Northumbria University NEWCASTLE

Are we significantly oversizing domestic water systems?

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WITH THIS ISSUE *Education Special*

SIZE MATTERS
Consequences of oversizing cold water systems

HANDLE WITH CARE
Bill Bordass on why government should value DECs

ARE WE SIGNIFICANTLY **OVERSIZING** DOMESTIC WATER SYSTEMS?

A focus on saving water is pushing down domestic water volume flow rates, but UK sizing methods have yet to reflect this change, say **Jess Tindall** and **Jamie Pendle**

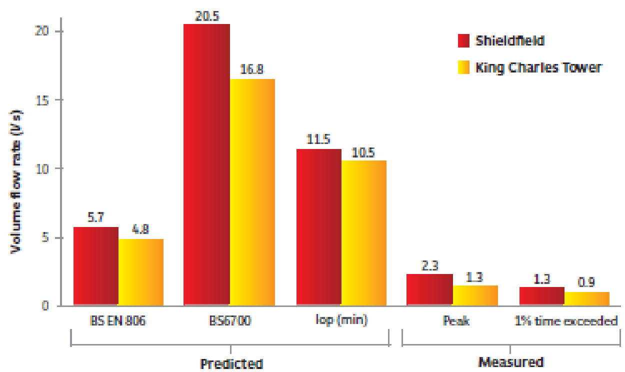

Figure 1: Design predicted vs measured volume flow rates

Over recent decades, a growing awareness of the need to reduce water and energy consumption has led to significant changes in the amount of water used. For example, manufacturers of washing machines are now obliged to show the water-consumption data for their products so that buyers can choose efficient models if they wish. Consequently, peak domestic water volume flow rates are likely to have reduced; however, UK sizing methods have yet to be updated to reflect this, resulting in the potential for oversizing.

To investigate this issue, incoming domestic cold water service (DCWS) volume flow rates were recorded at two multi-storey residential blocks. The measured peak flow rates were then compared with the flow rates predicted by the three most widely used UK sizing guidance documents; BS EN 806[1], BS 6700[2] and the Institute of Plumbing (IoP) guidance[3]. Secondary data, supplied by a leading UK manufacturer of DCWS pumping equipment, was used to validate the primary data, and enables firm conclusions to be drawn from the study.

King Charles Tower

The problem

Oversizing of DCWS is detrimental to projects, not only because of the obvious capital-cost implications but also because it can lead to reduced water quality and problems with the operation of booster sets.

A recent paper[4] stated that oversizing pipework reduces water velocities, resulting in water remaining in the distribution pipework far longer than is ideal for health and hygiene reasons. This problem is most extreme in tall buildings, where the domestic cold and hot-water pipework runs within the same riser space, resulting in unwanted heating of the cold water.

Over-estimation of the DCWS flow rates can also lead to problems with the booster sets that are necessary for tall buildings. It is advisable to combine multiple smaller pumps into one booster set, to minimise the consequences of oversizing and ensure reliable operation by increasing the range of modulation. However, wouldn't it be a better idea to match the predicted and actual demand more closely, narrowing the design to operation gap?

UK sizing guidance

The three sizing guides listed in the introduction employ the same approach: the flow rate, duration and frequency of use of each outlet type are considered to arrive at an allocated number of 'loading units' (LU). The LUs are then added up and a chart used to convert the LUs to a volume flow rate, which is intended to be exceeded for 1% of the time.

Housing association Your Homes Newcastle allowed access to two of its

> Oversizing of DCWS is detrimental to projects, not only because of the obvious capital-cost implications but also because it can lead to reduced water quality

properties: Shieldfield House, which has 26 storeys and 125 flats; and King Charles Tower, which has 15 storeys and 90 flats. Both properties were built around 1960 and recently benefited from modernisation, so the DWS outlets are typical of new builds.

All of the flats had a bath, shower, toilet, hand basin and kitchen sink. Both buildings used electrically heated DHWS storage vessels within each flat, so hot water LUs were calculated and added to the DCWS LUs, to arrive at predicted incoming DCWS volume flow rates. The low-frequency loading units were used where possible.

A clamp-on, ultrasonic flow meter was used to gather flow-rate data over a period of one week per building. From this, the peak volume flow rate – and that exceeded for 1% of the time – was identified and compared with the predictions.

Results

Figure 1 shows the predicted volume flow rates for each of the three UK calculation methods, as well as the measured peak and the 1% (of time) exceeded volume flow rate for both buildings. DCWS flow-rate data for a number of multi-storey residential buildings was supplied by an independent UK manufacturer of fluid-pumping equipment. This was used to increase the sample size and to validate the primary data. (See Figure 2.)

There is some variance around the line of best fit, as expected, given the different sizes of flat and number and type of outlets. However, there is a clear correlation between the primary and secondary data.

Findings

It is evident that BS EN 806 predicts volume flow rates closer than the two other methods for all buildings in the study. Additionally, the line of best fit is almost parallel to that for the measured data (see Figure 3), so it results in less error for large projects. The IoP and BS 6700 methods both show that the margin of error increases in proportion to the size of the development.

There is a significant margin between the predicted and measured peak flow rates – a greater margin still if the 1% time exceeded is taken into account – so engineers should use BS EN 806 for similar projects. The IoP method led to more than double the oversizing compared to the use of BS EN 806, while the predictions of BS 6700 were many times the required value – so very significantly oversized.

These findings should be welcome news for architectural and building services engineers as we aim to 'narrow the design to operation gap'. **CJ**

● A poster of this article will be presented at the CIBSE 2015 Technical Symposium on 16-17 April, at UCL London. More information at **www.cibse.org/symposium**

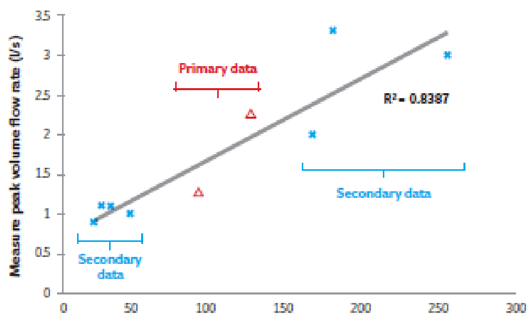

Figure 2: Primary and secondary data measured peak volume flow rates

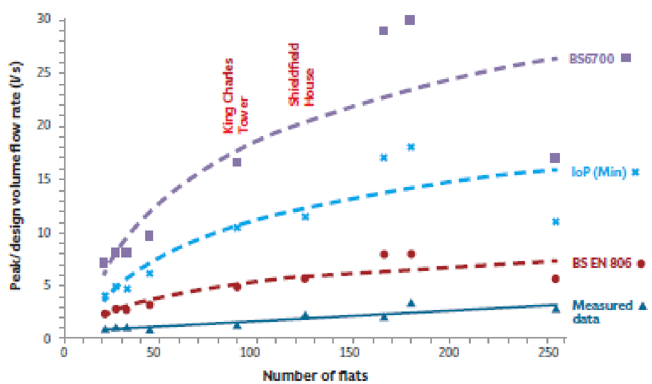

Figure 3: Design flow rates predicted for the nine buildings, alongside the measured peak volume flow rates

References:

1 British Standards Institution, BS EN 806-3:2006, *Specifications for installations inside buildings conveying water for human consumption*. London, BSI, 2006.

2 British Standards Institution, BS 6700:2006, *Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Specification*. London, BSI, 2006.

3 The Institute of Plumbing. *Plumbing Engineering Services Design Guide*. Hornchurch, The Institute of Plumbing, 2002.

4 Agudelo-Vera C, Scheffer W, Pieterse-Quirijns I, Blokker M. New Method to Design Domestic Water Systems, *REHVA Journal*, December 2013, p12-16.

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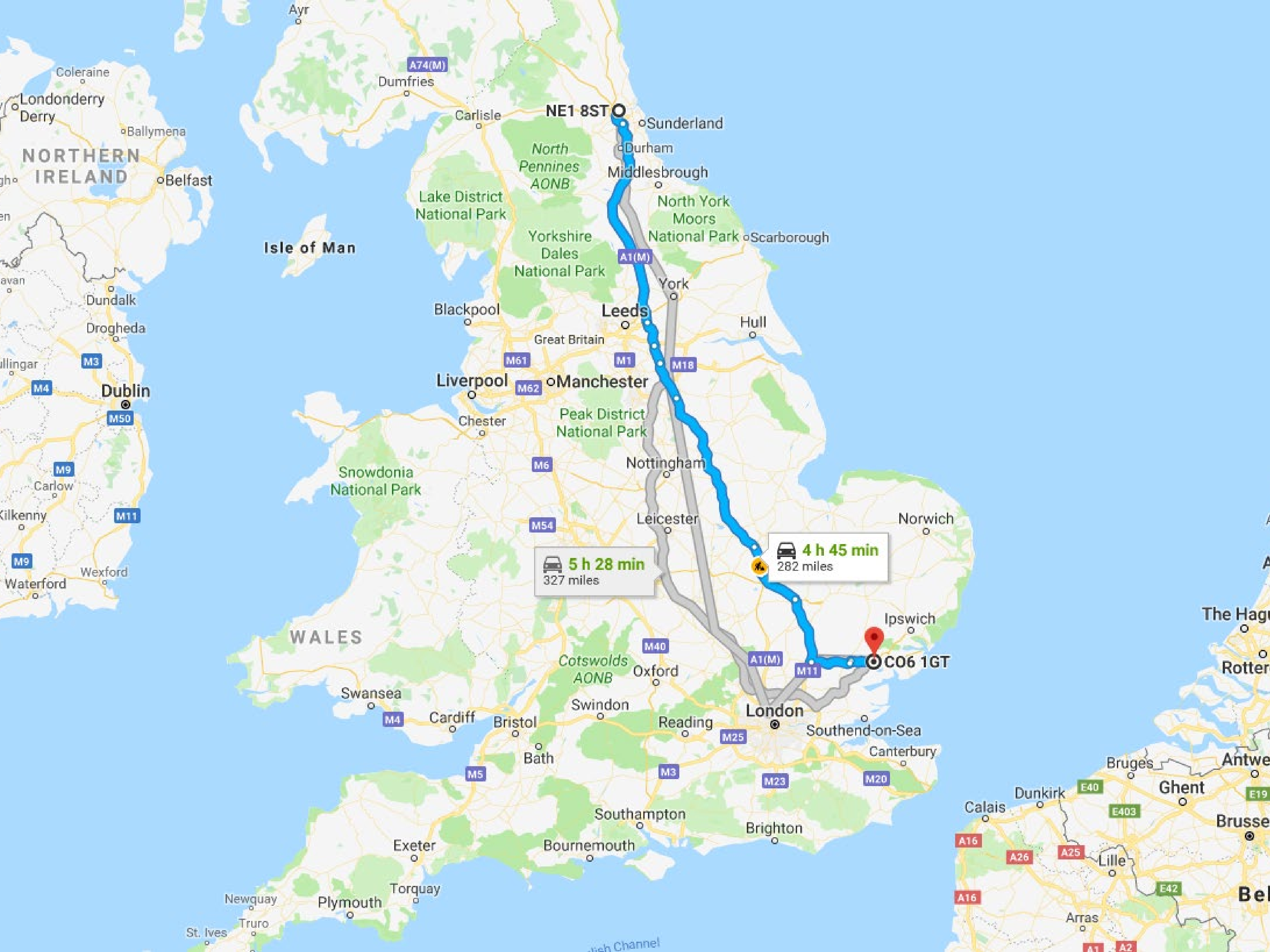

NE1 8ST
CO6 1GT
4 h 45 min
282 miles
5 h 28 min
327 miles
Ayr
Dumfries
A74(M)
Carlisle
Sunderland
Durham
Middlesbrough
North Pennines AONB
Lake District National Park
North York Moors National Park
Scarborough
Yorkshire Dales National Park
A1(M)
York
Blackpool
Leeds
Hull
Great Britain
M61
M1
M18
Liverpool
M62
Manchester
Chester
Peak District National Park
Nottingham
M6
Snowdonia National Park
Leicester
M54
Norwich
Ipswich
WALES
M40
A1(M)
M11
Cotswolds AONB
Oxford
Swansea
Swindon
London
M4
Cardiff
Bristol
Reading
M25
Southend-on-Sea
Bath
Canterbury
M5
M3
M23
M20
Southampton
Brighton
Exeter
Bournemouth
Torquay
Newquay
Plymouth
Truro
St. Ives
Coleraine
Londonderry
Derry
Ballymena
NORTHERN IRELAND
Belfast
Isle of Man
Dundalk
Drogheda
M3
M4
Dublin
M50
M9
Carlow
M11
Kilkenny
M9
Wexford
Waterford
The Hague
Rotter
Bruges
Antwe
Ghent
Dunkirk
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E403
E19
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Bruss
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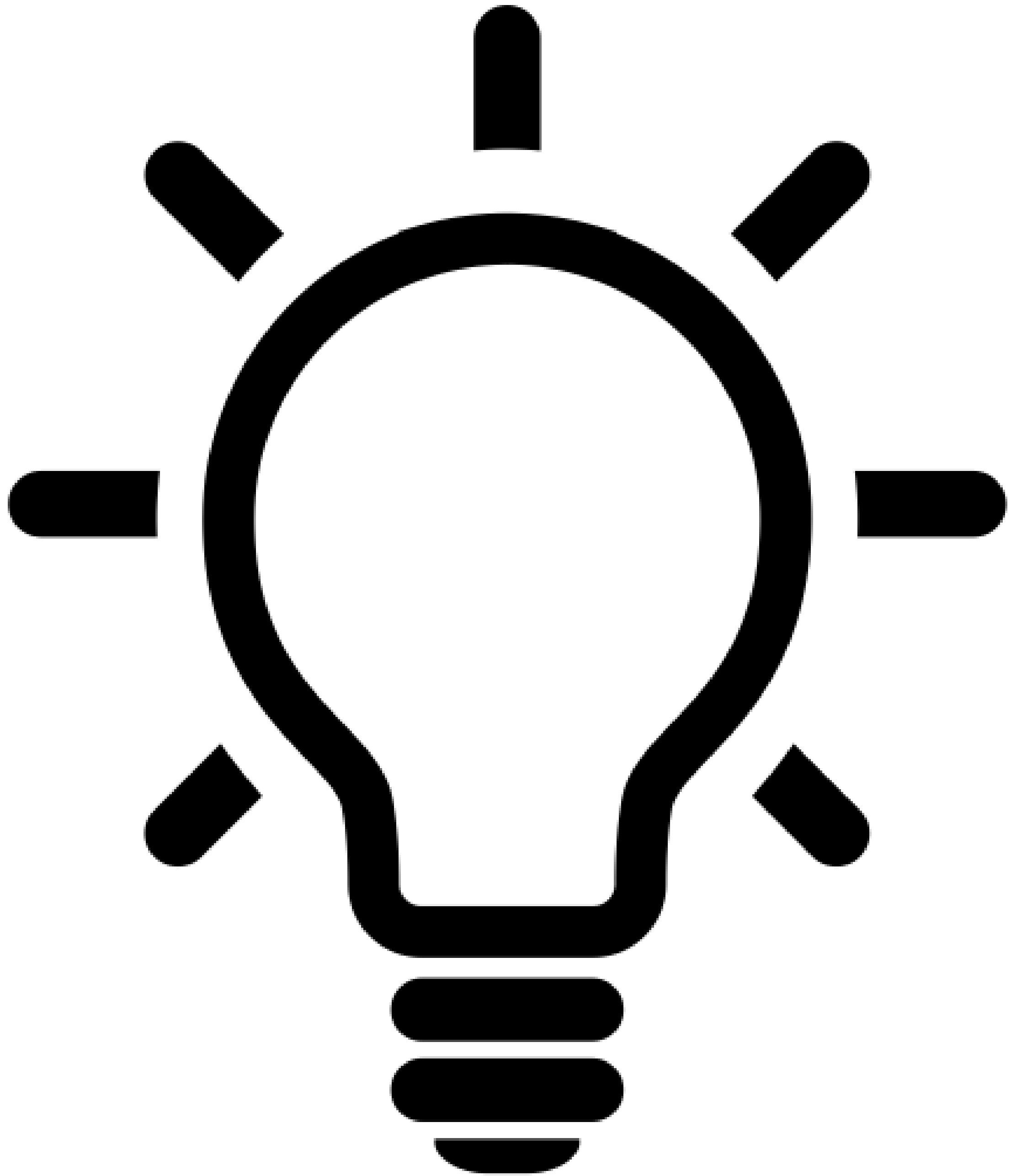
RESTRICTED TECHNICAL INFORMATION BULLETIN

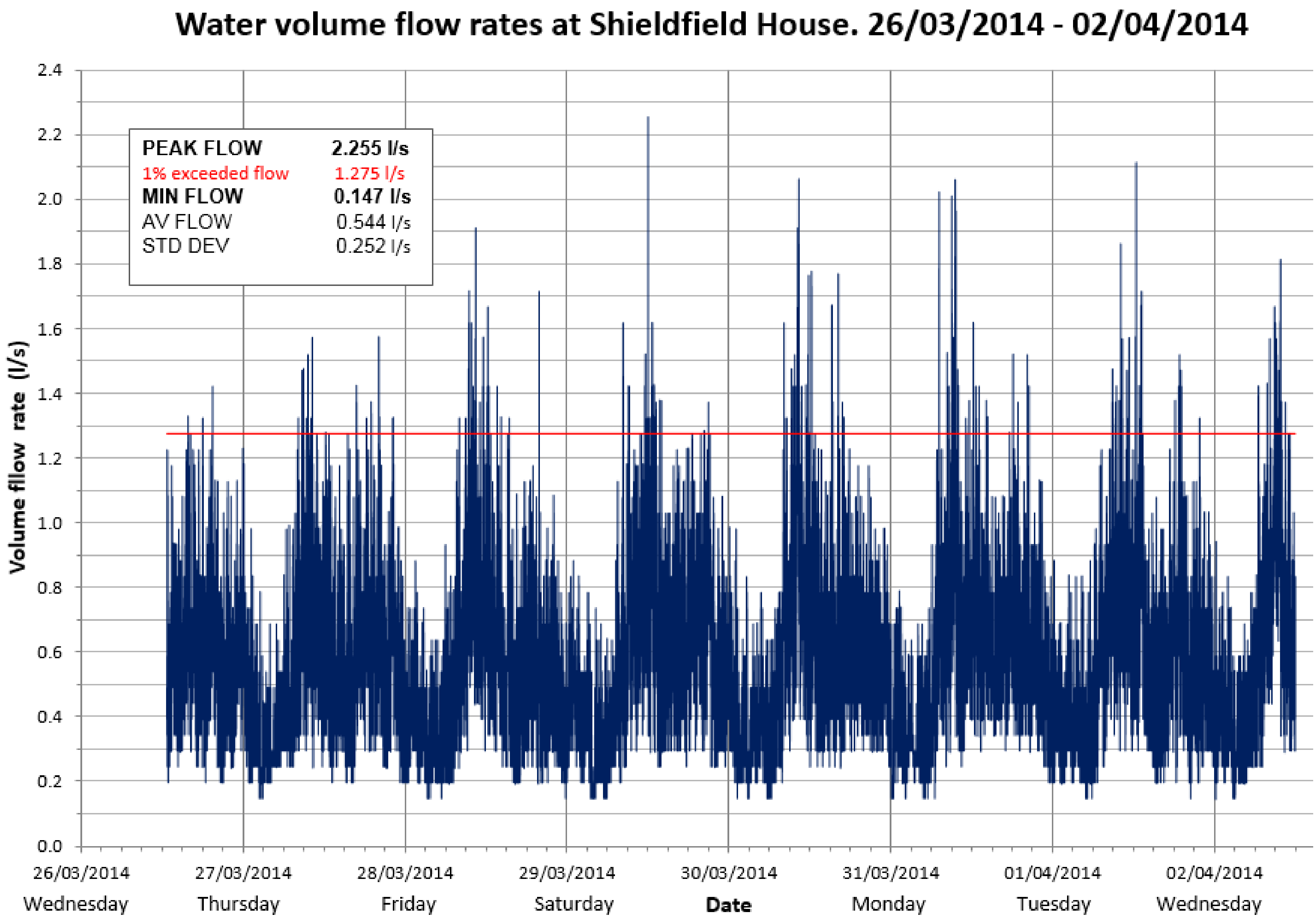
Results taken from the Panametrics Ultrasonic Flow Meter

Overview

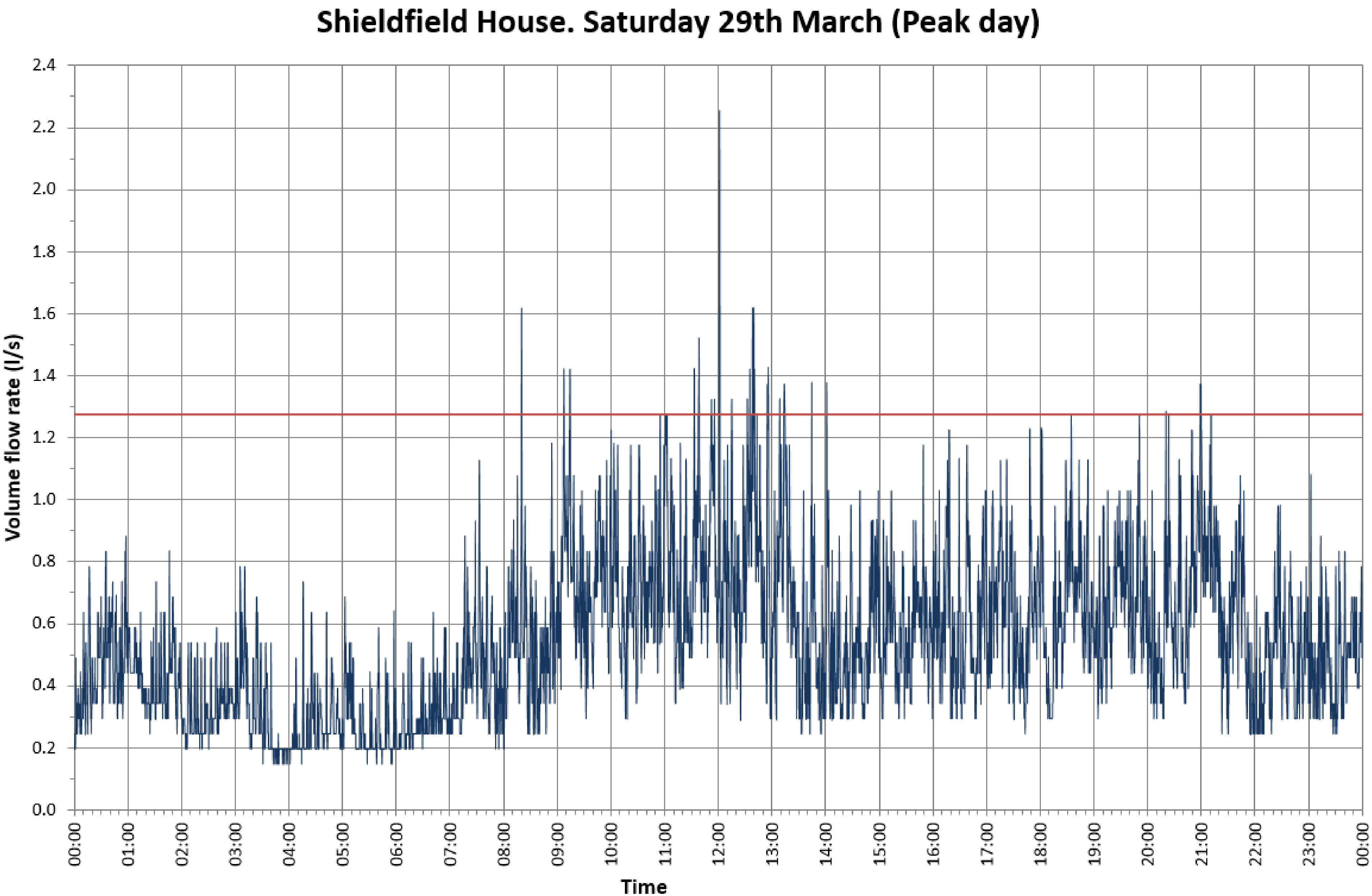
This TIB is to record and compare the onsite results taken with the Panametrics Ultrasonic Flow Meter. This is to allow us to compare and better understand the predicted usage patterns for different types and sizes or buildings, together with allowing us to monitor the performance of various booster sets.

Sites:

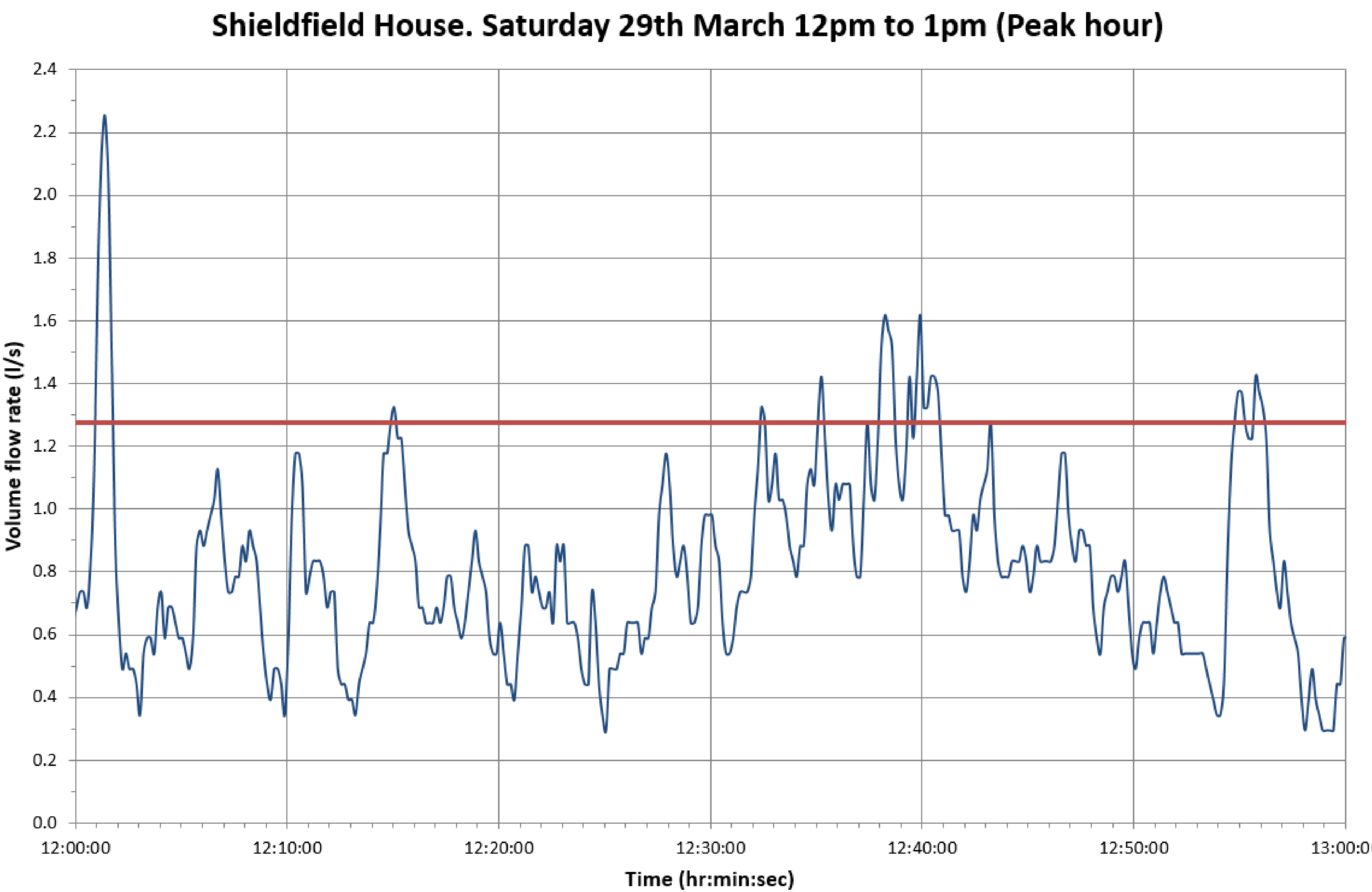




Water volume flow rates at Shieldfield House. 26/03/2014 - 02/04/2014
PEAK FLOW 2.255 l/s
1% exceeded flow 1.275 l/s
MIN FLOW 0.147 l/s
AV FLOW 0.544 l/s
STD DEV 0.252 l/s
Volume fllow rate (l/s)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
26/03/2014
Wednesday
27/03/2014
Thursday
28/03/2014
Friday
29/03/2014
Saturday
30/03/2014
Date
31/03/2014
Monday
01/04/2014
Tuesday
02/04/2014
Wednesday



Shieldfield House. Saturday 29th March (Peak day)
Volume flow rate (l/s)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Time



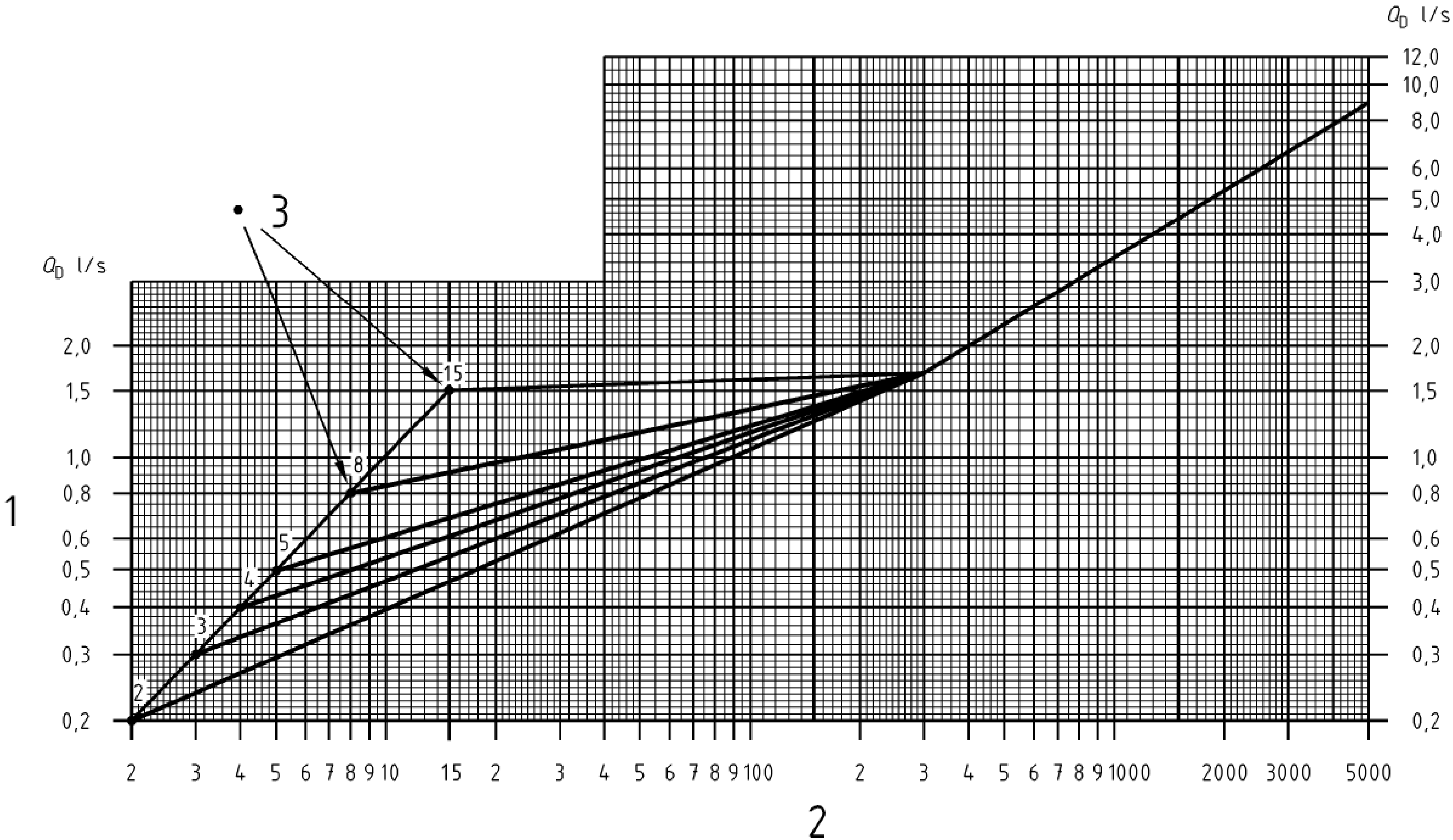
Shieldfield House. Saturday 29th March 12pm to 1pm (Peak hour)
Volume flow rate (l/s)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12:00:00
12:10:00
12:20:00
12:30:00
12:40:00
12:50:00
13:00:00
Time (hr:min:sec)

5.4 Loading unit

1 loading unit (LU) is equivalent to a draw-off flow rate Q_A of 0,1 l/s.

Table 2 — Draw-off flow-rates Q_A , minimum flow-rates at draw-off points Q_{min} and loading units for draw-off points

Draw-off point	Q_A l/s	Q_{min} l/s	Loading units
Washbasin, handbasin, bidet, WC-cistern	0,1	0,1	1
Domestic kitchen sink, - washing machine [a], dish washing machine, sink, shower head	0,2	0,15	2
Urinal flush valve	0,3	0,15	3
Bath domestic	0,4	0,3	4
Taps /garden/garage)	0,5	0,4	5
Non domestic kitchen sink DN 20, bath non domestic	0,8	0,8	8
Flush valve DN 20	1,5	1,0	15
[a] For non domestic appliances check with manufacturer.			



Key

1 Design flow rate Q_D

2 Total flow rate Q_T in LU

3 Example of highest single value LU

Figure B.1 — Design flow rate Q_D in l/s

Type of appliance	Frequency of use		
	Low	Med	High
Basin, 15mm sep. taps	1	2	4
Basin, 2 × 8mm mix. tap	1	1	2
Sink, 15mm sep/mix tap	2	5	10
Sink, 20mm sep/mix tap	-	7	-
Bath,15mm sep/mix/tap	4	8	16
Bath, 20mm sep/mix tap	-	11	-
WC Suite, 6.litre cistern	1	2	5
Shower, 15mm head	2	3	6
Urinal, single bowl/stall	-	1	-
Bidet, 15mm mix tap	1	1	-
Hand Spray, 15mm	-	1	-
Bucket sink, 15mm taps	-	1	-
Slop Hopper, cistern only	-	3	-
Slop Hopper, cistern/taps	-	5	-
Clothes washing m/c, dom.	2	-	-
Dishwasher m/c domestic	2	-	-

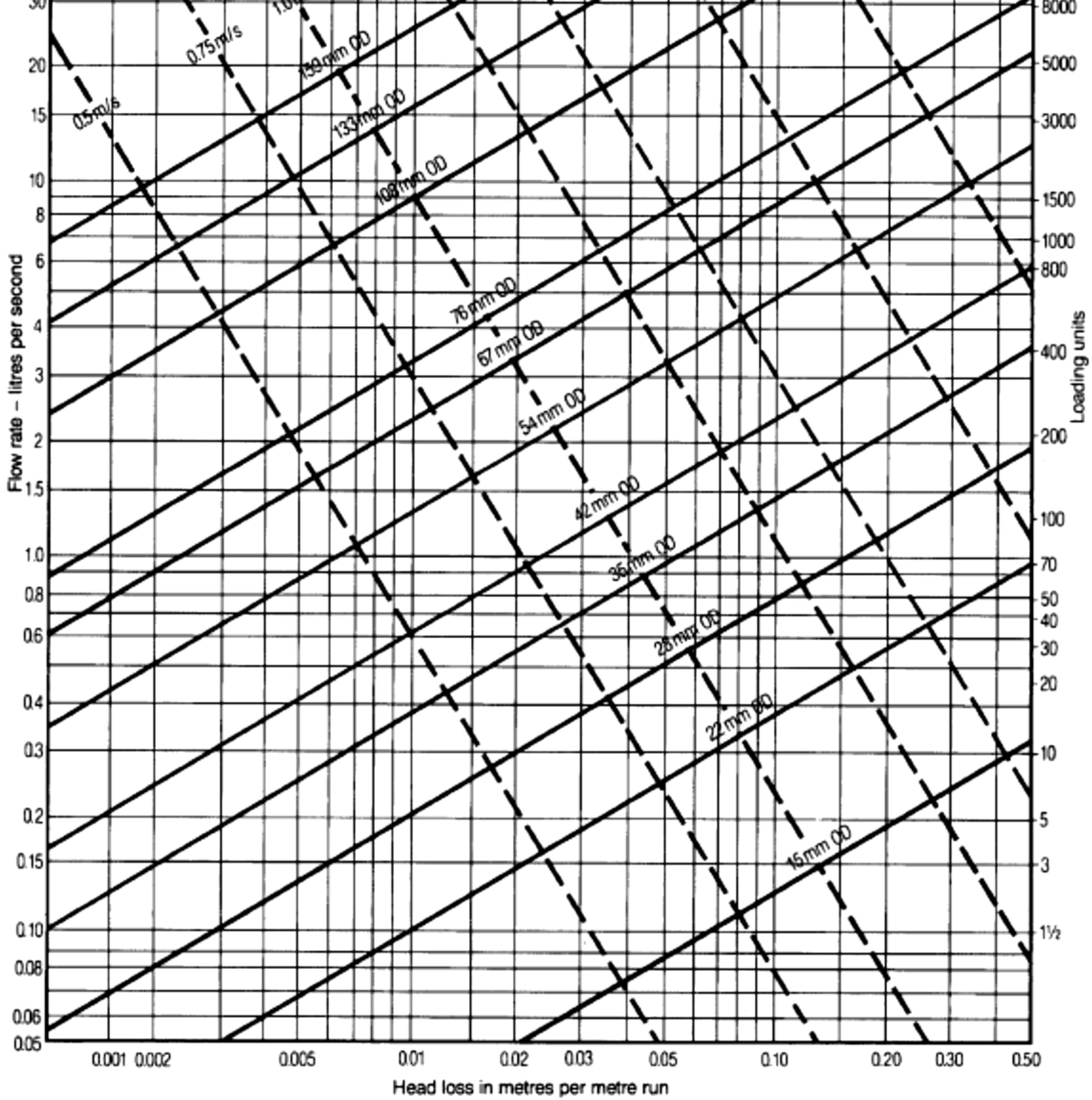

Flow rate – litres per second
Head loss in metres per metre run
Loading units
0.5 m/s
0.75 m/s
159 mm OD
133 mm OD
108 mm OD
76 mm OD
67 mm OD
54 mm OD
42 mm OD
35 mm OD
28 mm OD
22 mm OD
15 mm OD
30 20 15 10 8 6 4 3 2 1.5 1.0 0.8 0.6 0.4 0.3 0.2 0.15 0.10 0.08 0.06 0.05
0.001 0.002 0.005 0.01 0.02 0.03 0.05 0.10 0.20 0.30 0.50
8000 5000 3000 1500 1000 800 400 200 100 70 50 40 30 20 10 5 3 1½

Table D.1 Loading units (hot or cold supply)	
Type of appliance	**Loading units**
WC flushing cistern	2
Wash basin $\frac{1}{2}$ - DN 15	1.5 to 3
Bath tap $\frac{3}{4}$ - DN 20	10
Bath tap 1 - DN 25	22
Shower	3
Sink tap $\frac{1}{2}$ - DN 15	3
Sink tap $\frac{3}{4}$ - DN 20	5
Domestic clothes or dishwashing machines $\frac{1}{2}$ - DN 15	3

NOTE 1. WC cisterns with either single or dual flush control have the same LU.

NOTE 2. The wash basin LU is for use where pillar taps are installed. The larger LU is applicable to situations such as schools and those offices where there is a peak period of use. Where spray taps are installed, an equivalent continuous demand of 0.04 l/s should be assumed.

NOTE 3. Urinal cistern demand is very low, and is normally disregarded.

NOTE 4. Outlet fittings for industrial purposes or requiring high peak demands, should be taken into account by adding 100 % of their flow rate to the simultaneous demand for other appliances obtained by using LUs.

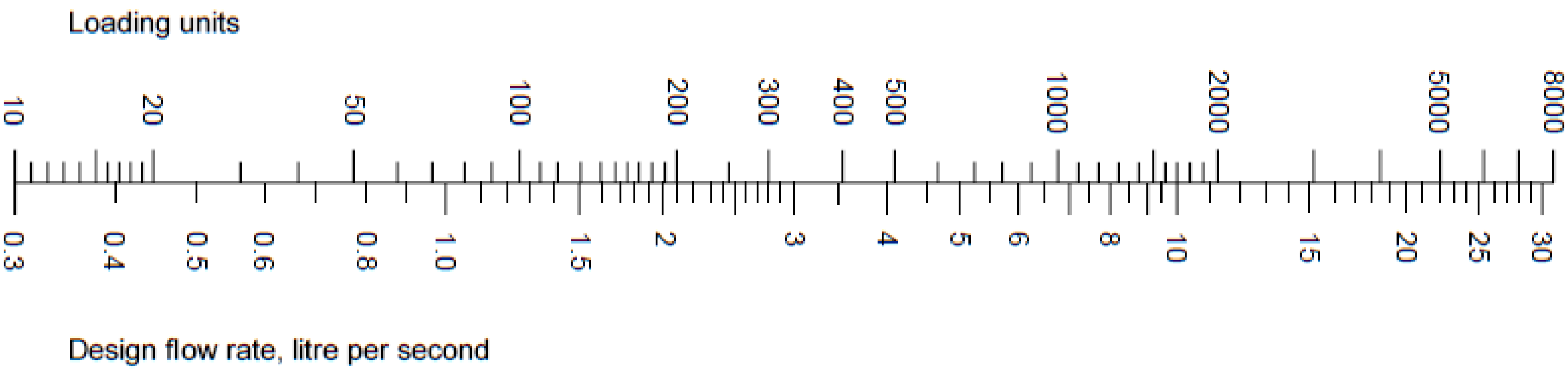


Figure D.1 Conversion of loading units to design flow rate

Loading Unit Calculation

Project	Fixture	Cold only Number	H&C Number
	Shower	125	125
	WC	125	125
	Washbasin Sep. Taps	125	125
	Kitchen Sink Sep/Mix 15mm	125	250
	Bath Sep/Mix 15mm	125	250

Method	Cold only Total Loading Units	H&C Total Loading Units
BS EN 806	1250	2000
IoP Min	1250	2000
IoP Mid	2500	4125
BS6700	2437.5	4062.5

[1] BS figures calculated from BS EN 806:3 Table 2

[2] IoP figures calculated from IoP Guide Table 15

BS EN 806	Loading Unit	Total	Total
	2	250	250
	1	125	125
	1	125	125
	2	250	500
	4	500	1000

BS 6700	Loading Unit	Total	Total
	3	375	375
	2	250	250
	1.5	187.5	187.5
	3	375	750
	10	1250	2500

IoP Guide	Min Loading Unit	Min Total	Min Total			Mid Loading Unit	Mid Total	Mid Total
	2	250	250			3	375	375
	1	125	125			2	250	250
	1	125	125			2	250	250
	2	250	500			5	625	1250
	4	500	1000			8	1000	2000

Loading Unit Calculation

		Cold only	H&C
Project	Fixture	Number	Number
	Shower	125	125
	WC	125	125
	Washbasin Sep. Taps	125	125
	Kitchen Sink Sep/Mix 15mm	125	250
	Bath Sep/Mix 15mm	125	250

Loading Unit Calculation

Project	Fixture	Number (Cold only)	Number (H&C)
	Shower	125	125
	WC	125	125
	Washbasin Sep. Taps	125	125
	Kitchen Sink Sep/Mix 15mm	125	250
	Bath Sep/Mix 15mm	125	250

Method	Total Loading Units (Cold only)	Total Loading Units (H&C)
BS EN 806	1250	2000
IoP Min	1250	2000
IoP Mid	2500	4125
BS6700	2437.5	4062.5

[1] BS figures calculated from BS EN 806:3 Table 2

[2] IoP figures calculated from IoP Guide Table 15

BS EN 806	Loading Unit	Total (Cold only)	Total (H&C)
	2	250	250
	1	125	125
	1	125	125
	2	250	500
	4	500	1000

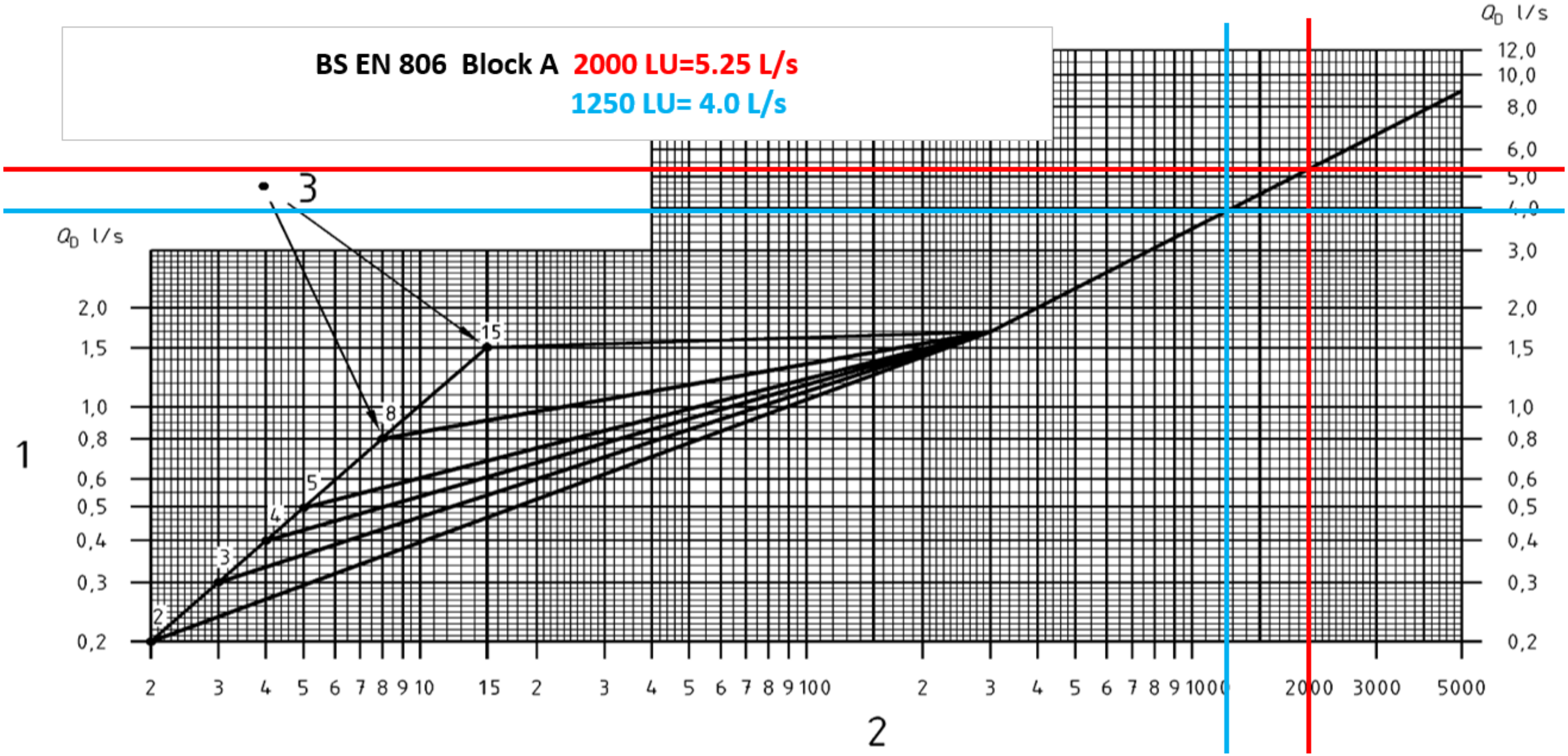
BS 6700	Loading Unit	Total (Cold only)	Total (H&C)
	3	375	375
	2	250	250
	1.5	187.5	187.5
	3	375	750
	10	1250	2500

IoP Guide	Min Loading Unit	Min Total (Cold only)	Min Total (H&C)		Mid Loading Unit	Mid Total (Cold only)	Mid Total (H&C)
	2	250	250		3	375	375
	1	125	125		2	250	250
	1	125	125		2	250	250
	2	250	500		5	625	1250
	4	500	1000		8	1000	2000

	Cold only	H&C
Method	Total Loading Units	Total Loading Units
BS EN 806	1250	2000
IoP Min	1250	2000
IoP Mid	2500	4125
BS6700	2437.5	4062.5

[1] BS figures calculated from BS EN 806:3 Table 2

[2] IoP figures calculated from IoP Guide Table 15


BS EN 806 Block A 2000 LU=5.25 L/s
1250 LU= 4.0 L/s
Q_D l/s
12,0
10,0
8,0
6,0
5,0
4,0
3,0
2,0
1,5
1,0
0,8
0,6
0,5
0,4
0,3
0,2
3
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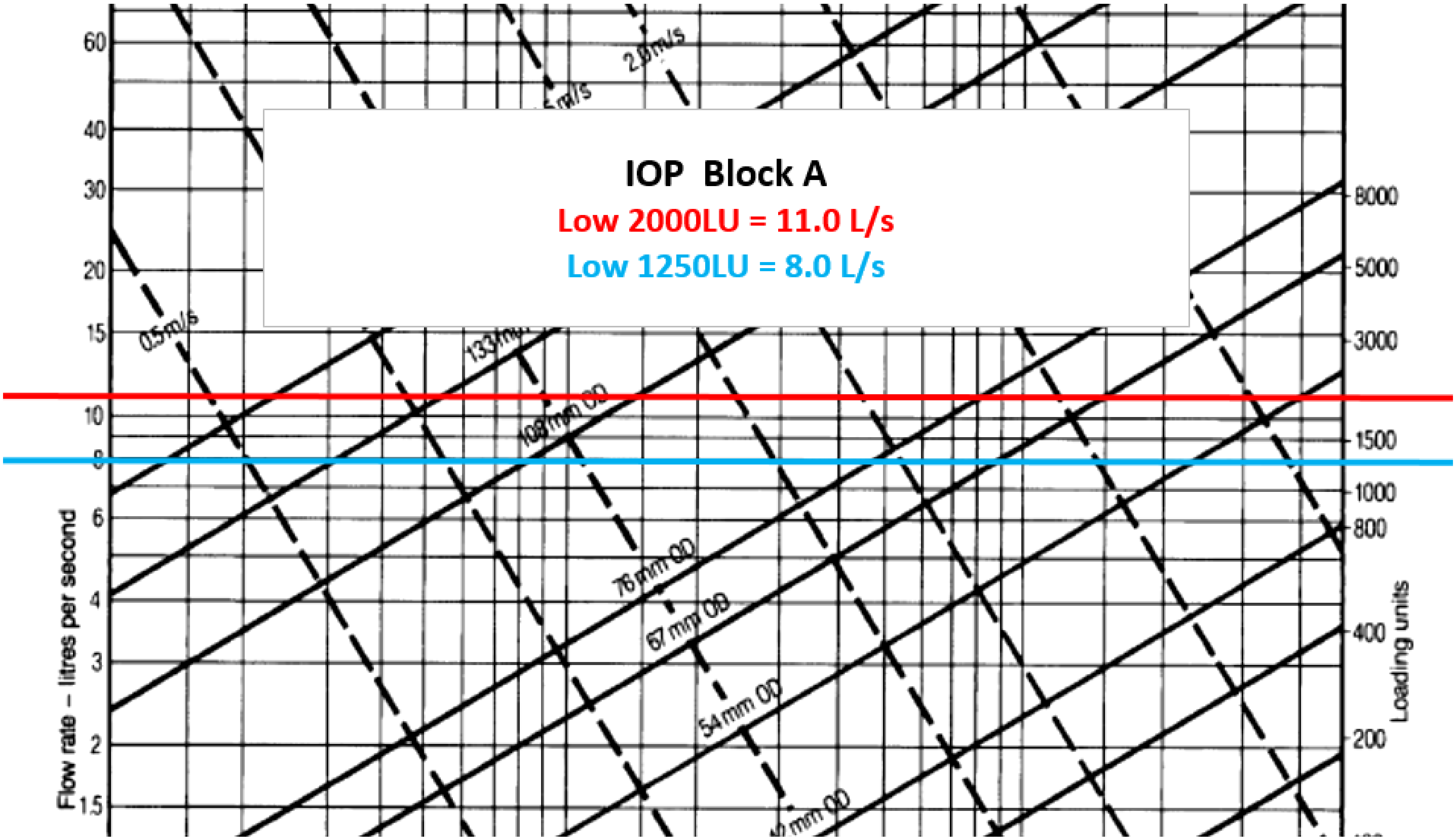
1000
2000
3000
5000
2

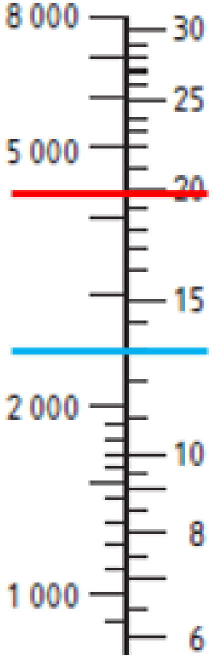

IOP Block A
Low 2000LU = 11.0 L/s
Low 1250LU = 8.0 L/s
Flow rate – litres per second
Loading units
60
40
30
20
15
10
8
6
4
3
2
1.5
8000
5000
3000
1500
1000
800
400
200
0.5m/s
108 mm OD
76 mm OD
67 mm OD
54 mm OD

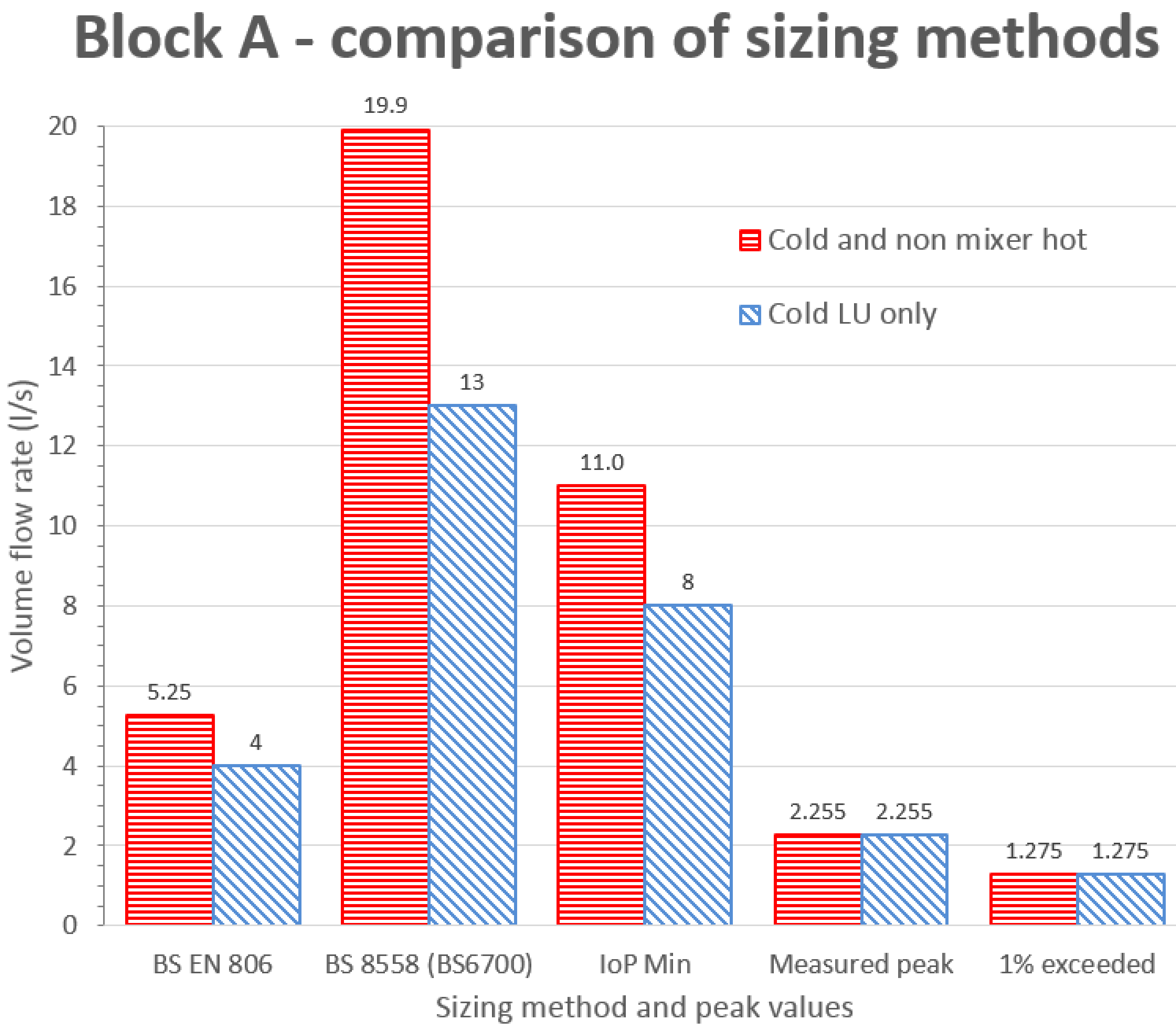
BS6700 Block A

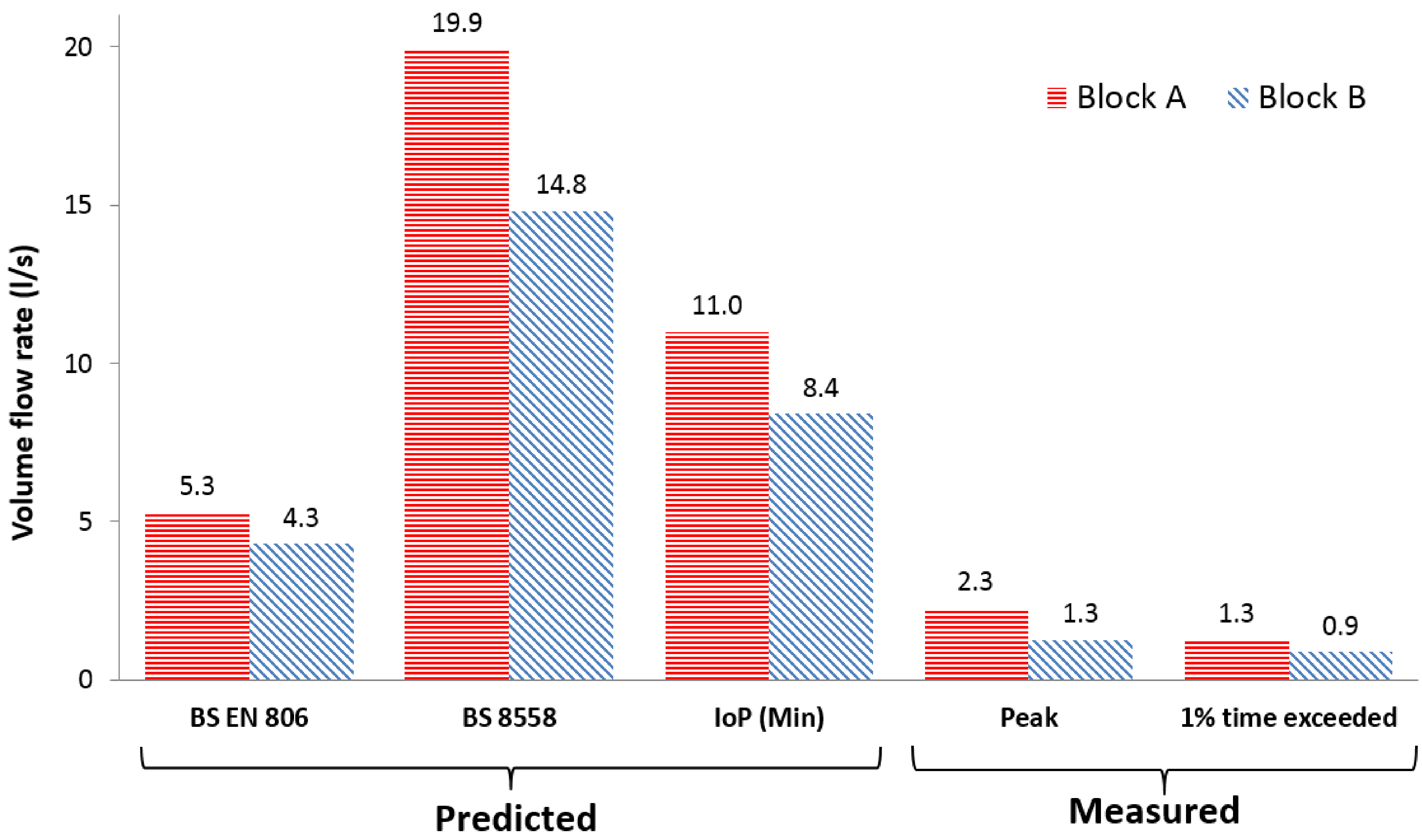
4062LU = 19.9 L/s

2438LU = 13 L/s

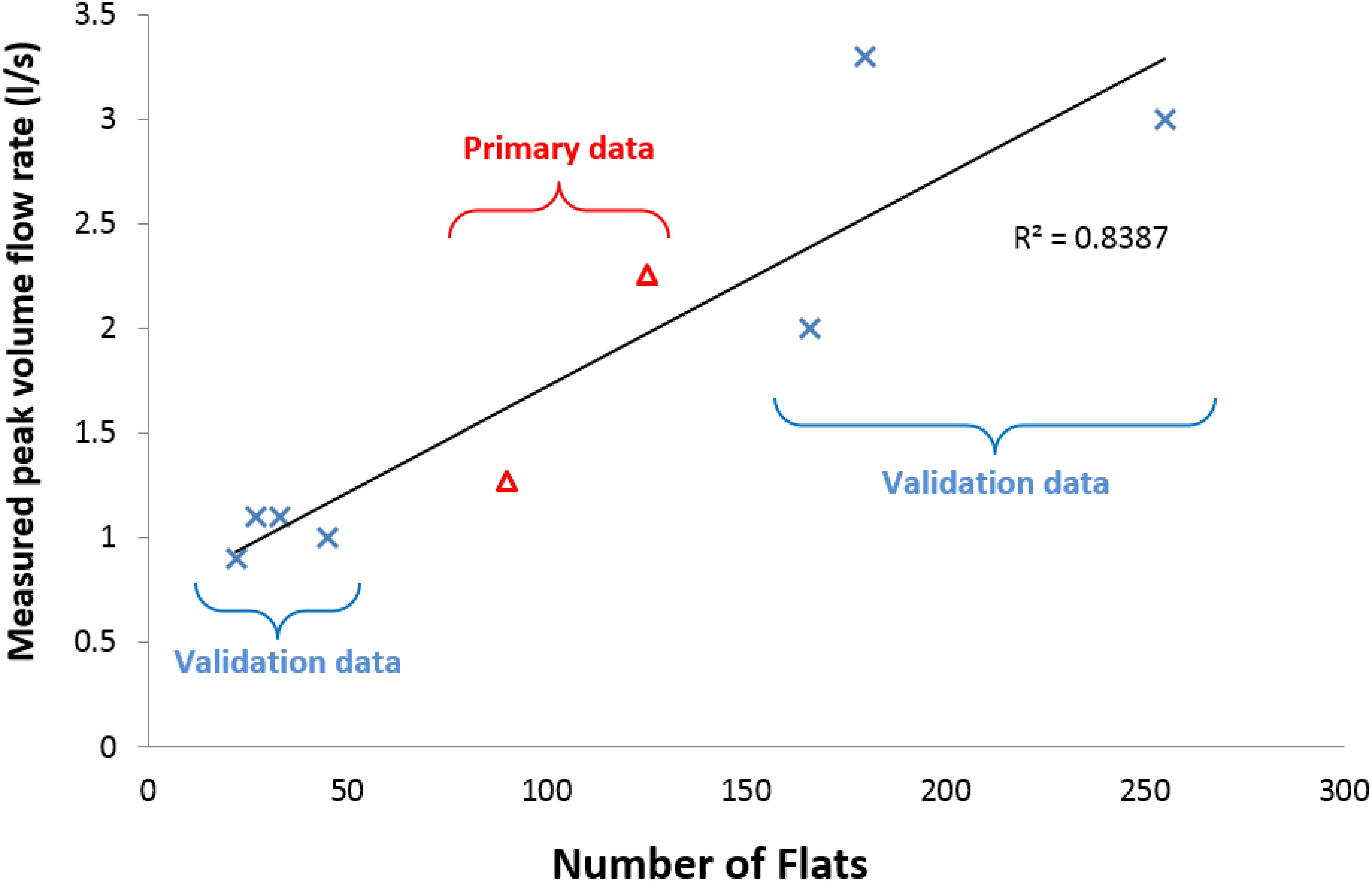
Figure D.1 Conversion of loading units to design flow rate



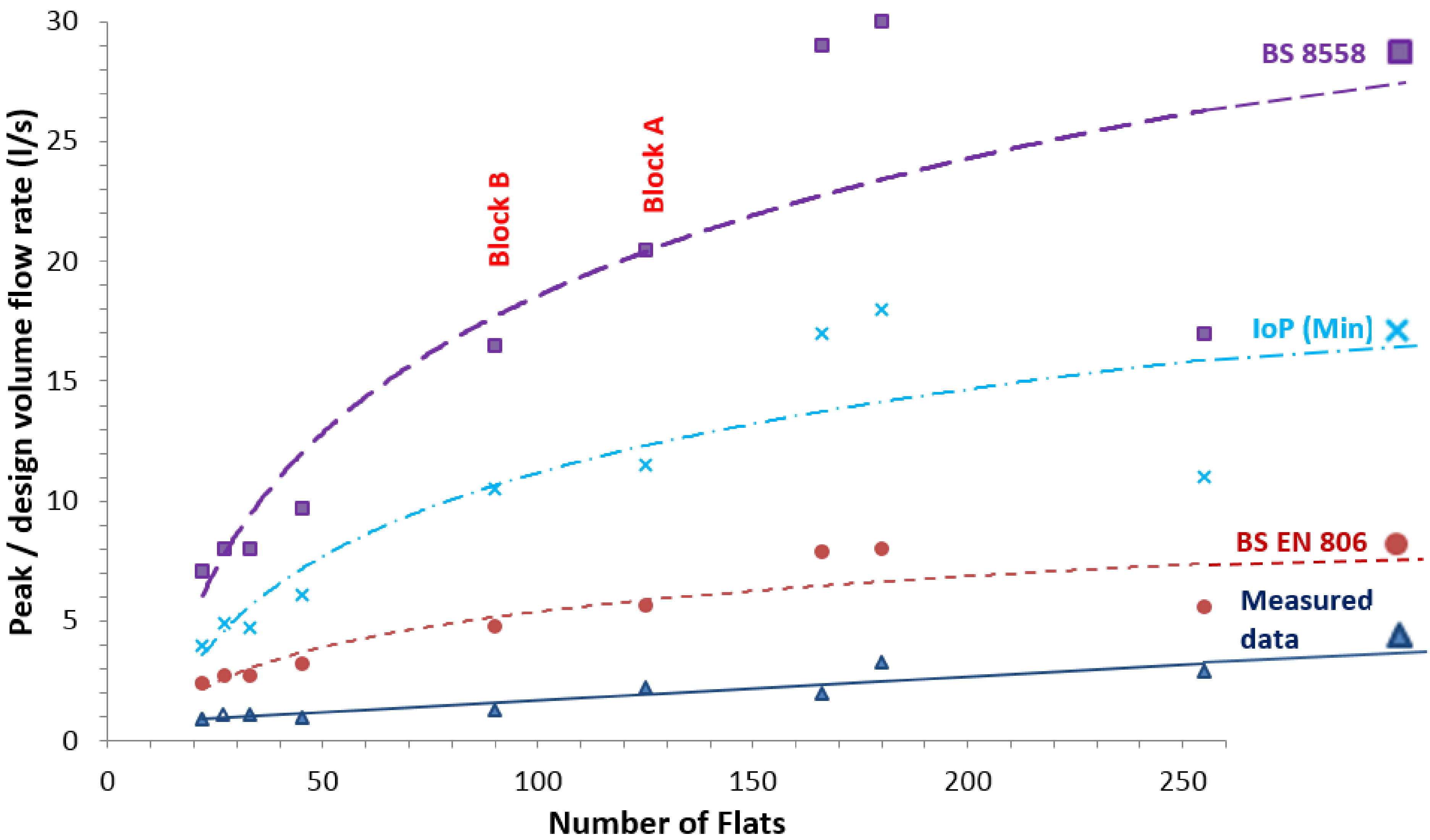

Block A - comparison of sizing methods
Volume flow rate (l/s)
0
2
4
6
8
10
12
14
16
18
20
Cold and non mixer hot
Cold LU only
5.25
4
19.9
13
11.0
8
2.255
2.255
1.275
1.275
BS EN 806
BS 8558 (BS6700)
IoP Min
Measured peak
1% exceeded
Sizing method and peak values



Volume flow rate (l/s)
20
15
10
5
0
Block A
Block B
19.9
14.8
11.0
8.4
5.3
4.3
2.3
1.3
1.3
0.9
BS EN 806
BS 8558
IoP (Min)
Peak
1% time exceeded
Predicted
Measured

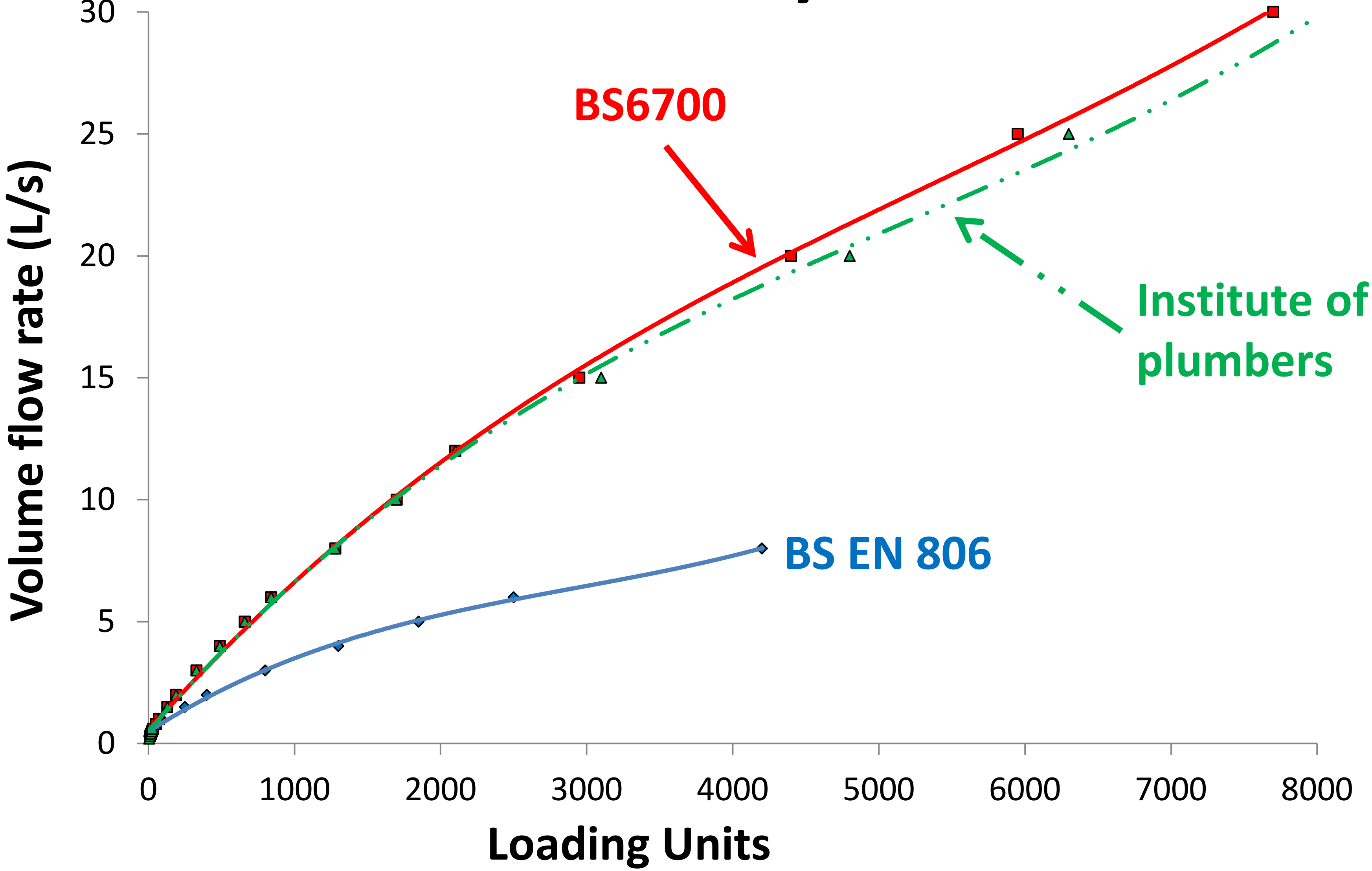


Measured peak volume flow rate (l/s)
3.5
3
2.5
2
1.5
1
0.5
0
Primary data
R² = 0.8387
Validation data
Validation data
0
50
100
150
200
250
300
Number of Flats



Peak / design volume flow rate (l/s)
Number of Flats
0
5
10
15
20
25
30
0
50
100
150
200
250
Block B
Block A
BS 8558
IoP (Min)
BS EN 806
Measured data

Method diversity difference



Thank you for listening

Any questions?

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BS 8558:2015

BSI Standards Publication

Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Complementary guidance to BS EN 806

In small, simple installations, such as those in single dwellings, it is often acceptable to size pipes on the basis of experience and convention. In all other cases the peak design flow rates should be assessed using a recognized method of **calculation given in this annex or specified in BS EN 806-3. The latter method produces significantly lower simultaneous design flows than the UK method. It is acknowledged that there is evidence to suggest that the traditional UK loading unit method overestimates the likely peak demand within a building, and scientific evaluation is currently ongoing.** Overestimation of the peak demand can result in larger than necessary pipe sizes, which can produce several adverse effects. Until such time as validated research has been published, either the loading unit method within BS EN 806-3 or the method within this annex may be used, as appropriate.

For residential installations supplying single and multiple dwellings the loading unit method in BS EN 806-3 may be used.

For non-residential installations supplying commercial and public buildings, traditional UK loading units may be used, as explained in this annex.

Care is needed when assessing the combined demand of hot and cold water supplies, for example at booster pumps, to reduce the effect of over-sizing. For appliances fed with both hot and cold water supplies, the traditional loading unit model assumes that the system demand imposed by the appliance is met fully by each separate supply. Although this is logical when separate hot and cold water taps are fitted to an appliance, **it is not valid when mixer taps/valves are used,** particularly when a flow-limiting device is fitted to the outlet or integral within the mixer.

For example, in the case of a shower with a flow-limiting device fitted after the shower mixer, the combined hot and cold water demand will not be any more than if the user selects cold only or hot only at the appliance.

Consequently, the relevant loading unit applied separately to the hot and cold water supplies for pipe sizing ought not to be added together when sizing the combined hot and cold water demand.