BHR Group

EXPERTS IN FLUID ENGINEERING

BHR System Losses Tool (SLOT)

Phivos Ioannou,

Mick Dawson,

Hara Papachristou,

Nigel Heywood,

Neil Alderman.

Contents

Why estimate pressure losses?

Estimate total pressure losses on suction and discharge side of a pump for alternative

- pipe diameters & velocities
- sludge types/concentrations
- laminar versus turbulent pipe flow

Select and size pump

Derate pump performance for sludge properties

Calculate pump power (volume flowrate x total pressure loss)

Optimise system using sets of pump characteristics and system curves

Existing Industry Practice

FROST,R.C., How to design sewage sludge pumping systems, Technical Report TR185, WRC Processes, January 1983.

Includes Sludge Rheology predictions or ‘guestimates’

Approach in TR 185 is a pragmatic and simplified one.

Enabled design calculation when there were no PCs, spreadsheets or programmable calculators.

However, this approach is fundamentally flawed

More reliable methods have been added to the literature since 1980s.

BHR System Losses Tool (SLOT)

BHR Group's SLOT applies a consistent, up-to-date methodology.

Sludge rheology entered using Herschel-Bulkley or Power Law parameters (can be read from SRDB).

SLOT calculates

- Frictional pressure losses in straight pipes
- Frictional pressure losses in a wide variety of fittings
- Pressure losses/gains due to elevation change
- System curves
- Pump start-up

BHR System Losses Tool (SLOT)

Straight Pipes

Laminar flow of non-Newtonian fluids
Laminar flow breakdown (Ryan & Johnson or Slatter models)
Turbulent flow of non-Newtonian fluids (Wilson-Thomas)

Pipe Fittings

Range of fittings: elbows, tees, expanders, reducers, valves, tank entries, tank outlets etc

Loss coefficients taking into account:

- Laminar and Turbulent regime
- Newtonian and non-Newtonian rheology
- Scale effect in laminar and turbulent regimes

Pump start-up

Pump start-up

To ensure that the sludge will begin to move the pump needs to generate a wall shear stress that exceeds the static frictional pressure loss.

SLOT enables start-up P_f to be calculated on suction and discharge sides of the pump once static τ_y entered.

Values of static τ_y for a range of sludge types was measured in WWM7 and entered into SRDB.

TR185 vs SLOT Comparison

Identical inputs

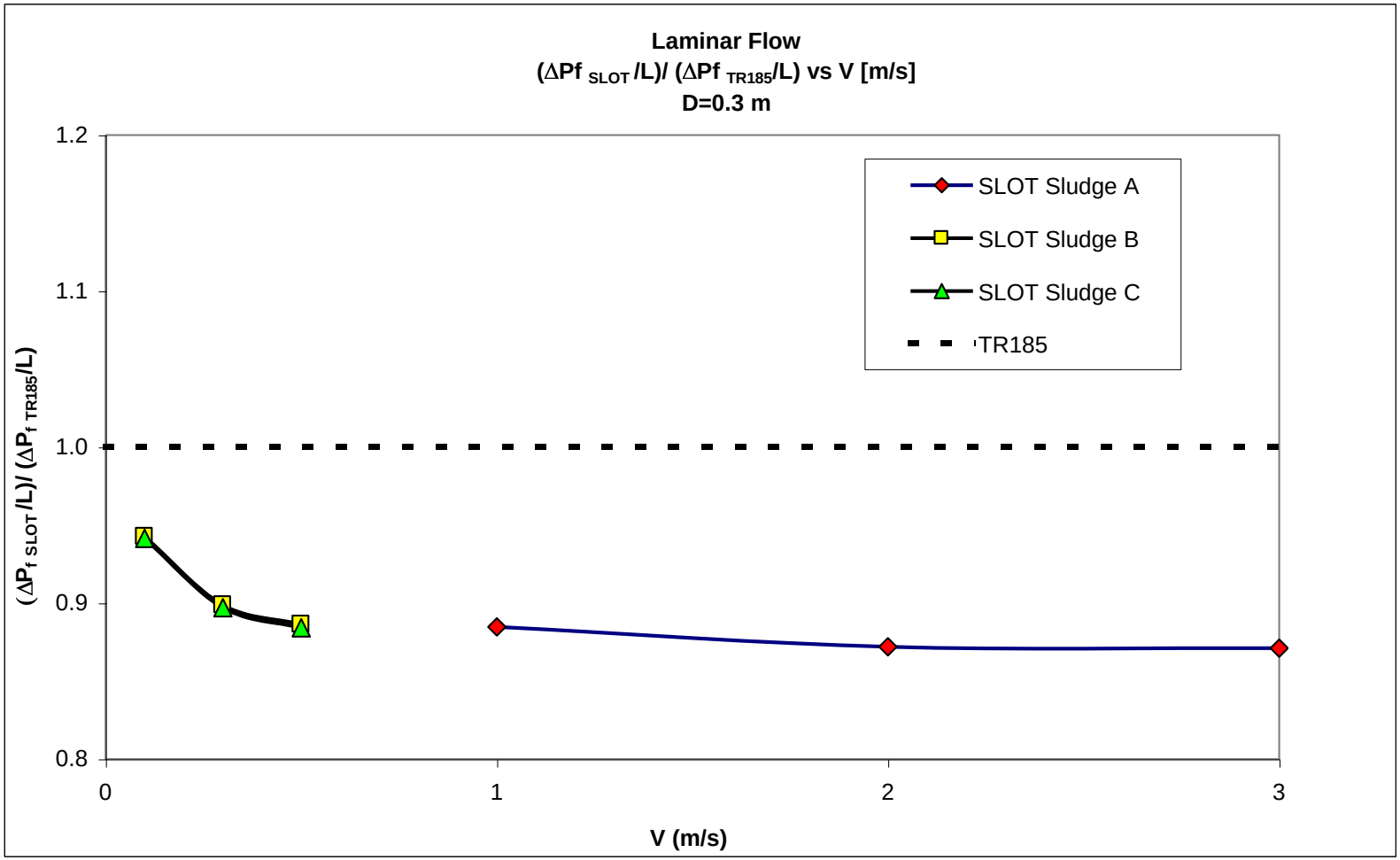
- Herschel-Bulkley sludge rheology model parameters.
- pipeline system and fitting characteristics
- sludge flowrates

Three sludge types

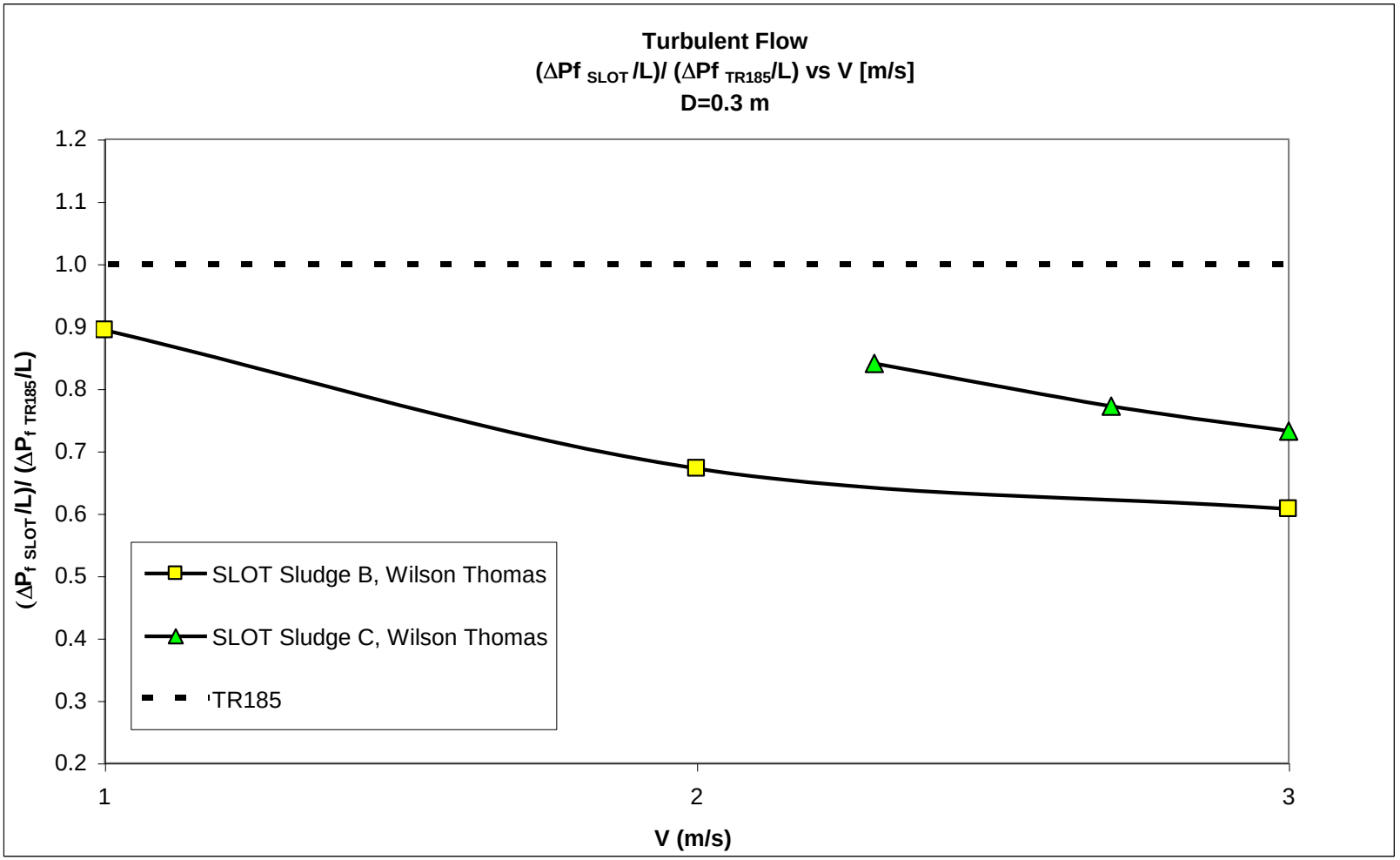
- Sludge A: Primary poly-thickened (7% DS), laminar flow.
- Sludge B: Digested (3% DS), laminar & turbulent flow.
- Sludge C: Digested (6% DS), laminar & turbulent flow.

Ratio of ΔP_{SLOT} to ΔP_{TR185} plotted against pipe velocity

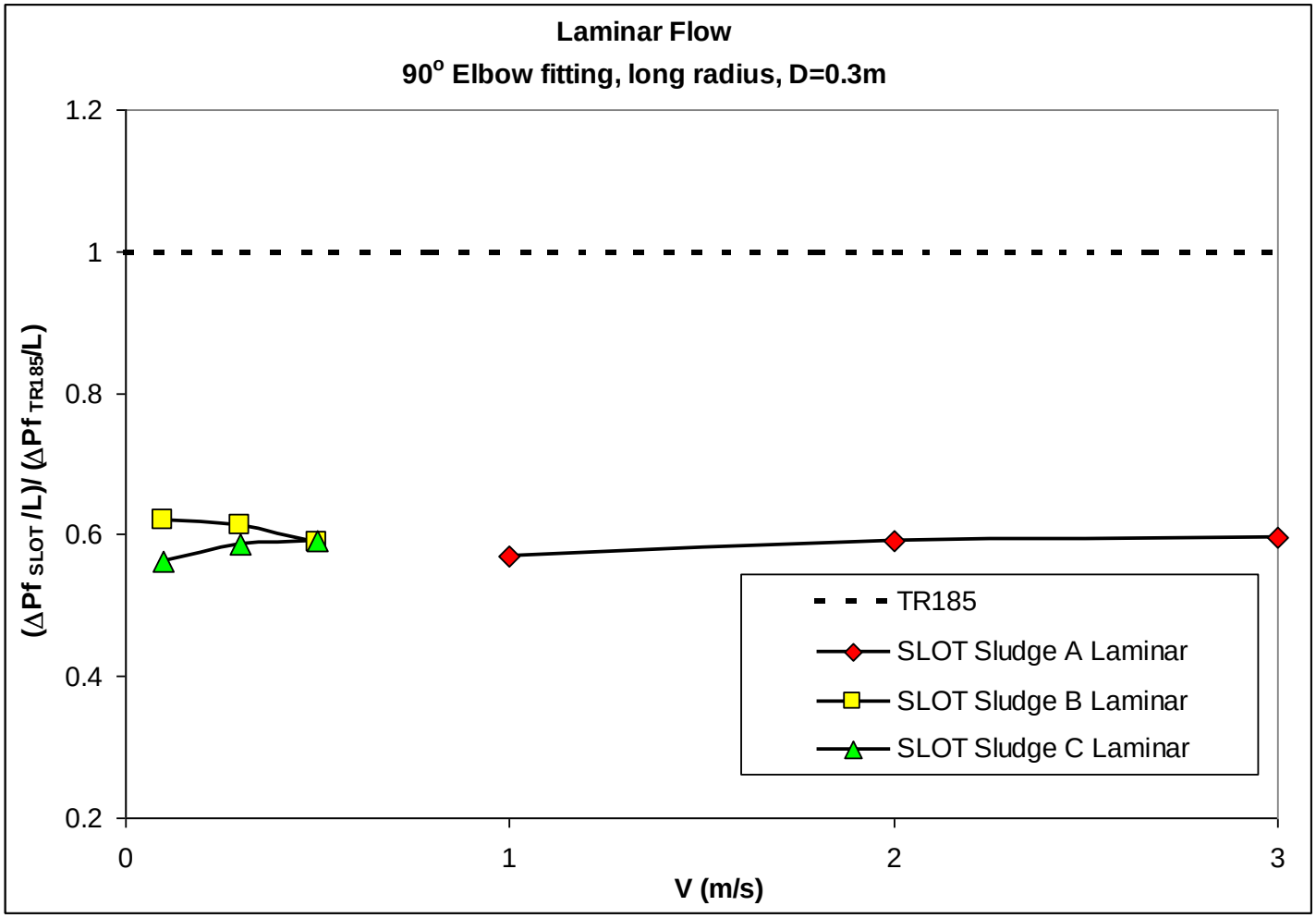
Straight Pipe: Laminar Flow



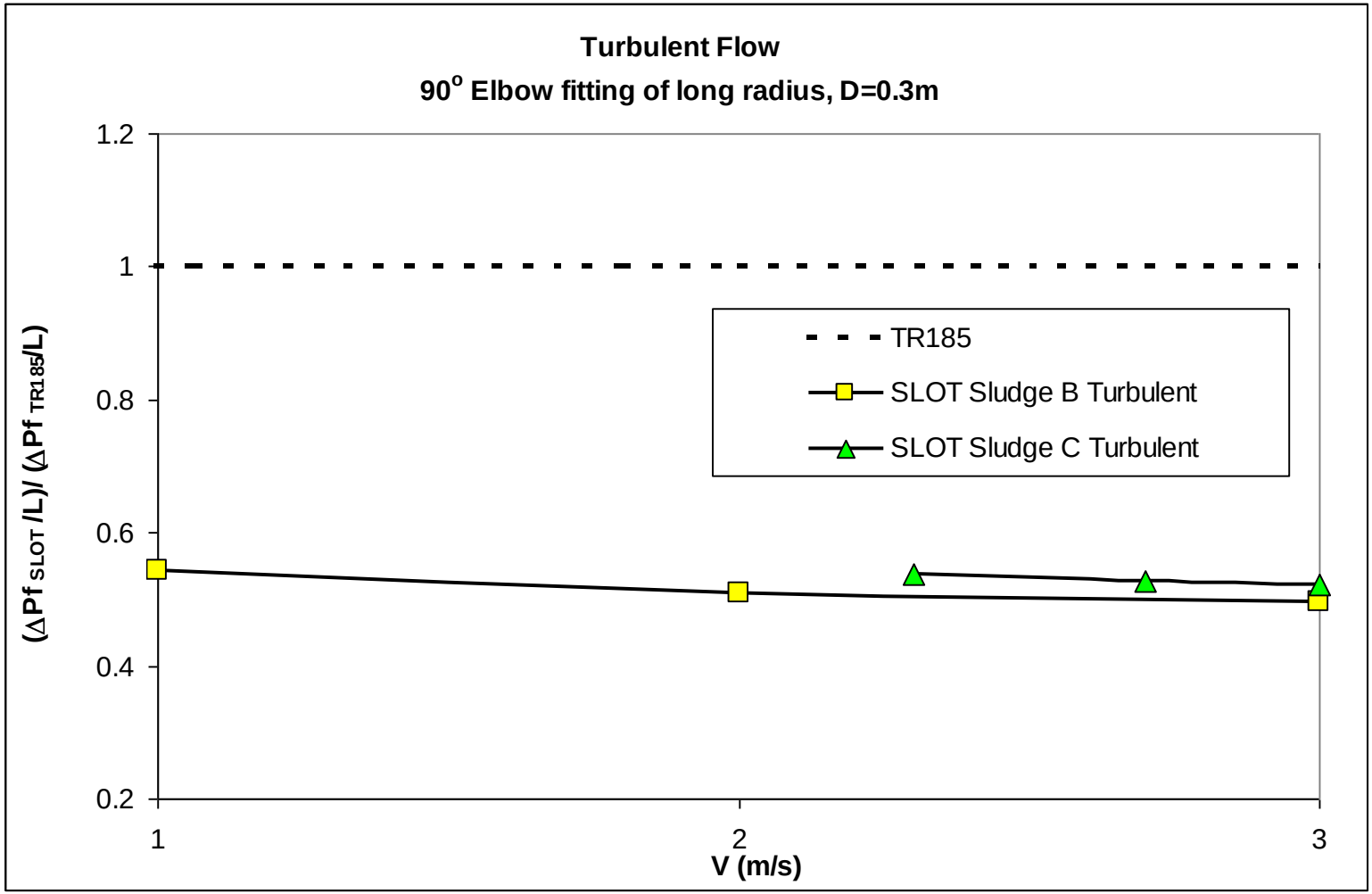
Straight Pipe: Turbulent Flow



90^0 Elbow: Laminar Flow



90^0 Elbow: Turbulent Flow



TR185 vs SLOT

Frictional losses calculated using TR185 were universally higher than those from the more rigorous SLOT when identical inputs are used

Largest differences related to laminar flow & fittings losses

Pumps specification based on TR185 could result in significant over-sizing

Use of BHR System Losses Tool could significantly reduce

- Capital costs
- Operating costs
- Carbon footprint

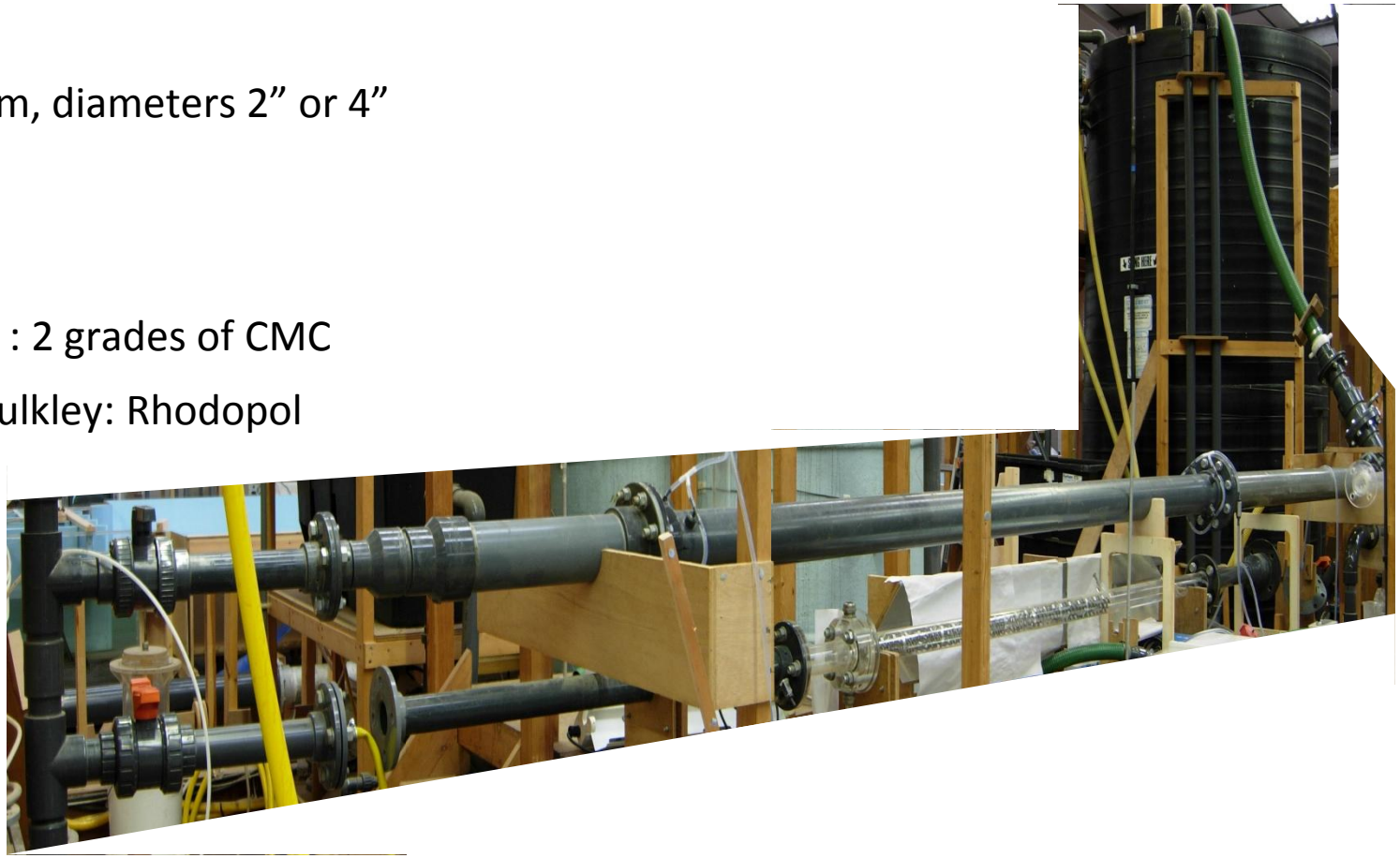
Experimental Testing – Test Section

Test section

- length: 4.9m, diameters 2” or 4”

Test Fluids

- Water
- Power Law : 2 grades of CMC
- Herschel-Bulkley: Rhodopol



WWM7 Proposed Tasks

Experimental testing

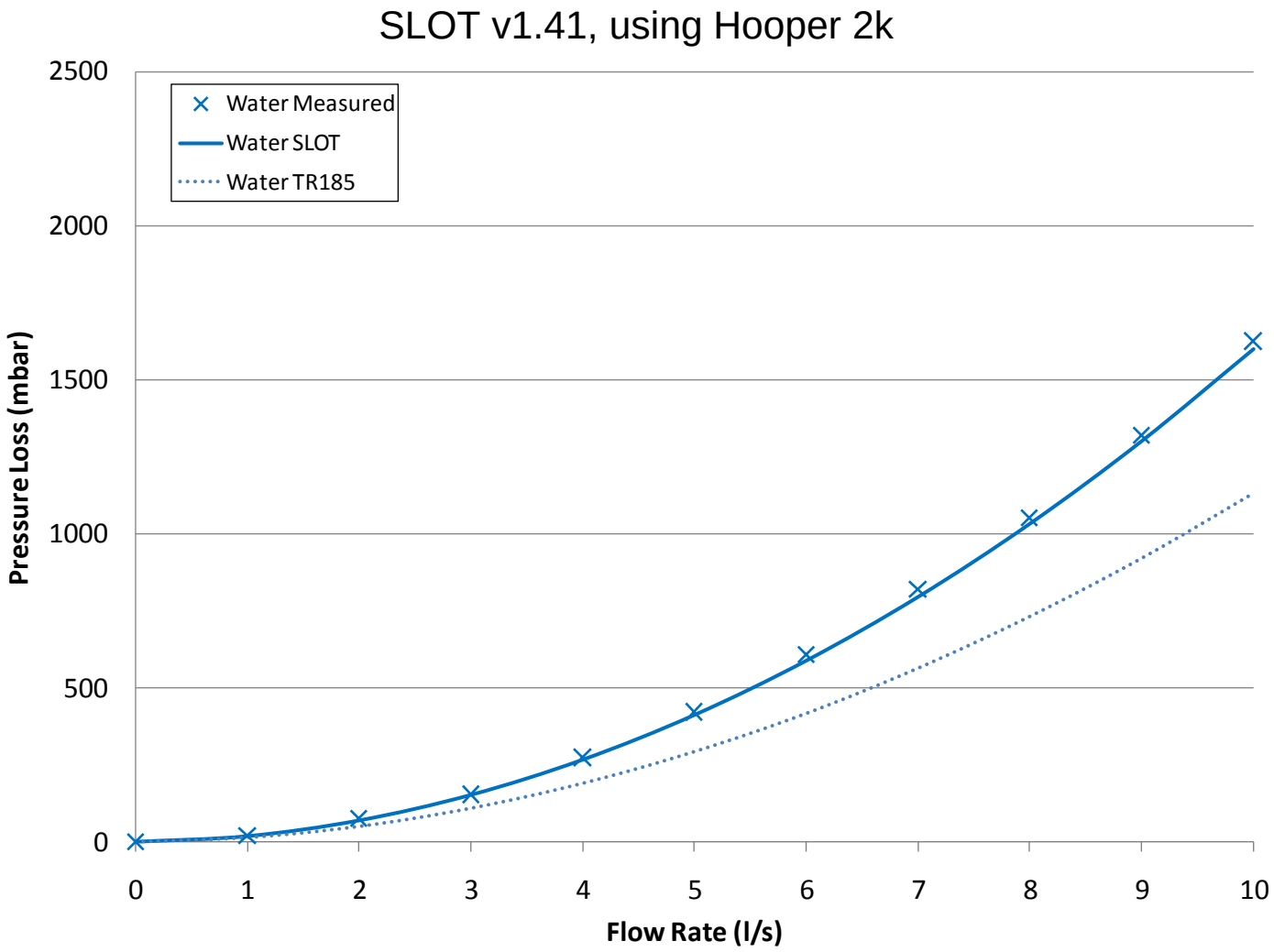
Pipe Loop

- length:20m, (horizontal and vertical sections)
- PVC
- diameters: 2”- 4”,
- fittings: valves, elbows, contractions, expansions, tees
- pumps

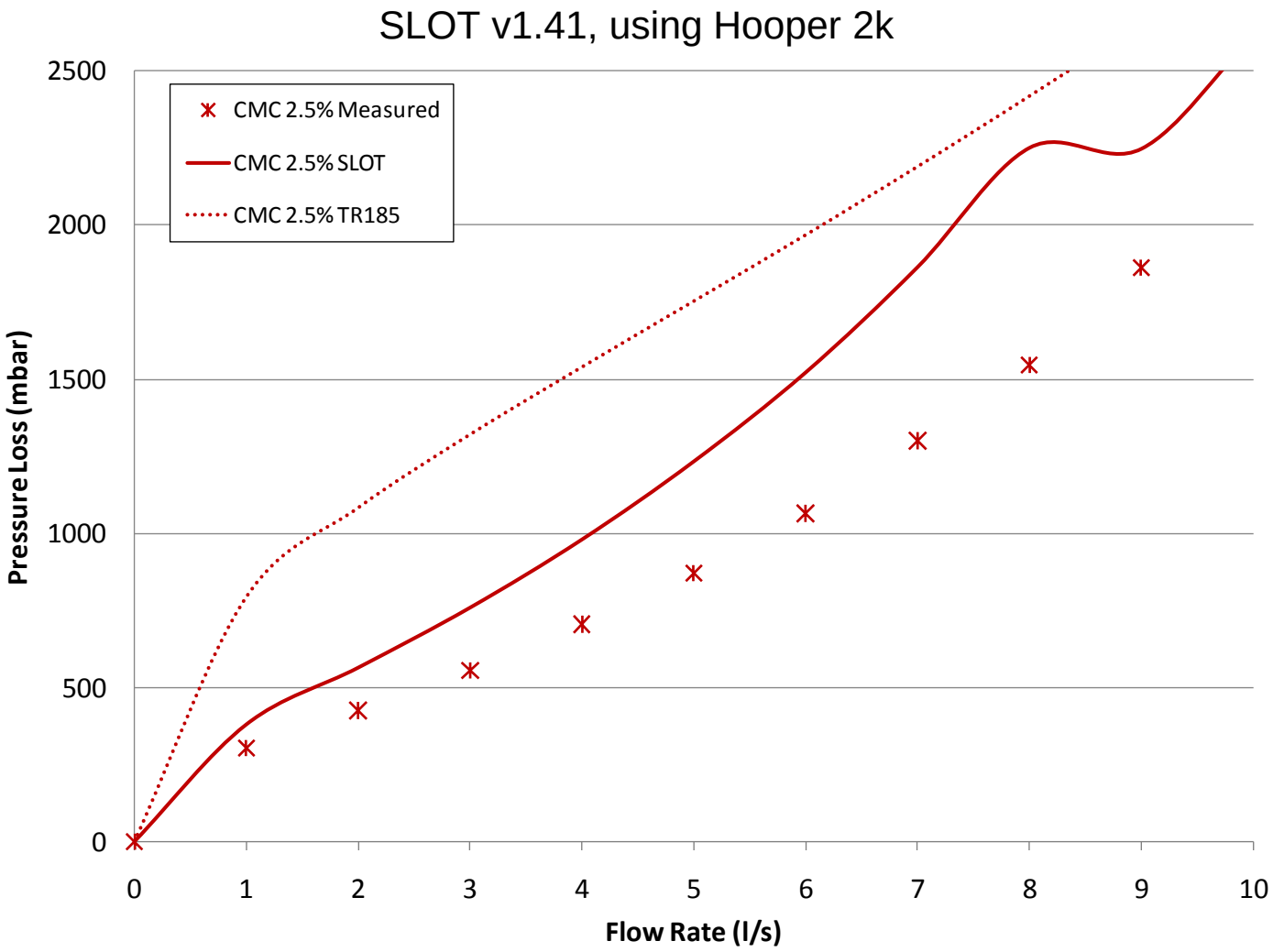
Test section

- Perspex
- length:3m, diameters 2” or 4”,

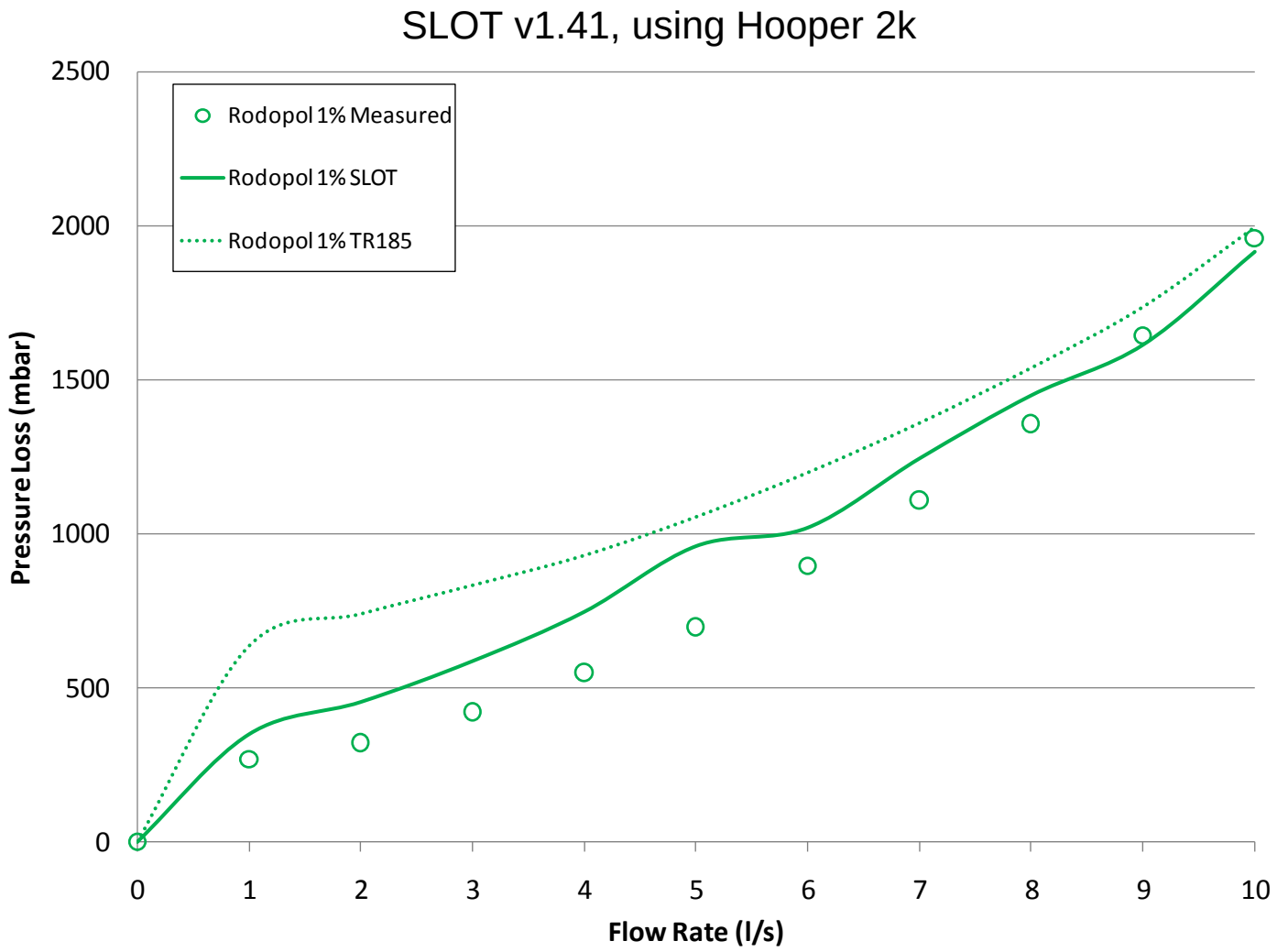
Experimental Results – System Loss



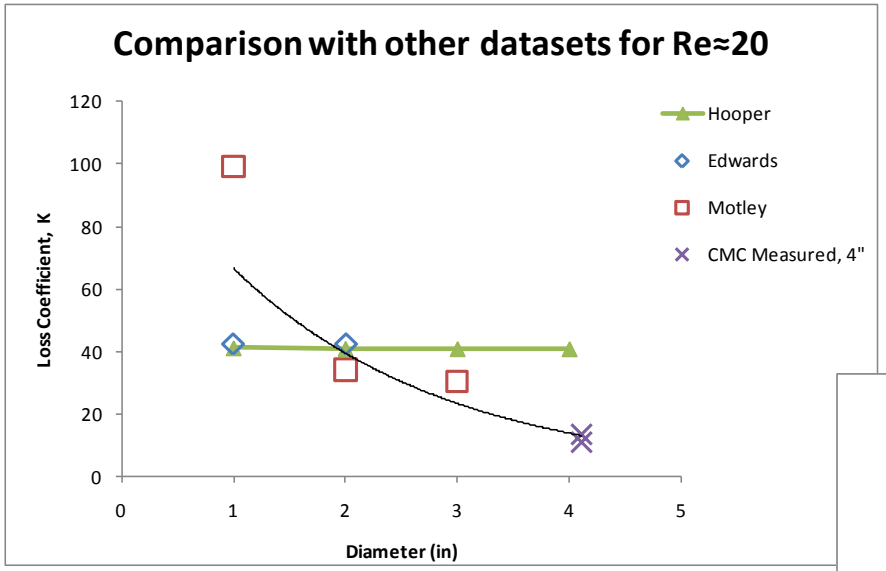
Experimental Results – System Loss



Experimental Results – System Loss



Fitting Loss – 90° Elbow



Extensive analysis for:

- Tees
- Elbows/Bends
- Swept Bends
- Valves

Conclusions – Whole System

SLOT

- Good agreement for turbulent water
- Poor agreement for laminar Power Law
- Fair agreement for laminar Herschel Bulkley

TR185

- Poor agreement for laminar Herschel Bulkley
- Poor agreement for laminar Power Law

SLOT validation by ITT

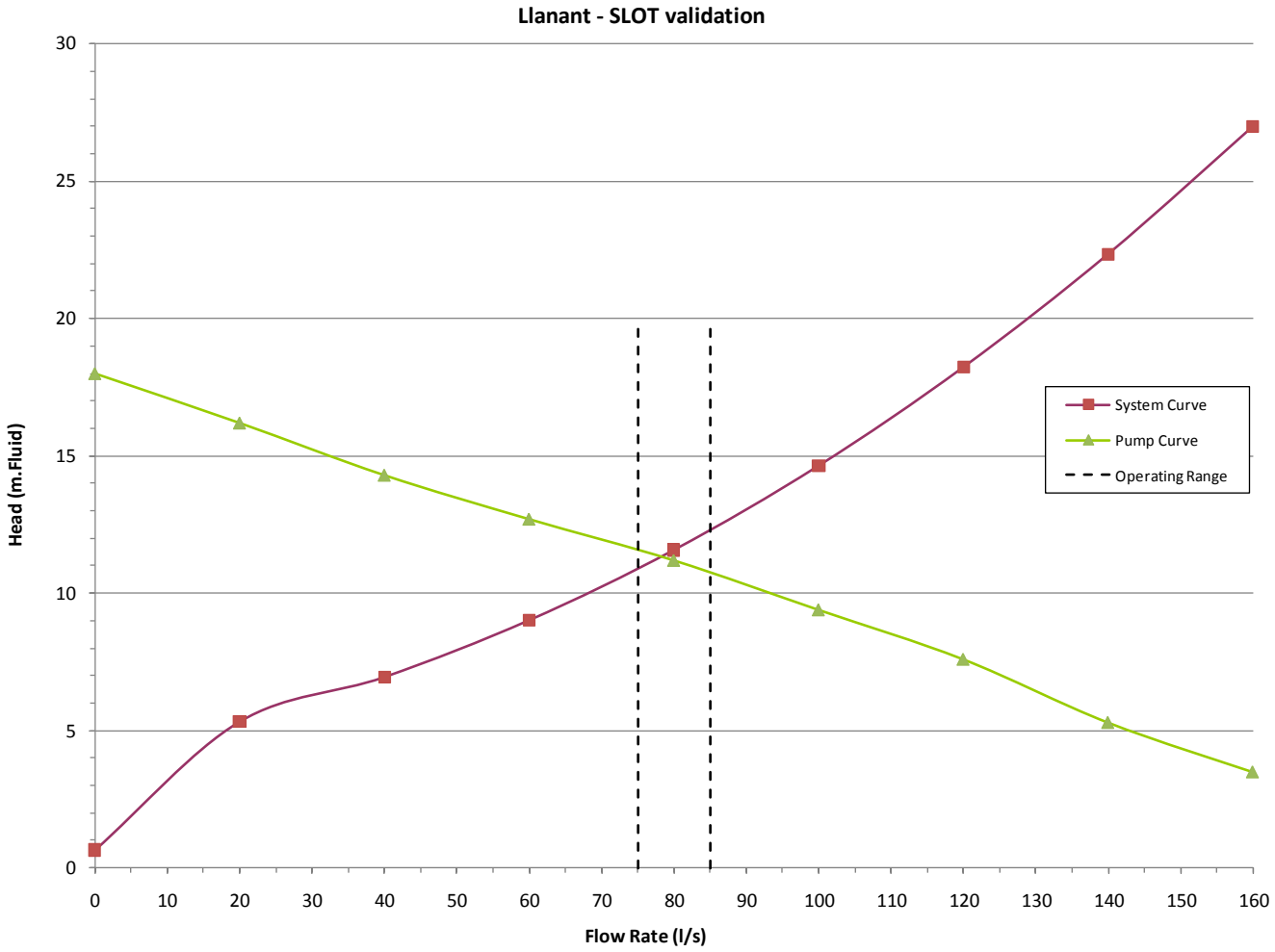
Background

- Site: Llanant
- Primary thickened sludge
- Dry solids content: 7.9%

System:

- 250mm diameter
  - 7m pipe
  - 1 standard bend
  - 1 gate valve
- 200mm diameter
  - 2.5m pipe
  - 5 standard bends
  - 1 gate vavle
  - 1 reducer to 120mm diameter

SLOT Validation by ITT – Llanant



Summary

SLOT uses the most up to date methodologies for system loss calculations of non-Newtonian fluids

Comparisons have shown generally good agreement with experimental data

Latest update includes results from:

- Fitting loss coefficients from literature
- Scale effects on both laminar and turbulent flows
- Pump start-up

BHR Group

EXPERTS IN FLUID ENGINEERING

Thank you

Phivos Ioannou: pioannou@bhrgroup.co.uk

Mick Dawson: mdawson@bhrgroup.co.uk

Hara Papachristou: hpapachristou@bhrgroup.co.uk

Nigel Heywood: nheywood@bhrgroup.co.uk

Neil Alderman: nalderman@bhrgroup.co.uk

Enquiries: contactus@bhrgroup.co.uk

Water, Environment & Power (WEP)

Fluid Systems

Academy

Process

BHR Group is a trading name of VirtualPiE Limited

www.bhrgroup.com