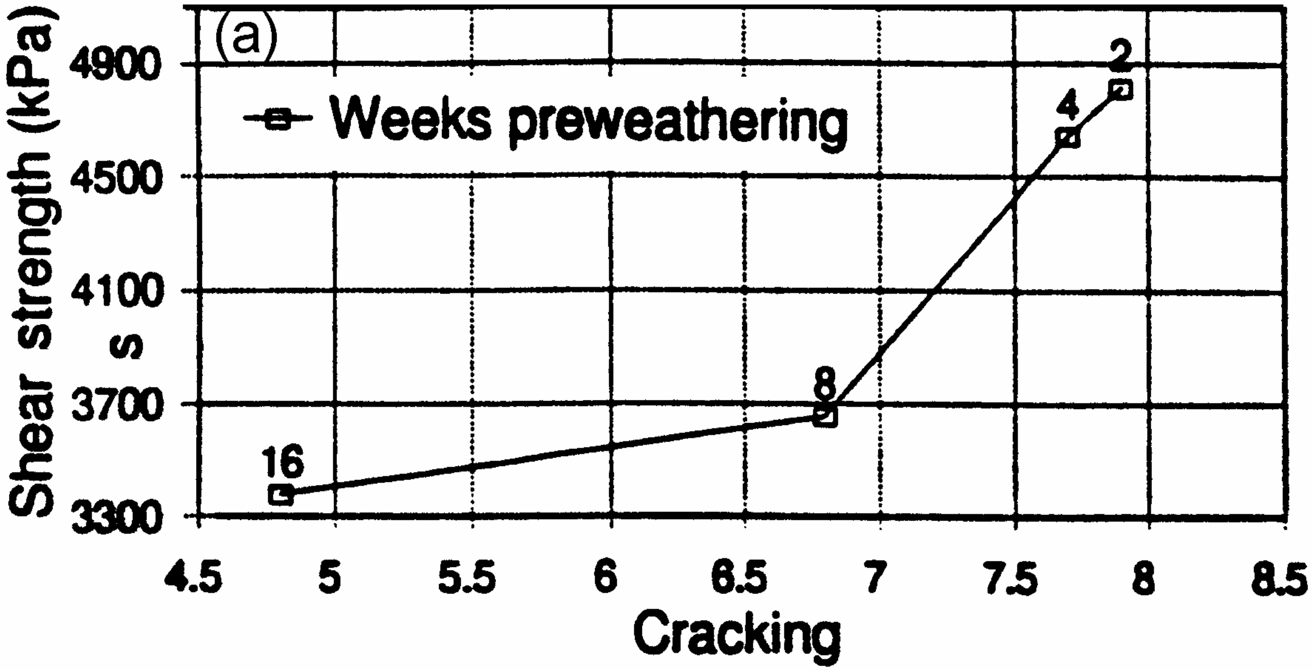
Paint evaluations

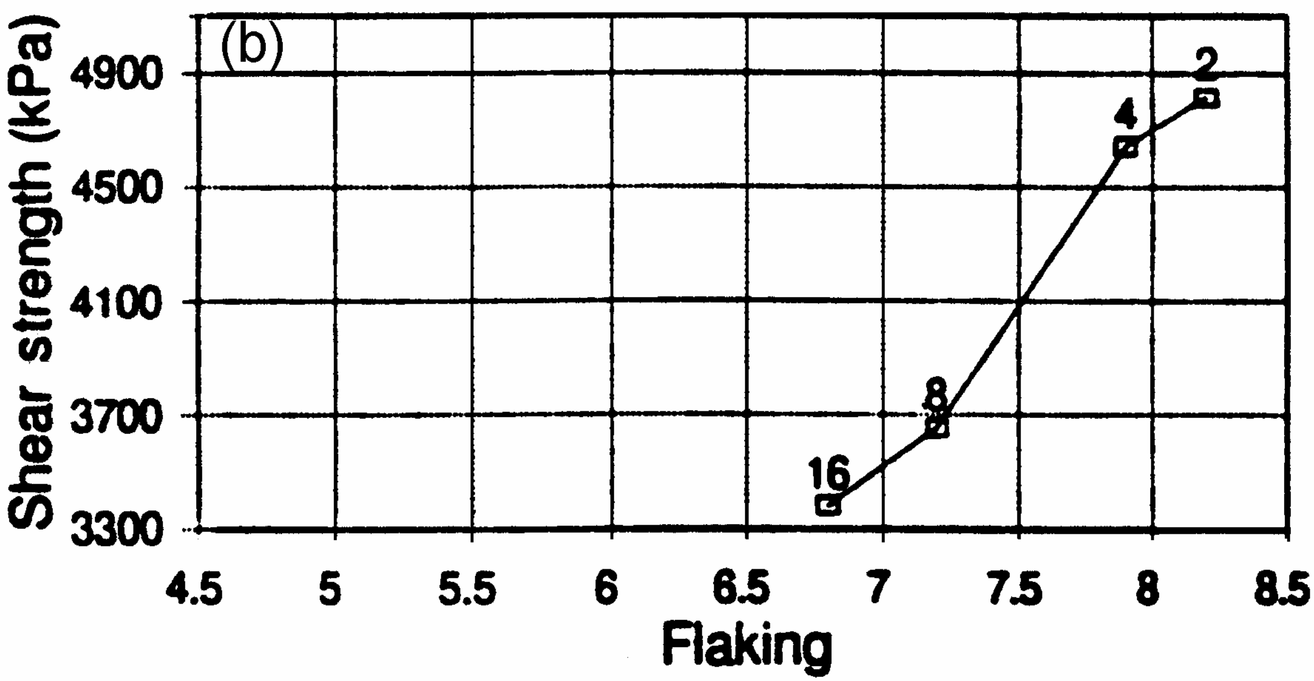
WRP
Alkyd primer
Latex top coat



Comparison of paint adhesion

With paint performance





Paint wood as soon as possible

Pretreatment of weathered surface with a WRP prior to painting improved paint performance slightly

Poor paint adhesion correlated well with decreased service life

Predicting service life

on the basis of

Reliability-Based Methods

Service Life Prediction (SLP)

"The ability to determine service life in less than real time with statistical confidence and reasonable accuracy"

Service Life Prediction (SLP)

How do we do this?

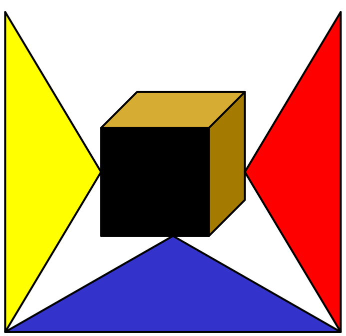
- Many types of materials
- Many different climates
- Inconsistent weather
- Subjective evaluations

Conventional SLP Metrology

Outdoor Aging

Make Comparison
Outdoor
Vs.
Accelerated Aging

Accelerated Aging



No correlation

Adjust accelerated aging conditions

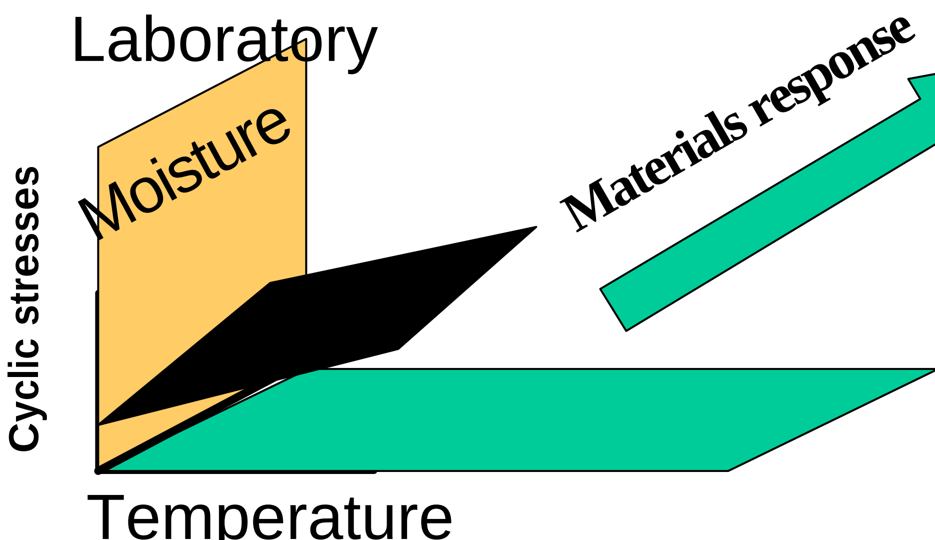
Reliability-Based SLP Methodology

Instrumented Outdoor Exposure

Temperature
RH, UV

Materials response

Data Bases



Materials response

Cumulative Damage Model

SLP Estimate

Laboratory Tests

Control and measure

- UV radiation
- Temperature
- Moisture/relative humidity
- Cyclic movement

Outdoor Exposure

Measure

- UV radiation
- Rainfall/snow
- Relative humidity
- Temperature
- Wind
- Cyclic movement

Sealant Degradation

Change in modulus

Loss of adhesion

Cracking

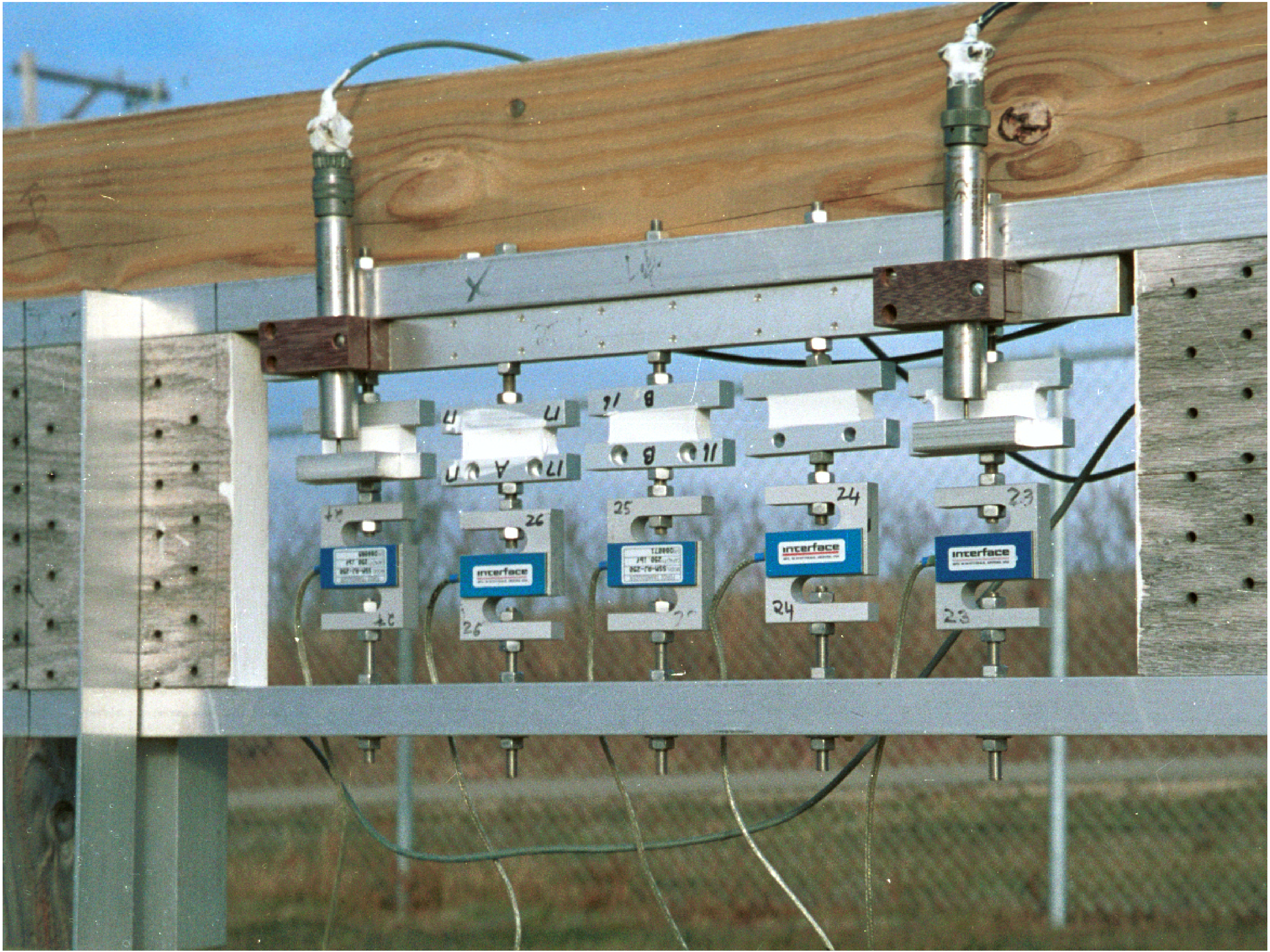
Can these changes be tracked during outdoor exposure

Sealant response in residential construction during outdoor exposure

Changes in relative humidity/moisture cause dimensional changes of wood

This in turn causes cyclic movement of sealant joints used with wood

Sealants were tested using wood to induce cyclic movement

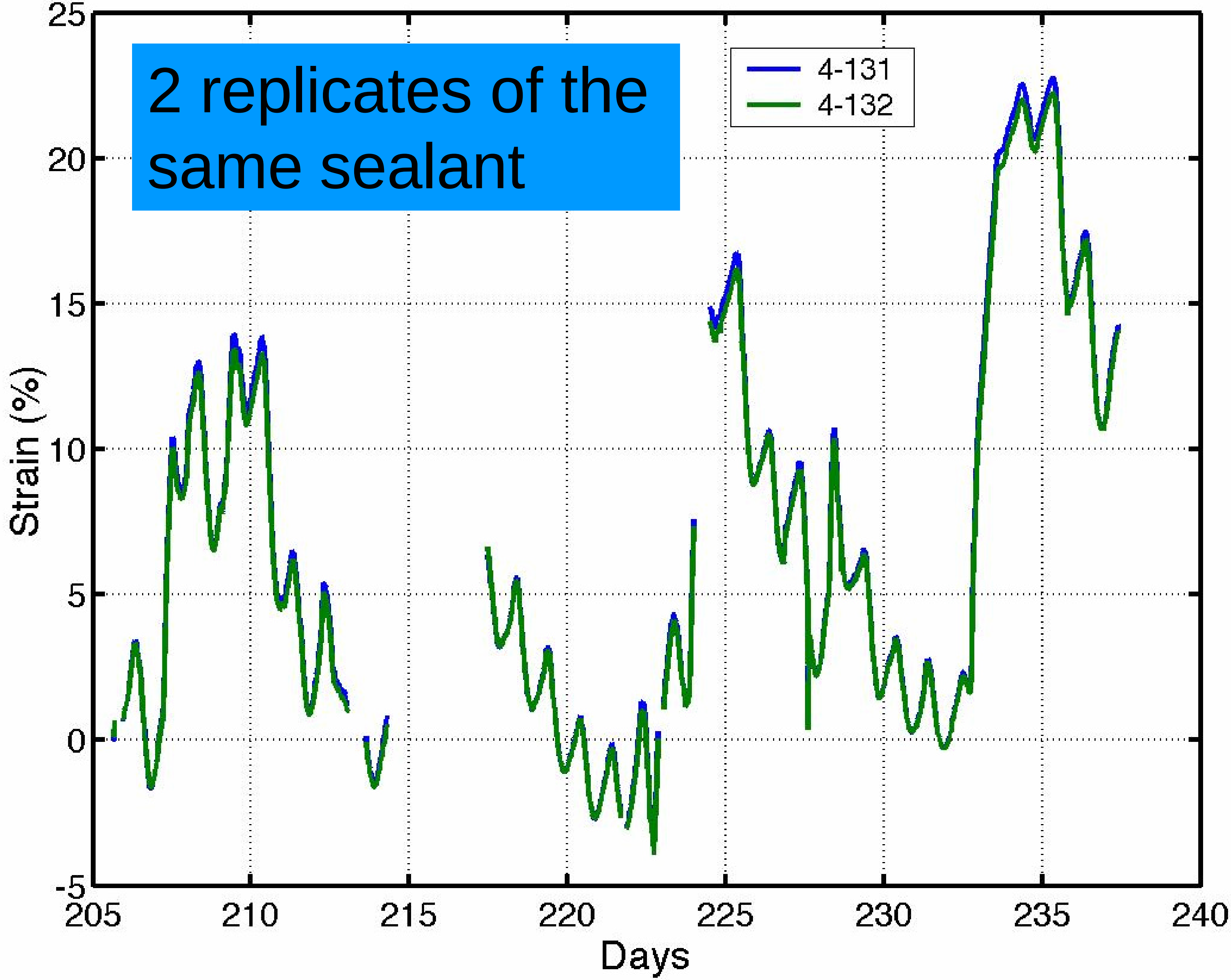

26
25
24
23
interface
interface
interface
24
23

LVDT

Sealant specimen

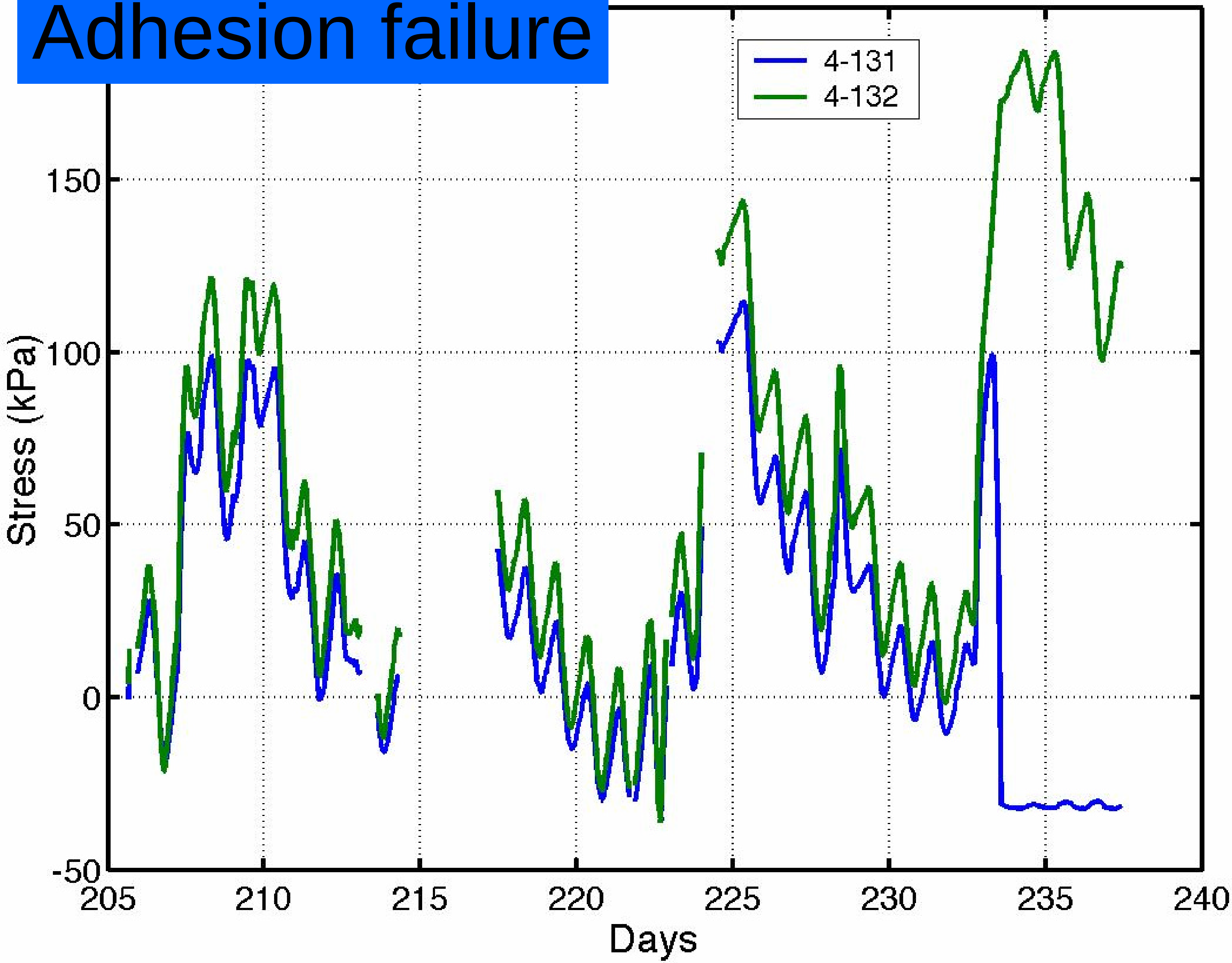
Force transducer (Load cell)

Weather and materials response data collection at the outdoor exposure site near Madison



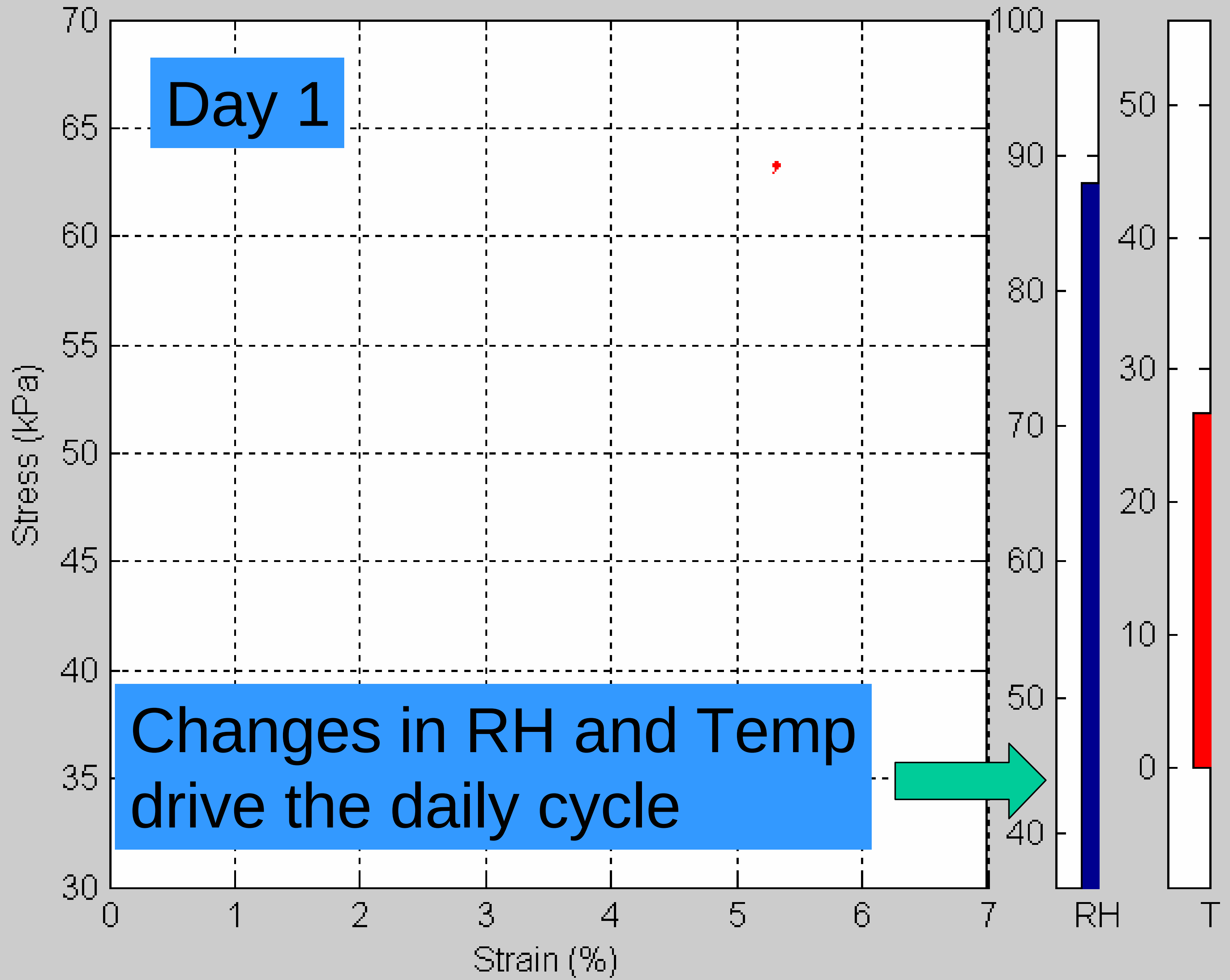
2 replicates of the same sealant
4-131
4-132
Strain (%)
Days
25
20
15
10
5
0
-5
205
210
215
220
225
230
235
240

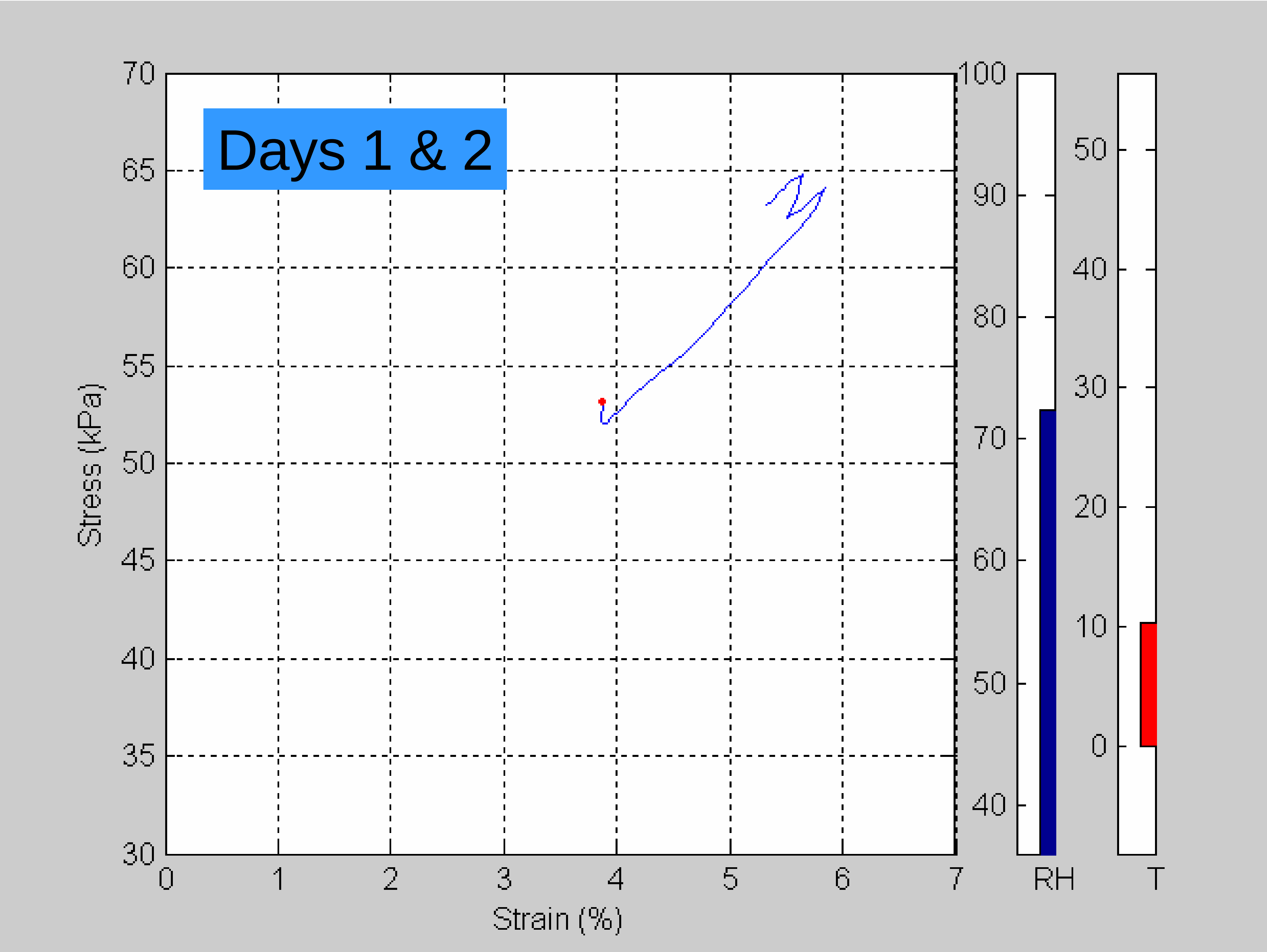
Adhesion failure

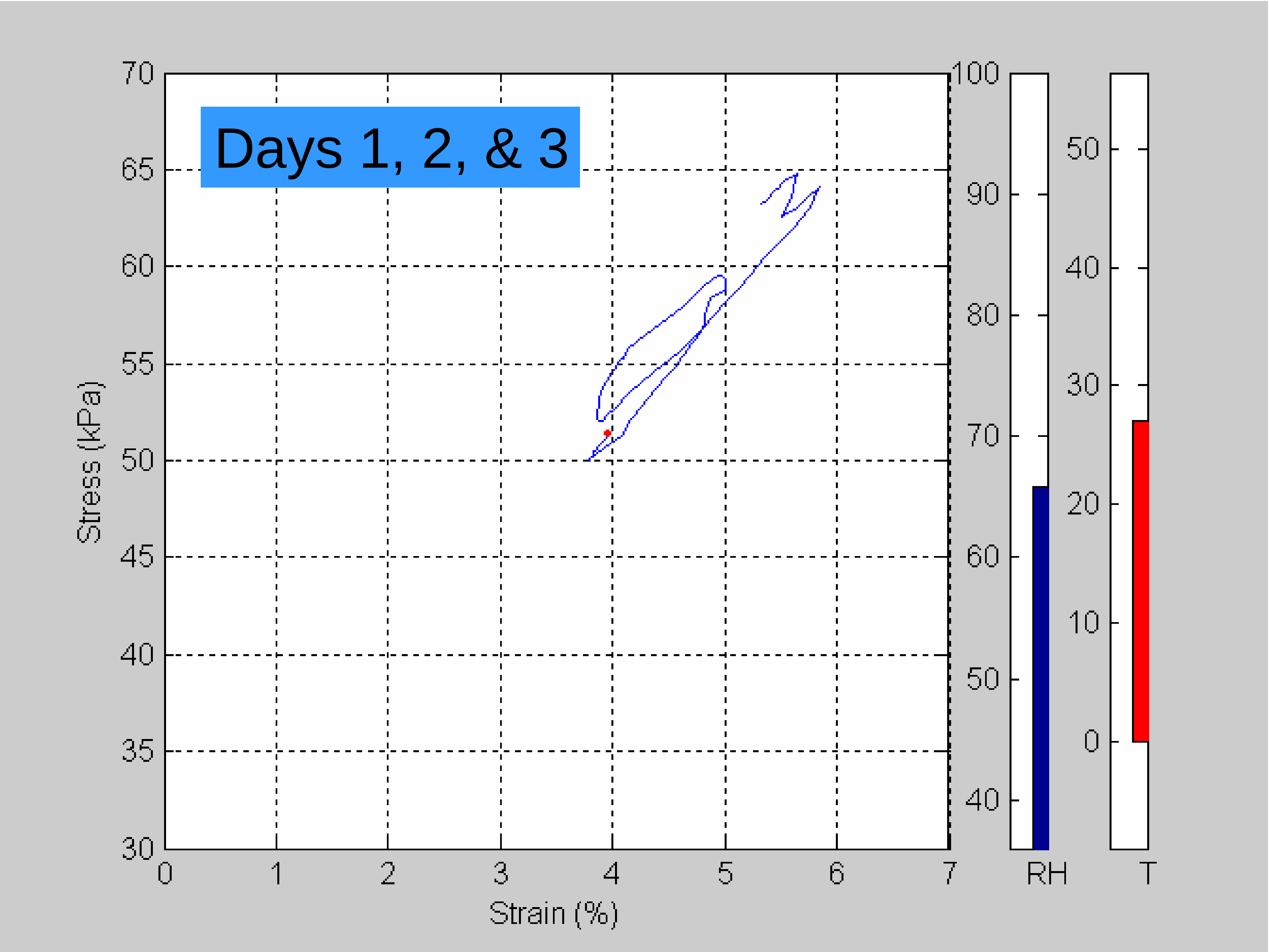


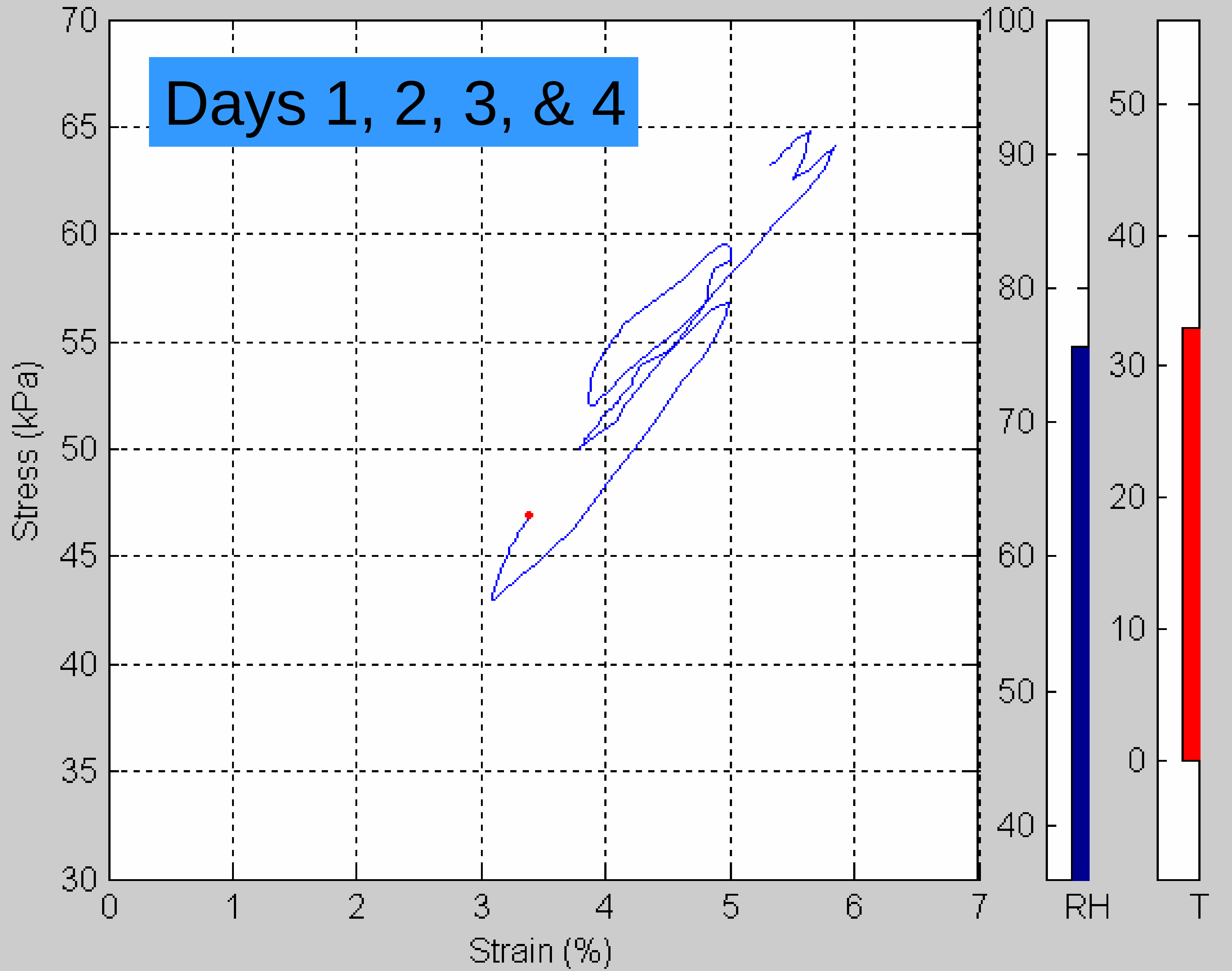

E18


C19
C19

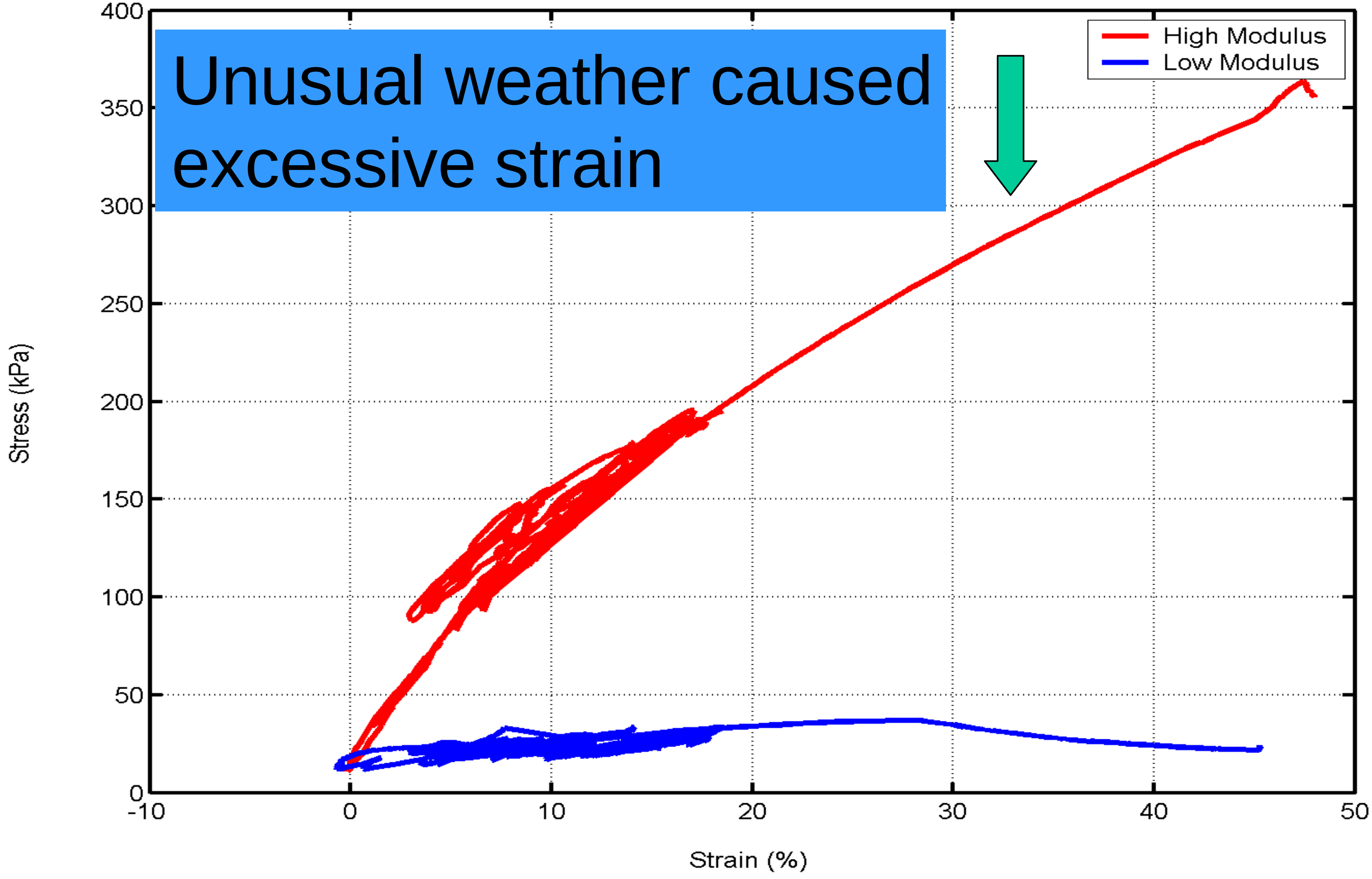

Day 1
Changes in RH and Temp drive the daily cycle
Stress (kPa)
70
65
60
55
50
45
40
35
30
0
1
2
3
4
5
6
7
Strain (%)
100
90
80
70
60
50
40
RH
50
40
30
20
10
0
T


Days 1 & 2
Stress (kPa)
Strain (%)
70
65
60
55
50
45
40
35
30
0
1
2
3
4
5
6
7
100
90
80
70
60
50
40
RH
50
40
30
20
10
0
T

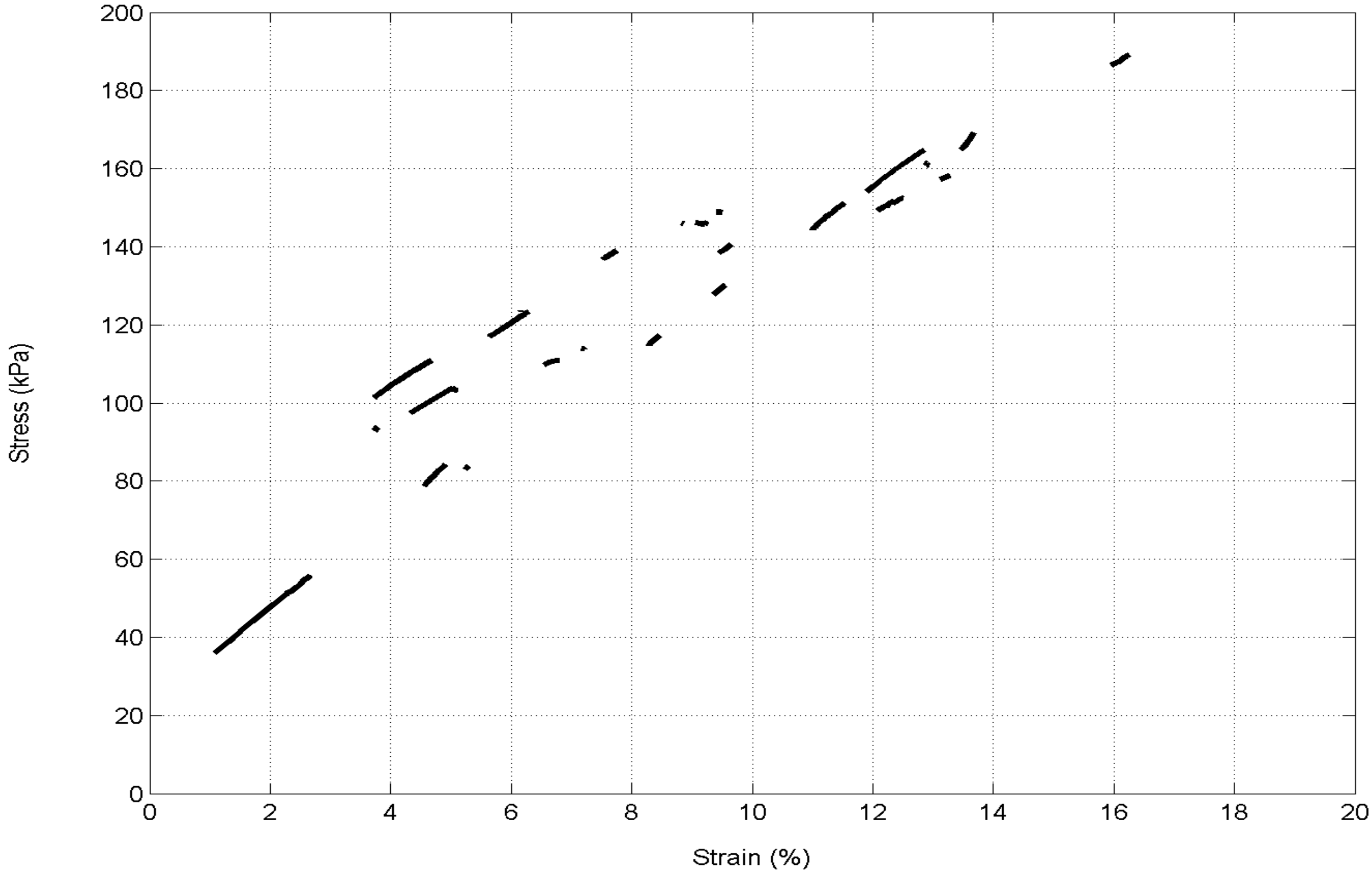

Days 1, 2, & 3
Stress (kPa)
Strain (%)
70
65
60
55
50
45
40
35
30
0
1
2
3
4
5
6
7
100
90
80
70
60
50
40
RH
50
40
30
20
10
0
T



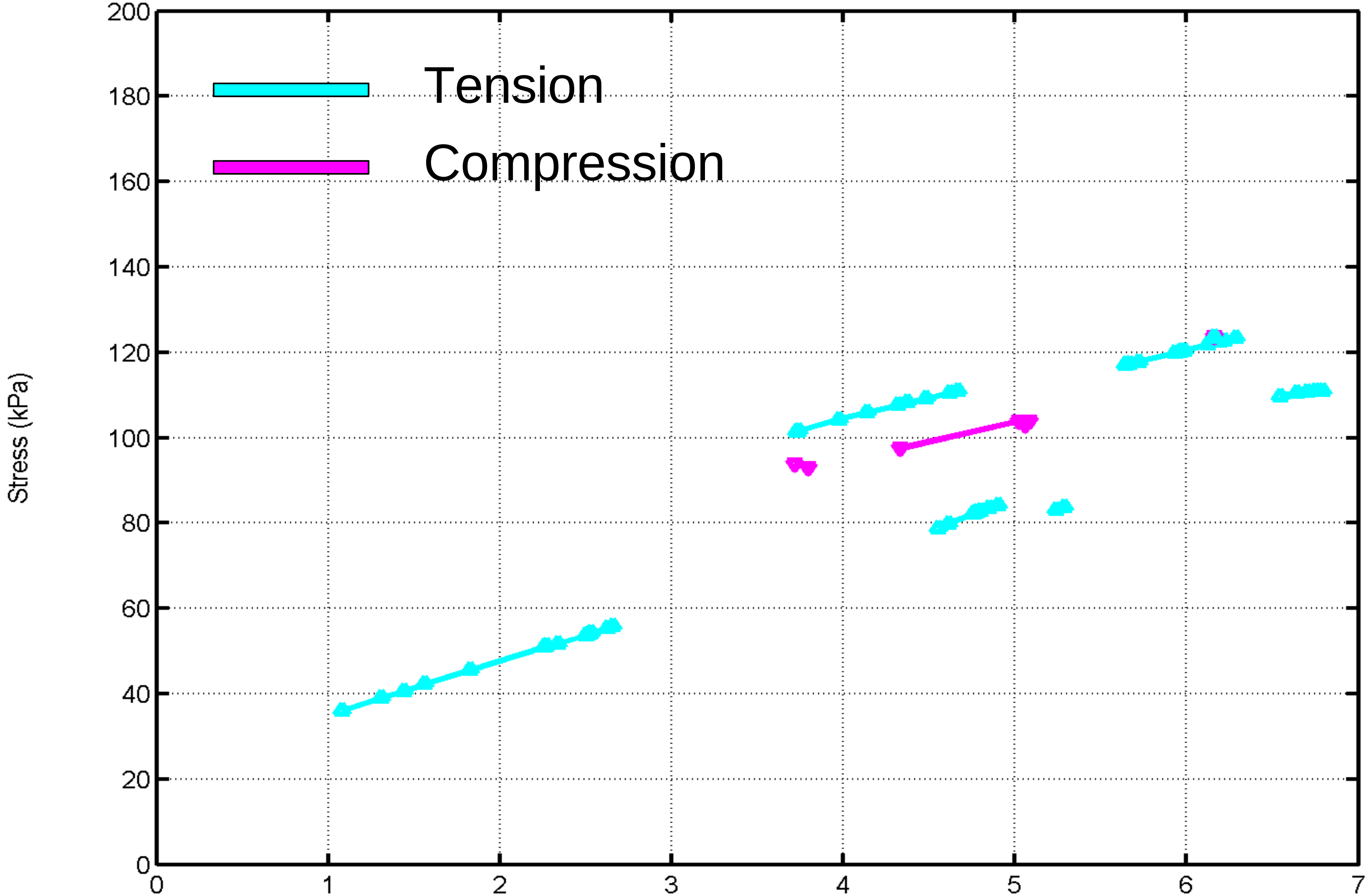
Days 1, 2, 3, & 4
Stress (kPa)
Strain (%)
RH
T



Stress/strain for two different sealants
All data for two-month exposure



Stress/strain, high modulus sealant
Only the data collected at –18^{o}C



Stress/strain further selected, 0-7% strain

The degradation of materials is not linear over the exposure period, but rather occurs more rapidly during certain “critical” times.

We need to know what the weather and the material response was during these “critical” times

By linking the materials response to the weather, it is possible to determine the critical factors to emphasize during laboratory tests.