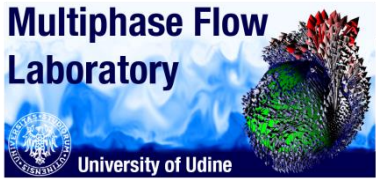
Università degli Studi di Udine

DIEGM: Dipartimento di Ingegneria Elettrica, Gestionale e Meccanica



Pressure loss evaluation in polymer and fibres laden flows

Update on Test Case

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cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

8th Joint MC/WG Meeting
Caen, October 22nd-24th 2014

Motivation

Develop a collaborative benchmark to perform pressure loss evaluation on polymer and fibre laden flows in different flow conditions (pipe dimensions, pipe material, flow regimes, pumping equipment,…)

Pulp and paper industry

VTT

TAMPERE UNIVERSITY OF TECHNOLOGY

UNIVERSIDADE DE COIMBRA

UCDAVIS UNIVERSITY OF CALIFORNIA

UBC

INNVENTIA

Fluid transport

Test cases

Polyox (PEO)

- PEO WSR 301, $M_w=4\cdot10^6$ g/mole
- PEO WSR 308, $M_w=8\cdot10^6$ g/mole

Effect of molecular weight

Polyamide fibres

- Dtex 0.9 L/D=120 (D_f=10 µm, L_f=1.2 mm)
- Dtex 3.3 L/D=16 (D_f=20 µm, L_f=0.32 mm)
- Dtex 3.3 L/D=120 (D_f=20 µm, L_f=2.4 mm)

Effect of diameter at constant L/D, effect of L/D at constant diameter

Dtex: density per unit length

Test cases

Optional Test: on POLYOX 301	UNIUD	TUT/MEIFRG	VTT	UBC	UCDavis	CIEPQPF-UC
C=0.00025% (2,5 ppm)						
C=0,00075% (7,5 ppm)						
C=0,0020% (20 ppm)						

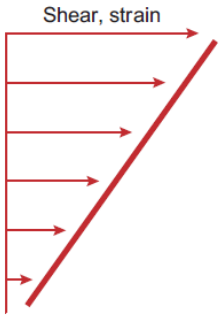
Optional Test: on POLYOX 308	UNIUD	TUT/MEIFRG	VTT	UBC	UCDavis	CIEPQPF-UC
C=0.0001% (1 ppm)						
C=0,0005% (5 ppm)						
C=0,0010% (10 ppm)						

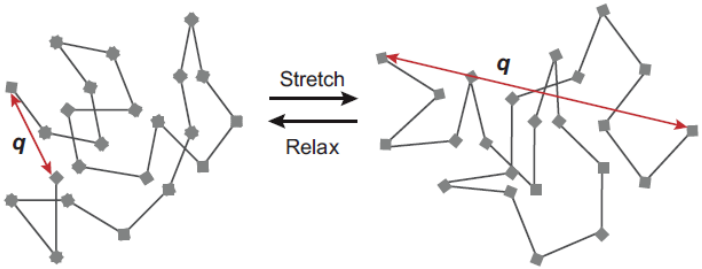
Optional Test: on POLYOX 308	UNIUD	TUT/MEIFRG	VTT	UBC	UCDavis	CIEPQPF-UC
C=0.0002% (2 ppm)						
C=0,0015% (15 ppm)						
C=0,0020% (20 ppm)						

Participating
Non Participating

UNIUD	TUT	VTT	UC
100 mm	20 mm	16 mm	100 mm

Polymer drag reduction mechanism



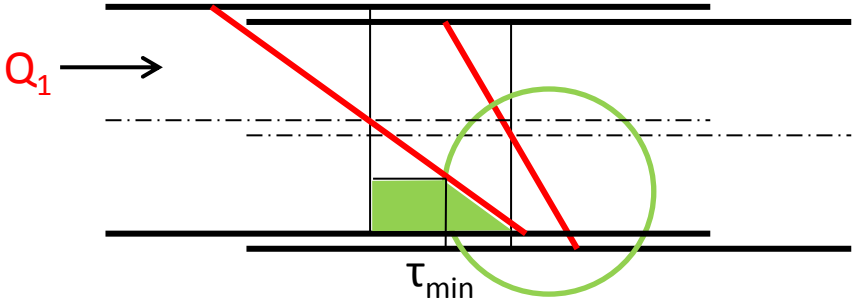


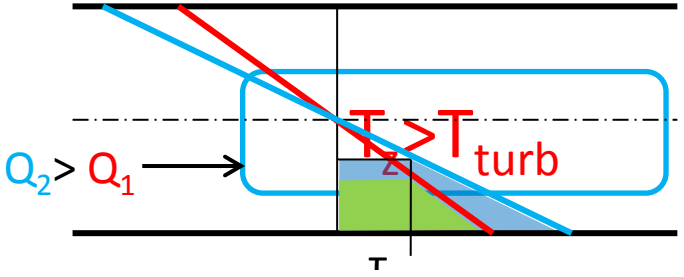
Coiled configuration

Stretched configuration

Minimum level of shear stress

Polymer relaxation time: T_z





Weissenberg number

Stress nc
not hom

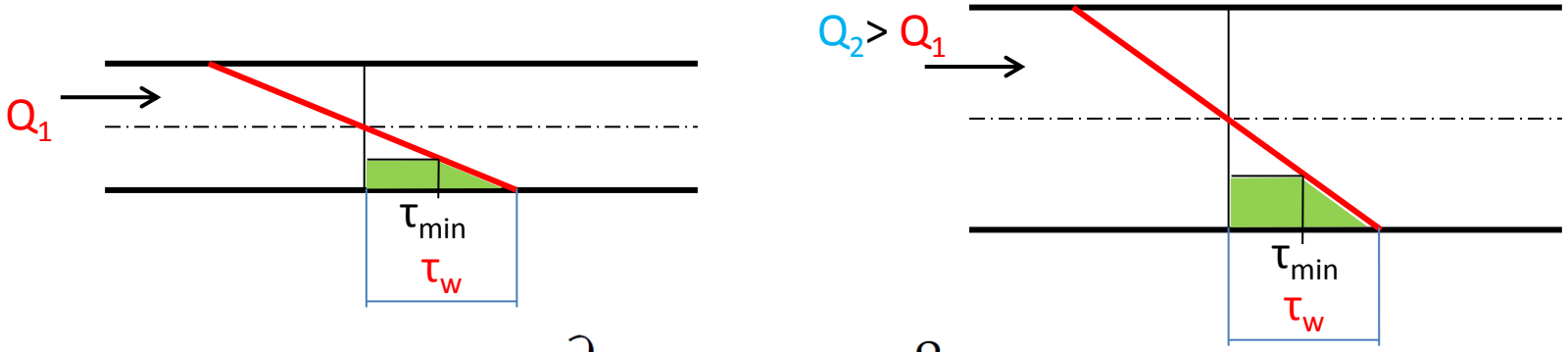
Limiting Drag Reduction LDR=f

Maximum Drag Reduction

$$We_\tau = \frac{T_z}{T_{turb}} = \frac{T_z \nu_0}{u_\tau^2} > 1$$

Drag Reduction mechanism

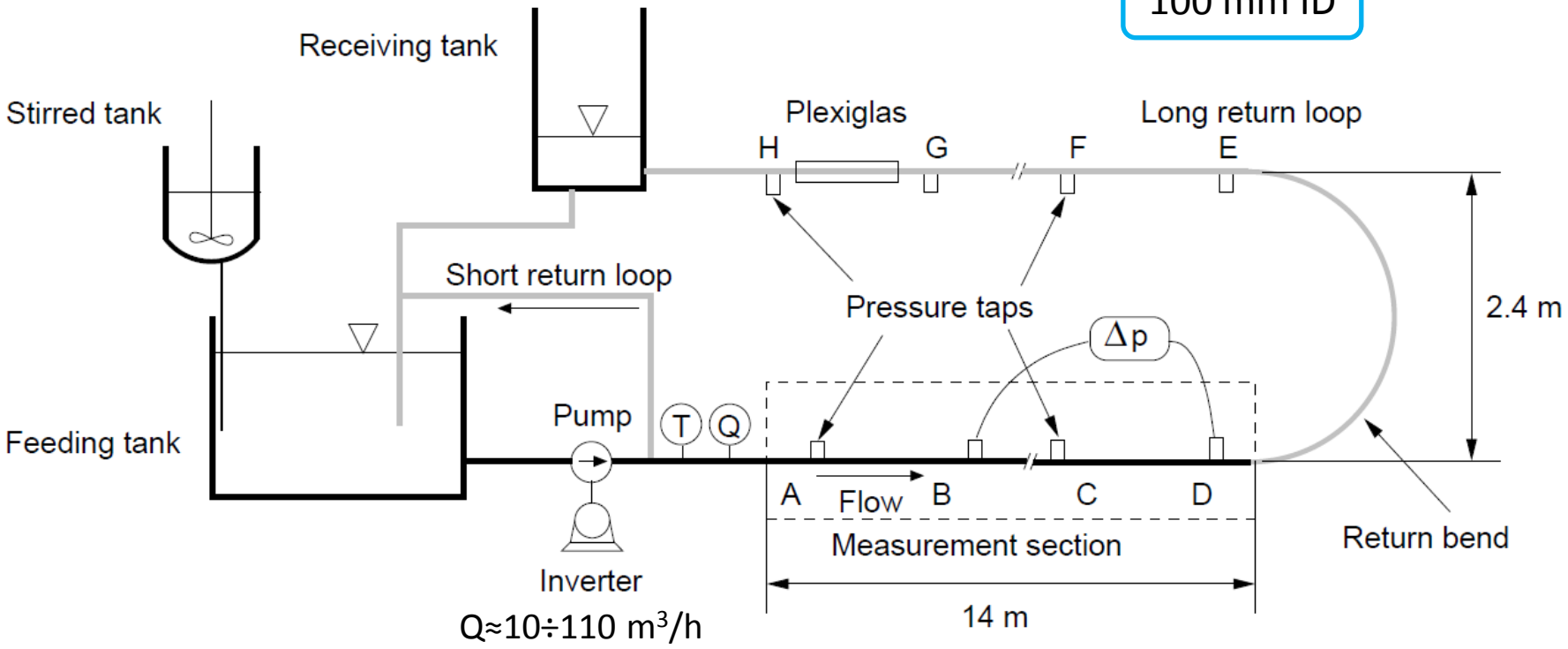
Diameter effect



$$\tau_w = \mu \frac{\partial u}{\partial y} = \mu \dot{\gamma} = \mu \frac{8u}{D} = cost$$

Experimental rig

100 mm ID



Q≈10÷110 m^3/h

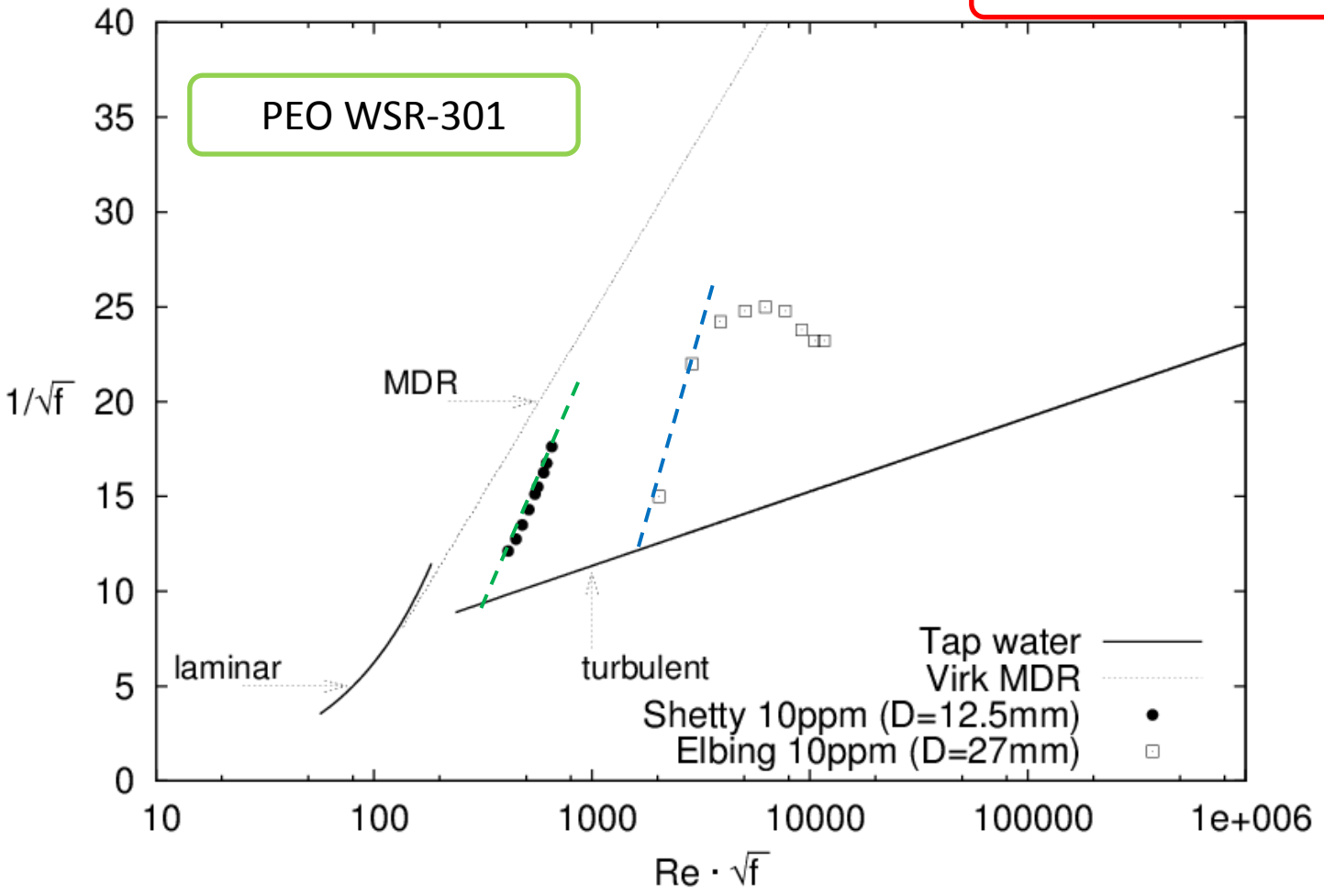
Re≈35000 ÷ 393000
(pure solvent)

- Solvent + polymer
- Solvent + fibre
- Solvent + fibre + polymer

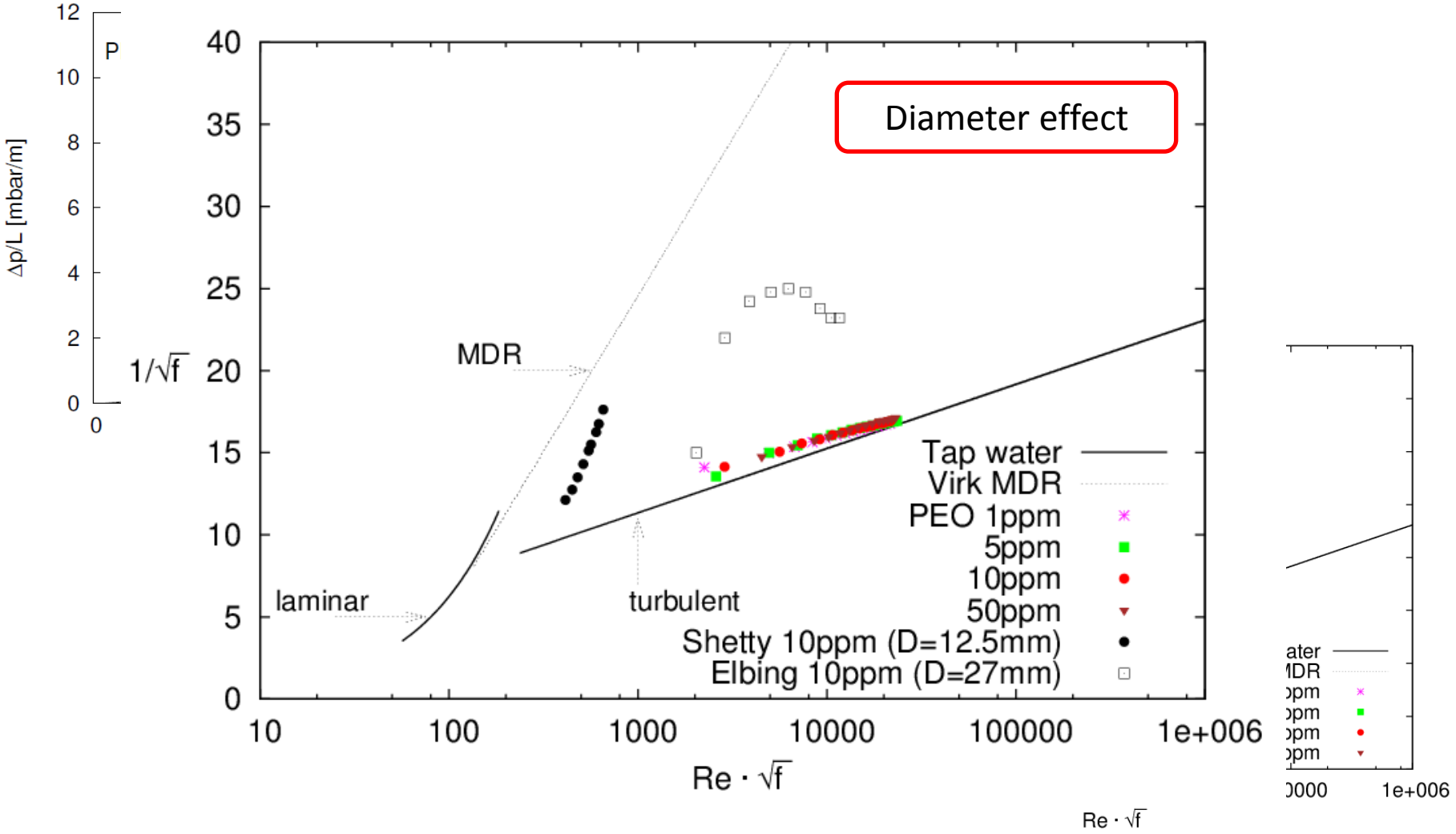
Polymer: literature review

PEO WSR-301

Diameter effect?



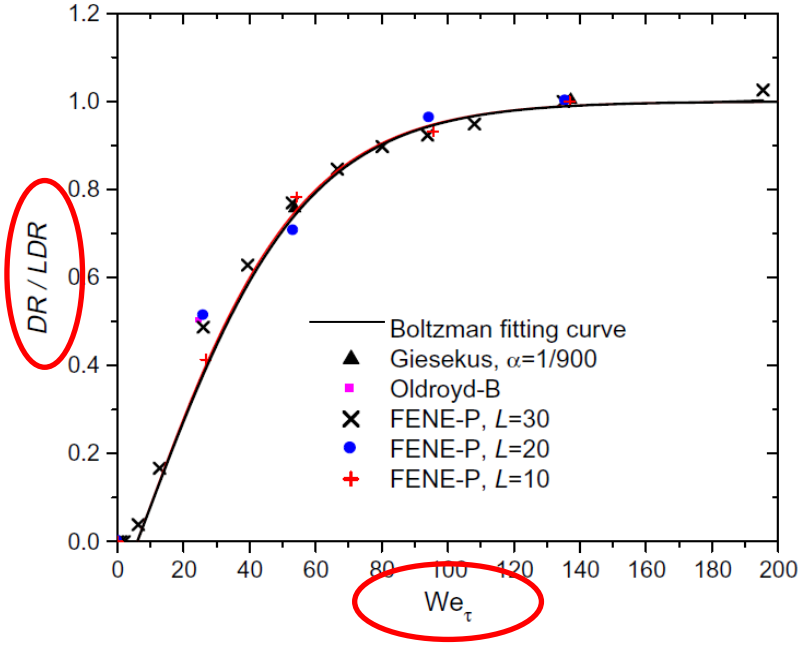
Polymer results PEO WSR-301



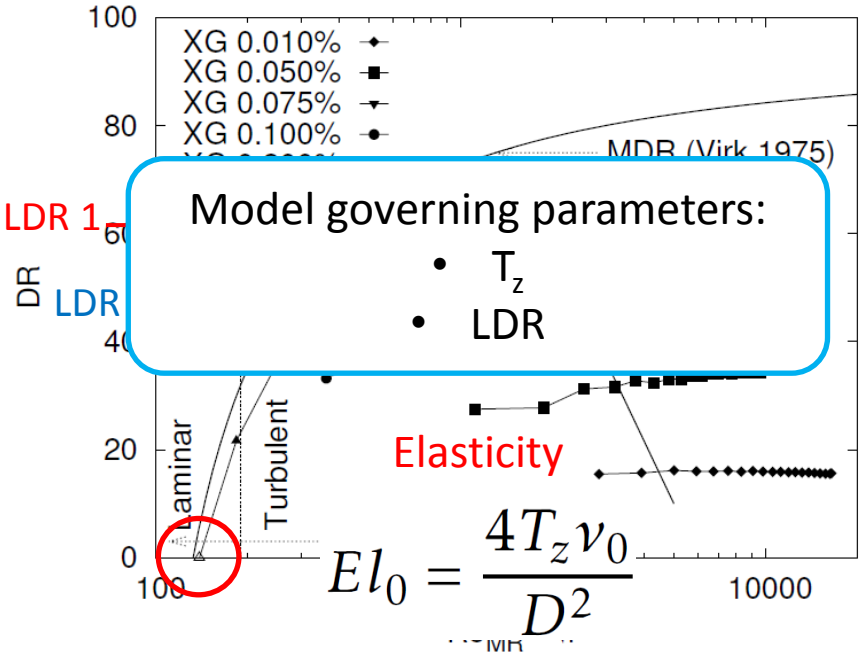
Modelling DR: which procedure?

$$\frac{1}{\sqrt{f}} = \frac{1}{(1 - DR)^{\tilde{n}/2}} \left(1.7678 \cdot \ln\left(Re_b\sqrt{f}\right) - 0.60 - \frac{162.3}{Re_b\sqrt{f}} + \frac{1586}{Re_b^2 f} \right)$$

Housiadas et al.,
International Journal of Heat and Fluid Flow 2013



Housiadas et al., 2013

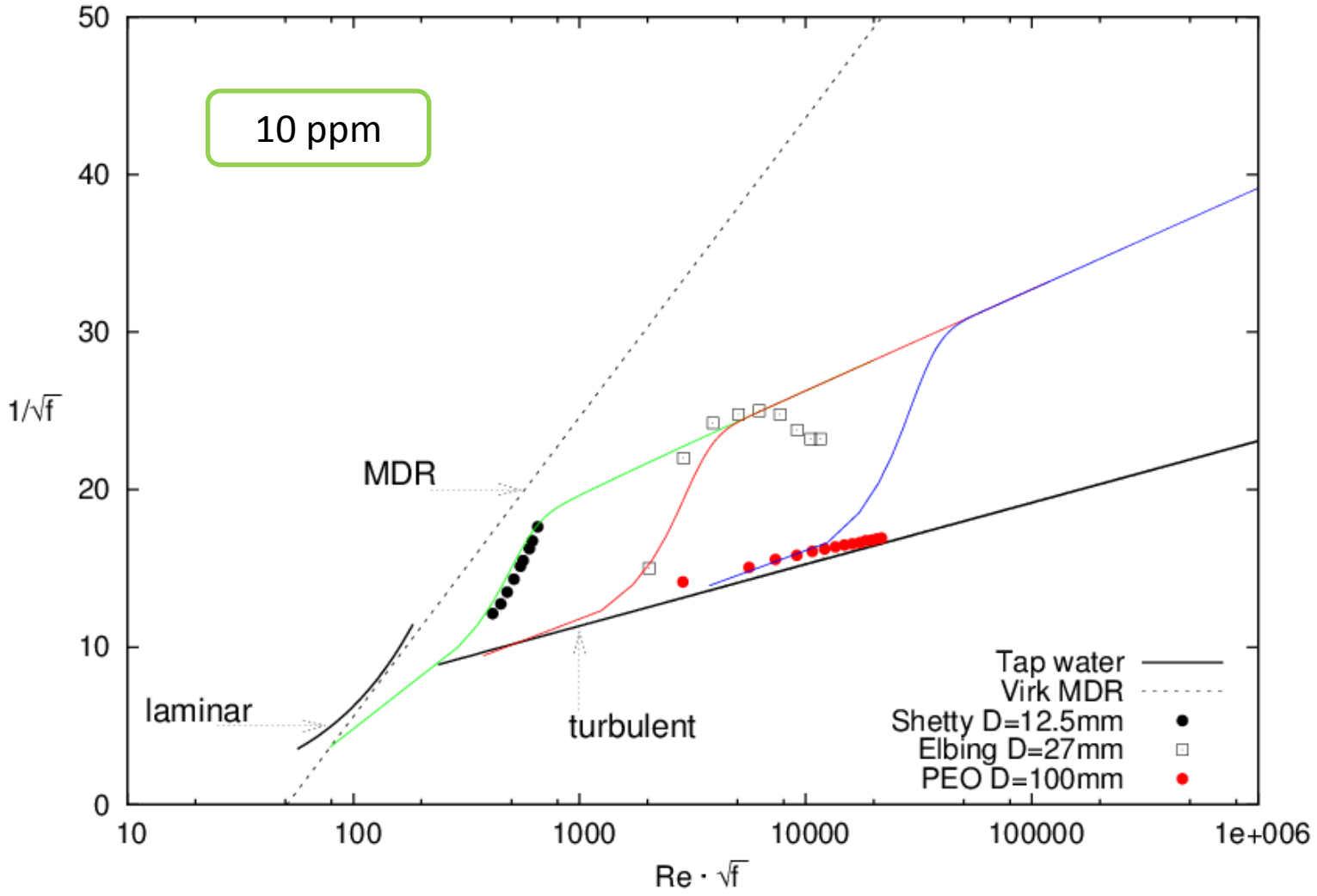


Model governing parameters:

- T_z
- LDR

D = pipe diameter

Scaling


10 ppm
MDR
laminar
turbulent
Tap water
Virk MDR
Shetty D=12.5mm
Elbing D=27mm
PEO D=100mm
1/√f
Re · √f
0
10
20
30
40
50
10
100
1000
10000
100000
1e+006

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Gestionale e Meccanica

Multiphase Flow Laboratory

University of Udine

Thank you for your attention

cost

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