CONDITION MONITORING AND LIFETIME ASSESSMENT OF GEOMEMBRANE LINERS AND COVERS

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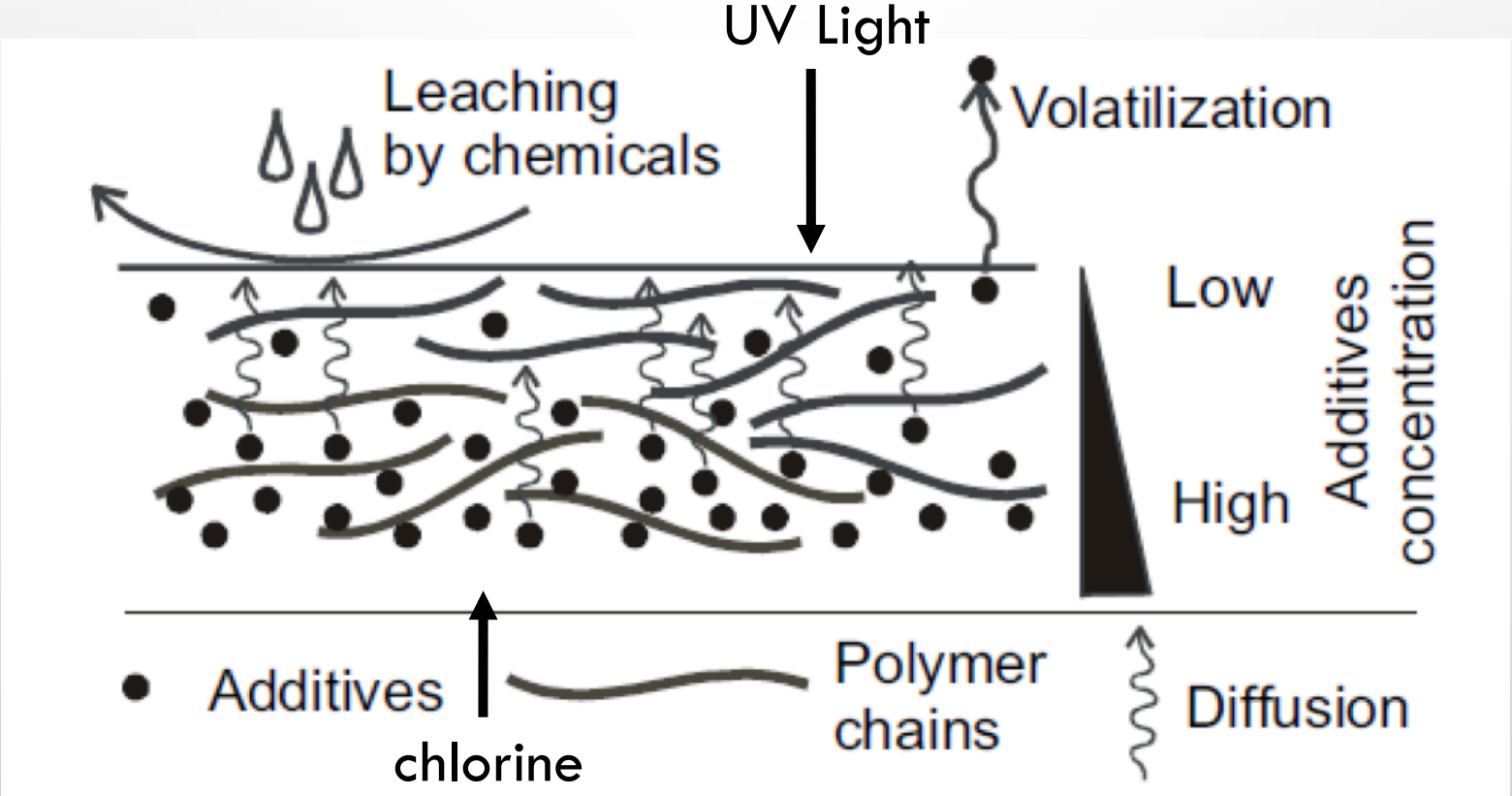
CONDITION MONITORING (CM) OF LINERS AND COVERS

- GIVES A ‘SHAPSHOT’ OF THE PRESENT CONDITION OF THE MATERIAL
- PROVIDES A BASELINE FOR FURTHER STUDIES
- PROVIDES A BASIS FOR ESTIMATION OF RESIDUAL LIFETIME
- PROVIDES ‘EARLY WARNING’ FOR PLANNING FOR REPLACEMENT
- ALLOWS TRACKING OF ASSET PERFORMANCE

MECHANISM OF ADDITIVE LOSS



C-SECTION ON COVER TO ACCESS LINER

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MONITORING TOOLS

	OIT	CARBONYL	180° BEND	CRIT	TENSILES	MELT FLOW RATE
HDPE	✔	✔	✔	✘	✔	✔
LLDPE	✔	✔	✔	✘	✔	✔
FPP	✔	✔	✔	✘	✔	✔
PVC	✘	✘	✔	✔	✔	✘
EIA	✘	✘	✔	✔	✔	✘
CSPE	✘	✘	✔ LT	✘	✔	✘
EPDM	✘	✔	✔ LT	✘	✔	✘

OIT = S-OIT & HP-OIT
CRIT = CONGO RED INDUCTION TIME
LT = LOW TEMPERATURE

RETAINED PROPERTIES

- THE ACTUAL VALUES OF THE TESTS ARE NOT CRITICAL RATHER IT IS THE % RETAINED PROPERTIES THAT ARE IMPORTANT FOR LONG-TERM MONITORING.

SAMPLES REQUIRED

IN ORDER TO COMPARE AND CONTRAST THE RESULTS OF THE TESTING THE FOLLOWING SAMPLES ARE PREFERRED:

- LINER SAMPLES FROM ABOVE THE WATERLINE (NORTHERN ASPECT)
- LINER SAMPLES FROM ABOVE THE WATERLINE (SOUTHERN ASPECT)
- LINER SAMPLES FROM BELOW WATERLINE
- ANCHOR TRENCH SAMPLES (NO UV, HEAT OR LIQUID EXPOSURE)
- RETAINED LINER SAMPLES FROM ROLLS REMAINING ON SITE (OPTIONAL)

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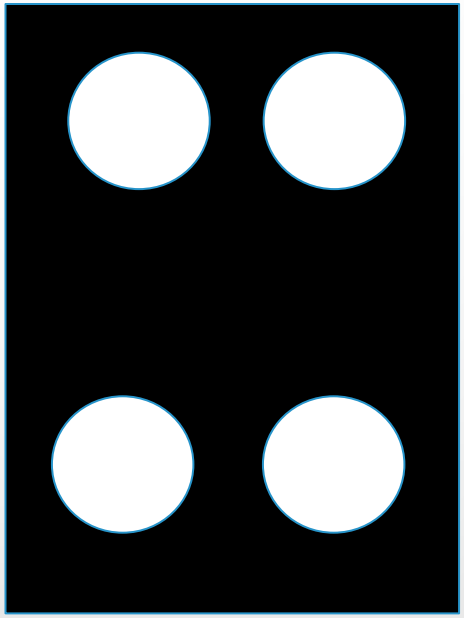
MINIMUM SAMPLE SIZE (POSTAGE STAMP)



← S-OIT x 2

← 180 DEGREE BEND

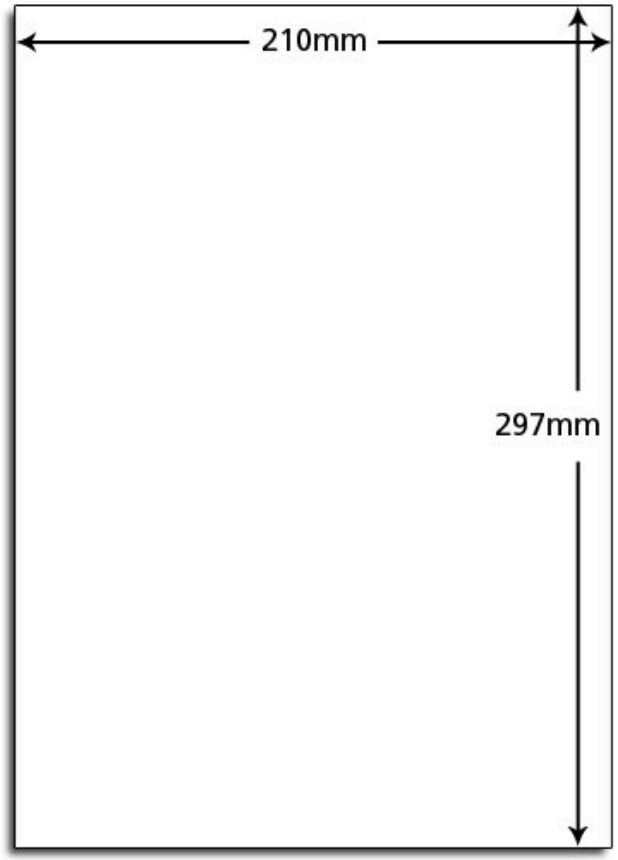
← HP-OIT x 2

← CARBONYL

NOTE: THIS SAMPLE CAN BE THE EDGE FLAP OF A WELD THAT IS EASILY REMOVED

LARGER SAMPLE (A4 SIZED)

- A4 SIZED SAMPLES ALLOW:
- TENSILES FOR TENSILE STRENGTH & ELONGATION
- MELT FLOW INDEX (MFI)
- TEAR (UNREINFORCED OR REINFORCED)



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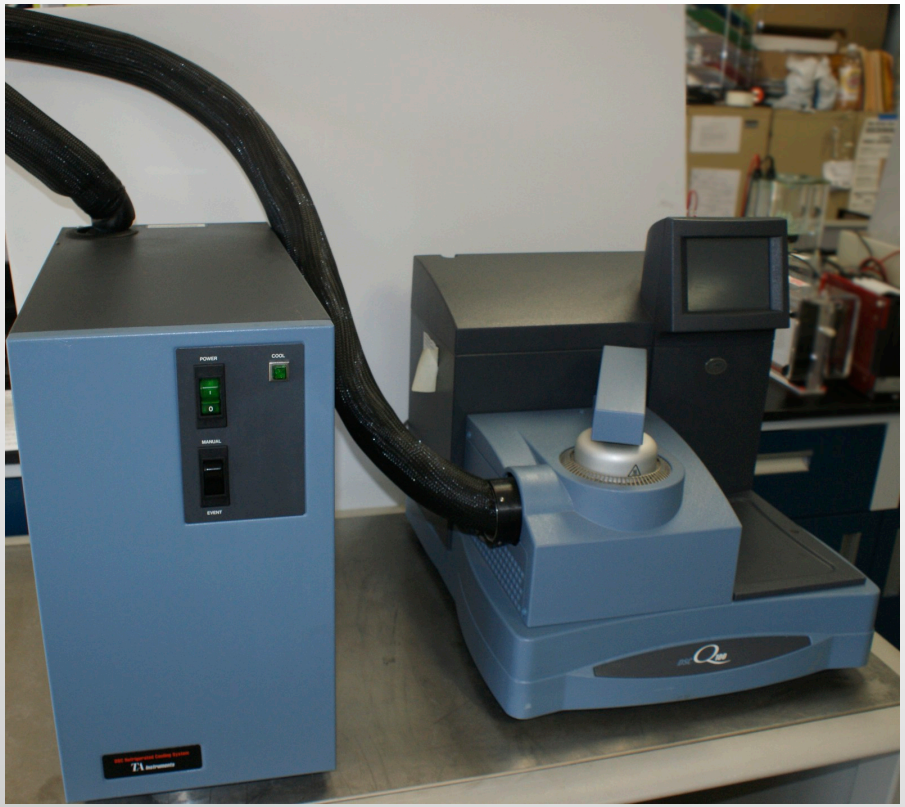
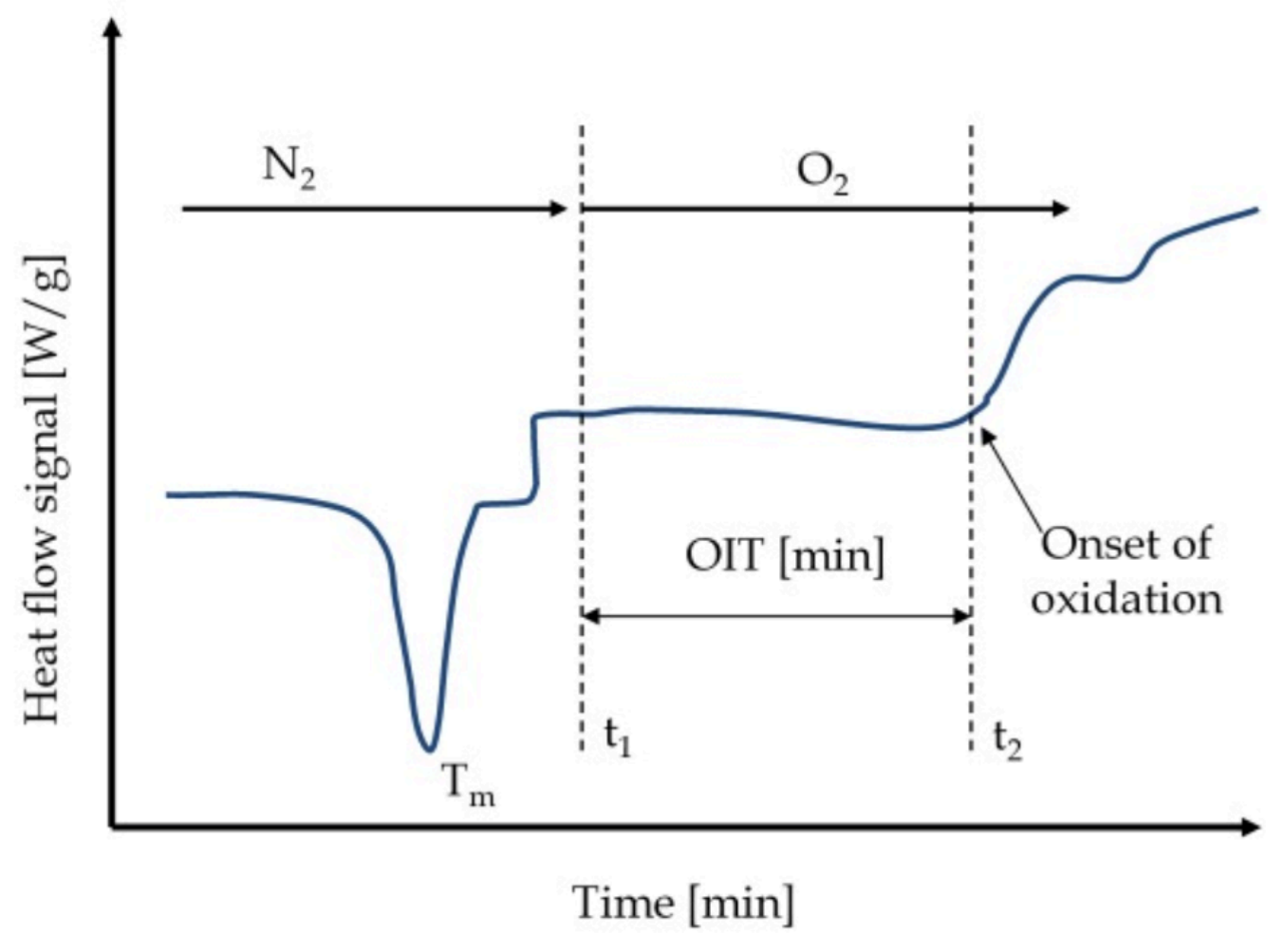
EQUIPMENT USED FOR OIT METHODS



TYPICAL OIT SCAN



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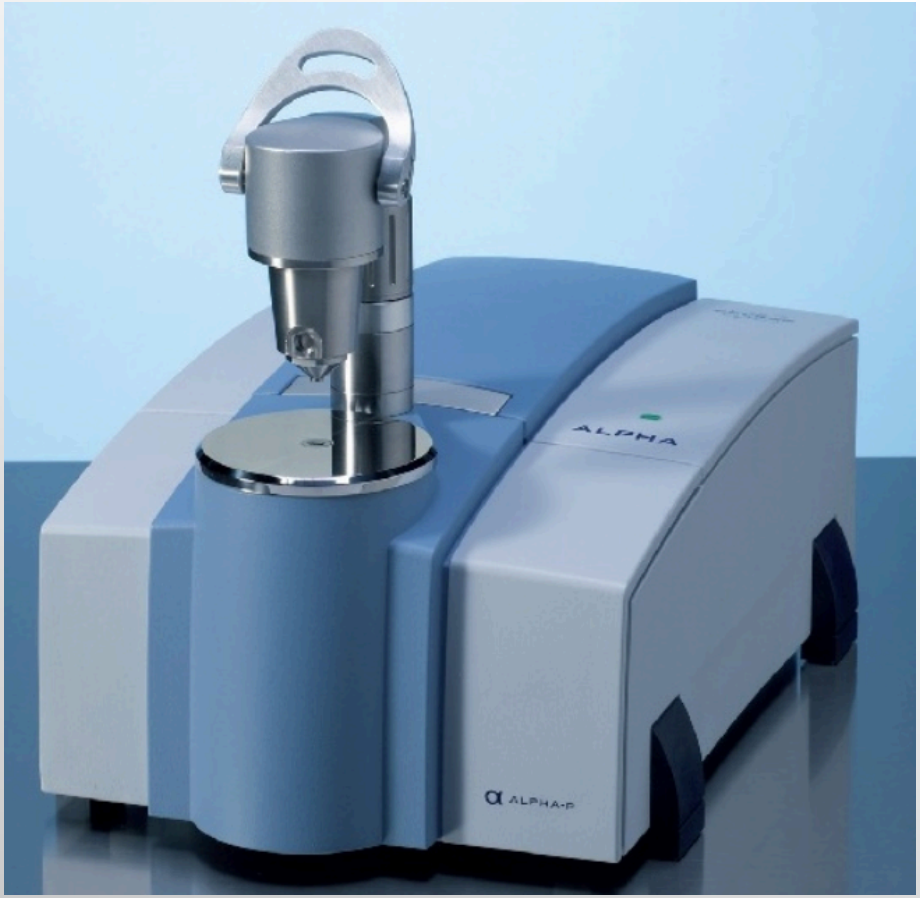
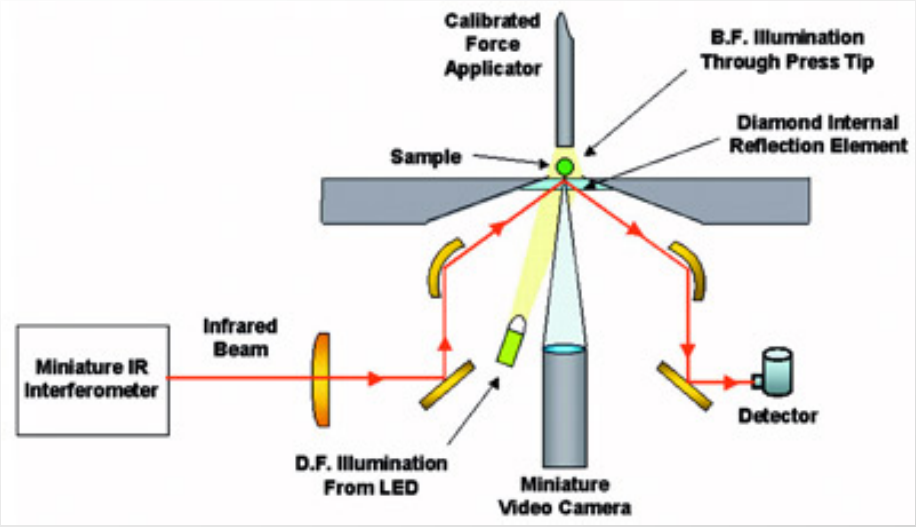
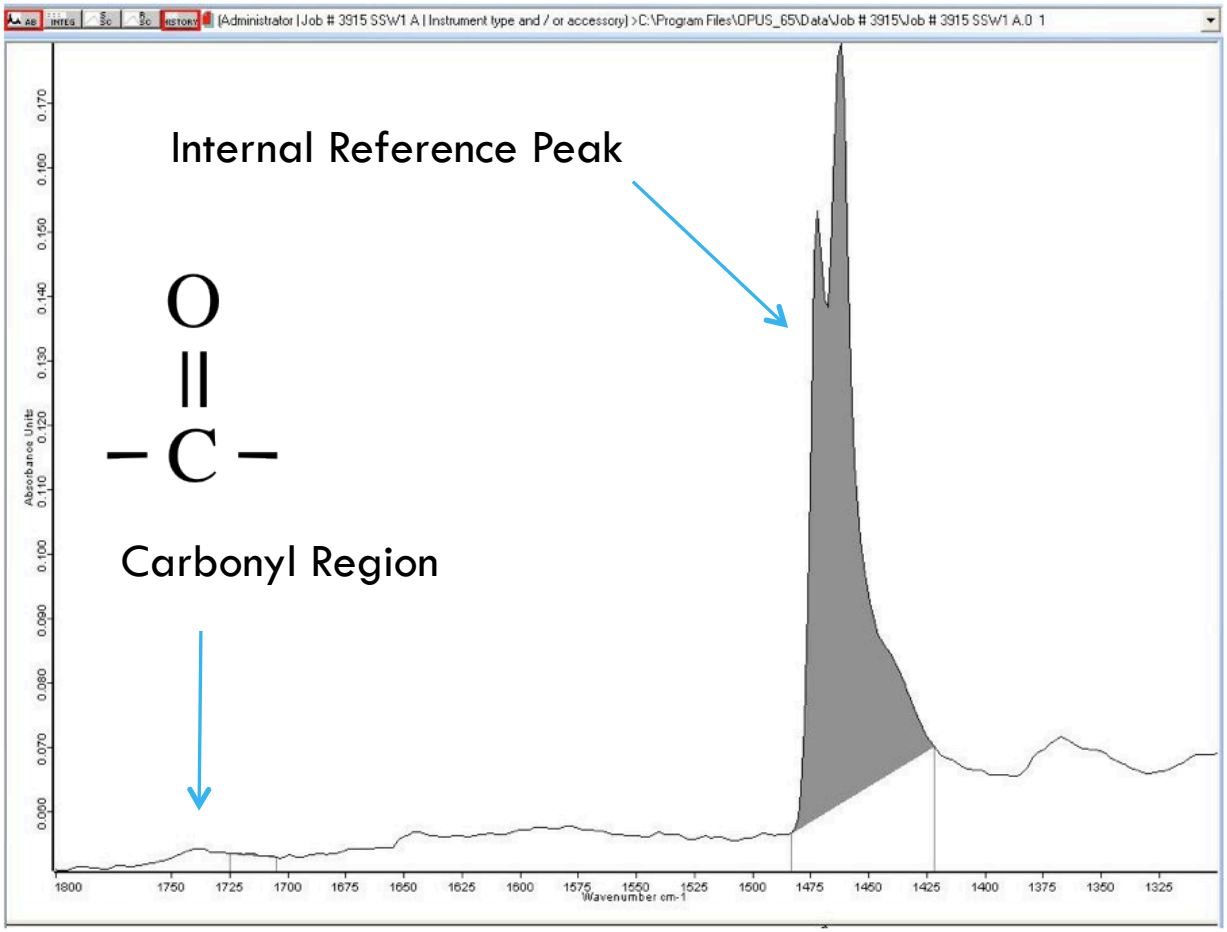
EQUIPMENT USED FOR CARBONYL INDEX





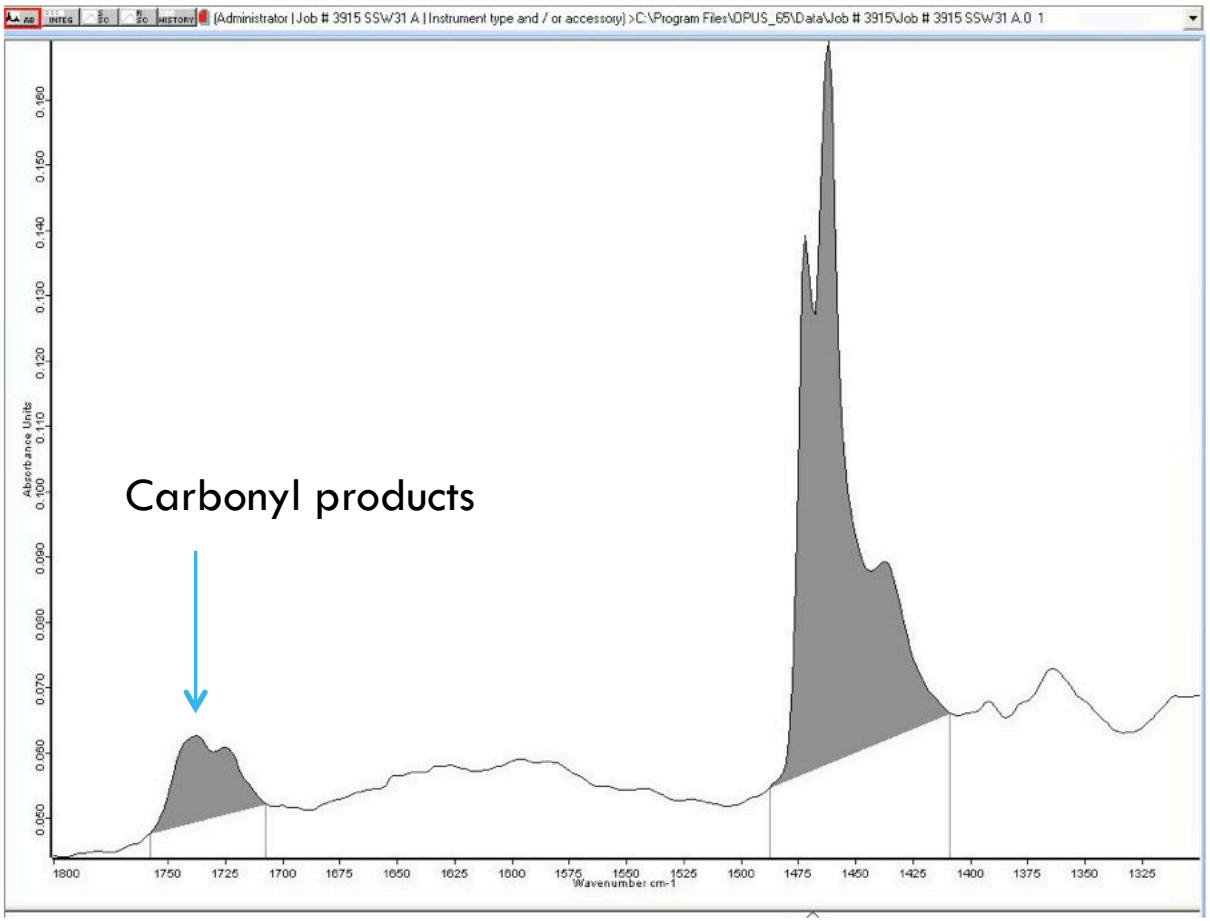
REFERENCE 1 - UNOXIDIZED HDPE

Carbonyl Index = 0.003 / 2.426 = 0.001



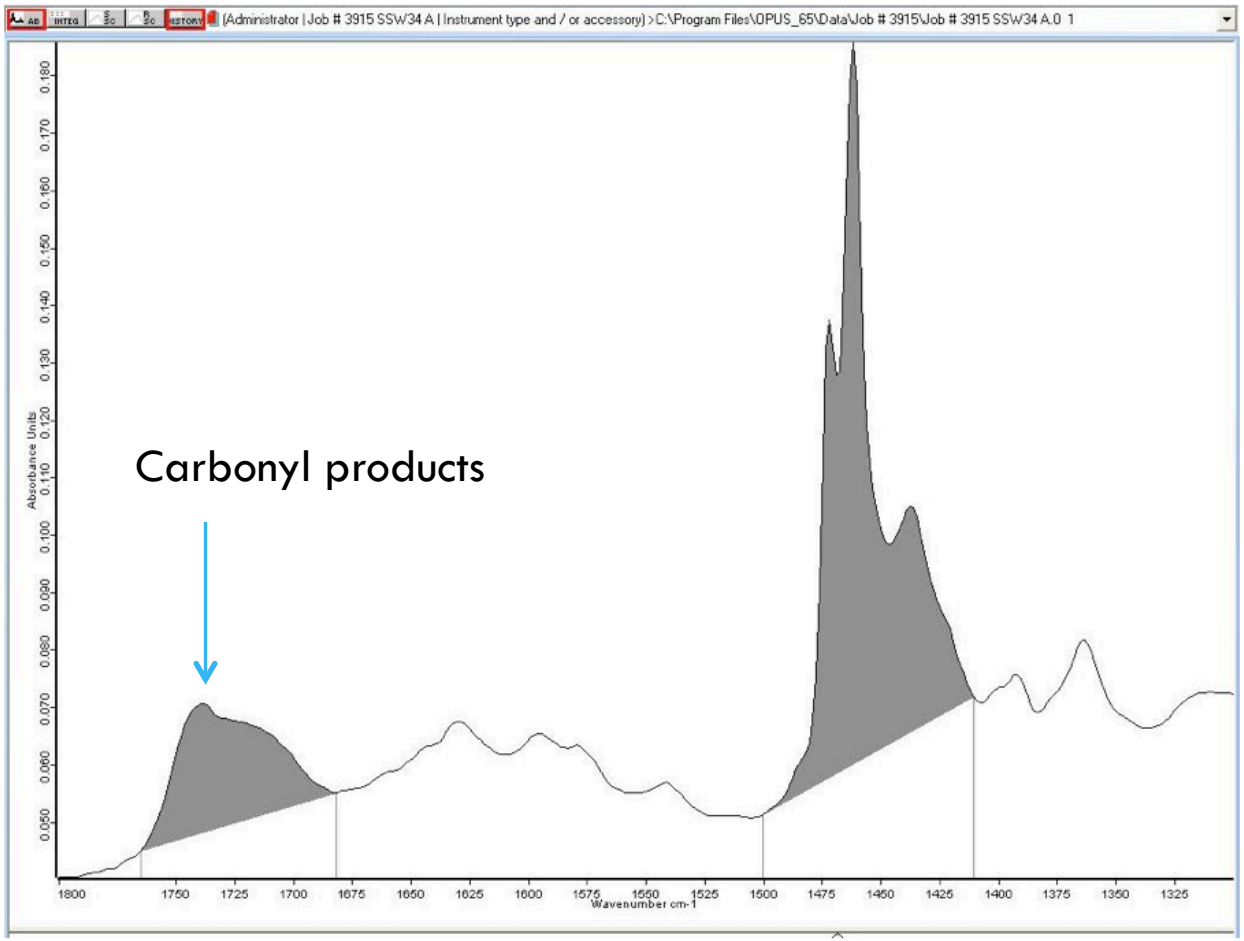
REFERENCE 2 - MODERATELY OXIDIZED

Carbonyl Index = 0.377 / 2.597 = 0.145



REFERENCE 3 - SEVERELY OXIDIZED HDPE

Carbonyl Index = 0.999 / 3.087 = 0.324



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EXAMPLES OF SEVERE SURFACE OXIDATION OF A LINER

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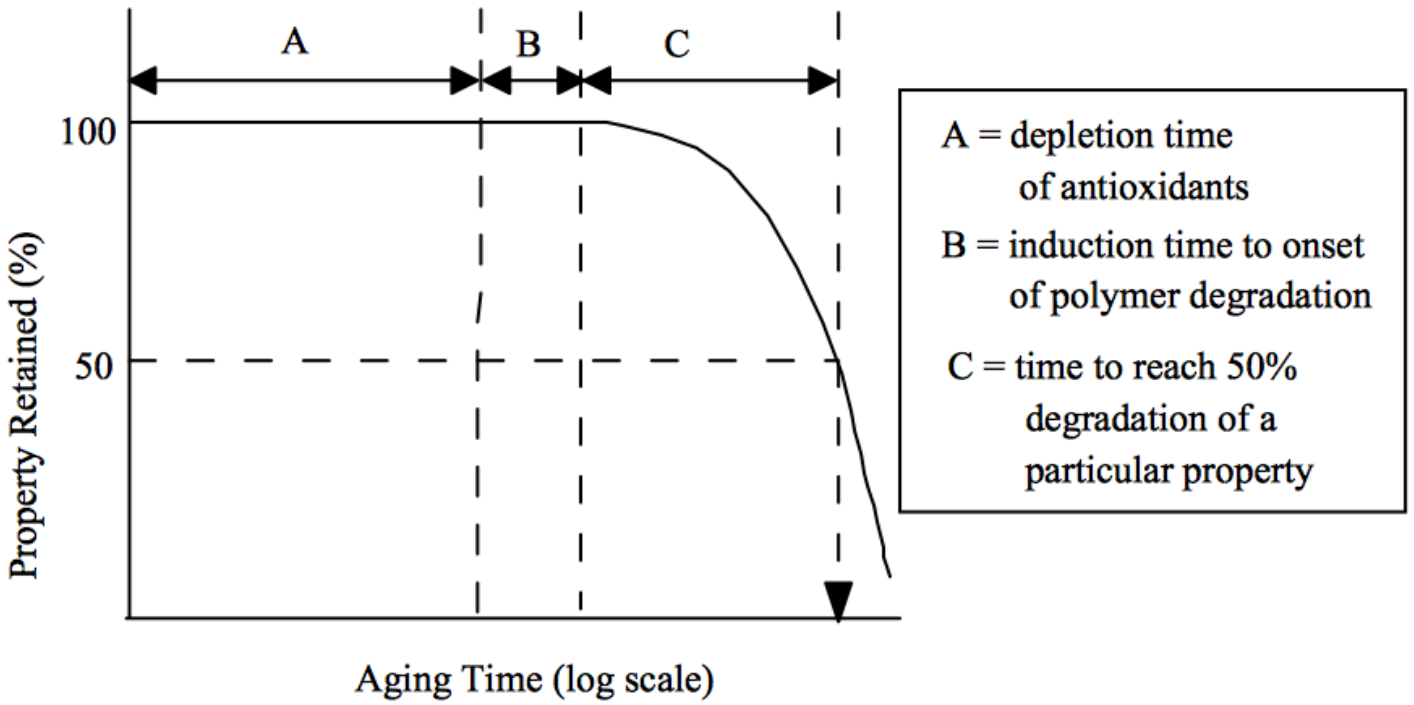
180 DEGREE BEND TEST CAN SHOW PRESENCE OF MICROCRACKING

CONCEPTUAL SERVICE LIFE OF POLYOLEFIN GEOMEMBRANES

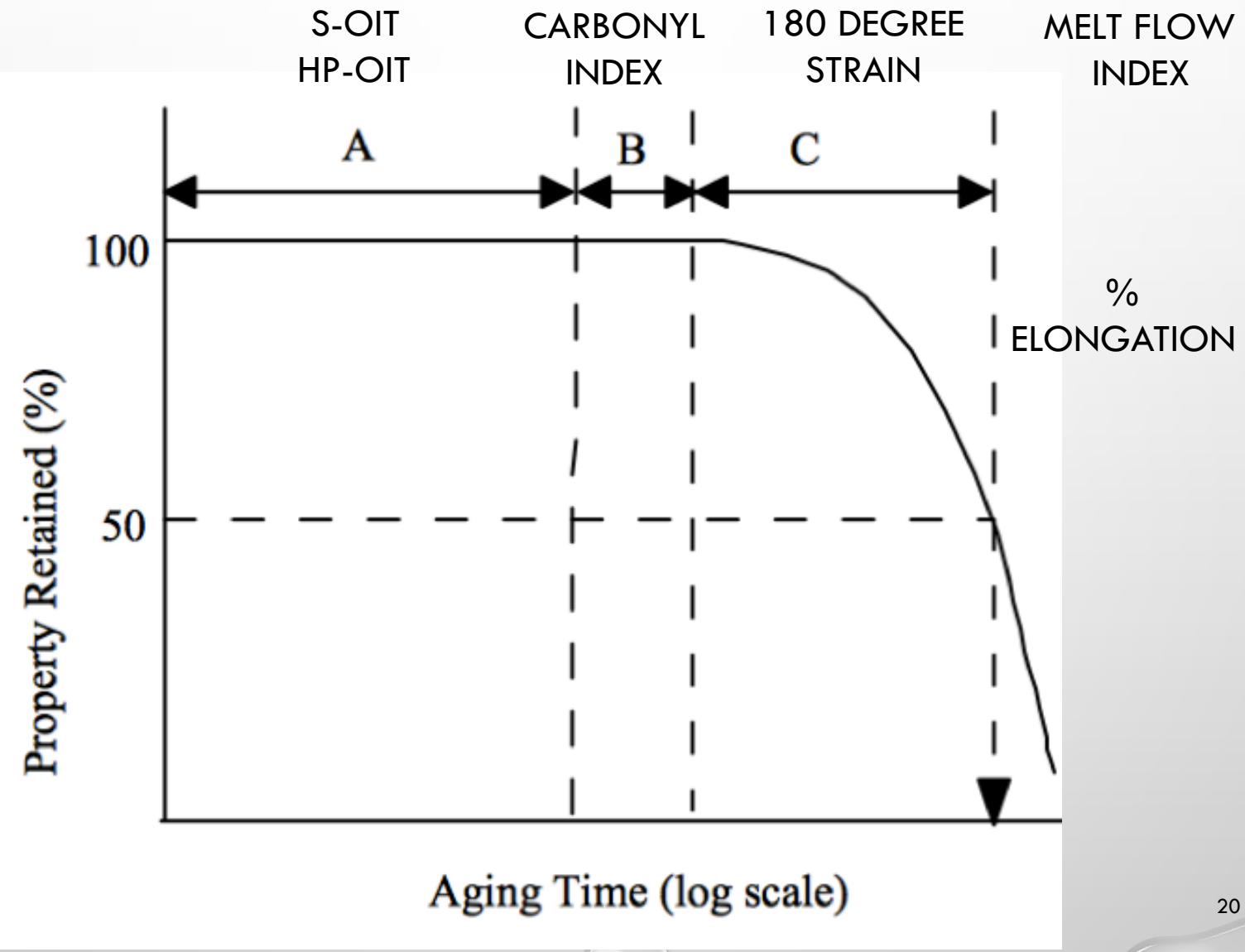


Three Conceptual Stages in Chemical Aging of Polyolefin Geomembranes

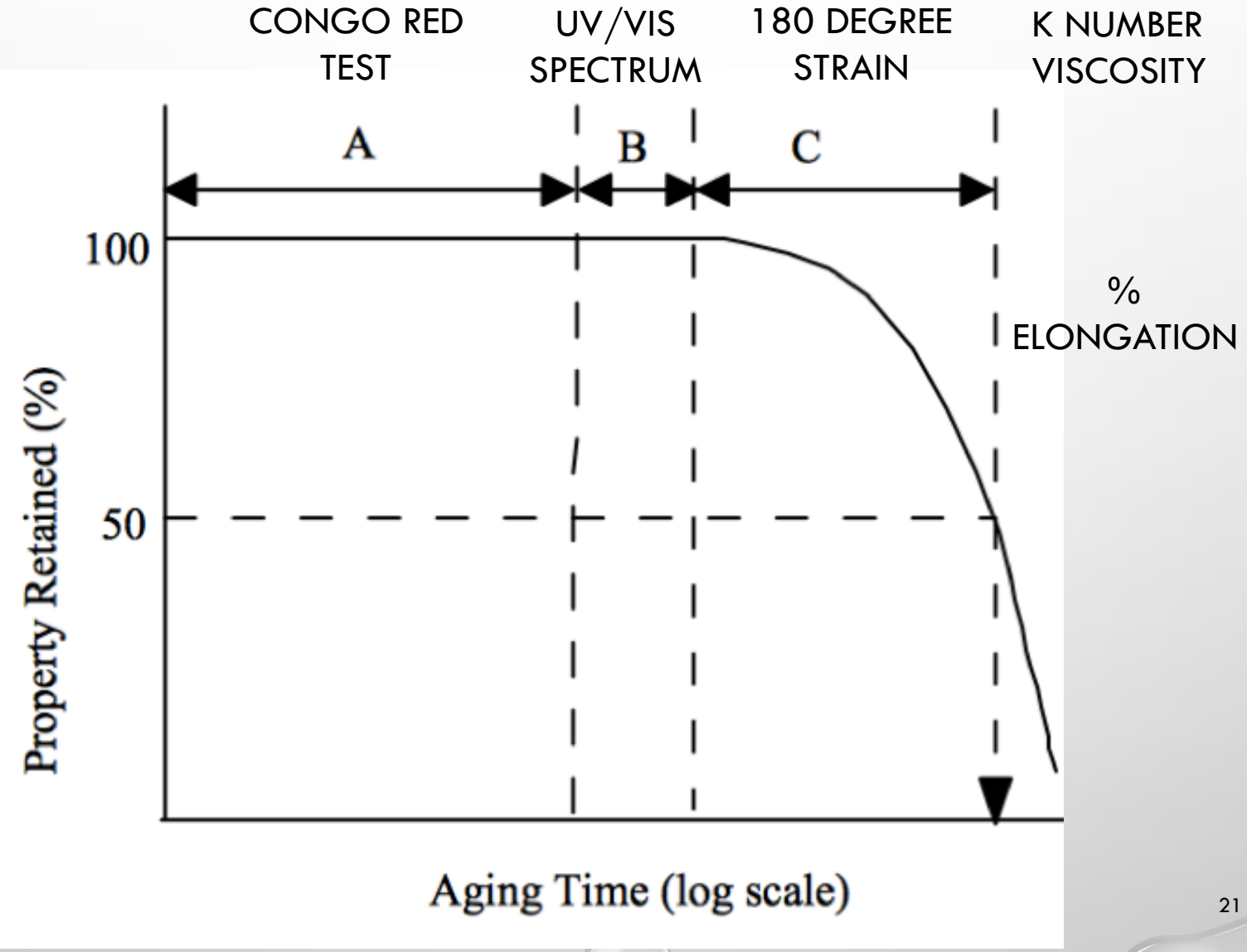
WHERE IS THE LINER IN ITS SERVICE LIFE?

- THE TEST RESULTS ALLOW ONE TO DETERMINE WHERE IN THE OVERALL LIFETIME CURVE THE LINER IS AT PRESENT.
- SEE NEXT FIGURE.

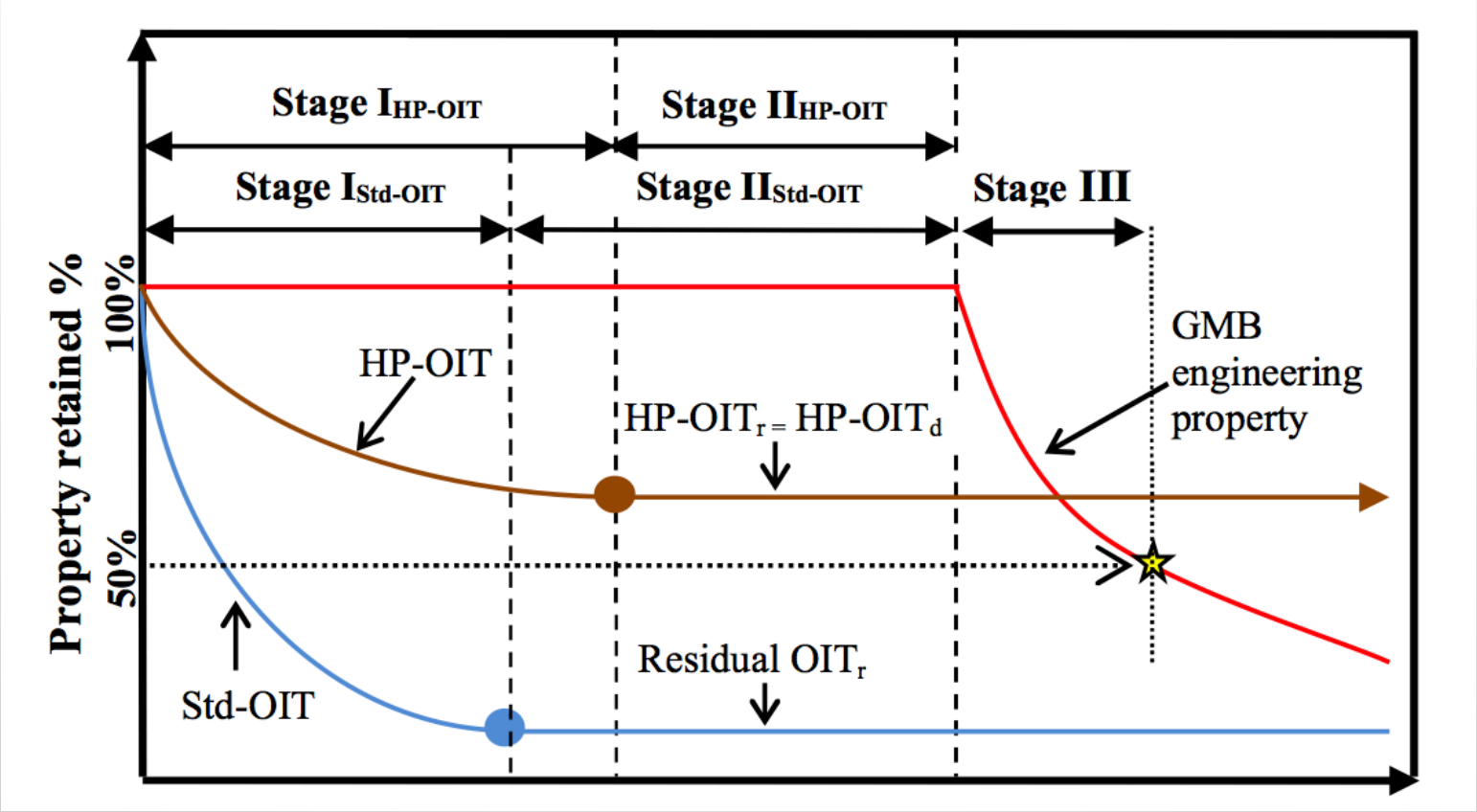
LIFETIME CURVE FOR POLYOLEFINS



LIFETIME CURVE FOR PVC-BASED LINERS



EFFECT OF S-OIT AND HP-OIT LEVELS ON GEOMEMBRANE FAILURE TIME



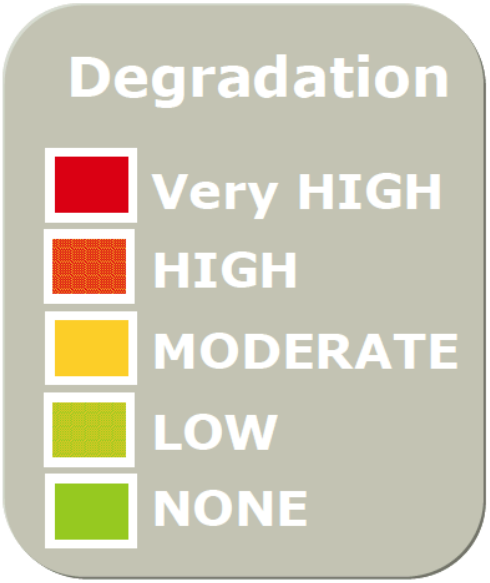
From **Ewais et al. 2014a**

QUESTIONS THAT CONDITION MONITORING CAN ANSWER

- HOW MUCH OF THE ANTIOXIDANTS HAVE BEEN DEPLETED SO FAR?
- HOW MUCH OF THE STABILIZERS HAVE BEEN DEPLETED SO FAR?
- WHAT LEVEL OF SURFACE OXIDATION HAS OCCURRED?
- HAVE THE PHYSICAL PROPERTIES BEEN AFFECTED YET?
- DO THE MECHANICAL PROPERTIES SHOW GREATER THAN 50% LOSS OF INITIAL PROPERTIES?
- HAS THE MATERIAL REACHED ITS 'END OF LIFE'?

RANKING LEVEL OF DEGRADATION

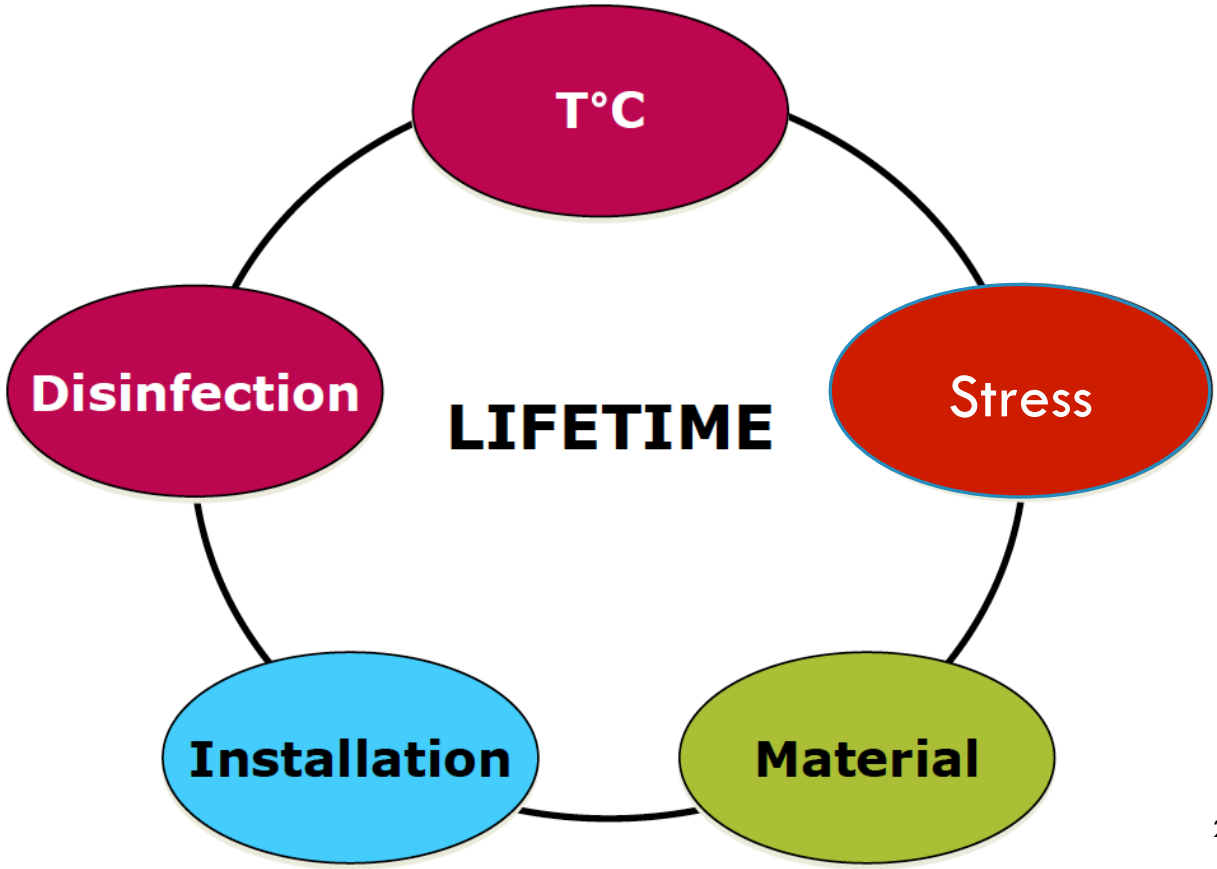
New methodology for ranking the level of degradation



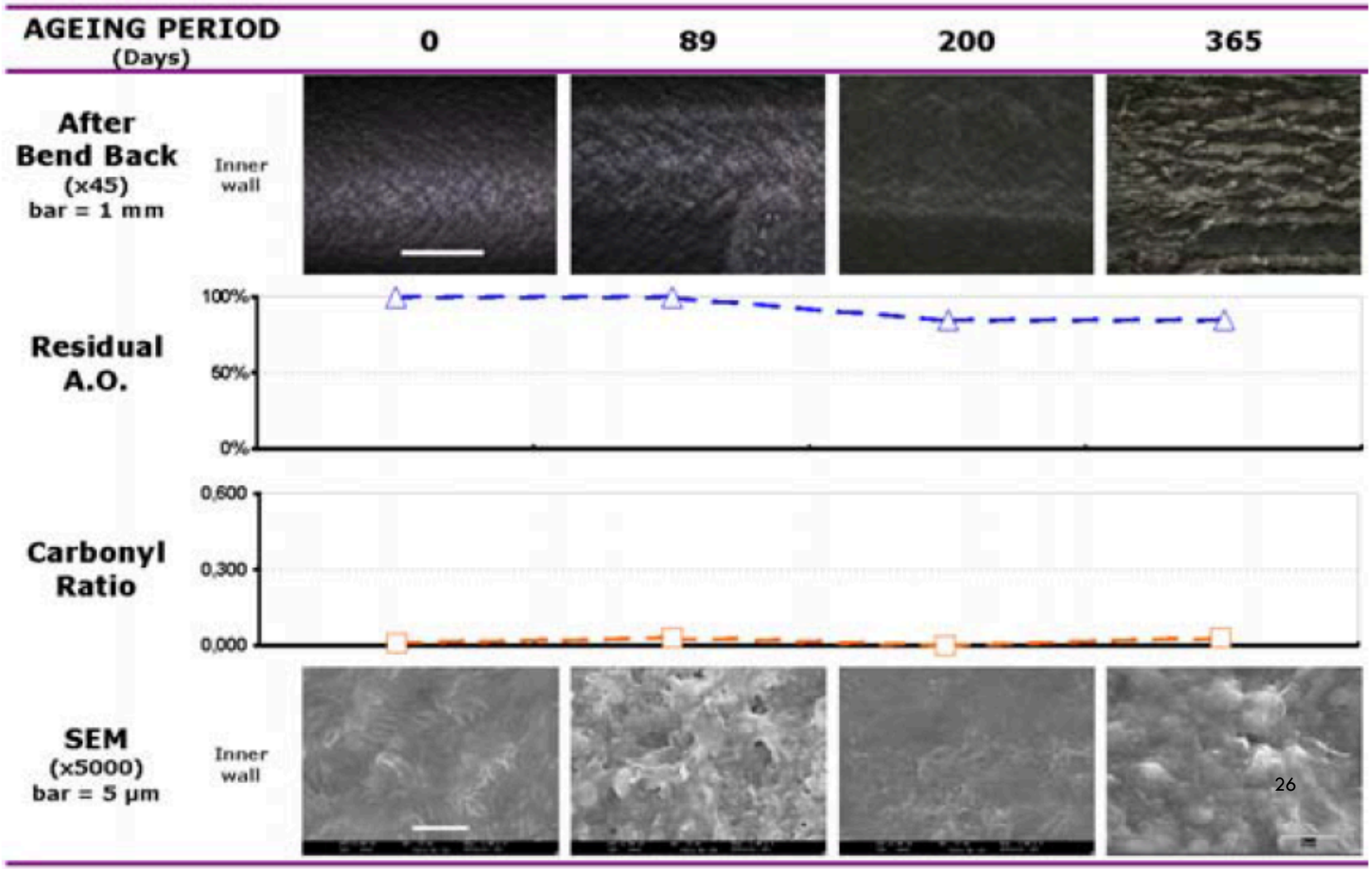
based on 4 tests

5 risk factors identified

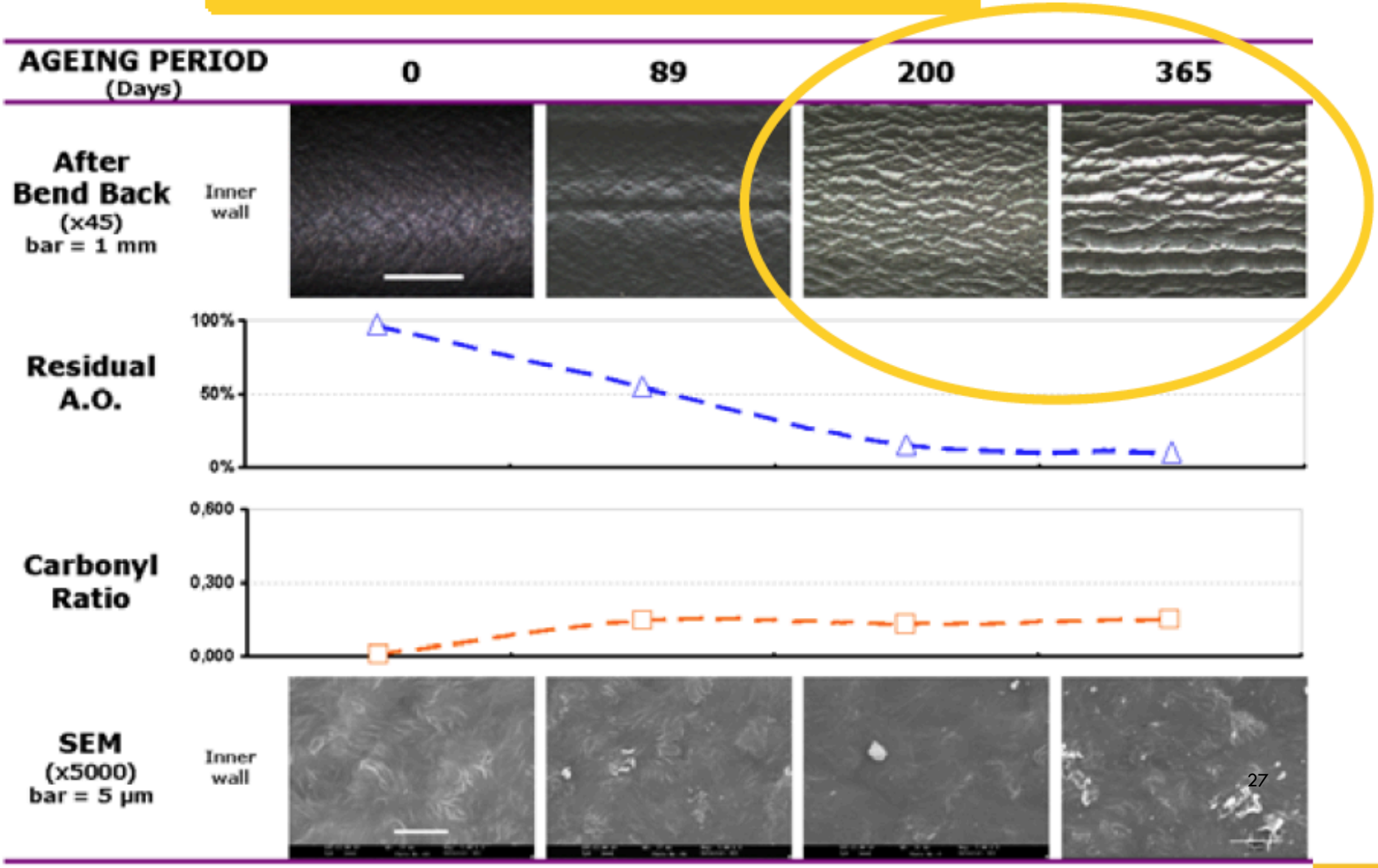
WATER TREATMENT



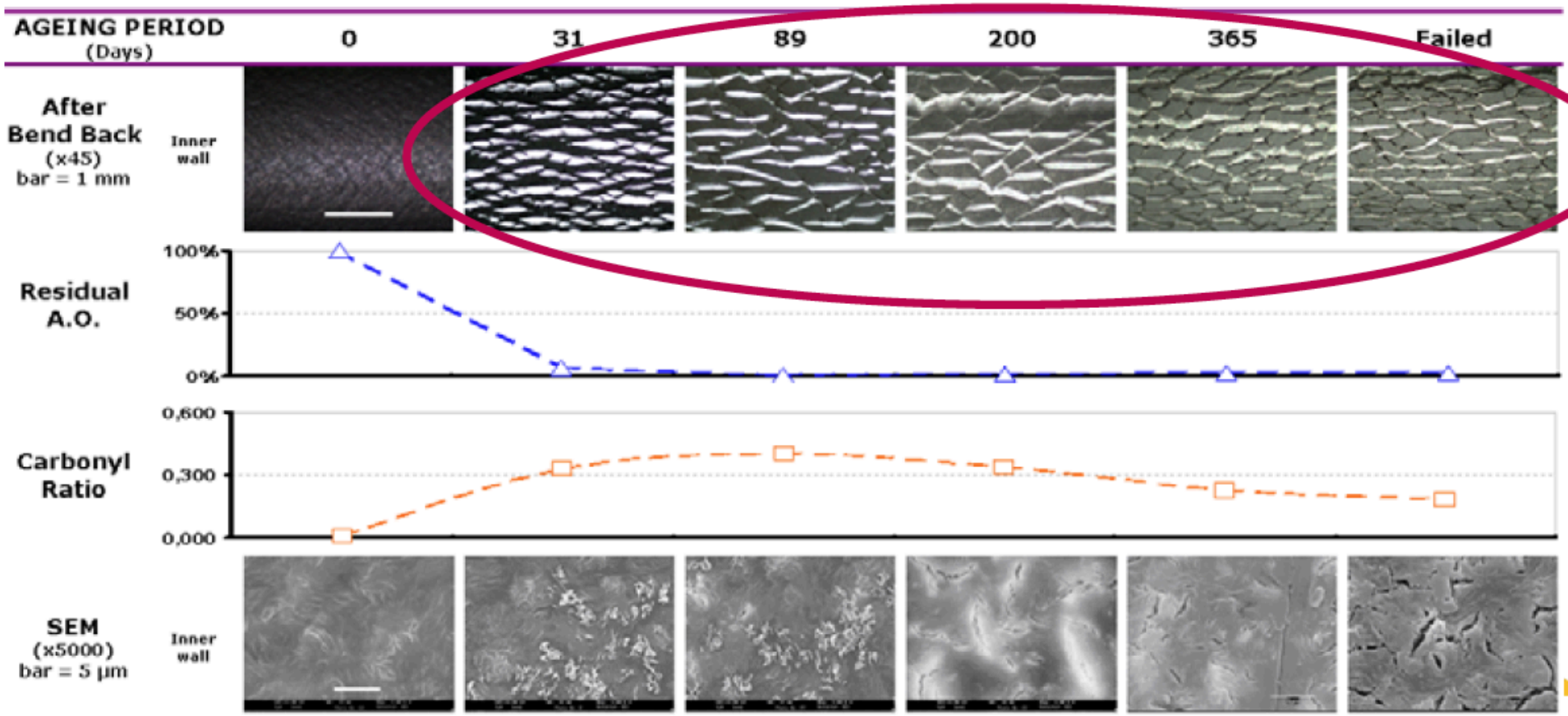
Without disinfectant



With chlorine



With chorine dioxide



LIFETIME ASSESSMENT (REL)

- RESIDUAL ESTIMATED LIFETIME IS IMPORTANT SO FACILITY OWNERS CAN TRACK PERFORMANCE OF THEIR LINER AND COVERS SYSTEMS AND PLAN FOR REPLACEMENT.
- OH&S IMPLICATIONS FOR PERSON WALKING ON COVERS FOR MAINTENANCE
- EPA IMPLICATIONS FOR CRITICAL CONTAINMENT
- 'EARLY WARNING' OF FAILURE

Calculate a regression line in accordance with ISO 2578:1993, Annex A.

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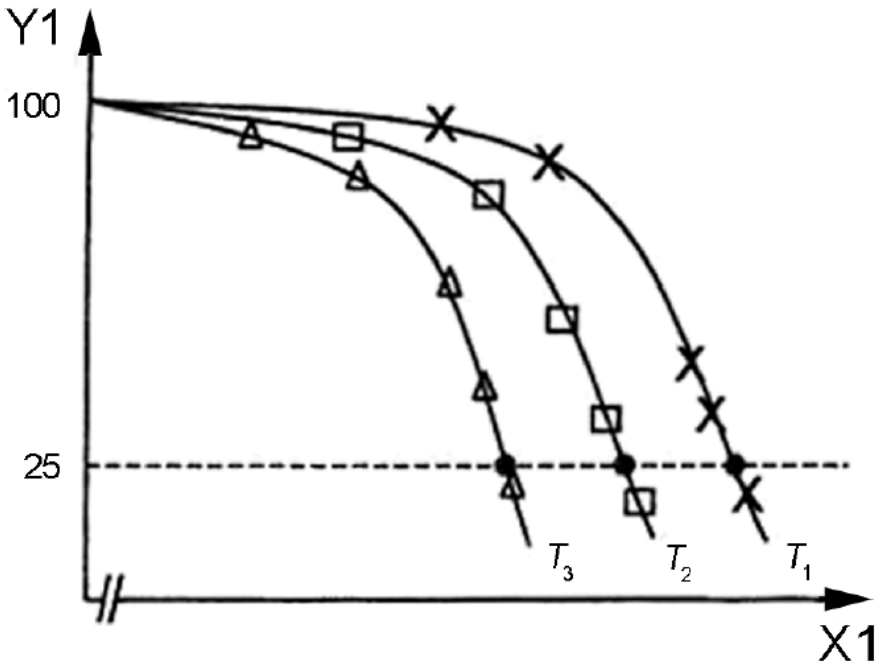
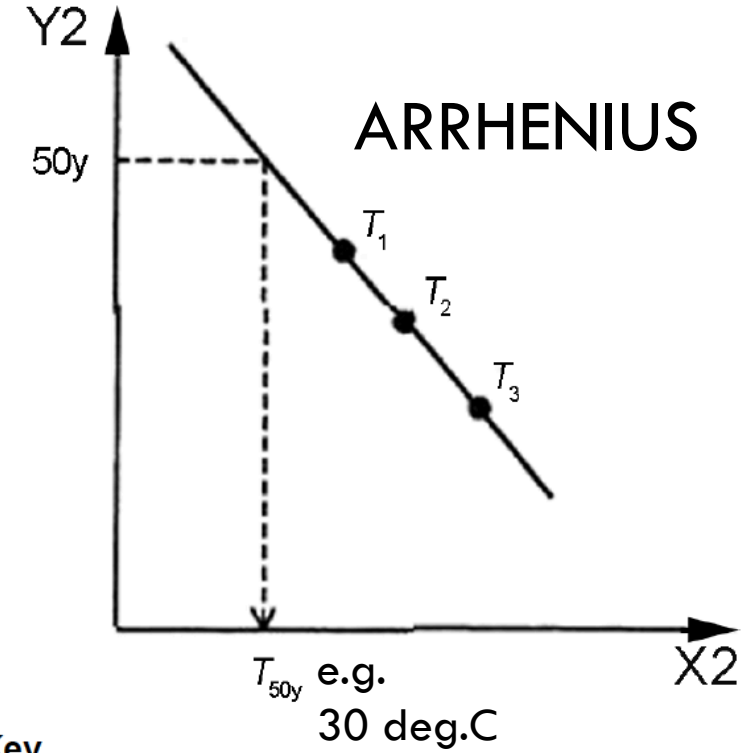
Determine the exposure temperature which, over a lifetime of 50 years (T_{50y}), would reduce the elongation at break to 25 % of its original value.



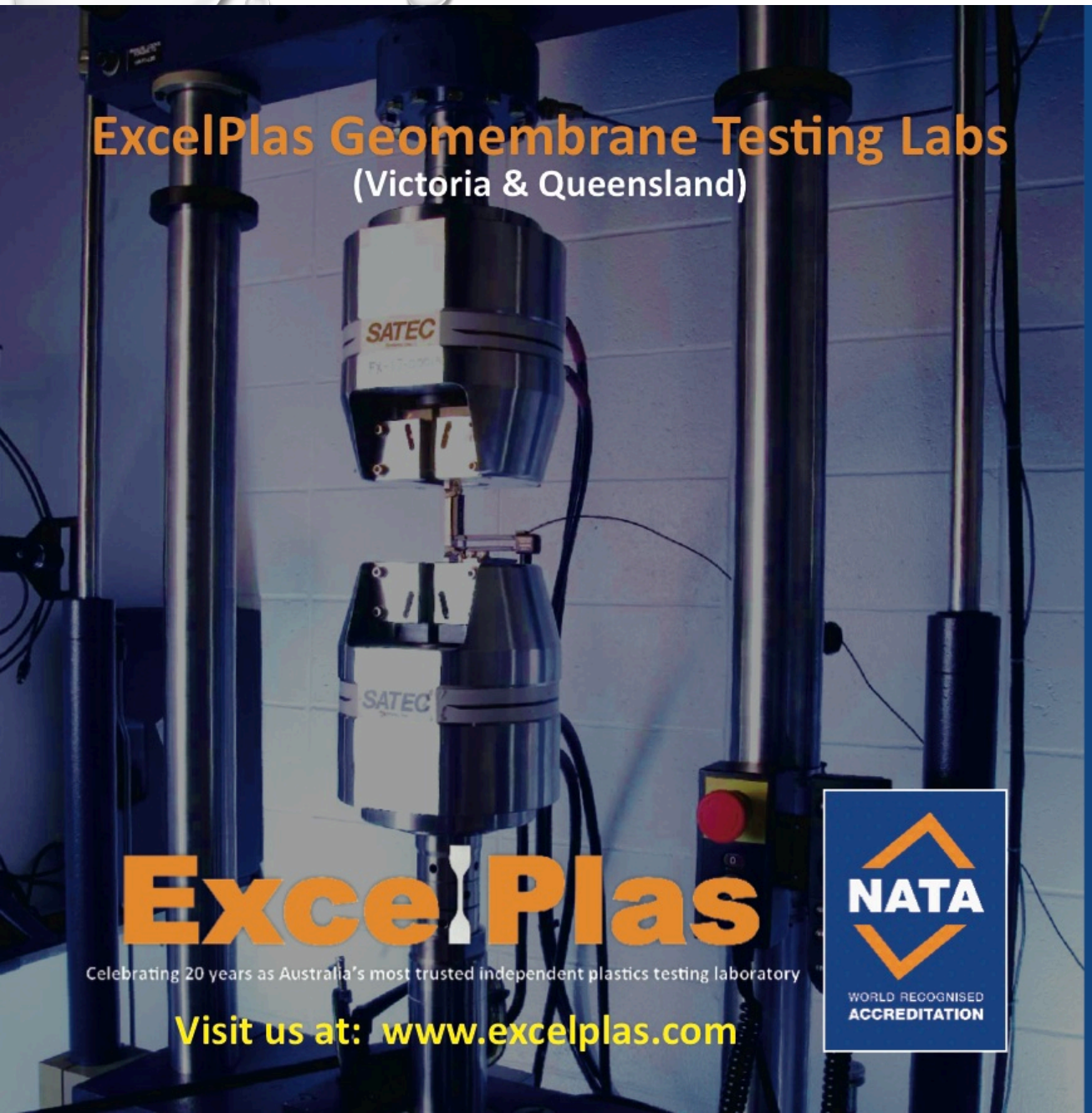
Key

X_1	log$t$ (t in years)
Y_1	% ε_B (elongation at break expressed as a percentage of the original, unexposed, elongation at break)
T_1, T_2, T_3	exposure temperatures used (°C)



Key

X_2	$1/T$ (T in °C)
Y_2	log$t$ (t in years)
T_1, T_2, T_3	exposure temperatures used (°C)
T_{50y}	exposure temperature at which the elongation at break would be reduced to 25 % after 50 years



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GEOMEMBRANE TESTING METHODS

Asperity Height of Textured Liners	ASTM D 7466
Axisymmetric Break Strain	ASTM D 5617
Carbon Black Content	ASTM D 4218/1603
Carbon Black Dispersion	ASTM D 5596
Chemical Resistance Testing	ASTM D 5322
Crystallinity (%) by DSC	ASTM D 3148
Density (g/cc)	ASTM D 792/1505
Melt Flow Index (at 190 deg.C)	ASTM D 1238
Oven Ageing (at 85 deg.C)	ASTM D 5721
Oxidative Induction Time (S-OIT)	ASTM D 3895
High Pressure OIT (HP-OIT)	ASTM D 5885
Peel/Shear of Welds (nonreinforced)	ASTM D 6392
Peel/Shear of Welds (reinforced)	ASTM D 751/413
Ply Adhesion (reinforced)	ASTM D 6636
Puncture Resistance (Rod/Pin)	ASTM D 4833
Puncture Resistance (Large Scale)	ASTM D 5514
Stress Crack Resistance (NCTL-SCR)	ASTM D 5397
Tear Resistance (nonreinforced)	ASTM D 1004
Tear Resistance (reinforced)	ASTM D 5884
Tear Resistance (reinforced) (Tongue)	ASTM D 751
Tear Resistance (Trapezoidal)	ASTM D 4533
Tensile Testing (nonreinforced)	ASTM D 6693
Tensile Testing (reinforced)	ASTM D 751
Tensile Testing (Grab)	ASTM D 7004
Tensile Testing (Multiaxial)	ASTM D 5617
Tensile Testing (Wide Width)	ASTM D 4885
Thickness (Smooth Membranes)	ASTM D 5199
Thickness (Core for Textured)	ASTM D 5994
Weathering (Accelerated by QUV)	ASTM D 7238
Weld Testing (Shear & Peel)	ASTM D 6392
UV Light Resistance (at 70 deg.C)	ASTM D 7238