CONDITION MONITORING AND LIFETIME ASSESSMENT OF EXISTING HDPE PIPELINES

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INTRODUCTION

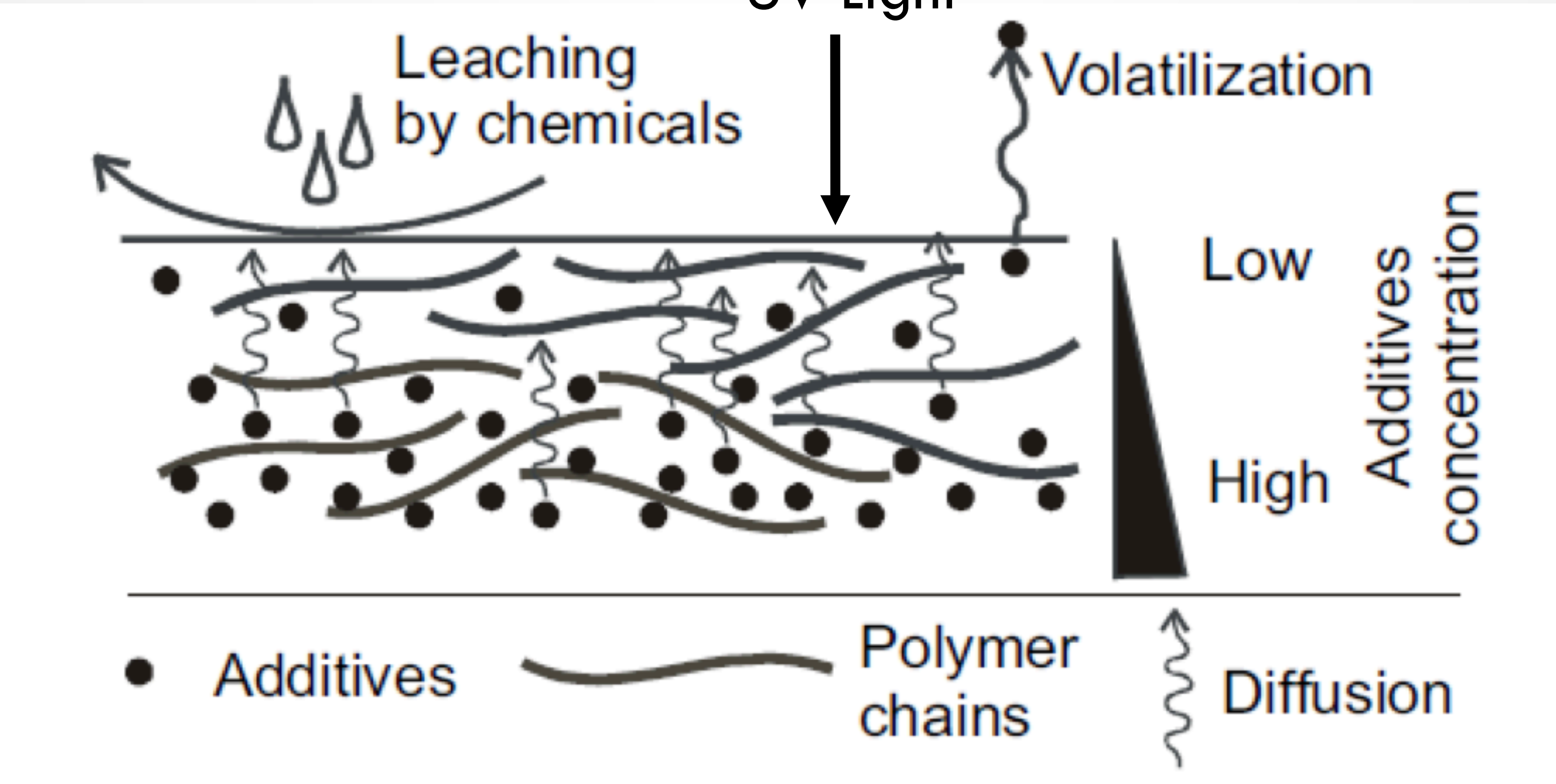
- EXCELPLAS LABS AUSTRALIA ARE EXPERTS IN THE CONDITIONING MONIORING (CM) AND CONDITION ASSESSMENT (CA) OF HDPE PIPES AND FITTINGS.
- HAVING OVER 20 YEARS EXPERIENCE IN TESTING AND ANALYSIS OF HDPE PIPELINES, EXCELPLAS LABS HAVE DEVELOPED AN ANALYTICAL TESTING PROTOCOL THAT CAN ACCURATELY DETERMINE THE CURRENT CONDITION AND ESTIMATED LIFETIME OF HDPE PIPELINES.

CONDITION MONITORING (CM) OF HDPE PIPELINES

- PROVIDES A ‘SHAPSHOT’ OF THE PRESENT CONDITION OF THE PIPES
- 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 FROM HDPE PIPES

UV Light



ANALYTICAL TESTING USED FOR CONDITION ASSESSMENT OF HDPE PIPES

- 1. OXIDATIVE INDICTION TIME (OIT) – TO TRACK LEVEL OF RESIDUAL ANTIOXIDANTS AND STABILIZERS
- 2. CARBONYL INDEX (CI) – TO TRACK LEVEL OF HDPE OXIDATION PRODUCTS
- 3. BEND-BACK TEST (BB) (UNDER 180 DEGREE STRAIN) – TO TRACK LOSS OF MECHANICAL PROPERTIES AND ONSET OF EMBRITTLEMENT
- 4. MELT FLOW RATE (MFR) – TO TRACK CHANGE IN MOLECULAR WEIGHT (MW) OF THE HDPE

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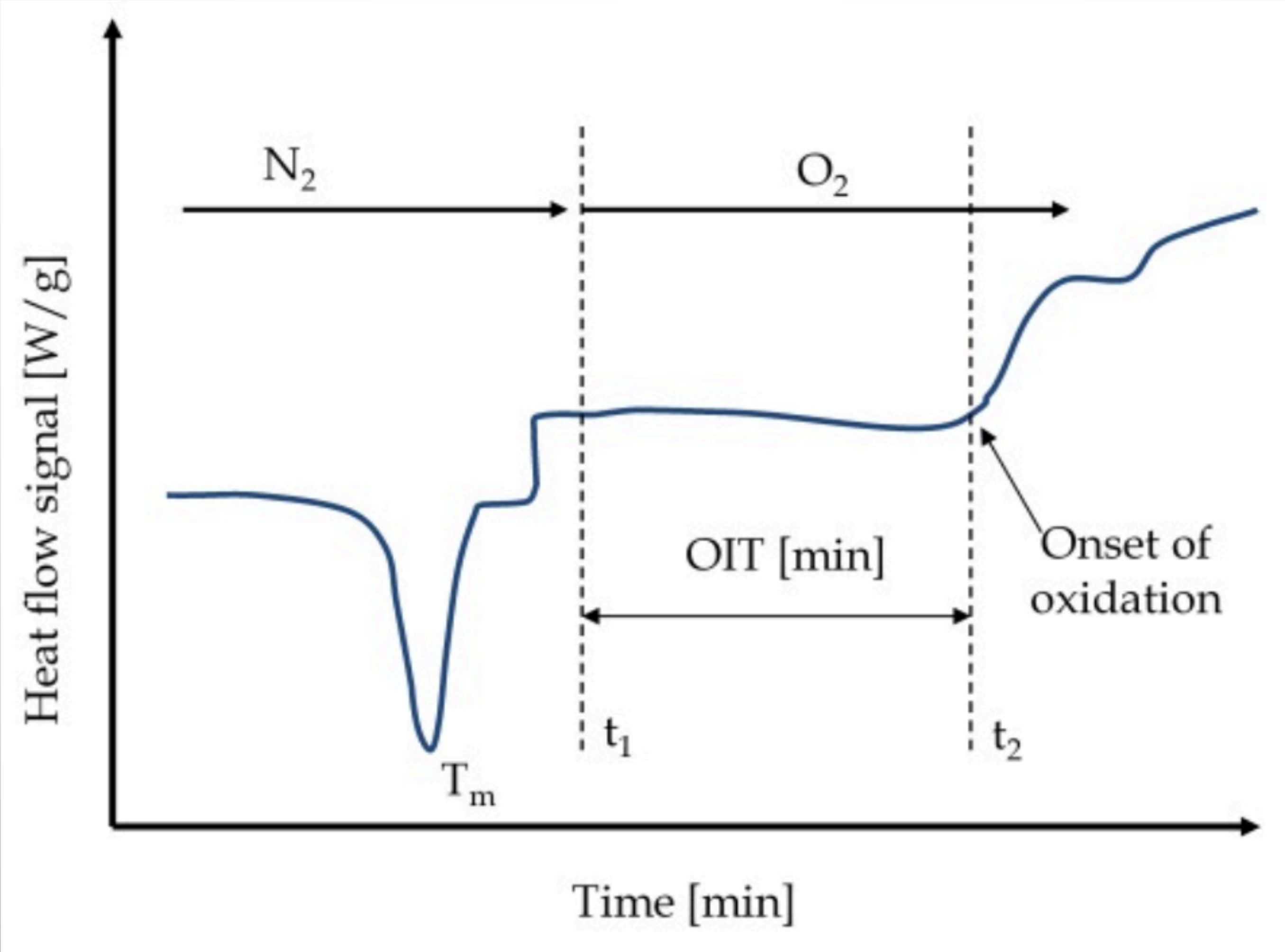
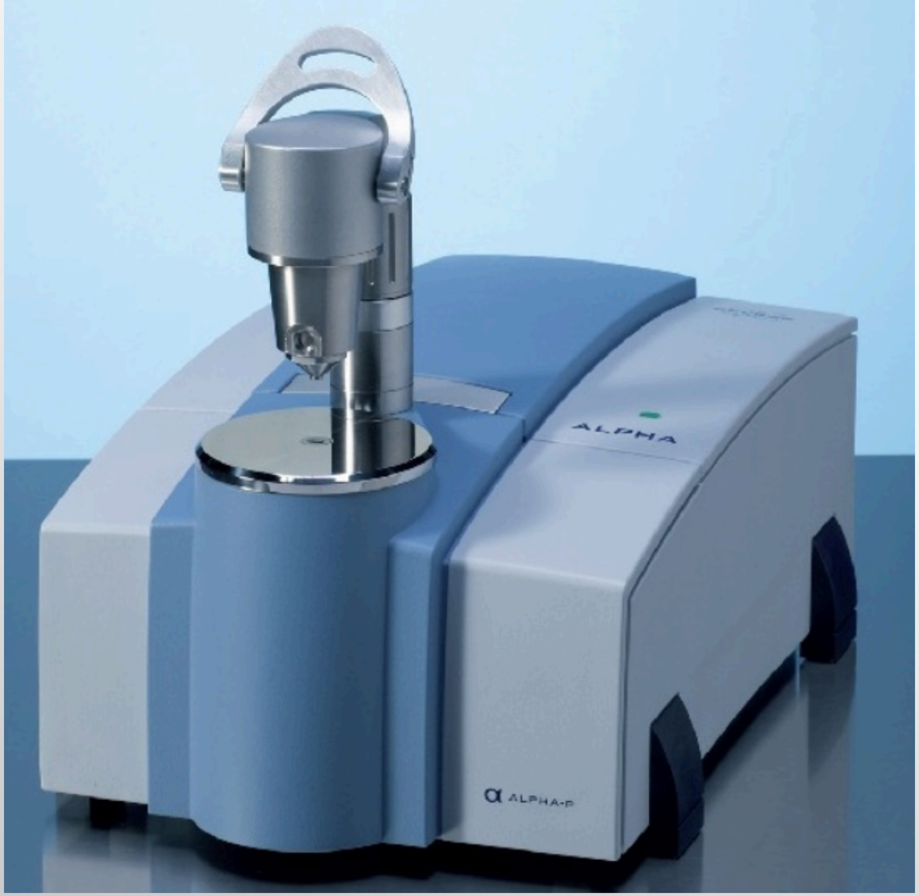
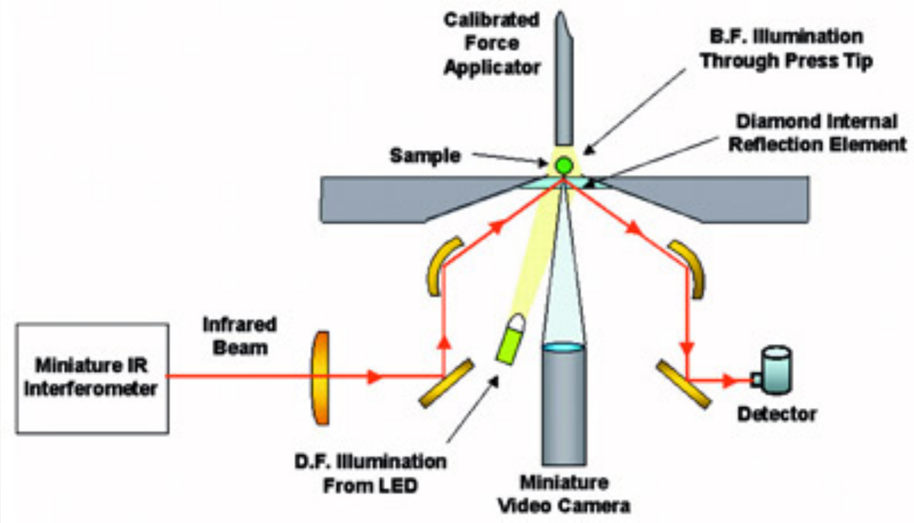
EQUIPMENT USED FOR OIT METHODS

TYPICAL OIT SCAN



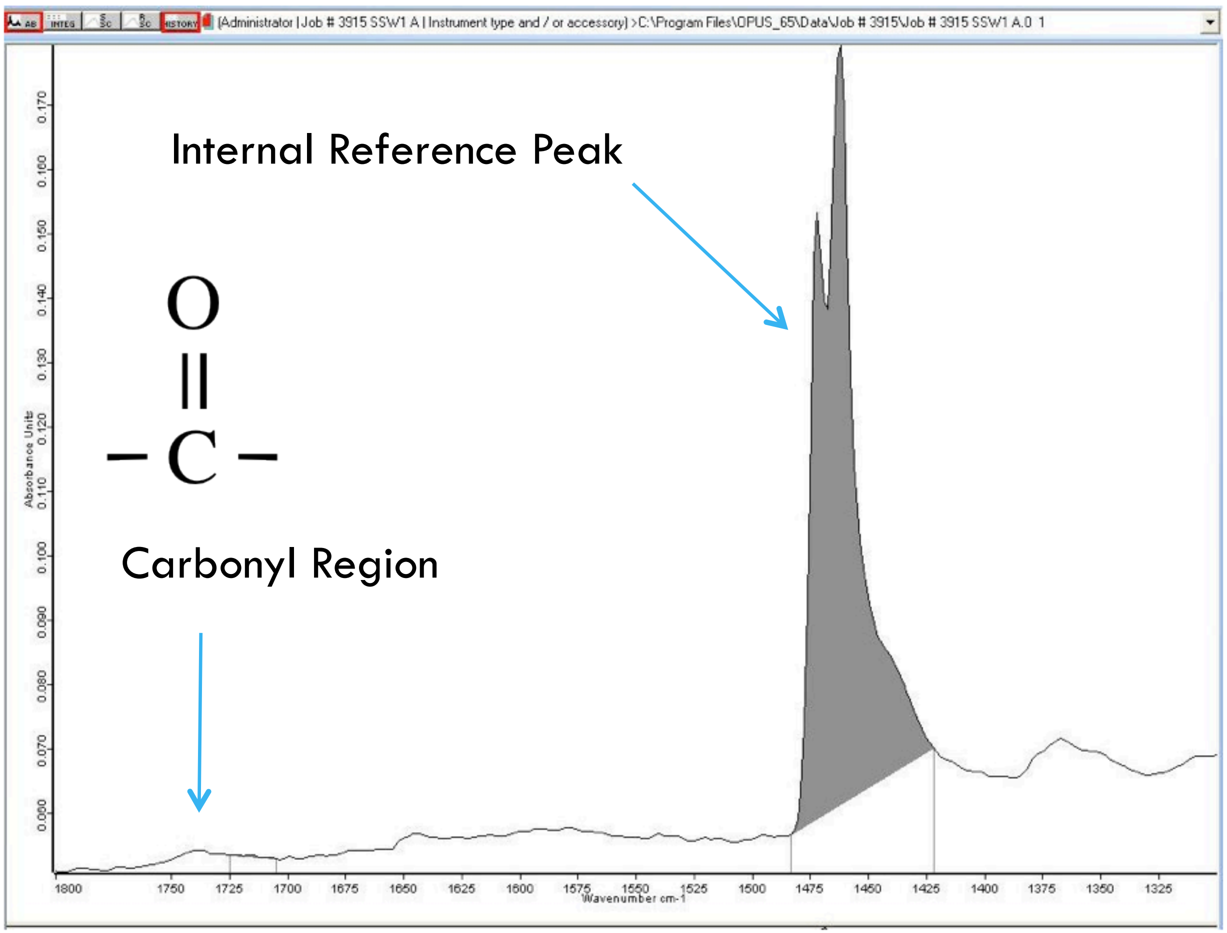
EQUIPMENT USED FOR CARBONYL INDEX





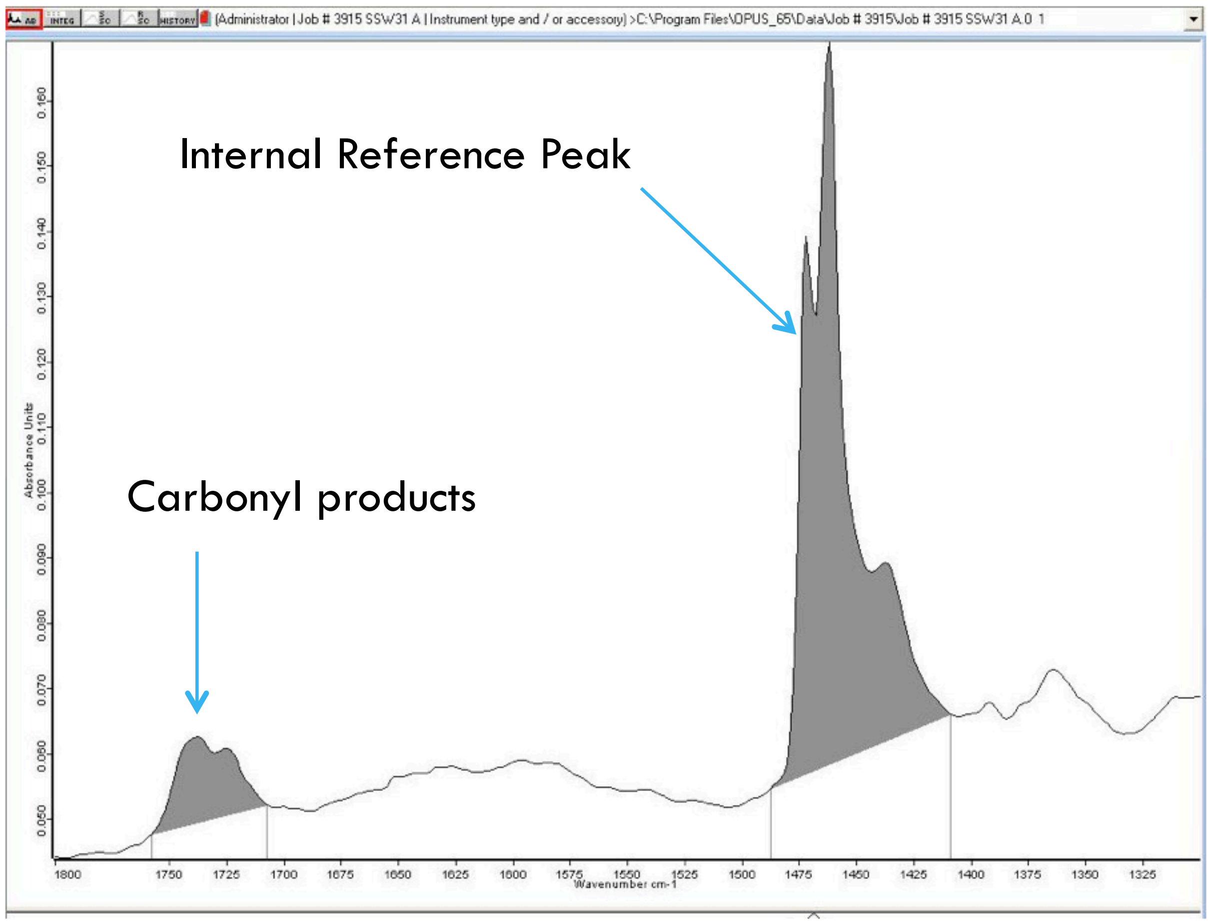
REFERENCE 1 - UNOXIDIZED HDPE

Carbonyl Index = 0.003 / 2.426 = 0.001



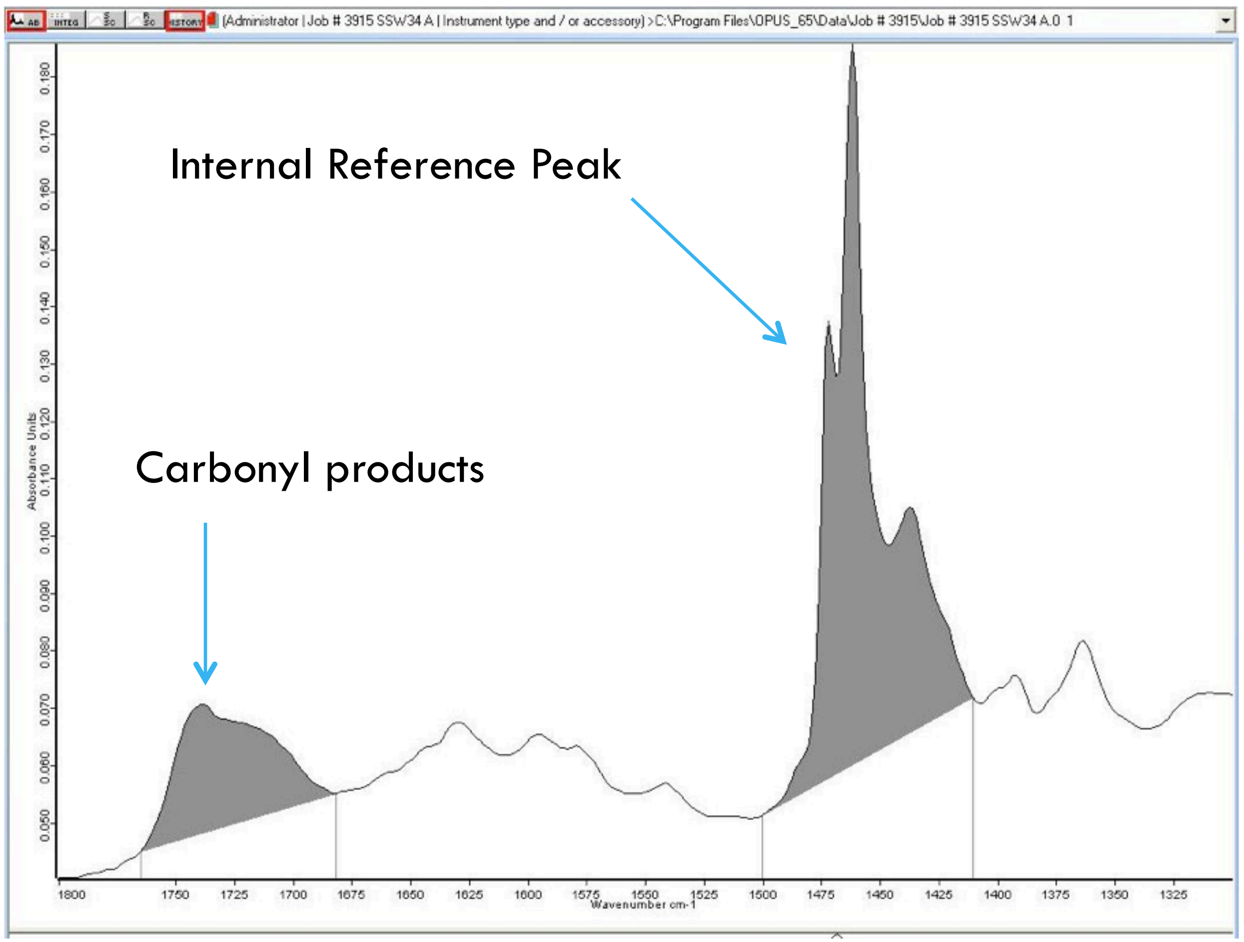
REFERENCE 2 - MODERATELY OXIDIZED

Carbonyl Index = 0.377 / 2.597 = 0.145

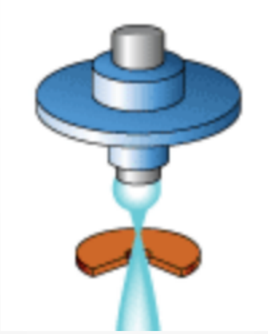


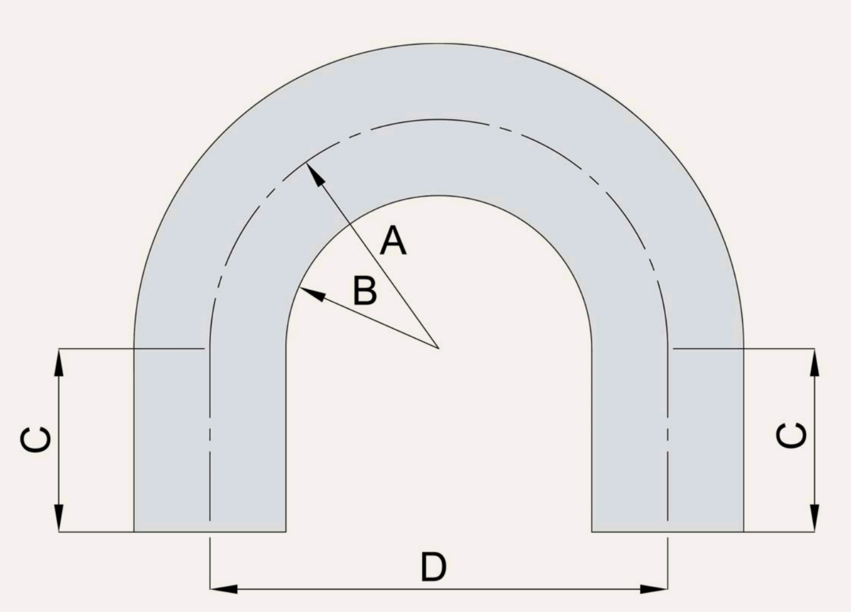
REFERENCE 3 - SEVERELY OXIDIZED HDPE

Carbonyl Index = 0.999 / 3.087 = 0.324

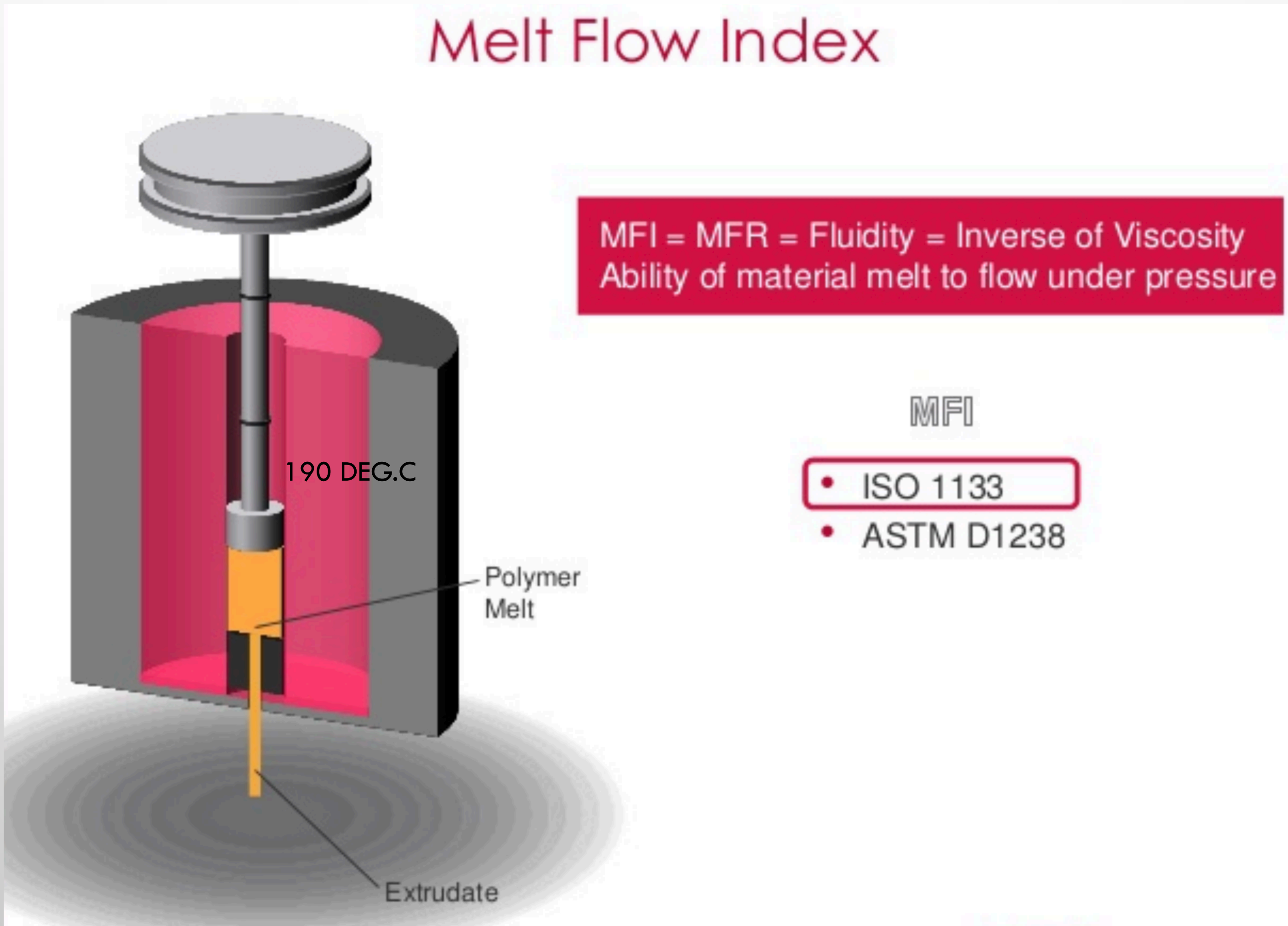


BEND BACK TEST AND SCANNING ELECTRON MICROSCOPY (SEM)

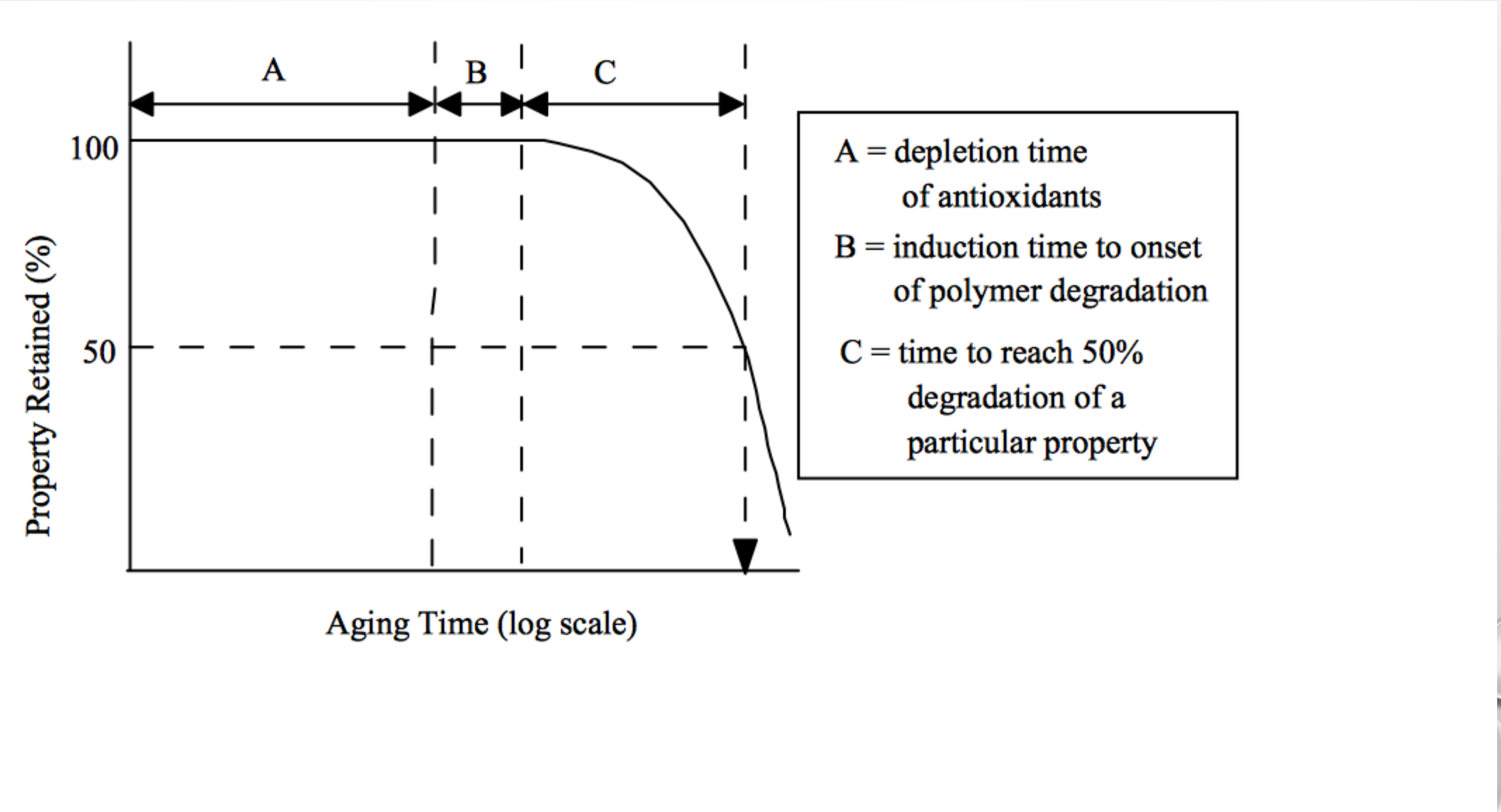




EQUIPMENT USED FOR MELT FLOW RATE



CONCEPTUAL SERVICE LIFE OF HDPE PIPES



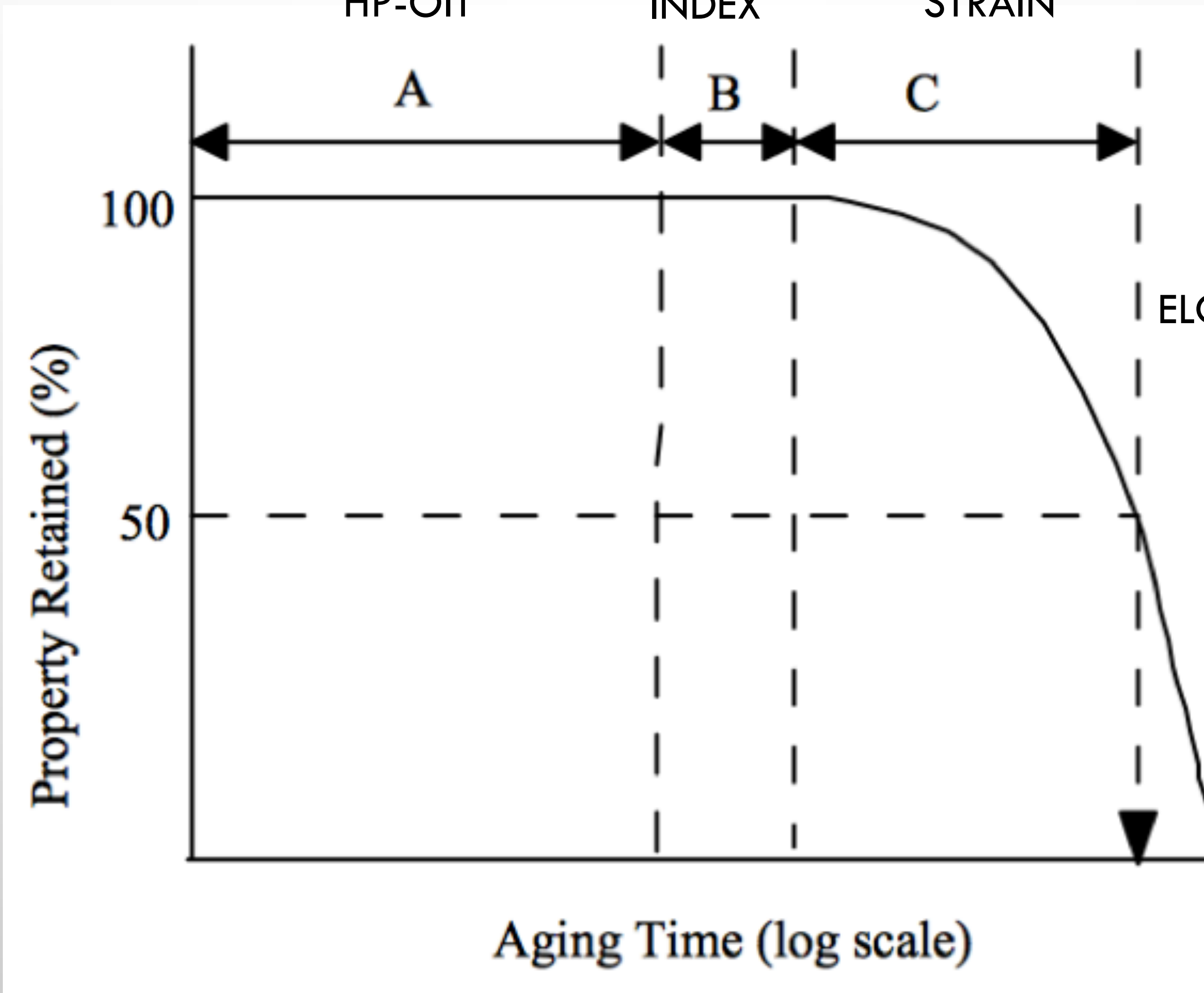
LIFETIME CURVE FOR POLYOLEFINS

S-OIT
HP-OIT

CARBONYL
INDEX

180 DEGREE
STRAIN

MELT FLOW
INDEX

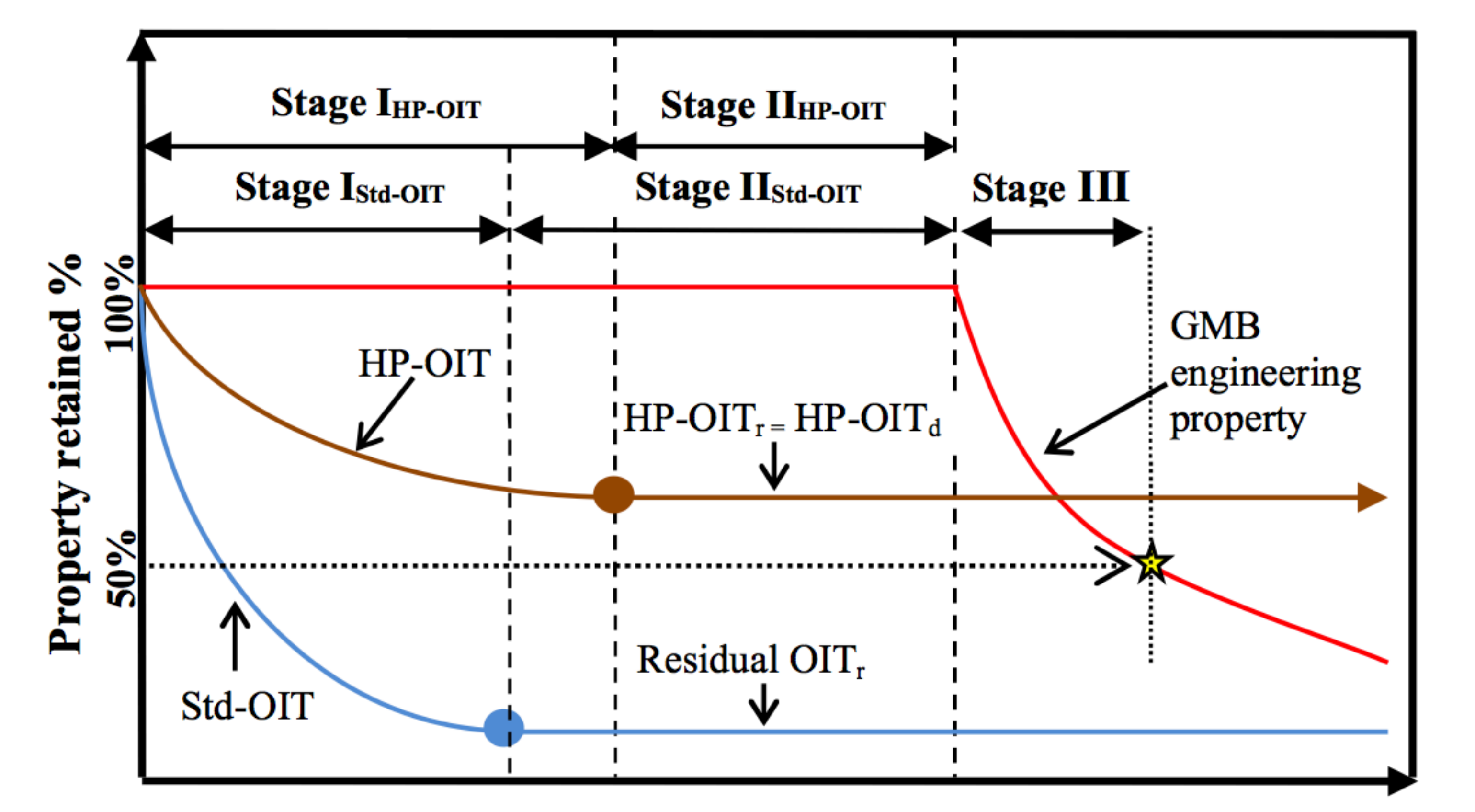


%
ELONGATION

WHERE IS THE HDPE PIPE 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.

EFFECT OF S-OIT AND HP-OIT LEVELS ON HDPE 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 PIPE MATERIAL REACHED ITS ‘END OF LIFE’?

RANKING LEVEL OF DEGRADATION

New methodology for ranking the level of degradation

Degradation

- Very HIGH
- HIGH
- MODERATE
- LOW
- NONE

based on 4 tests

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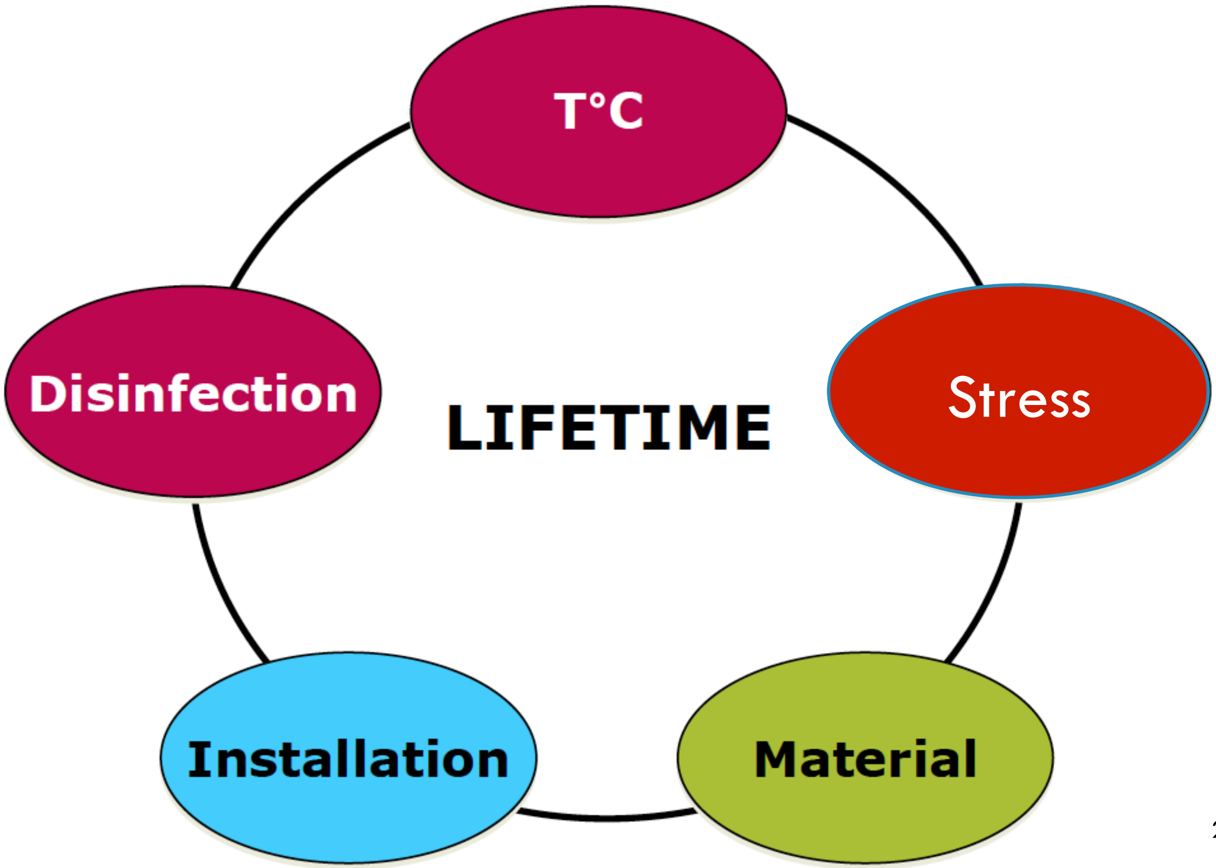
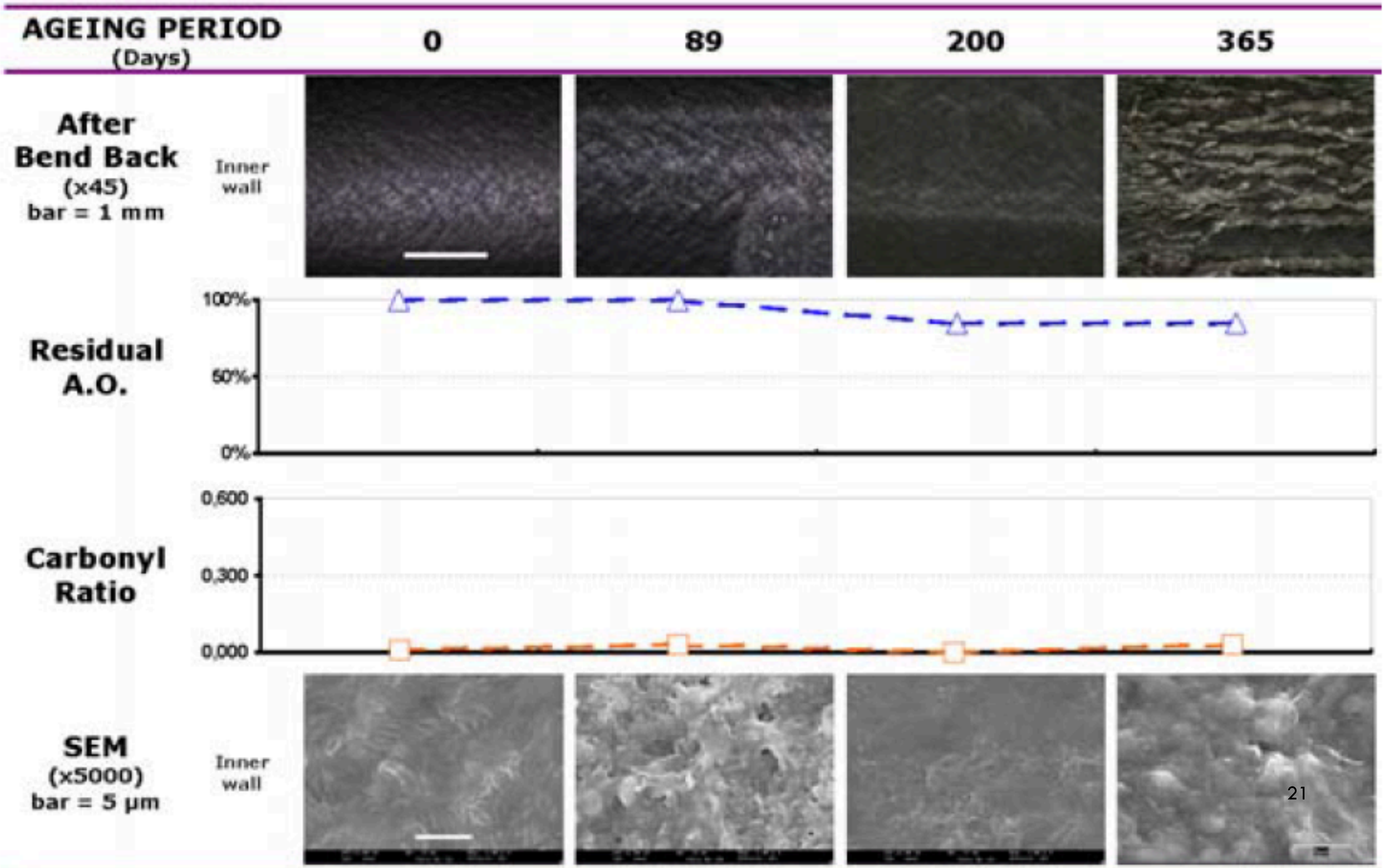
5 risk factors identified

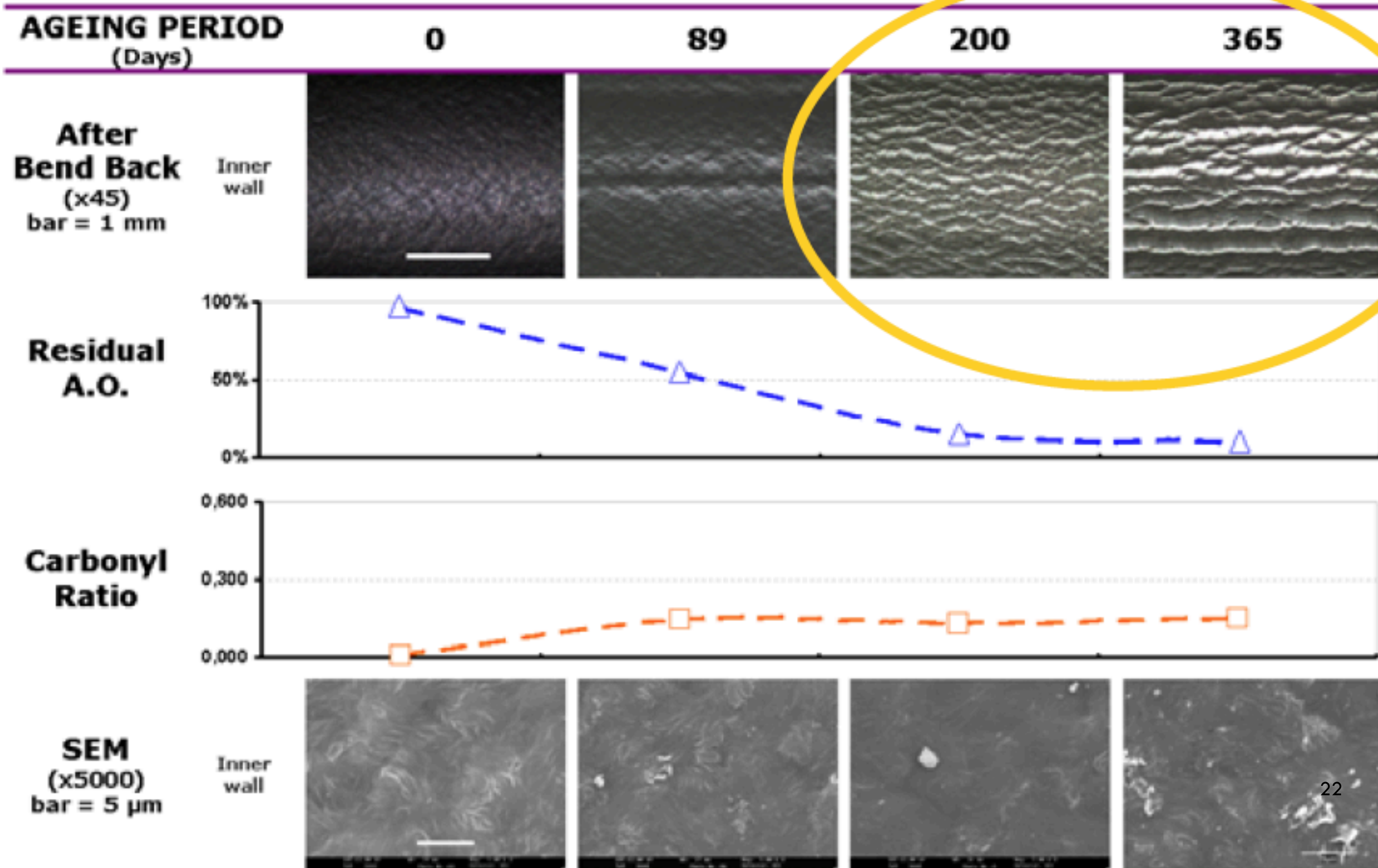
WATER TREATMENT



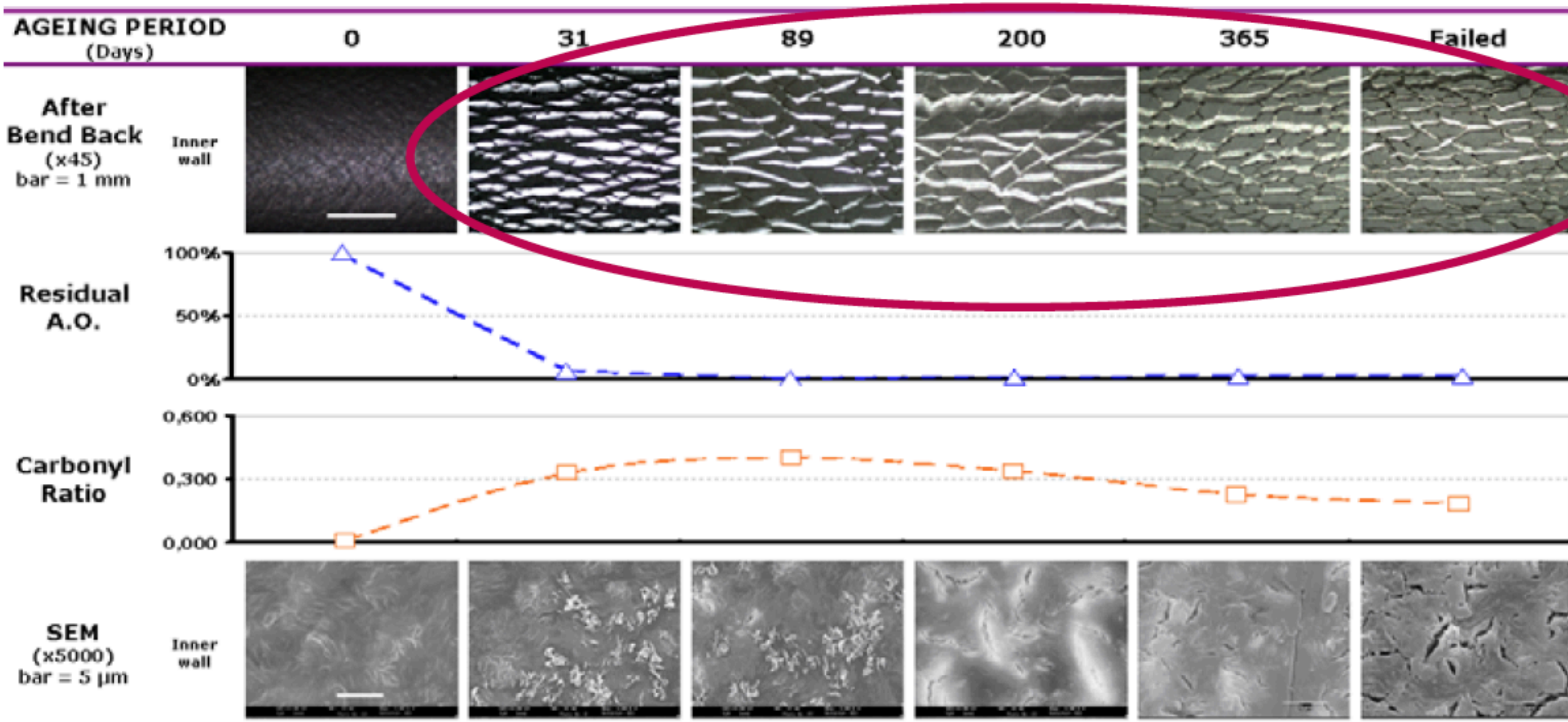
Without disinfectant



With chlorine



With chorine dioxide



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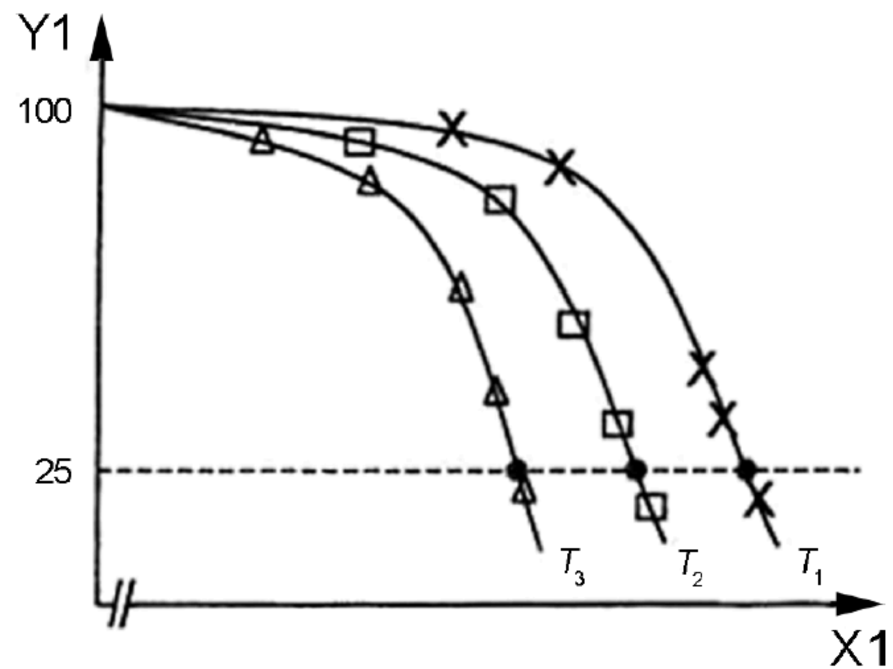
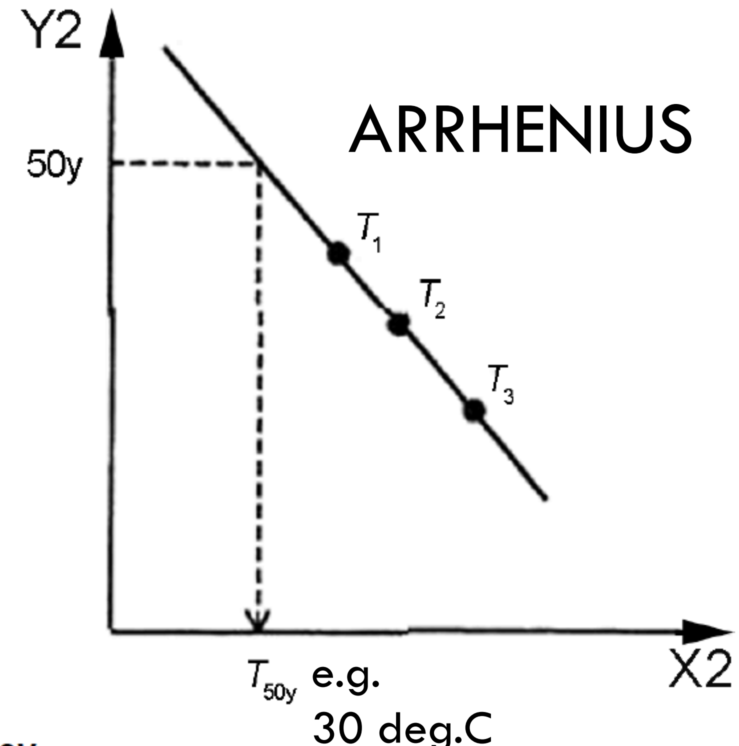
LIFETIME ASSESSMENT (REL)

- RESIDUAL ESTIMATED LIFETIME IS IMPORTANT SO FACILITY OWNERS CAN TRACK PERFORMANCE OF THEIR HDPE PIPELINES AND PLAN FOR MAINTENANCE & REPLACEMENT.
- EPA IMPLICATIONS FOR CRITICAL CONTAINMENT
- ’EARLY WARNING’ OF FAILURE

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

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

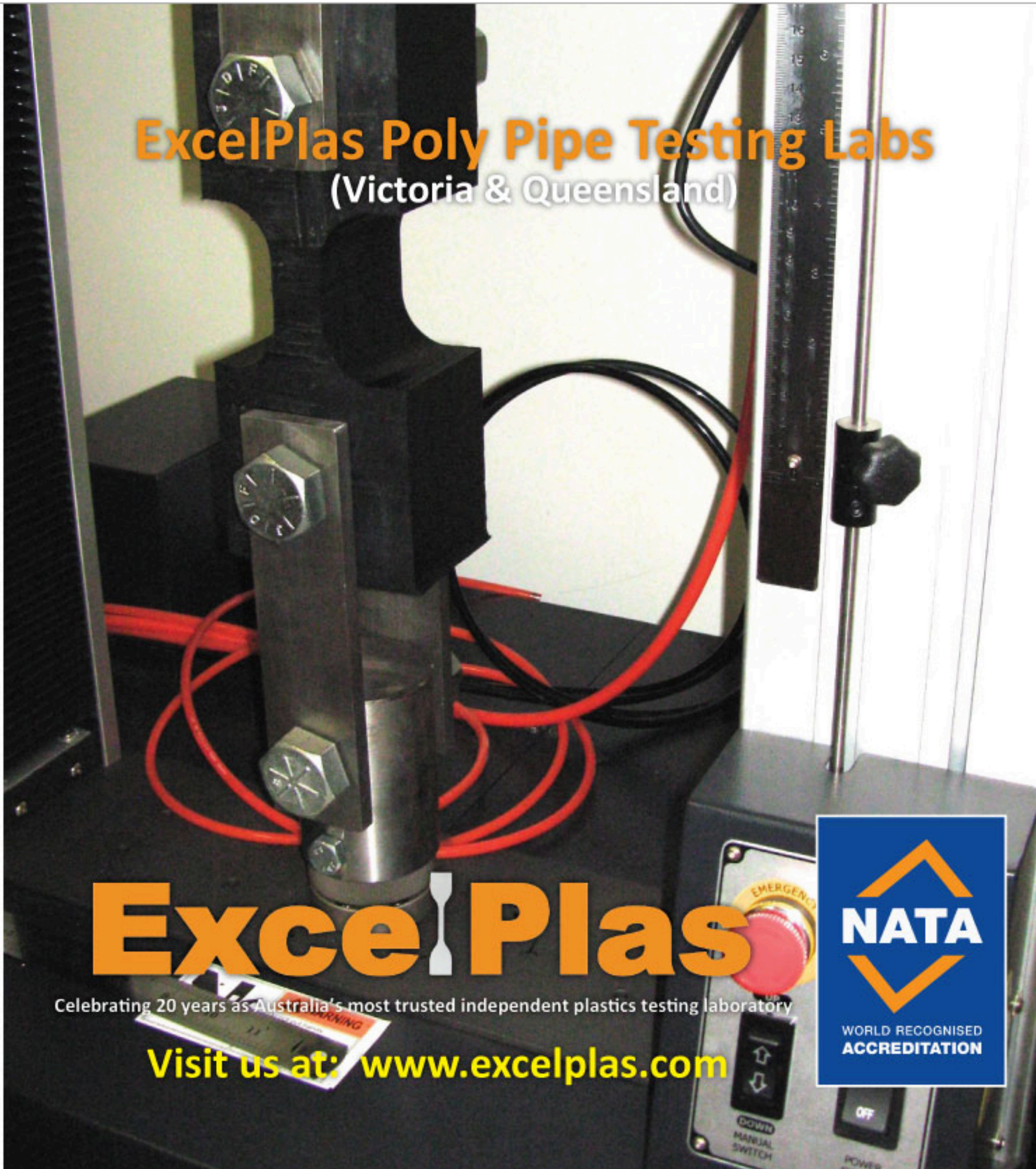
X_2 $1/T$ (T in °C)

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

V2



POLY PIPE TESTING METHODS

Analysis of Weld Contaminants by TOF-SIMS	ASTM E2695
Carbon Black Content of PE Pipes	ASTM D4218
Carbon Black Dispersion of PE Pipes	ASTM D5596
Carbonyl Index of Polyolefin Pipes	ASTM F2102
Crush Testing of Plastic Pipes	ISO 13955
Decohesion Testing of Saddle Fusion Joints	ISO 13956
Degree of Crosslinking of PEX Pipe	AS 2492 (ISO 10147)
Degree of Fusion of PVC Pipes by DSC	ISO18393-2
Degree of Pigment Dispersion incl Carbon	AS 1462.28
Density of Pipe Compounds	ASTM D792
Dimensions of Plastic Pipes and Fittings	AS 1462.1
Environmental Stress Cracking Resistance	ASTM D5397
Evaluating the Extent of Oxidation of PP-R pipes	ASTM F2102
Melt Flow Rate (MFR) of PE and PP	ASTM D1238 (ISO 1133)
Metal Deactivator Efficiency in Cu Pan by OIT	ASTM D3895
Oxidative Induction Time of PE and PP-R Pipes	ASTM D3895
Peel Decohesion of Electrofusion Assemblies	ISO 13954
Pipe Stiffness Testing	AS1462.22
Reversion of Plastic Pipes	AS 1462.4
Ring Flexibility Testing	AS1462.23
Tensile Strength of Butt-Fused Joints (welds)	ISO 13953
Tensile Testing of PE Pipe Compounds	ASTM D638 (ISO 6259)
Testing PE Butt Fusion Joints using Tensile-Impact	ASTM F2634
Testing PE Pipe Butt Fusions Using Tensile Testing	ASTM F2928