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COMBINED LOADING OF BURIED THERMOPLASTICS PRESSURE PIPES

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Introduction

EN805 “Water supply-Requirements for systems and components outside buildings”

demands product standards to

“State the relationship between product pressure classification (PN) and Operational pressure (PFA)”

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Introduction

Proposed approach with thermoplastics (see also EN1401)

$$PFA = fa * ft * PN$$

PN = Pressure rating of product
ft = Temperature rating factor
fa = Application rating factor

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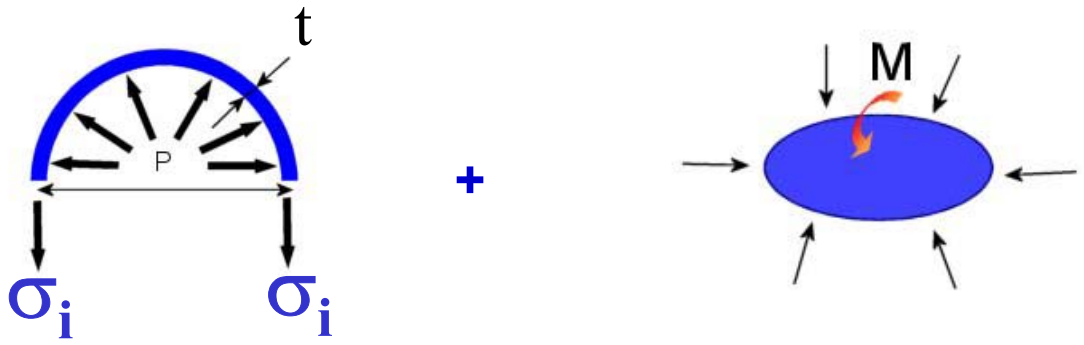
Introduction: Traditional (materials) design

Stress = Stress from internal pressure + Stress from external load



(MRS / C =) **HDS = PFA / 2 * (SDR-1) + ? M / W**

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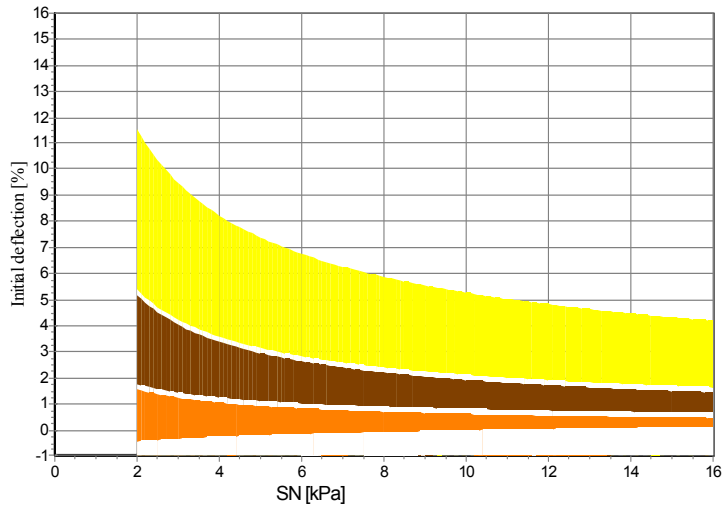
Approach

Loading condition:
- depth
- soil
- traffic
- SN
- Installation

(δ/d) + internal pressure (P)

PFA = fa * PN



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CEN TC164/165 JWG1 TG2

"defined 9 loading conditions to which to refer to in the product standard"

Case	fa
1	1
2	0.9 ? etc
3	..
4	..
5	..
6	..
7	..
8	..
9	..

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Possible approaches

Analytical / numerical analysis

geometrical modeling

material modeling

creep

relaxation

Experimental analysis

test methods delivering

similar to practice

situations.

Deflected pipe test

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Deflected pipe test

1. Pipe deformed to x% deflection
Stress relaxation starts

2. Internal pressure applied
Sustained load = creep

3. Measure the time to failure

4. Ratio=Failure time_x%/ failure time_0%

$$\varepsilon = 4.28 * (\delta/d) * (s/d)$$

$$\sigma(t) = [E/(1-\nu^2)] * \varepsilon * t^{(-m)}$$

$$\sigma_{crown} = P\,(d-\delta-2s)/(2*s)$$

$$\sigma_{springline} = P\,(d+\delta-2s)/(2*s)$$

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Deflected pipe test: Test program

Material	*Stress*	*Temperature*	*Deflections*
PE100	12.5	20	0 & 8
PE80 standard	5.9	80	0 & 5 & 10
PE80 type 1	4.5	80	0 & 5 & 10
PE80 type 2	4.0	80	0 & 5 & 10
PVCO	26.0	60	0 & 5 & 10

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Deflected pipe test: Test program

Material	*(δ/d) [%]*	*Ratio t_(δ/d) / t_(0)*	*Failure type*
PE100	**8**	**1.83**	**ductile**
PE80 standard	**5**	**616**	**ductile**
	10	**647**	**ductile**
PE80 type 1	**5**	**1.05**	**brittle**
	10	**1.07**	**brittle**
PE80 type 2	**12.5**	**1.14**	**brittle**
PVCO	**5**	**4.14**	**ductile**
	10	**8.73**	**ductile**

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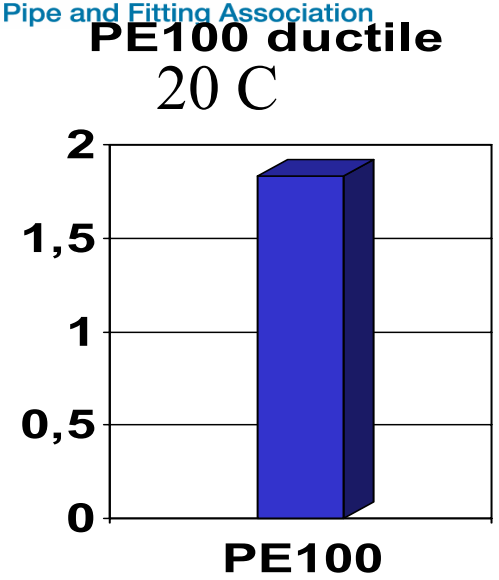
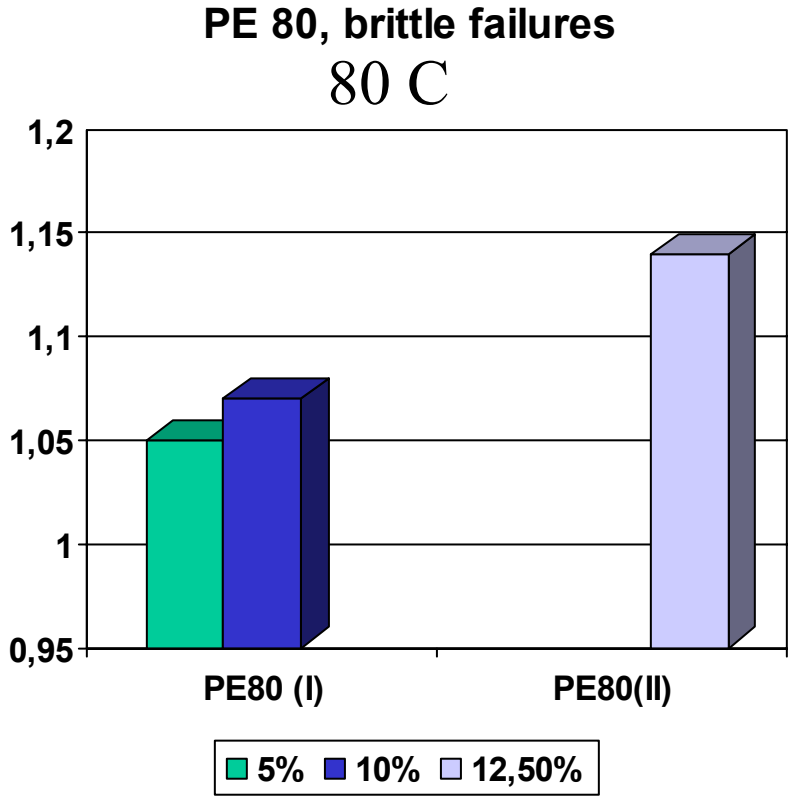
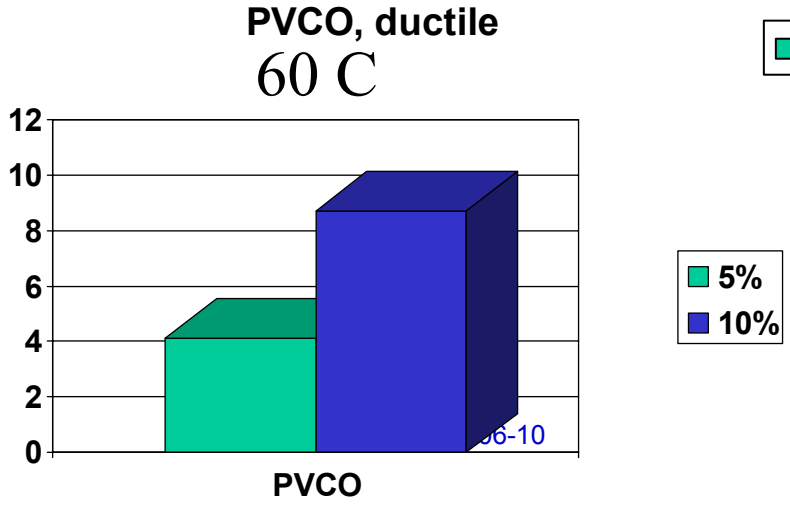
Results deflected pipe test. Value below 1 then effect; value=1 then no effect; value>1 then positive effect







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Concluding remarks deflected pipe tests

Pipes failing in a ductile manner profit from combined loading

Pipes failing in a brittle manner are not affected by combined loading

The free creep condition (as with material classification) is the worst condition

In an actual buried situation this condition refers to pipes installed in weak soils like peat.

Hence:

PFA = PN = 2*HDS / (SDR-1)

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Combined loading

‘Bicycle’ test

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Combined loading by axial bending

Prof. Wintergerst (1973)

Axial bending

Ring deflection

+

Internal pressure

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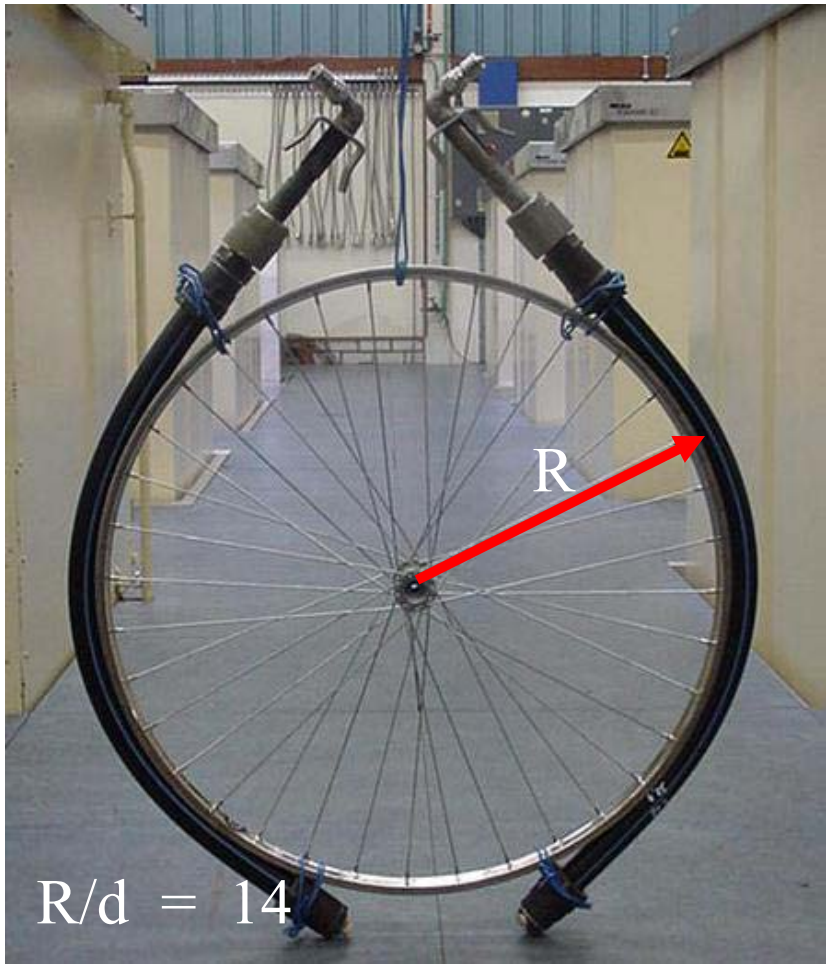
Bicycle test



Note:Test allows re-rounding

1. Pipe bend to fixed radius
   Stress relaxation starts

2. Internal pressure applied
   Sustained load = creep

3. Measure the time to failure

$$(\delta/d) = 1/16 * (d/s)^2*(D/R)^2*(1-v^2)$$

$$\varepsilon_o = 3 * (\delta/d) * (s/d)$$

$$\varepsilon_{ax} = (D-((\delta/d)*d)/2)) / (2*R)$$

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Bicycle test program

Material	R/d	Temperature	Stress [MPa]
PVC	14	20	32.2 - 39.1
PE80	11	20	9.6-13.6
	11	80	3.94 - 4.6

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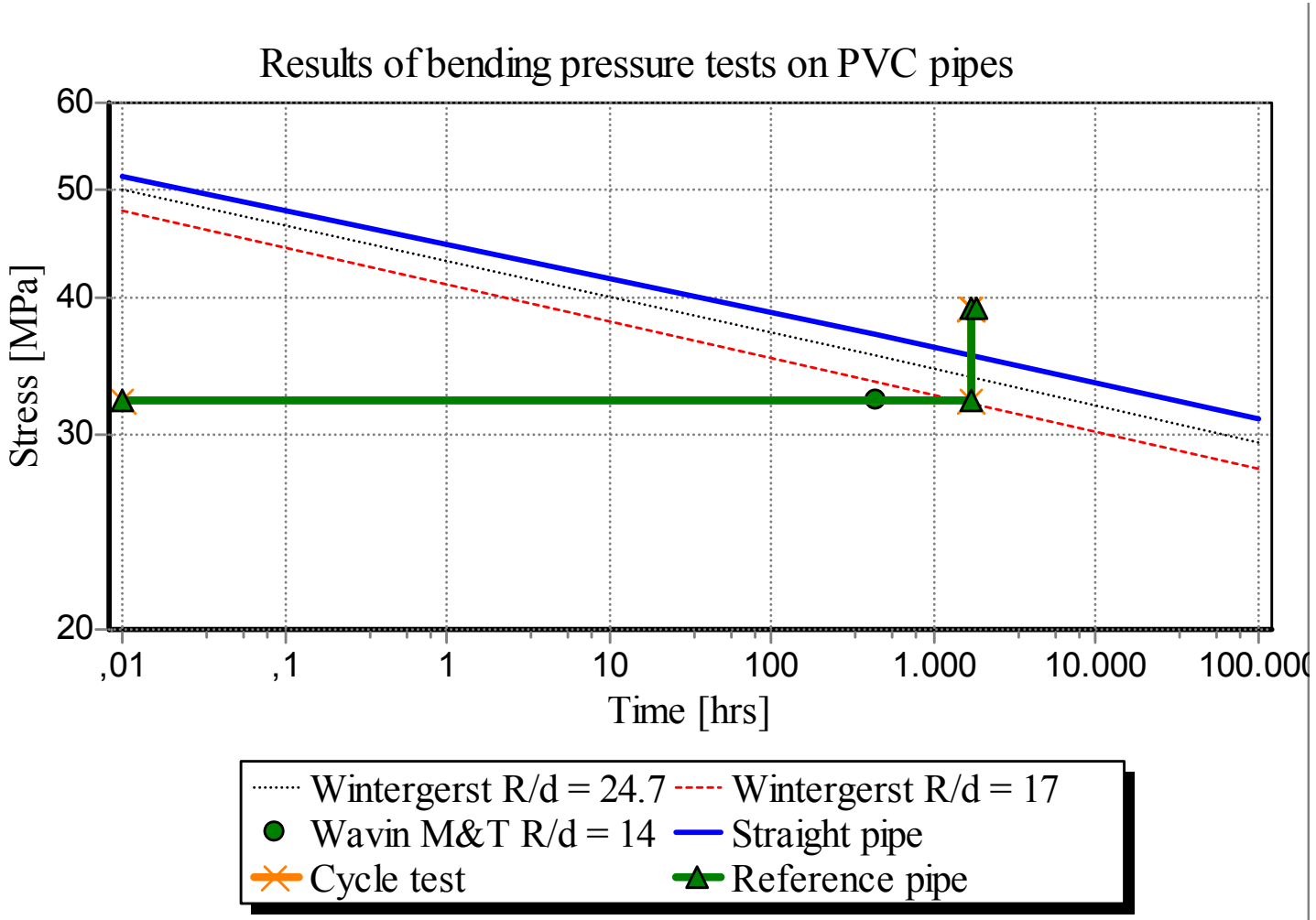
Results PVC, 20 C



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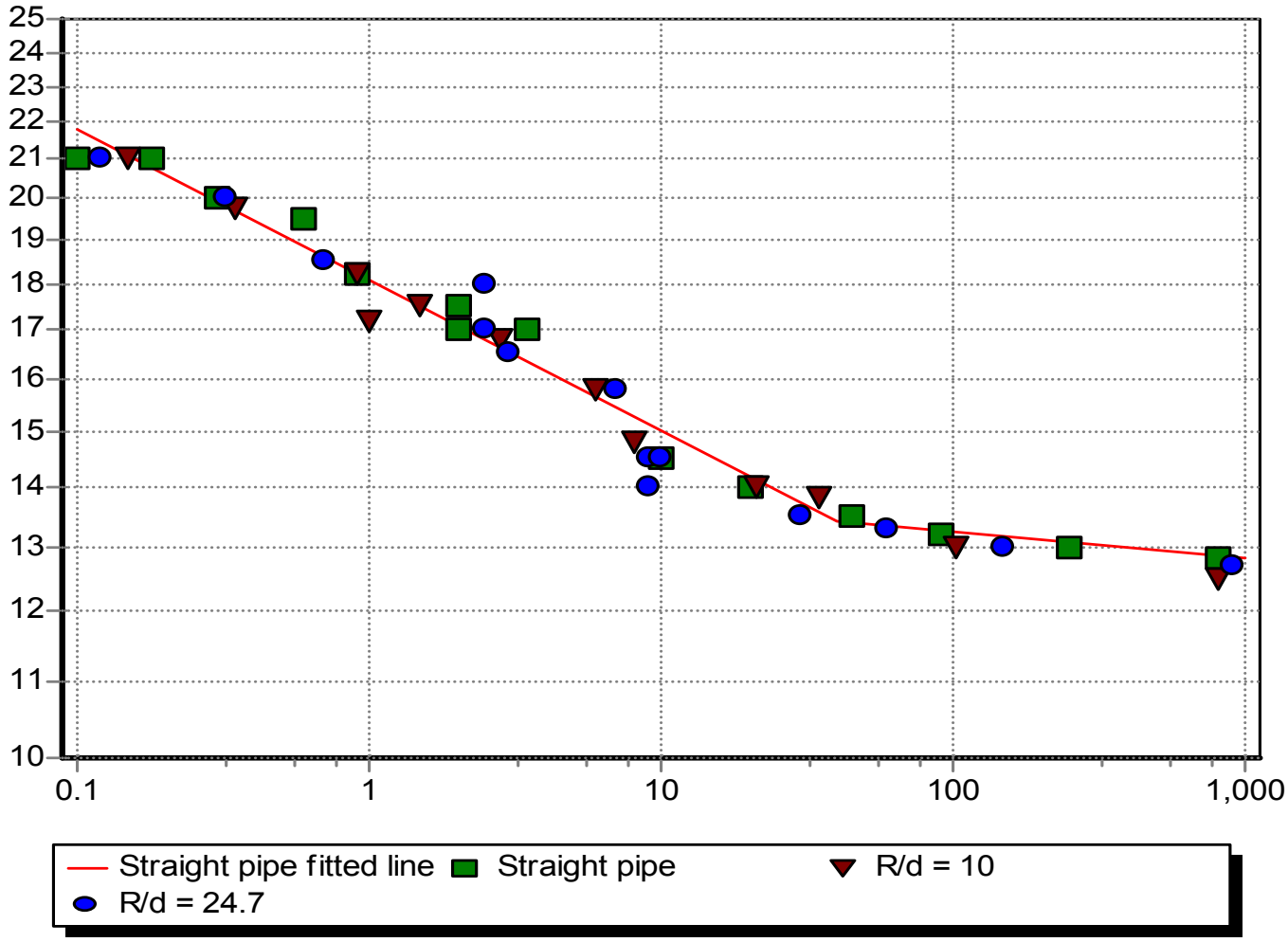
Results Wintergerst



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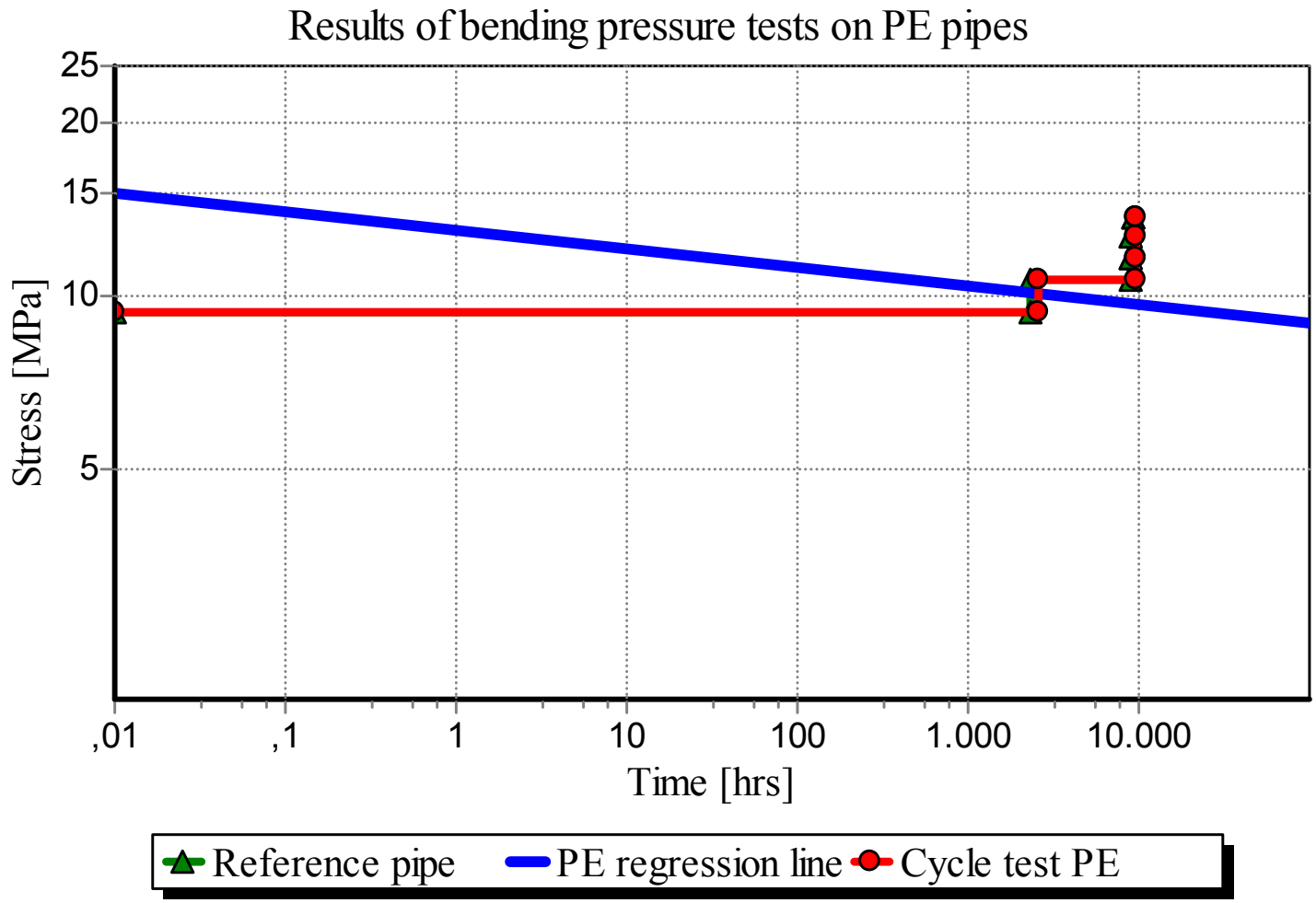
Results PE at 20 ºC, ductile failures



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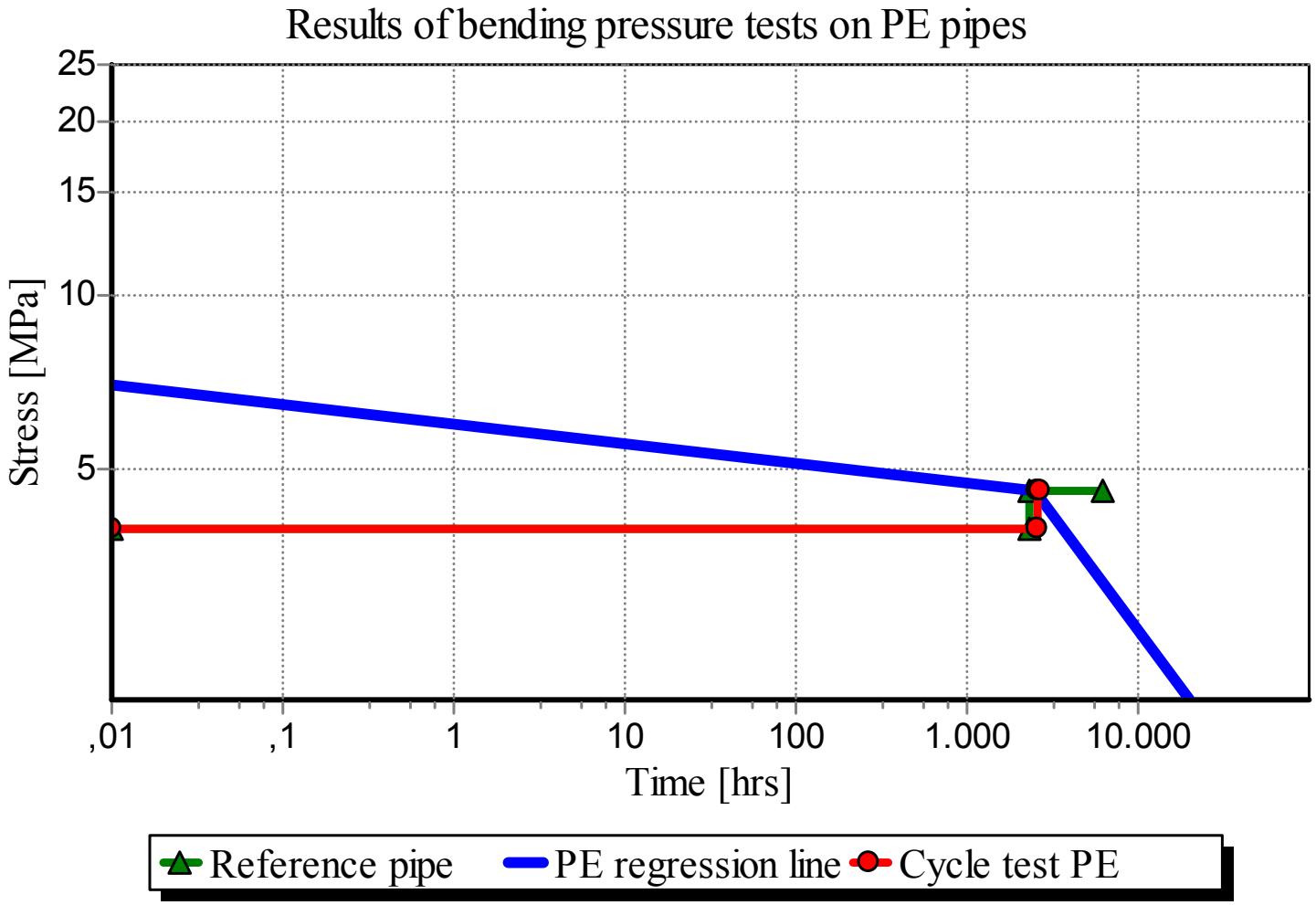
Results PE 80 ºC , brittle failures



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Overall conclusions

PFA = fa * ft * PN

ft = material dependent, but only an issue when T> 20 ºC

fa = 1 under condition that:

$(\delta/d) < 12.5\ \%$

Bending radii

R > 50*d

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TEPFFA

The European Thermoplastics Pipes and Fitting Association

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CEN TC155 AHG40

“Design related material properties”