Office of the
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Creating sustainable communities

Hydraulic Calculation of Wet and Dry Risers, Hoses and Branches

December 2004
Building Research Establishment
On behalf of the
Office of the Deputy Prime Minister: London

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Executive Summary

This project is being undertaken in response to a request from ODPM Fire Statistics and Research Division (FSRD) to undertake a number of hydraulic calculations on wet and dry risers in high rise buildings.

This report provides results of sample calculations using a BRE software package “Riser flow” to calculate water flows in wet and dry risers.

The report describes the assumptions made to undertake the calculations and details the results obtained for the specific conditions requested in the contract proposal, “Firefighting in buildings hydraulic calculation in wet and dry risers, hoses and branches”.

Contents

1 Introduction

This project is being undertaken for Fire Statistics and Research Division (FSRD), ODPM under contract CI 71/5/19 to provide an insight into the limitations of fire fighting rising mains complying with BS 5306: Part 1,[1] with specified fire appliance pumps as the pumping effort.

The project entails the development of PC based calculation software to determine the pressure losses in fire fighting wet and dry rising mains. Suitable input data have been identified. The project includes a series of pressure loss calculations using the software and data provided by the project against specified scenarios. The software will be provided to FSRD, ODPM at a later stage in the project.

2 Background

Wet or dry riser systems are terminal pipe configuration systems installed in accordance with BS 5306: Part 1. The pipework is a series configured pipe array consisting of:

1. Pump or water supply;
2. Hose from pump to dry riser inlet (the pump outlet may not be at the same elevation as the riser inlet);
3. Riser inlet fittings, pipework and bend(s) to base of riser;
4. The riser;
5. Riser outlet and fittings (on wet risers BS 5306: Part 1, Clause 9.4.4 limits the outlet pressure to 4 bar minimum, 5 bar maximum at flows of at least 1500 l/min);
6. Hose line(s) from riser outlet to branch connection; and
7. Branch.

Figure 1 shows a typical dry riser arrangement.

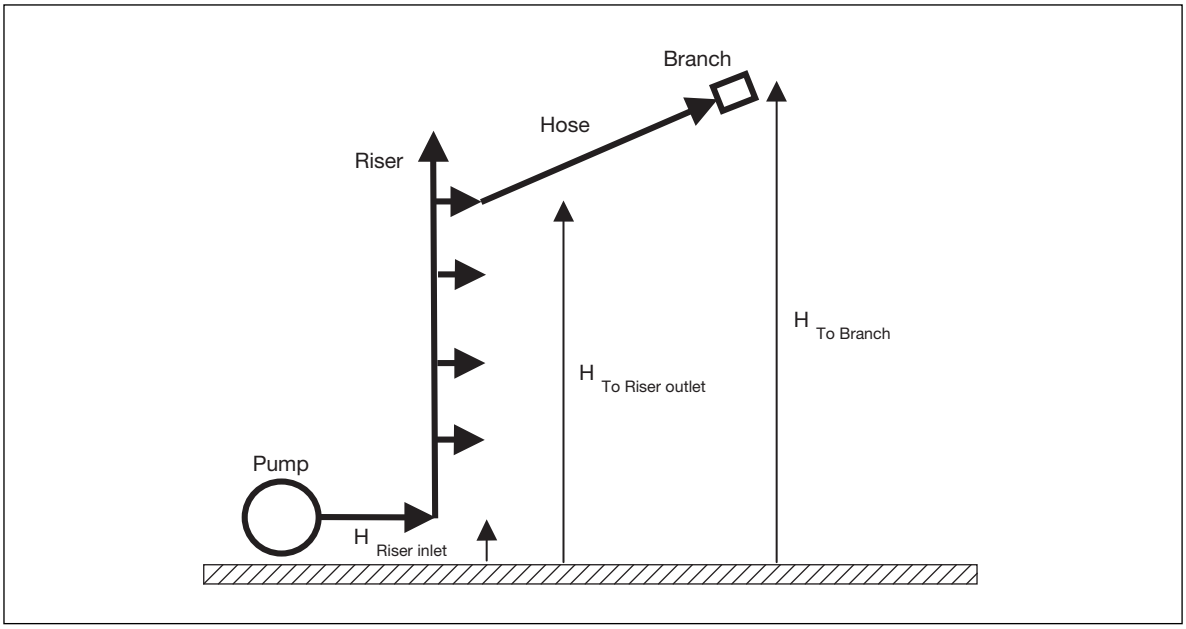


Figure 1. Schematic of dry riser network

To predict the pressures and water flows from a branch accurately, detailed information is required about the system and components, such as:

1. The water supply characteristic;

2. Pipe fitting details;

3. Pipe size details such as pipe specification, pipe length (m), pipe diameter (mm); change in elevation between inlet and outlet (m); and friction losses through the pipe at flow;

4. Flexible hose details such as length (m), hose diameter (mm), change in elevation between inlet and outlet and end fittings (m), (characteristics may vary between different products of the same nominal diameter) and friction losses through the hose under flow conditions (the friction losses may also vary due to pressure);

5. Branch performance characteristics such as nozzle entry pressure (bar) and flow (dm^3/min) over the operating pressure range of the branch or the branch k factor (see paragraph 3.1.8 for an explanation of k factor).

3 Assumptions and Data used for calculations

3.1 Elements used in the calculations

3.1.1 Water supplies

The pump used for calculation purposes is a Godiva WT30/10 (LP stage), complying with BS EN 1028-1,[2] unless otherwise stated. Zero suction lift has been assumed for all calculations. See Appendix C.

NOTE. Where pumps draw directly from a town main, providing the town main can satisfy the pump demand, there will be a positive supply pressure advantage, depending on the positive pressure at the pump inlet.

3.1.2 Connection details between the pump and the riser

It has been assumed that the connection between the pump and the riser consists of 2 × 70 mm Nominal Diameter (ND) hoses each of 25 m length. The change in elevation between the pump outlet and riser inlet has been taken as (zero) 0 m.

3.1.3 Riser inlet connection (breeching)

Each inlet connection complying with BS 5041-3[3] is required to be fitted with spring loaded non-return valve(s) (see BS 5041-3; Clause 7.3) and will therefore have a friction loss which exceeds that for straight pipe under flow conditions. No friction loss information has been provided by suppliers of inlet connections. (It may be that the friction loss values have been derived during the development of the product, but are not readily available within the supplying companies). A friction loss equivalent to a single mushroom type non-return valve has therefore been assumed down-stream of the inlet connection.

3.1.4 Riser pipe size

BS 5306: Part 1; clause 8.1.2, specifies the nominal bore size of wet and dry risers. Where only one outlet is provided on a floor a 100 mm ND riser is permitted. If two are "permitted" a riser of 150 mm ND is specified. For all the calculations BS1387[4] heavy gauge, galvanised pipe, 100 mm ND has been used as this will yield a greater pressure loss than 150 mm ND pipe.

3.1.5 Fitting friction losses for fittings and pipes

The fitting friction losses have been based on BS 5306: Part 2,[5] Table 37. Calculations of pipework losses have been based on BS 5306: Part 2, Section 18. A friction loss C factor of 120 has been assumed for BS 1387 Heavy gauge pipe. See Appendix B.

3.1.6 Landing valves

No friction loss information has been forthcoming from suppliers for landing valves. The friction loss equivalent to a "straightway" gate valve has therefore been used.

3.1.7 Hose

Hose diameters of 45, 51 and 70 mm have been included. A calculation method and values has been developed for each of the hose sizes that agree closely with one of the UK major hose suppliers' hydraulic calculation programme.

3.1.8 Branches

The water flow through the branches may be calculated using the equation:

$$Q = k\sqrt{P}$$

Where

Q = flow rate through the branch (dm^3/min)
P = pressure at the entry to the branch (bar)
k = nozzle constant

The following branches were selected to represent the range of branches available:

SRDB Code No	Details	k factor
46	Angloco Ltd – Rosenbauer R.B. 201	80
53	Walter Frank and Sons – Elkhart chief 4000 -3	230
45	Angloco Ltd – Rosenbauer R.B. 102	330

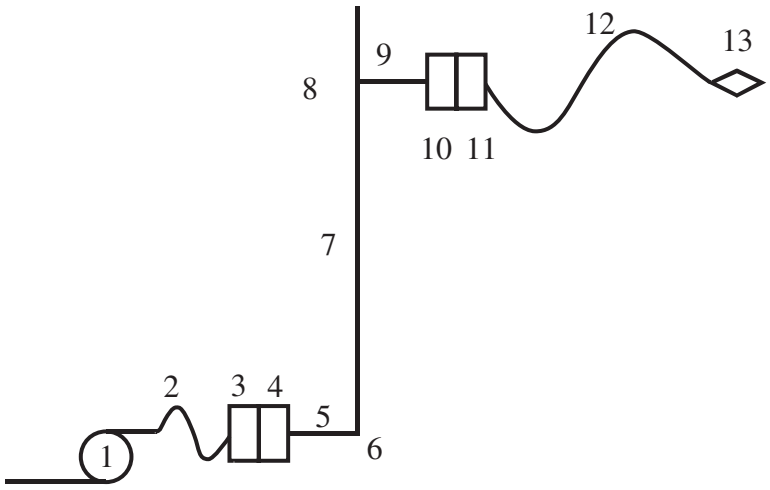
The k factors attributed to the branches are based on performance data made available by the ODPM and data published in Jet/Spray Branches Data sheets.[6] The available data indicate that the k factors of branches are not always a constant, some branches varying more than others. The amount that the k factor varies will be dependent on a number of factors such as bore size, degree of adjustment, and automaticity. The branches selected represented those that appeared to represent low (SRBD 46), median (SRDB 53) and high (SRDB 45) values within the range of branches for which data are available and also had reasonably consistent k factor values within the 4 to 5 bar operating range. It is important to note that the k factor values used in this report will not be representative for all possible branch settings or for the full operating branch pressure range of the branch cited.

3.1.9 Pump characteristics

Where a fire appliance pump complying with BS EN 1028-1 has been specified, the pump performance of a Godiva WT30/10 (LP stage) has been used, see Appendix C.

3.1.10 Schematic of installation used for calculations

Where dry-riser calculations have been carried-out, the arrangement in Figure 2 has been used.



1. Godiva pump WT30/10 LP or LP stage;
2. Two hoses in parallel each 70 mm ND × 25 m long;
3. Riser inlet (no loss);
4. Non return valve (mushroom pattern);
5. Pipe (riser inlet to riser), 100 mm ND × 10 m long, (no change in elevation);
6. Elbow (screwed), 100 mm ND;
7. Riser pipe, 100 mm ND × Height (variable);
8. Tee (screwed), 100 mm ND;
9. Pipe (riser to riser landing valve) 100 mm ND × 10 m long, no change in elevation;
10. Gate valve, 100 mm ND;
11. Landing valve (no loss);
12. Hose 70mm, 51 mm or 45 mm ND, hose length variable 3 × 25 m or 4 × 25 m;[1]
13. Branches SRDB 46, 53 or 45.[2]

Figure 2. Schematic of installation dimensions and arrangements used for calculations

[1] Hose size and length defined in item.
[2] Three branch sizes have been used for most calculations.

4 Calculation results

The results follow the same order as Framework Research Proposal, "Firefighting in buildings hydraulic calculation in wet and dry risers, hoses and branches", Appendix A – Specific conditions to be evaluated in hydraulic calculations. The Proposal Appendix item is inserted in *italic* preceding the results.

It should be noted the following calculations include theoretical maxima based on possible pump performance. These can exceed the pressures to which riser pipework is currently designed and tested (BS 5306-1: 1976).

4.1 Proposal Appendix A; Item 1

The maximum pressures achievable at outlets of a firefighting rising main complying to BS 5306:Part 1:1976 when supplied with a BS EN 1028-1 specification fire appliance pump. This pressure to be calculated at outlet levels of floors one to eighteen with a notional storey height of 3.5 m.

The maximum pressures at the outlet have been calculated for two conditions:

(a) closed valve pressures (zero flow); and

(b) flowing pressure with Branch SRBD No 53

The calculations for the flow through the branch, assume the branch is directly connected to the outlet. The pressure riser outlet height results are shown graphically in Figure 3 and the numeric data are provided in Appendix A, Table A.1 of this report.

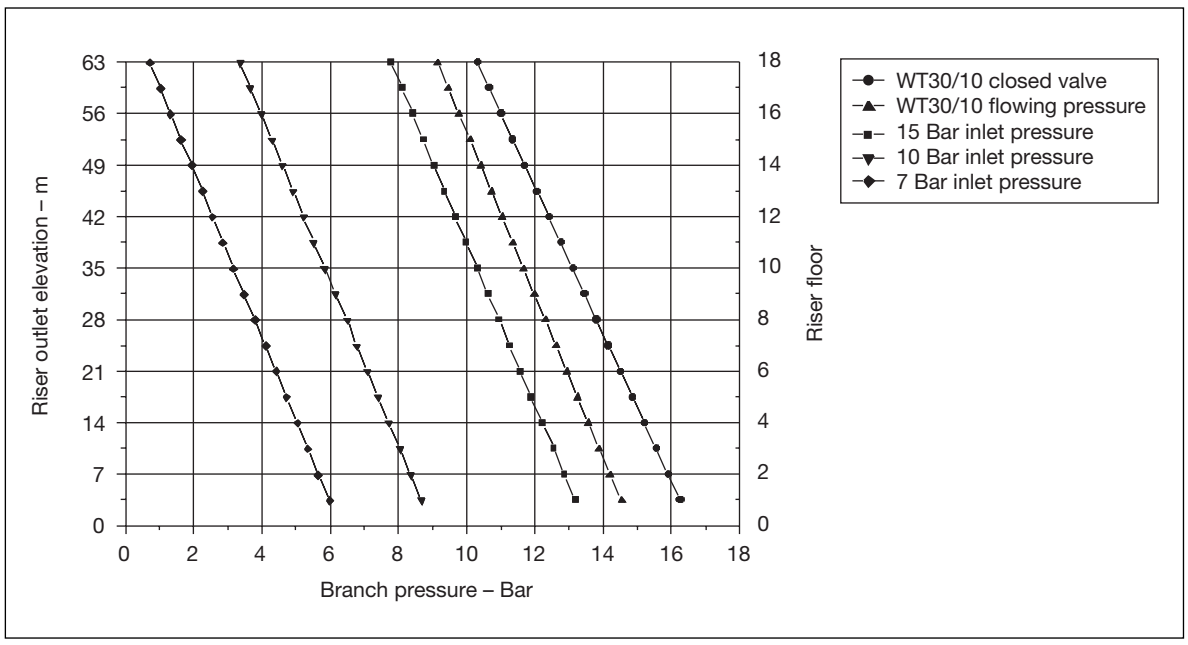


Figure 3. Maximum riser outlet pressures for outlet heights of 3.5 to 63 m

4.2 Proposal Appendix A; Item 2

The maximum pressures available at a firefighting branch when supplied with three lengths of British Standard BS 6391:1983, 45 mm, 51 mm and 70 mm hose using the rising main outlet pressures calculated in 1, with the firefighting branch operating on the same floor level.

The maximum pressure will vary depending on the flow generated by the branch attached at the end of the hose. The pressure flow calculations have therefore been carried out for each case specified using Branches SRDB No's 46 (k factor 80), 53 (k factor 230) and 45 (k factor 330). The riser heights vs. branch pressure results are shown graphically in Figures 4, 5 and 6. The data are provided in numeric form in Appendix A, Tables A.2.1, A.2.2 and A.2.3.

The details of the assumptions made on which the calculations are based are given in Appendix A, Tables A.2.1, A.2.2 and A.2.3.

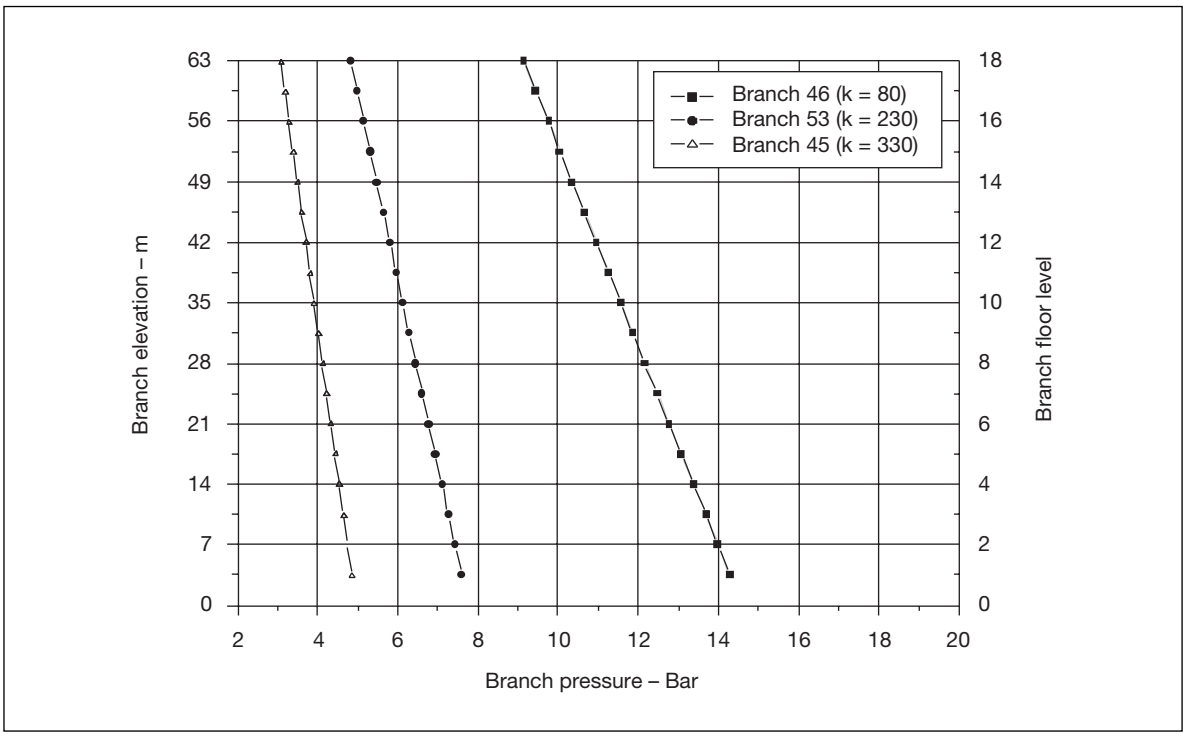


Figure 4. Maximum branch pressures with 3 lengths of 45 mm hose

4.3 Proposal Appendix A; Item 3

The maximum pressure available at a firefighting branch when supplied with four lengths of British Standard BS 6391:1983 45 mm, 51 mm and 70 mm hose using the rising main outlet pressures calculated in 1 with the firefighting branch operating a) one floor higher than the rising main outlet, b) two floors higher than the rising main outlet. Assume a notional storey height of 3.5m.

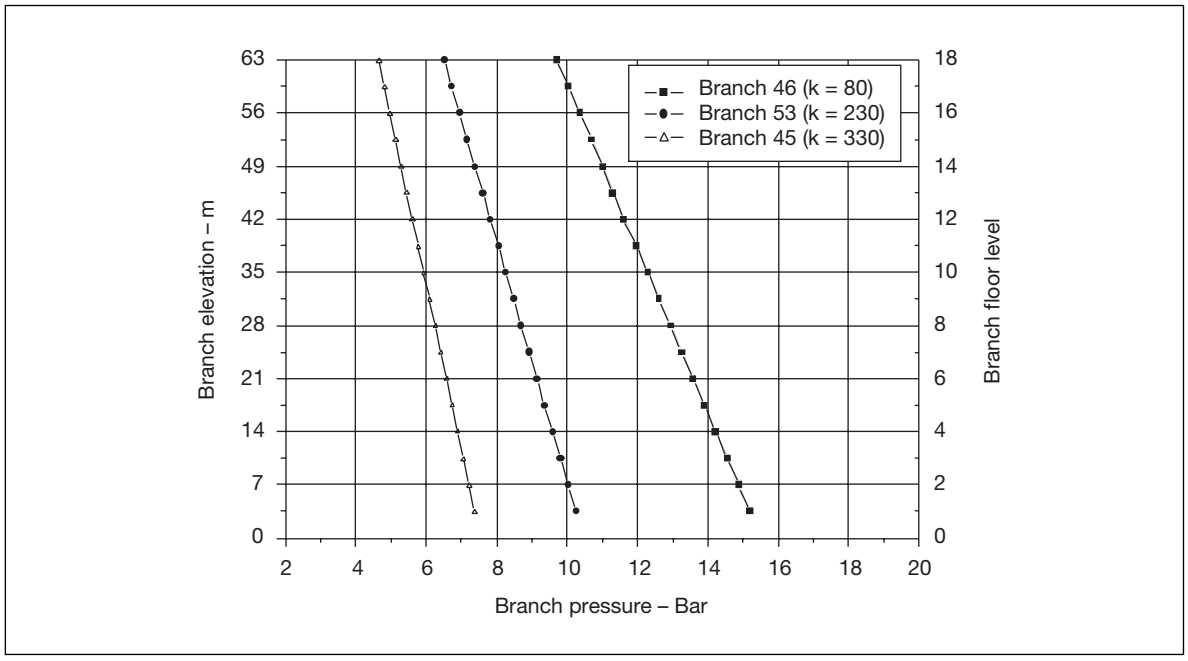


Figure 5. Maximum branch pressures with 3 lengths of 51 mm hose

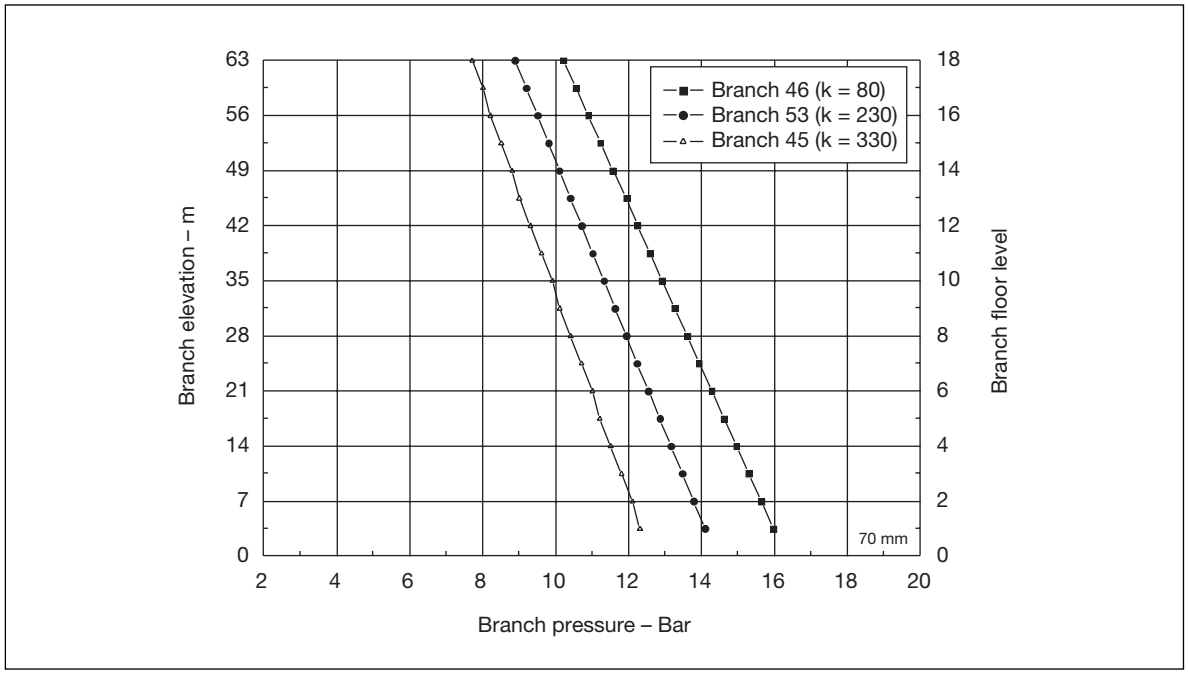


Figure 6. Maximum branch pressures with 3 lengths of 70 mm hose

The results of the six calculation sets using Branch 53 (k = 230) are shown graphically in Figure 7. The results for the pair sets (for hoses of the same dimensions connecting riser outlets to branches 3.5 and 7.0 m above the outlet) are the same (to the nearest whole number) and the pairs of plots in Figure 7 overlay each other. The pressure at the branches 7.0 m above the riser outlets are marginally higher than those for 3.5 m above the riser

outlets, due to a shorter equivalent length of 3.5 m of 100 mm pipe. The data are provided in numeric form in Appendix A, Table A.3.

The details of the assumptions made on which the calculations are based are given in Appendix A, Table A.3.

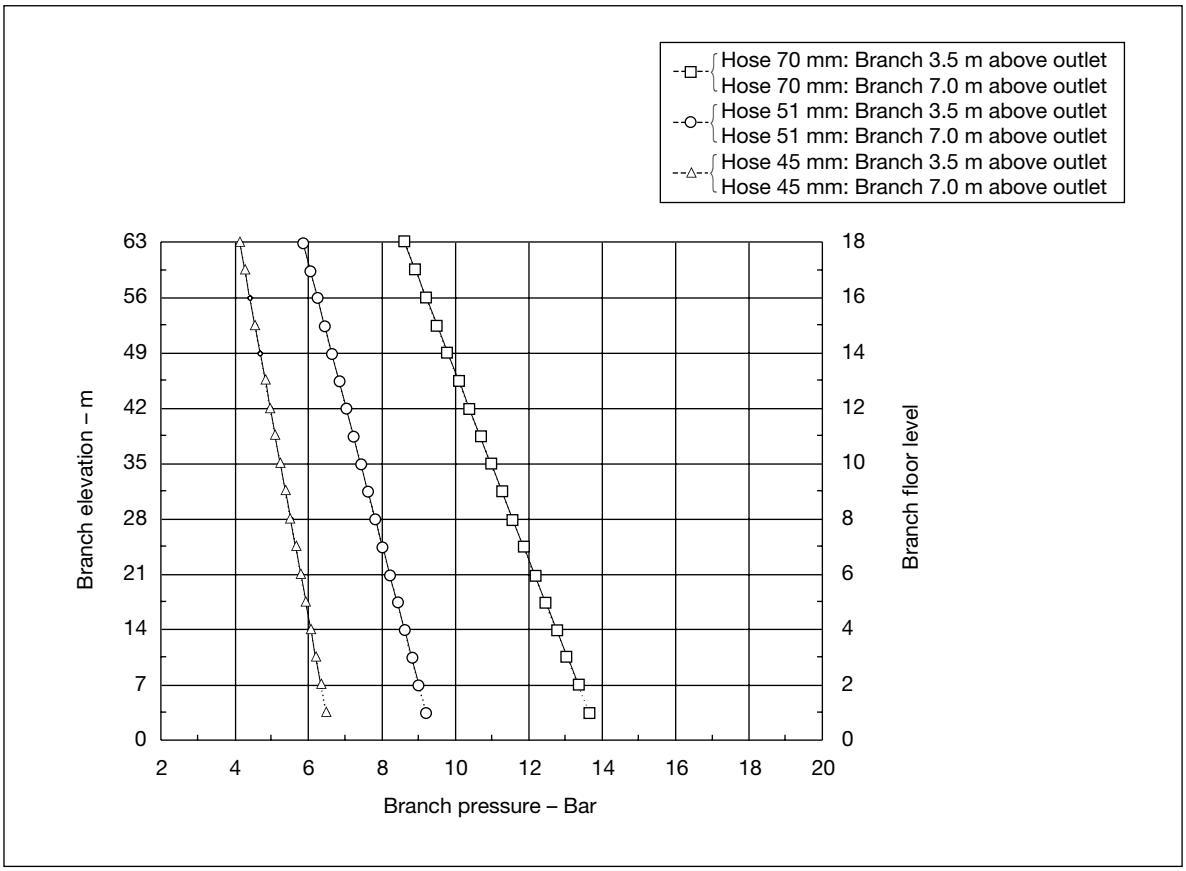


Figure 7. Maximum Branch No 53 (k = 230) pressure with 4 × 25 m lengths of hose connecting riser outlet to branch 3.5 m and 7.0 m above the outlet

4.4 Proposal Appendix A; Item 4

The maximum elevation of rising main outlet which if supplied by a BS EN 1028-1 specification fire appliance pump is capable to delivering 4 bars pressure at a firefighting branch when supplied through three lengths of British Standard BS 6391:1983 45 mm, 51 mm and 70 mm hose connected to the riser outlet, with the firefighting branch operating on the same floor as the rising main outlet.

The results of the calculations are shown graphically in Figure 8 and the data are provided in numeric form in Appendix A, Table A.4.

The data show clearly the relationship between branch size, hose size and their influence on branch elevation for the given conditions.

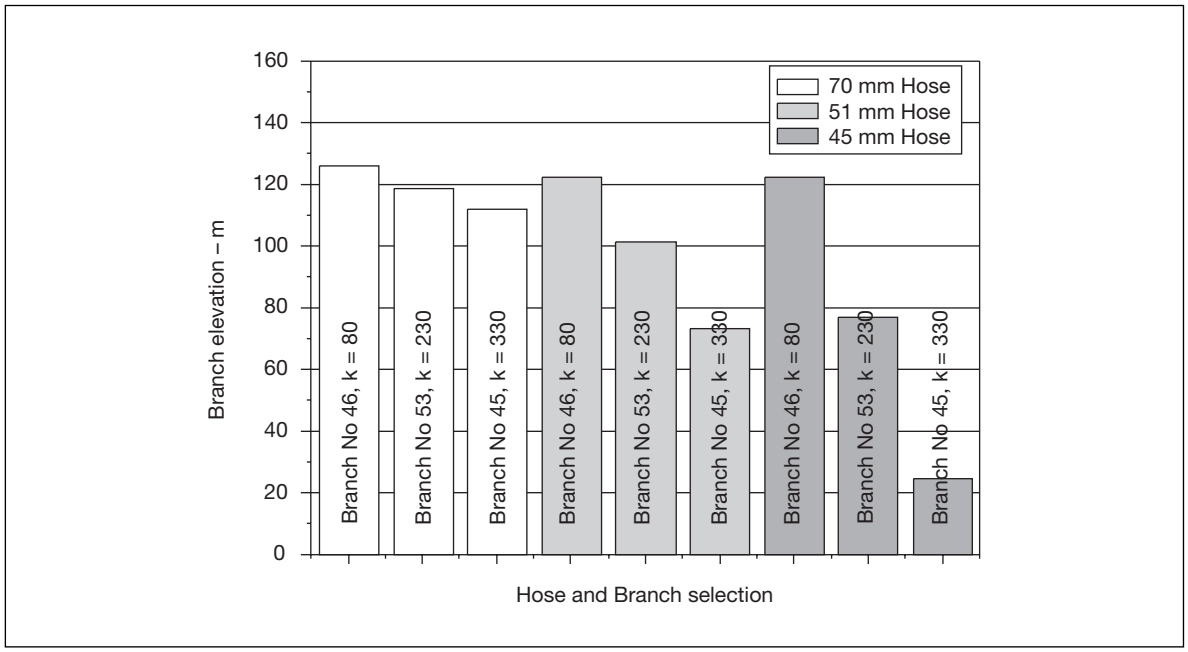


Figure 8. Maximum branch elevation for a branch pressure of 4 bar 3 × 25 m hose lengths

4.5 Proposal Appendix A; Item 5

The maximum elevation of rising main outlet which if supplied by a BS EN 1028-1 specification fire appliance pump is capable to delivering 4 bars pressure at a firefighting branch when supplied through four lengths of British standard BS 6391:1983 45 mm, 51 mm and 70 mm hose connected to the riser outlet, with the firefighting branch operating a) one floor higher than the rising main outlet, b) two floors higher than the rising main outlet. Assume a notional storey height of 3.5 m.

The results of the calculations are shown graphically in Figure 9 and the data are provided in numeric form in Appendix A, Table A.5. Two sets of calculation were undertaken for four lengths of 25 m hose, with the branch 3.5 m and 7.0 m above the riser outlet. Both calculation sets were very similar and can be represented by one graph and numeric data set.

The details of the assumptions made on which the calculations are based are given in Appendix A, Table A.5.

4.6 Proposal Appendix A; Item 6

The maximum elevation of rising main outlet which if supplied by a BS EN 1028-1 specification fire appliance pump is capable to delivering 2 bars pressure at a firefighting branch when supplied through three lengths of British standard BS 6391:1983 45 mm hose connected to the riser outlet, with the firefighting branch operating on the same floor as the rising main outlet.

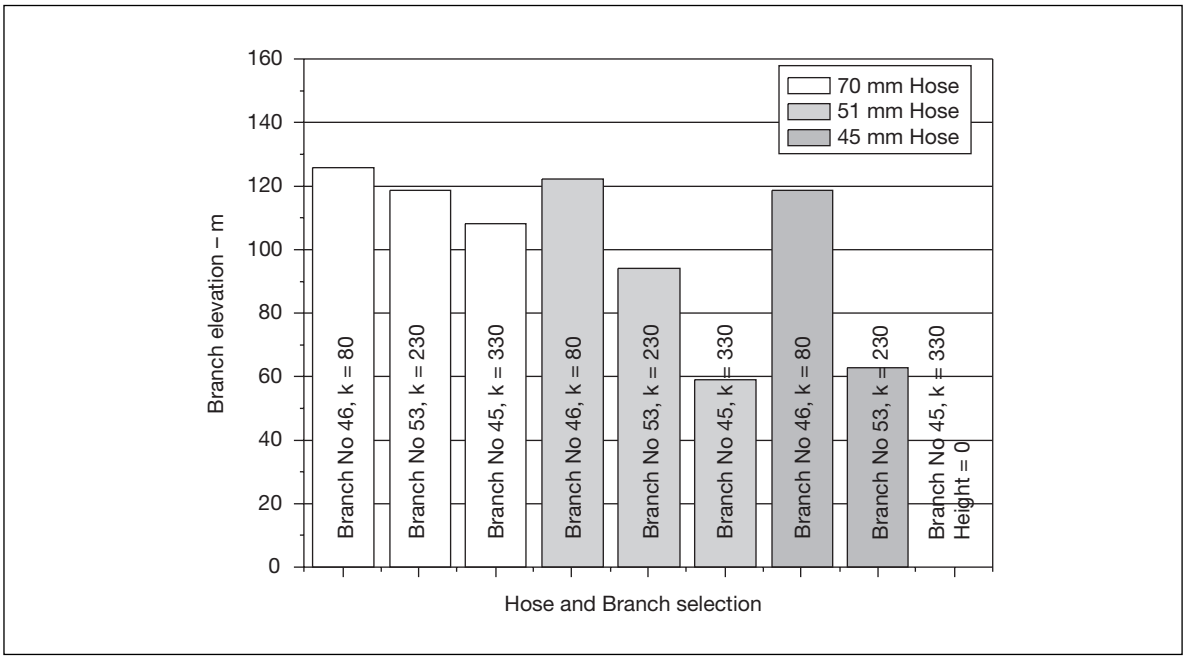


Figure 9. Maximum branch elevation for a branch pressure of 4 bar 4 × 25 m hose lengths

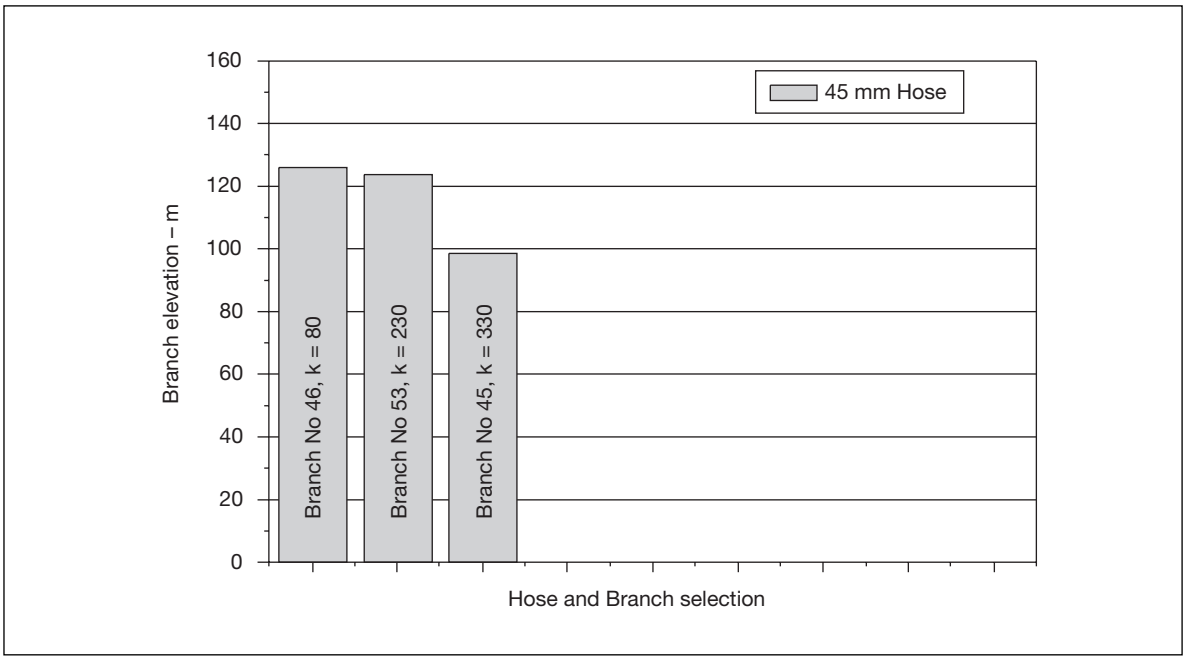


Figure 10. Maximum branch elevation for a branch pressure of 2 bar 4 × 25 m hose lengths

The results of the calculations are shown graphically in Figure 10 and the data are provided in numeric form in Appendix A, Table A.6.

The details of the assumptions made on which the calculations are based are given in Appendix A, Table A.6.

4.7 Proposal Appendix A; Item 7

The maximum elevation of rising main outlet which if supplied by a BS EN 1028-1 specification fire appliance pump is capable to delivering 2 bars pressure at a firefighting branch when supplied through four lengths of British standard BS 6391:1983 45 mm, 51 mm and 70 mm hose connected to the riser outlet, with the firefighting branch operating a) one floor higher than the rising main outlet, b) two floors higher than the rising main outlet. Assume a notional storey height of 3.5m.

The results of the calculations are shown graphically in Figure 11 and the data are provided in numeric form in Appendix A, Table A.7. The results for the branch one and two floors above the branch outlets were similar values. Only one set of data have therefore been plotted.

The details of the assumptions made on which the calculations are based are given in Appendix A, Table A.7.

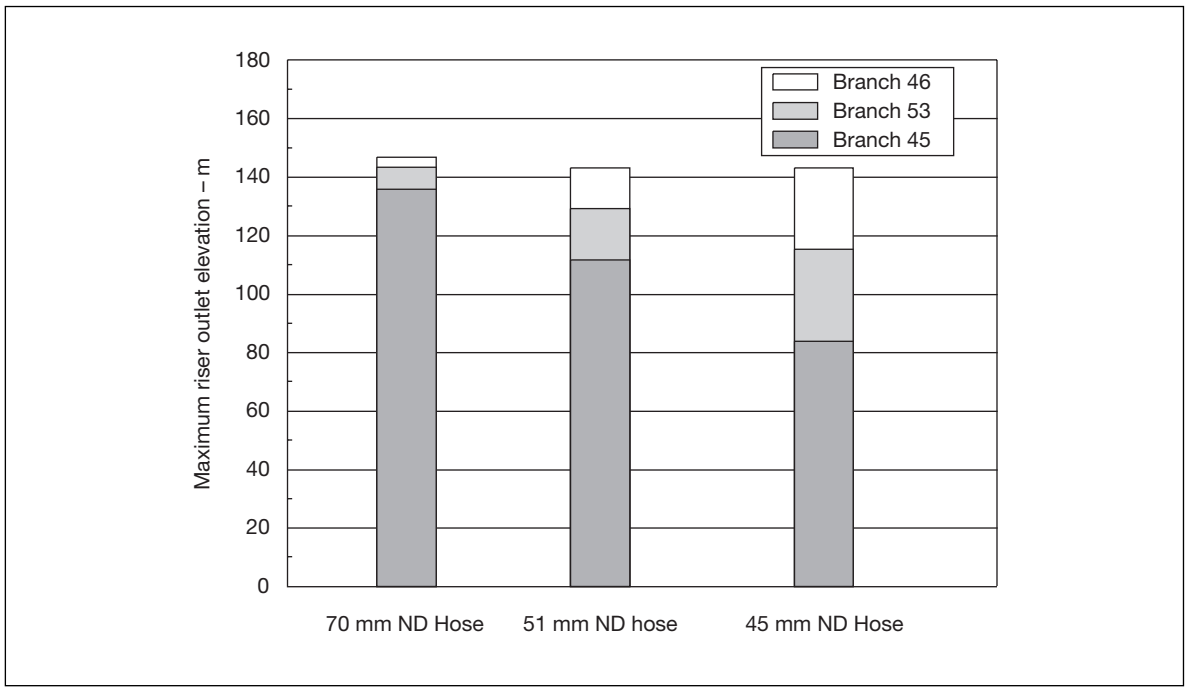


Figure 11. Maximum riser outlet height for a 2 bar branch pressure

4.8 Proposal Appendix A; Item 8

The maximum pressures available at a firefighting branch when supplied with three lengths of British standard BS 6391:1983 45 mm, 51 mm and 70 mm hose using the performance standard of outlet pressures and pump performance in BS 5306 clause 9.4.4. The firefighting branch is taken to be operating on the same floor level as the riser outlet.

The results of the calculations are shown graphically in Figure 12 and the data are provided in numeric form in Appendix A, Table A.8.

The calculations have been carried out at the minimum pressure (4 bar) and the maximum pressure (5 bar), which are specified wet riser outlet pressure limits.

The details of the assumptions made on which the calculations are based are given in Appendix A, Table A.8.

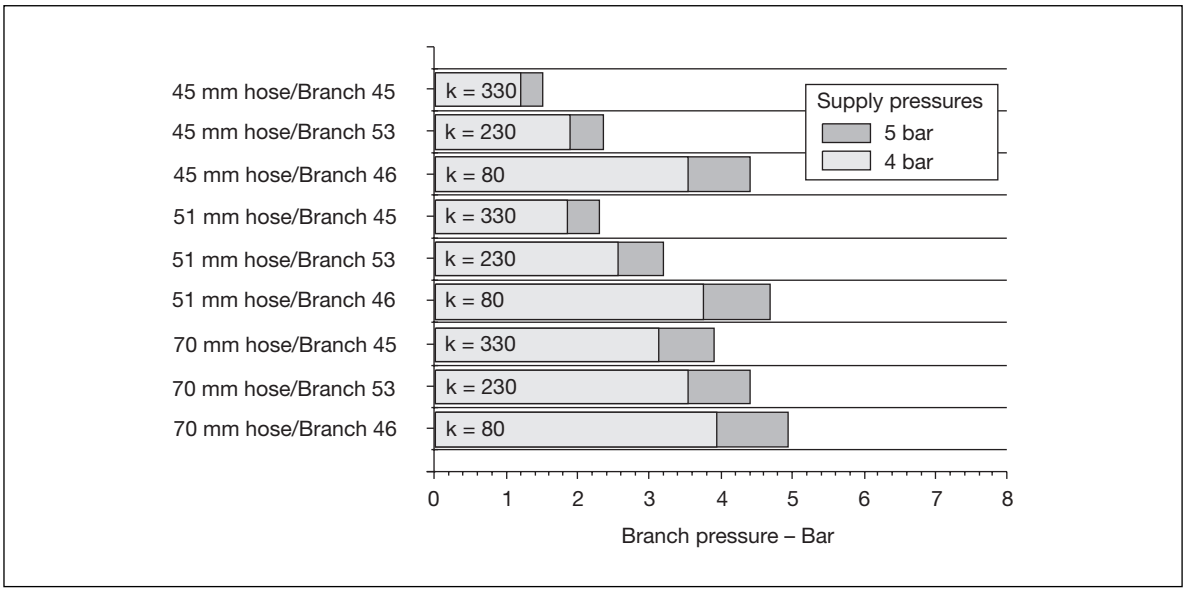


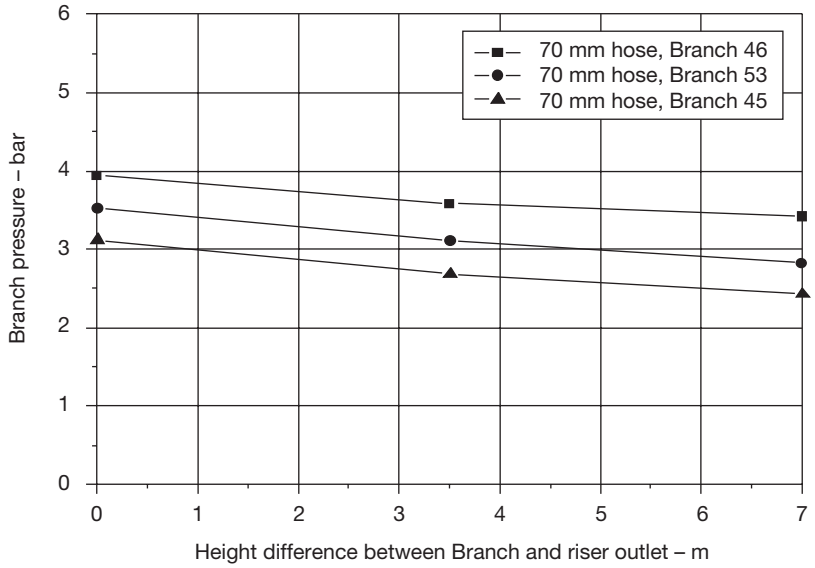
Figure 12. Maximum branch pressures for BS 5306: Part 1 (Clause 9.4.4) supply

4.9 Proposal Appendix A; Item 9

The maximum pressures available at a firefighting branch when supplied with four lengths of British standard BS 6391:1983 45 mm, 51 mm and 70 mm hose using the performance standard of outlet pressures and pump performance in BS 5306 clause 9.4.4. The firefighting branch is taken to be operating a) one floor higher than the rising main outlet, b) two floors higher than the rising main outlet. Assume a notional storey height of 3.5 m.

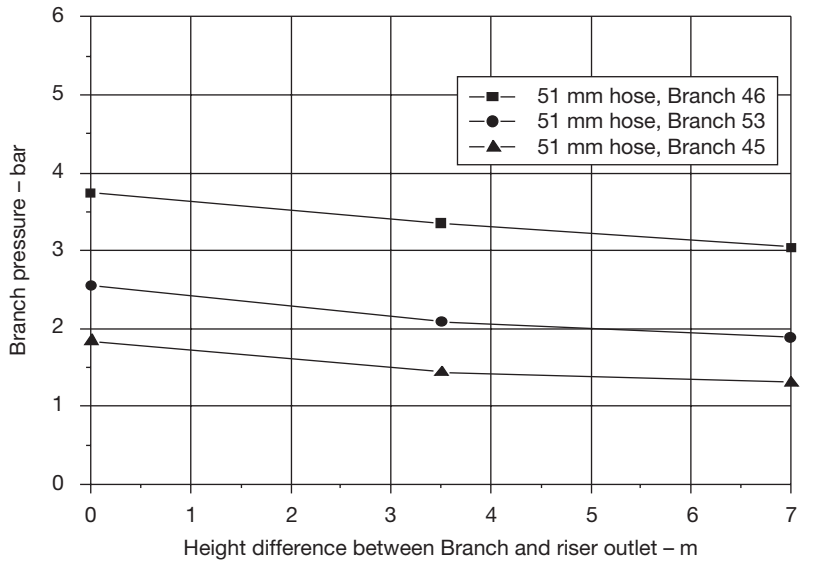
The results of the calculations are for 4 bar outlet pressures shown graphically in Figures 13, 14 and 15 and the data for 4 bar and 5 bar outlet pressures is provided in numeric form in Appendix A, Tables A.9.1, A.9.2 and A.9.3.

For comparison purposes data from “Item 8” have been included in the plots.



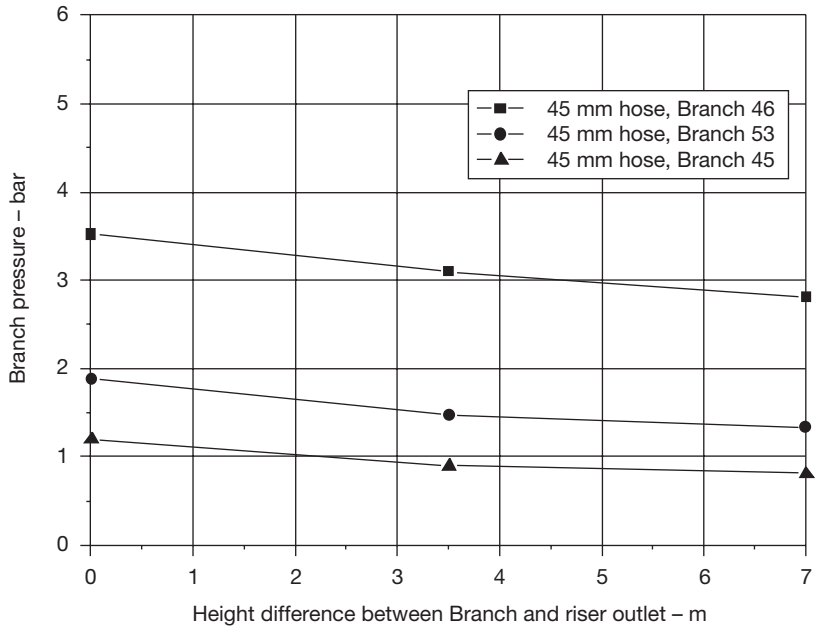
NOTES
1. For 0 m branch/outlet height difference, 3 × 25 m of 70 mm ND hose (item 8)
2. For 3.5 and 7 m branch/outlet height difference, 4 × 25 m 70 mm ND hose
3. For 5 bar riser outlet pressure values see Appendix A, Table A.9.1

Figure 13. Maximum branch pressures vs. height difference between branch and riser outlet, 4 bar riser outlet pressure, 70 mm hose



NOTES
1. For 0 m branch/outlet height difference, 3 × 25 m of 51 mm ND hose (item 8)
2. For 3.5 and 7 m branch/outlet height difference, 4 × 25 m 51 mm ND hose
3. For 5 bar riser outlet pressure values see Appendix A, Table A.9.2

Figure 14. Maximum branch pressures vs. height difference between branch and riser outlet, 4 bar riser outlet pressure, 51 mm hose



NOTES
1. For 0 m branch/outlet height difference, 3 × 25 m of 45 mm ND hose (Item 8)
2. For 3.5 and 7 m branch/outlet height difference, 4 × 25 m 45 mm ND hose
3. For 5 bar riser outlet pressure values see Appendix A, Table A.9.3

Figure 15. Maximum branch pressures vs. height difference between branch and riser outlet, 4 bar riser outlet pressure, 45 mm hose

4.10 Proposal Appendix A; Item 10

Calculation of the maximum elevations where 2 bars pressure is available at a firefighting branch when supplied through British Standard 45 mm, 51 mm and 70 mm hose connected to a BS EN 1028-1 specification fire appliance pump.

The maximum branch elevations are shown graphically in Figures 17, 18 and 19. The numeric data is given in Appendix A Tables A.10.1, A10.2 and A10.3. The assumptions on which the calculations are based are given in Appendix A.10.

NOTE
Figures 17, 18 and 19 also include plots for Proposal Appendix A, item 11 (4 bar branch pressure).

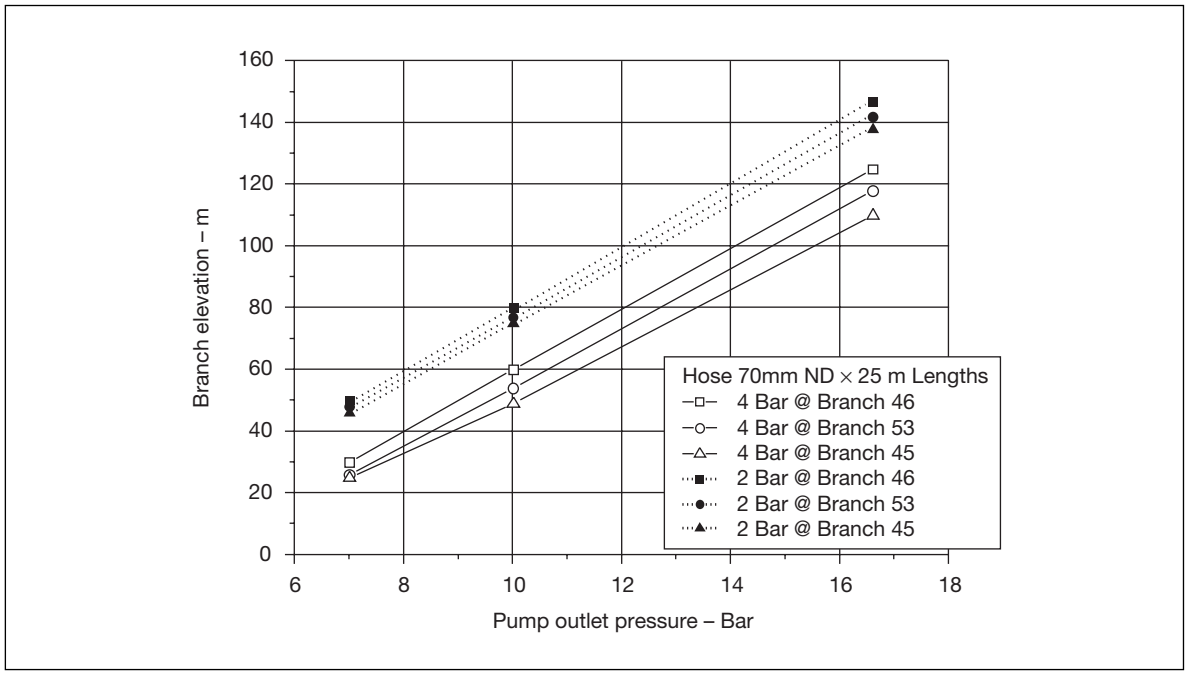


Figure 17. Maximum branch elevations vs. Pump outlet pressure for 70 mm hose

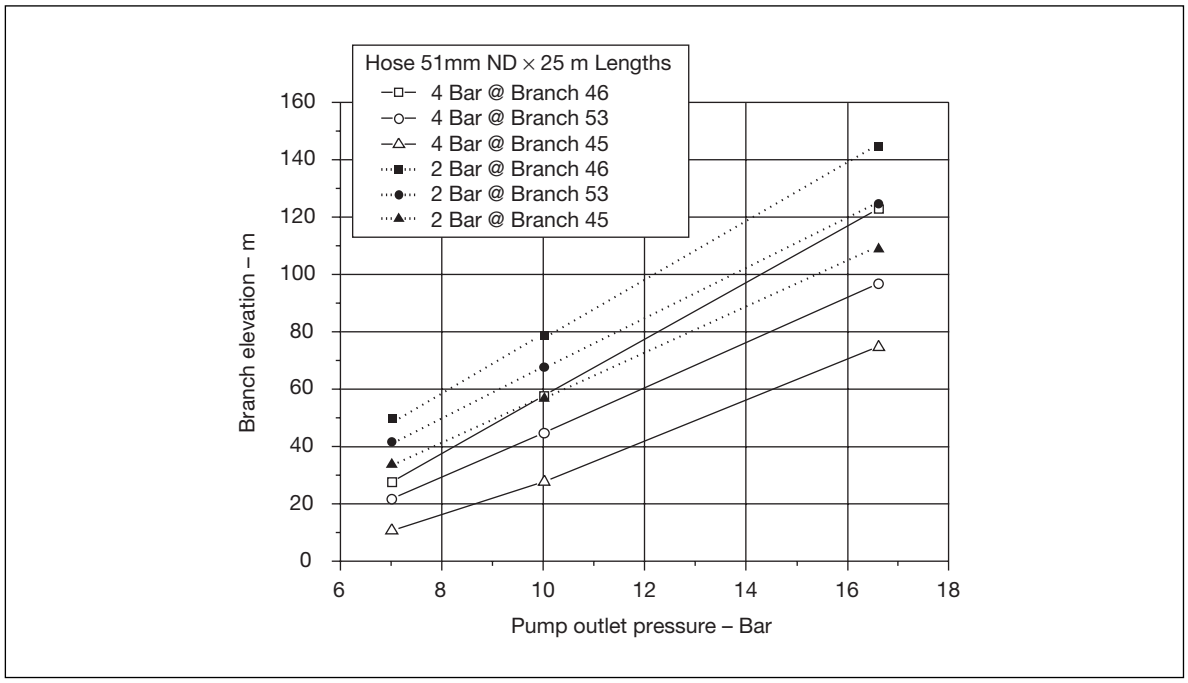


Figure 18. Maximum branch elevations vs. Pump outlet pressure for 51 mm hose

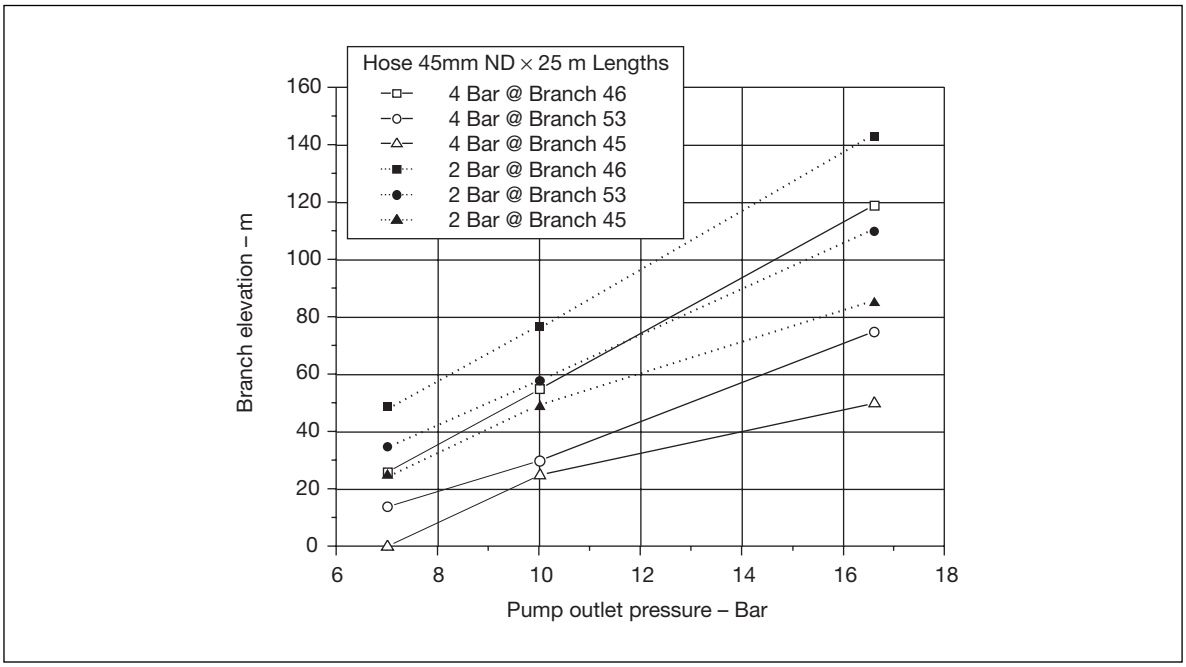


Figure 19. Maximum branch elevations vs. Pump outlet pressure for 45 mm hose

4.11 Proposal Appendix A; Item 11

Calculation of the maximum elevations where 4 bars pressure is available at a firefighting branch when supplied through British Standard 45 mm, 51 mm and 70 mm hose connected to a BS EN 1028-1 specification fire appliance pump.

The maximum branch elevations are shown graphically in Figures 17, 18 and 19. The numeric data is given in Appendix A, Tables A.11.1, A11.2 and A11.3.

4.12 Proposal Appendix A; Item 12

Calculation of the maximum elevations where 2 bars pressure is available at a firefighting branch when supplied through British standard 45 mm, 51 mm and 70 mm hose connected to a High pressure pump - specification to be supplied.

The pump performance curve for the HFS 3000 submersible pump at 2100 l/min was used to determine the maximum branch elevation for 2 bar pressure. The numerical data is given in Appendix A, Table A.12.

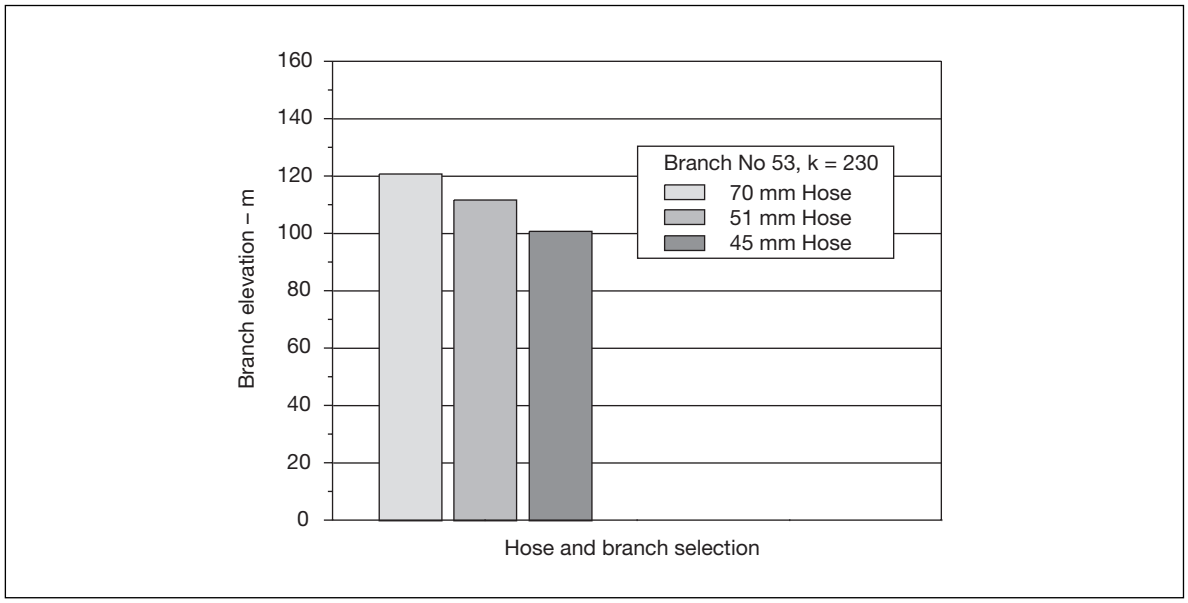


Figure 20. Maximum branch elevation for a branch pressure of 2 bar

4.13 Proposal Appendix A; Item 13

Calculation of the maximum elevations where 4 bars pressure is available at a firefighting branch when supplied through British standard 45 mm, 51 mm and 70 mm hose connected to a High pressure pump – specification to be supplied.

The pump performance curve for the HFS 3000 submersible pump at 2100 l/min was used to determine the maximum branch elevation for 4 bar pressure. The numerical data is given in Appendix A, Table A.13.

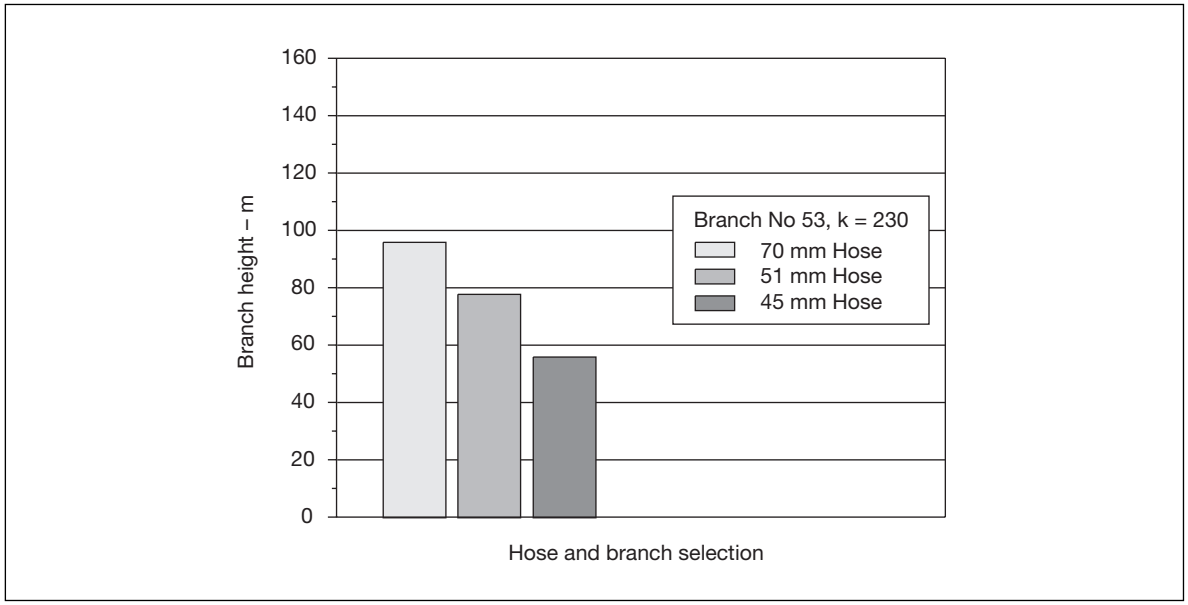


Figure 21. Maximum branch elevation for a branch pressure of 4 bar

5 Observations

5.1 Hose connections to riser outlets on floors beneath the floor of use

The calculations show the branch pressure differences between connecting a hose to a dry riser outlet on the floor of use compared to a connection one or two floors below were not significant, providing the total hose length remains constant. If a greater hose length is required when connecting at a floor lower than the point of use, this will result in additional pressure losses.

The pressure losses when connecting to a wet riser, below the floor of use, will be more significant due to the regulated pressure at the riser outlet.

5.2 Riser fittings

Suppliers of riser fittings should be encouraged to provide pressure loss data (based on flow tests) for items such as inlet breechings, outlet connections and any other fittings where the pressure losses may be significant

5.3 Branch k factors

The data provided to the project indicates that branch k factors vary considerably. As some branches have throttles controls, the k factors may vary over the operating range and settings. To undertake pressure flow calculations on dry risers it has been necessary to attribute specific pressure/flow characteristics (k factors) to the branches used. Caution should be exercised when calculating specific scenarios to make sure that not only a suitable branch is selected, but that the k factor for an appropriate setting is used. Branch suppliers should be encouraged to supply the appropriate branch performance information to carryout such an evaluation accurately.

A specification for the evaluation of branch performance may be desirable.

5.4 Choice of branch

The results clearly show that the choice of branch or branch setting is a significant variable to achieve satisfactory branch operating pressures.

5.5 Hose

The influence of hose size on pressure losses decreases with diminishing branch k factor. Where it is essential to use branches with a high k factor this may require larger hose sizes when working at height or where long lengths of hose are required.

5.6 Pump performance

The Godiva WT30/10 pump is capable of yielding greater pressures (at the pump outlet) at closed system conditions (16.6 bar) and for flows generated by any one branch and hose combination (16.6 bar) than the riser pipework is designed and tested to (10 bar).

The HFS-3000 standard and HiFlow impeller arrangements yield lower pressures and greater flows than the Godiva WT30/10 pump. The decline in the HFS-3000 pressure flow curve is more gradual, but this would only be of benefit if higher flow rates were required at relatively low elevations The standard impeller delivered higher pressures at closed system conditions and flowing conditions (14.2 bar) than the riser pipework is designed and tested to. The HiFlow impeller delivered a maximum of about 10.2 bar and therefore would not exceed current design limitations of the riser pipework.

5.7 Considerations for the design, installation and use of rising mains

5.7.1 Pressure strength of rising main hoses, pipework and fittings

In order to take full advantage of the capability of the pumping appliances, the rising main, hoses (inlet), pipework and fittings should be rated to an appropriate potential working pressure.

5.7.2 Pressure relief of rising mains

Where pumping capacity exceeds the maximum working pressure of the riser consideration should be given to appropriately located pressure relief device or alternatively over pressure alarm device at the inlet to the riser.

5.7.3 Riser staging stop valves

Where there is concern that a riser could suffer a catastrophic failure, consideration should be given to staging stop valves at intervals up the riser. When a failure occurs the staging valve below the pipe failure and above the riser outlet to be used should be closed.

5.7.4 Monitoring of riser stop valves

Any normally open stop valves which may interrupt flow of water through the riser should be electrically monitored and the condition transmitted to a permanently manned location.

5.7.5 Fire brigade access to riser valve monitoring

Fire brigade access to riser stop valve condition monitoring should preferably be by means of a data relay connection (for a PC with appropriate software) or alternatively by a relay panel at the riser inlet connection. Consideration should also be given to accessing critical fire alarm, smoke ventilation and sprinkler installation data, through any riser inlet data relay connection.

5.7.6 Pressure at wet riser outlets

Current practice limits the wet riser outlet pressure appropriate for hose and branch use on the riser outlet floor. Consideration should be given to designing wet risers based on the assumption that the hose connections will be made to the riser below the floor of use. Where appropriate, fire brigade practice should be changed to reflect such an installation design change.

5.7.7 Water priming of dry-risers

Where there is no risk of freezing, consideration should be given to permanently priming dry-risers with water at an appropriate standing pressure. Water primed risers could be topped up either by a low-flow feed from a header tank at the top of the riser or by an appropriately sized jockey pump at the base. Loss of water would indicate that integrity of the riser was impaired. Priming the riser with water would:

- reduce the fill time and water volume required to bring the riser into use;
- reduce the volume of air to be expelled; and
- allow continuous riser condition monitoring.

The volumes of 63 m high, 100 mm ND and 150 mm ND risers would be of the order of 0.7 m^3 and 1.5 m^3 respectively.

5.7.8 Riser outlet pressure regulation

Where pressures at risers outlets may exceed operational requirements on wet risers, outlet pressures are regulated using pressure reducing valves. Pressure reducing valves are most effective when there is a continuous flow; pressures across the regulator may equalise with time if there is no flow. In some instances pressure regulating devices may not be correctly adjusted at the time of installation or may become defective with time if not serviced correctly. Consideration should be given to the use of portable pressure reducing devices

which may be carried as part of the hose and branch kit. Such devices could be tested and calibrated regularly.

5.7.9 Design of wet and dry risers

The requirements of BS 5306:Part 1 are basically sound and pipe sizing practices should limit losses in the risers to comparatively low levels. There are however a number of unknowns such as friction losses through fittings. Consideration should be given to designing wet and dry risers by hydraulic calculation, based on specified performance requirements. At least, riser pipework designs should be checked by calculation to establish fitness for purpose.

6 References

1. BS 5306: Part 1: 1976 – Fire Extinguishing installations and equipment on premises: Hydrant systems, hose reels and foam inlets. (Formerly CP 402.101)

2. BS EN 1028-1 – Fire-fighting pumps. Fire-fighting centrifugal pumps with primer. Classification. General and safety requirements.

3. BS 5041 – Fire hydrant systems equipment. Specification for landing valves for wet risers.

4. BS 1387: 1985 (1990) Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads

5. BS 5306: Part 2: 1990 – Fire Extinguishing installations and equipment on premises: Specification for sprinkler installations.

6. Jet/Spray branches data sheets Part 1 and 2; Central Fire Brigades Advisory council for England and Wales; Scottish Central Fire Brigades Advisory Council.

Appendix A – Calculation results in numeric form

Appendix A.1: Proposal Appendix A; Item 1

The maximum pressures achievable at outlets of a firefighting rising main complying to BS 5306:Part 1:1976 when supplied with a BS EN 1028-1 specification fire appliance pump. This pressure to be calculated at outlet levels of floors one to eighteen with a notional storey height of 3.5m.

Table A1. Maximum pressure achievable at riser outlets

	Inlet pressures – Bar									
	16.6 (1)		16.6 (1)		15 (2)		10 (2)		7 (2)	
Outlet Height	Outlet Pressures (P) and flows (Q)									
	P	Q	P	Q	P	Q	P	Q	P	Q
m	Bar	l/min	Bar	l/min	Bar	l/min	Bar	l/min	Bar	l/min
63	10.3	0	9.15	696	7.78	642	3.36	422	0.71	194
59.5	10.65	0	9.46	707	8.1	655	3.66	440	1.02	232
56	11	0	9.77	719	8.41	667	3.97	458	1.32	264
52.5	11.35	0	10.1	731	8.72	679	4.28	476	1.62	293
49	11.7	0	10.4	742	9.04	692	4.59	493	1.93	320
45.5	12.05	0	10.71	753	9.35	703	4.9	509	2.24	344
42	12.4	0	11.03	764	9.67	715	5.21	525	2.54	367
38.5	12.75	0	11.34	775	9.98	727	5.52	540	2.85	388
35	13.1	0	11.66	785	10.3	738	5.83	555	3.16	409
31.5	13.45	0	11.97	796	10.62	750	6.15	570	3.47	428
28	13.8	0	12.29	806	10.94	761	6.49	586	3.78	447
24.5	14.15	0	12.61	817	11.26	772	6.77	598	4.09	465
21	14.5	0	12.92	827	11.57	782	7.09	612	4.4	482
17.5	14.85	0	13.24	837	11.89	793	7.4	626	4.71	499
14	15.2	0	13.56	847	12.21	804	7.72	639	5.03	516
10.5	15.55	0	13.88	857	12.54	814	8.04	652	5.34	531
7	15.9	0	14.2	867	12.86	825	8.35	665	5.65	547
3.5	16.25	0	14.52	876	13.18	835	8.67	677	5.97	562

NOTES:
1. Godiva WT30/10 pump at 3600 l/min ≈ 16.6 bar outlet pressure for flow conditions given
2. Inlet Pressures limited to 15 bar, 10 bar or 7 bar as indicated
3. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length
4. Riser 100 mm ND pipe
5. Outlet to Branch hose: 70 mm ND hose, 1 × 25 m long
6. Riser equivalent length: 20 m + fittings + Height
7. Branch elevation – riser outlet height = 0 m

Appendix A.2: Proposal Appendix A; Item 2

The maximum pressures available at a firefighting branch when supplied with three lengths of British standard BS 6391:1983, 45 mm, 51 mm and 70 mm hose using the rising main outlet pressures calculated in 1, with the firefighting branch operating on the same floor level.

Table A.2.1 Branch pressures vs. outlet heights for 45 mm BS 6391 Hose of 3 × 25 m lengths (75 m)

		Branch SRDB No, (k factor)					
		46 (80)		53 (230)		45 (330)	
Floor No	Height m	Branch Pressure	Flow	Branch Pressure	Flow	Branch Pressure	Flow
		Bar	l/min	Bar	l/min	Bar	l/min
18	63.0	9.1	242	4.8	505	3.1	579
17	59.5	9.4	246	5.0	514	3.2	588
16	56.0	9.8	250	5.2	522	3.3	598
15	52.5	10.0	254	5.3	530	3.4	607
14	49.0	10.4	257	5.5	538	3.5	616
13	45.5	10.7	261	5.6	546	3.6	625
12	42.0	11.0	265	5.8	554	3.7	634
11	38.5	11.3	268	6.0	561	3.8	643
10	35.0	11.6	272	6.1	569	3.9	652
9	31.5	11.9	276	6.3	577	4.0	661
8	28.0	12.2	279	6.5	584	4.1	669
7	24.5	12.5	282	6.6	591	4.2	678
6	21.0	12.8	286	6.8	598	4.3	686
5	17.5	13.1	289	6.9	606	4.4	694
4	14.0	13.4	293	7.1	613	4.5	702
3	10.5	13.7	296	7.3	620	4.6	710
2	7.0	14.0	299	7.4	627	4.7	718
1	3.5	14.3	302	7.6	634	4.9	726

NOTES:
8. Pump: Godiva WT30/10 (LP Stage)
9. Pump speed: 3600 r/min
10. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length
11. Riser 100 mm ND
12. Outlet to Branch hose: 45 mm ND hose, 3 × 25 m long
13. Riser equivalent length: 20 m + Fittings + Height
14. Branch elevation – riser outlet height = 0 m

Table A.2.2 Branch pressures vs. outlet heights for 51 mm BS 6391 Hose of 3 × 25 lengths (75 m)

		Branch SRDB No, (k factor)					
		46 (80)		53 (230)		45 (330)	
Floor No	Height m	Branch Pressure	Flow	Branch Pressure	Flow	Branch Pressure	Flow
		Bar	l/min	Bar	l/min	Bar	l/min
18	63.0	9.7	249	6.5	587	4.7	711
17	59.5	10.0	253	6.7	596	4.8	723
16	56.0	10.4	257	6.9	606	5.0	735
15	52.5	10.7	261	7.2	616	5.1	747
14	49.0	11.0	265	7.4	625	5.3	758
13	45.5	11.3	269	7.6	634	5.4	770
12	42.0	11.6	273	7.8	643	5.6	781
11	38.5	12.0	277	8.0	652	5.8	792
10	35.0	12.3	280	8.3	661	5.9	803
9	31.5	12.6	284	8.5	670	6.1	813
8	28.0	12.9	288	8.7	678	6.2	824
7	24.5	13.3	291	8.9	687	6.4	835
6	21.0	13.6	295	9.1	695	6.6	845
5	17.5	13.9	298	9.4	704	6.7	855
4	14.0	14.2	302	9.6	712	6.9	866
3	10.5	14.6	305	9.8	720	7.0	876
2	7.0	14.9	308	10.0	728	7.2	886
1	3.5	15.2	312	10.3	737	7.4	896

NOTES:
1. Pump: Godiva WT30/10 (LP Stage)
2. Pump speed: 3600 r/min
3. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length
4. Riser 100 mm ND
5. Outlet to Branch hose: 51 mm ND hose, 3 × 25 m long
6. Riser equivalent length: 20 m + Fittings + Height
7. Branch elevation – riser outlet height = 0 m

Table A.2.3 Branch pressures vs. outlet heights for 70 mm BS 6391 Hose of 3 x 25 lengths (75m)

		Branch SRDB No, (k factor)					
		46 (80)		53 (230)		45 (330)	
Floor No	Height m	Branch Pressure	Flow	Branch Pressure	Flow	Branch Pressure	Flow
		Bar	l/min	Bar	l/min	Bar	l/min
18	63.0	10.2	256	8.9	686	7.7	915
17	59.5	10.6	260	9.2	697	8.0	931
16	56.0	10.9	264	9.5	709	8.2	947
15	52.5	11.2	268	9.8	720	8.5	962
14	49.0	11.6	277	10.1	731	8.8	977
13	45.5	11.9	276	10.4	742	9.0	992
12	42.0	12.2	280	10.7	753	9.3	1007
11	38.5	12.6	284	11.0	763	9.6	1021
10	35.0	12.9	288	11.3	774	9.9	1036
9	31.5	13.3	291	11.6	784	10.1	1049
8	28.0	13.6	295	11.9	794	10.4	1064
7	24.5	13.9	299	12.2	804	10.7	1078
6	21.0	14.3	302	12.5	815	11.0	1092
5	17.5	14.6	306	12.9	824	11.2	1105
4	14.0	15.0	309	13.2	834	11.1	1119
3	10.5	15.3	313	13.5	844	11.8	1132
2	7.0	15.6	316	13.8	854	12.1	1146
1	3.5	16.0	320	14.1	863	12.3	1189

NOTES:
1. Pump: Godiva WT30/10 (LP Stage)
2. Pump speed: 3600 r/min
3. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length
4. Riser 100 mm ND
5. Outlet to Branch hose: 70 mm ND hose, 3 × 25 m long
6. Riser equivalent length: 20 m + Fittings + Height
7. Branch elevation – riser outlet height = 0 m

Appendix A.3: Proposal Appendix A; Item 3

The maximum pressure available at a firefighting branch when supplied with four lengths of British standard BS 6391:1983 45 mm, 51 mm and 70 mm hose using the rising main outlet pressures calculated in 1 with the firefighting branch operating a) one floor higher than the rising main outlet, b) two floors higher than the rising main outlet. Assume a notional storey height of 3.5m.

All calculations were carried-out using branch 53 (k = 230).

Table A.3 Branch pressures vs. outlet heights for 45, 51 and 70 mm BS 6391 Hose of 4 × 25 lengths (100m)

Branch Height	Hose 45 mm x 100 m				Hose 51 mm x 100 m				Hose 70 mm x 100m			
	Branch elevation – Riser outlet height m											
	3.5		7		3.5		7		3.5		7	
	Press	Flow	Press	Flow	Press	Flow	Press	Flow	Press	Flow	Press	Flow
m	Bar	l/min	Bar	l/min	Bar	l/min	Bar	l/min	Bar	l/min	Bar	l/min
63.0	4.1	467	4.1	467	5.9	556	5.9	556	8.6	675	8.6	675
59.5	4.3	475	4.3	475	6.0	565	6.0	566	8.9	686	8.9	687
56.0	4.4	483	4.4	483	6.2	574	6.2	575	9.2	698	9.2	698
52.5	4.5	490	4.5	490	6.4	583	6.4	584	9.5	709	9.5	709
49.0	4.7	498	4.7	498	6.6	593	6.6	592	9.8	719	9.8	720
45.5	4.8	505	4.8	505	6.8	601	6.8	601	10.1	730	10.1	730
42.0	5.0	512	5.0	512	7.0	610	7.0	610	10.4	741	10.4	741
38.5	5.1	519	5.1	519	7.2	618	7.2	618	10.7	751	10.7	751
35.0	5.2	526	5.2	526	7.4	626	7.4	627	11.0	761	11.0	762
31.5	5.4	533	5.4	533	7.6	635	7.6	635	11.3	772	11.3	772
28.0	5.5	540	5.5	540	7.8	643	7.8	643	11.6	782	11.6	782
24.5	5.7	547	5.7	547	8.0	651	8.0	651	11.9	792	11.9	792
21.0	5.8	553	5.8	553	8.2	659	8.2	659	12.1	802	12.2	802
17.5	5.9	560	5.9	560	8.4	667	8.4	667	12.4	811	12.5	812
14.0	6.1	566	6.1	566	8.6	675	8.6	675	12.7	821	12.8	821
10.5	6.2	573	6.2	573	8.8	682	8.8	683	13.0	831	13.1	831
7.0	6.3	579	6.3	579	9.0	690	9.0	690	13.3	840	13.4	840
3.5	6.5	585			9.2	697			13.6	849		

NOTES:
1. Pump: Godiva WT30/10 (LP Stage)
2. Pump speed: 3600 r/min
3. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length
4. Riser 100 mm ND
5. Outlet to Branch hose: 70 mm ND hose, 3 × 25 m long
7. Branch 53 (k = 230) used for all calculations
8. Riser equivalent length: 20 m + Fittings + Height
9. Branch elevation – riser outlet height = 3.5 m or 7.0 m as indicated

Appendix A.4: Proposal Appendix A; Item 4

The maximum elevation of rising main outlet which if supplied by a BS EN 1028-1 specification fire appliance pump is capable to delivering 4 bars pressure at a firefighting branch when supplied through three lengths of British standard BS 6391:1983 45 mm, 51 mm and 70 mm hose connected to the riser outlet, with the firefighting branch operating on the same floor as the rising main outlet.

Table A.4 Maximum branch elevation to deliver 4.0 bar pressure

Hose size	Branch SRDB No	Branch k factor	Maximum branch elevation	Branch pressure	Flow
mm			m	Bar	l/min
70	46	80	126.0	4.1	162
70	53	230	119.0	4.2	468
70	45	330	112.0	4.1	666
51	46	80	122.5	4.3	165
51	53	230	101.5	4.1	466
51	45	330	73.5	4.2	674
45	46	80	122.5	4.0	160
45	53	230	77.0	4.2	470
45	45	330	24.5	4.2	677

NOTES:
1. Pump: Godiva WT30/10 (LP Stage)
2. Pump speed: 3600 r/min
3. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length
4. Riser 100 mm ND
5. Outlet to Branch hose: 70 mm ND hose, 3 × 25 m long
6. Riser equivalent length: 20 m + Fittings + Height
7. Branch elevation – riser outlet height = 0 m
8. Branch elevations calculated to nearest floor level.

Appendix A.5: Proposal Appendix A; Item 5

The maximum elevation of rising main outlet which if supplied by a BS EN 1028-1 specification fire appliance pump is capable to delivering 4 bars pressure at a firefighting branch when supplied through four lengths of British standard BS 6391:1983 45 mm, 51 mm and 70 mm hose connected to the riser outlet, with the firefighting branch operating a) one floor higher than the rising main outlet, b) two floors higher than the rising main outlet. Assume a notional storey height of 3.5 m.

The two sets of calculations for the 3.5 m and 7.0 m heights are represented by a single data set due to the similarity of the results.

Table A.5 Maximum branch elevation to deliver 4.0 bar pressure

Hose size	Branch SRDB No	Branch k factor	Maximum branch elevation	Branch pressure	Flow
mm			m	Bar	l/min
70	46	80	126	4.1	162
70	53	230	119	4	461
70	45	330	108.5	4.1	666
51	46	80	122.5	4.1	163
51	53	230	94.5	4.1	465
51	45	330	59.5	4.1	669
45	46	80	119	4.1	162
45	53	230	63	4.1	467
45	45	330	0	4	663

NOTES:
1. Pump: Godiva WT30/10 (LP Stage)
2. Pump speed: 3600 r/min
3. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length
4. Riser 100 mm ND
5. Outlet to Branch hose: 70 mm ND hose, 4 × 25 m long
6. Riser equivalent length: 20 m + Fittings + Height
7. Branch elevation – riser outlet height = 3.5 and 7.0 m
8. Branch elevations calculated to nearest floor level.

Appendix A.6: Proposal Appendix A; Item 6

The maximum elevation of rising main outlet which if supplied by a BS EN 1028-1 specification fire appliance pump is capable to delivering 2 bars pressure at a firefighting branch when supplied through three lengths of British standard BS 6391:1983 45 mm hose connected to the riser outlet, with the firefighting branch operating on the same floor as the rising main outlet.

Table A.6. The maximum branch elevation to deliver 2.0 bar pressure at the branch

Branch No	Height m
46	145
53	124
45	99

NOTES:
1. Pump: Godiva WT30/10 (LP Stage)
2. Pump speed: 3600 r/min
3. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length
4. Riser 100 mm ND
5. Outlet to Branch hose: 45 mm ND hose, 3 × 25 m long
6. Riser equivalent length: 20 m + Fittings + Height
7. Branch elevation – riser outlet height = 0 m
8. Branch elevations calculated to nearest floor level.

Appendix A.7: Proposal Appendix A; Item 7

The maximum elevation of rising main outlet which if supplied by a BS EN 1028-1 specification fire appliance pump is capable to delivering 2 bars pressure at a firefighting branch when supplied through four lengths of British standard BS 6391:1983 45 mm, 51 mm and 70 mm hose connected to the riser outlet, with the firefighting branch operating a) one floor higher than the rising main outlet, b) two floors higher than the rising main outlet. Assume a notional storey height of 3.5 m.

Four lengths of hose were used for calculation purposes.

Table A.7. The maximum branch elevation to deliver 2.0 bar pressure

Hose size	Branch elevation – riser outlet height	Maximum branch elevation m		
		Branch No		
m	m	46	53	45
70	3.5	147	143.5	136.5
70	7	147	143.5	136.5
51	3.5	143.5	129.5	112
51	7	143.5	129.5	112
45	3.5	143.5	115.5	84
45	7	143.5	115.5	84

NOTES:
1. Pump: Godiva WT30/10 (LP Stage)
2. Pump speed: 3600 r/min
3. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length
4. Riser 100 mm ND
5. Outlet to Branch hose: 45 mm ND hose, 4 × 25 m long
6. Riser equivalent length: 20 m + Fittings + Height
7. Branch elevation – riser outlet height = 3.5 m and 7.0 m
8. Branch elevations calculated to nearest floor level.

Appendix A.8: Proposal Appendix A; Item 8

The maximum pressures available at a firefighting branch when supplied with three lengths of British standard BS 6391:1983 45 mm, 51 mm and 70 mm hose using the performance standard of outlet pressures and pump performance in BS 5306 clause 9.4.4. The firefighting branch is taken to be operating on the same floor level as the riser outlet.

Table A.8 Maximum branch pressures for BS 5306: Part 1 (Clause 9.4.4) water supply			
Outlet pressure	Branch pressures	and	*Flows*
Bar	Bar		*L/min*
	70 mm ND Hose		
	Branch No / (k factor)		
	46 (80)	53 (230)	45 (330)
4	3.94, *160*	3.52, *432*	3.12, *582*
5	4.92, *177*	4.4, *619*	3.9, *652*
	51 mm ND Hose		
	Branch No / (k factor)		
	46 (80)	53 (230)	45 (330)
4	3.74, *155*	2.55, *367*	1.84, *448*
5	4.68, *176*	3.19, *411*	2.3, *500*
	45 mm ND Hose		
	Branch No / (k factor)		
	46 (80)	53 (230)	45 (330)
4	3.52, *150*	1.88, *315*	1.2, *361*
5	4.4, *168*	2.35, *353*	1.51, *405*

NOTES
1. Maximum outlet pressure = 5 bar
2. Minimum outlet pressure = 4 bar
3. Three lengths of 25 m hose from outlet to branch

Appendix A.9: Proposal Appendix A; Item 9

The maximum pressures available at a firefighting branch when supplied with four lengths of British standard BS 6391:1983 45 mm, 51 mm and 70 mm hose using the performance standard of outlet pressures and pump performance in BS 5306 clause 9.4.4. The firefighting branch is taken to be operating a) one floor higher than the rising main outlet, b) two floors higher than the rising main outlet. Assume a notional storey height of 3.5m.

The results are given in three Tables A.9.1, A.9.2 and A.9.3. The results for items 8 and 9 have been combined for ease of comparison.

Table A.9.1 Maximum pressures at fire fighting branches for 70 mm ND hose

Proposal Item	Riser outlet pressure bar	Branch pressure bar			Branch elevation above outlet m	25 m hose lengths
		Branch no (k factor)				
		46 (80)	53 (230)	45 (330)		
A.8	4	3.94	3.52	3.12	0	3
A.8	5	4.92	4.4	3.9	0	3
A.9	4	3.58	3.11	2.69	3.5	4
A.9	5	4.56	3.96	3.42	3.5	4
A.9	4	3.24	2.82	2.43	7	4
A.9	5	4.22	3.67	3.17	7	4

Table A.9.2 Maximum pressures at fire fighting branches for 51 mm ND hose

Proposal Item	Riser outlet pressure bar	Branch pressure bar			Branch elevation above outlet m	25 m hose lengths
		Branch no				
		46	53	45		
A.8	4	3.74	2.55	1.84	0	3
A.8	5	4.68	3.19	2.3	0	3
A.9	4	3.35	2.09	1.44	3.5	4
A.9	5	4.27	2.66	1.83	3.5	4
A.9	4	3.04	1.89	1.3	7	4
A.9	5	3.95	2.46	1.69	7	4

Table A.9.3 Maximum pressures at fire fighting branches for 45 mm ND hose

Proposal Item	Riser outlet pressure bar	Branch pressure bar			Branch elevation above outlet m	25 m hose lengths
		Branch no				
		46	53	45		
A.8	4	3.52	1.88	1.2	0	3
A.8	5	4.4	2.35	1.51	0	3
A.9	4	3.1	1.47	0.9	3.5	4
A.9	5	3.94	1.87	1.14	3.5	4
A.9	4	2.81	1.33	0.81	7	4
A.9	5	3.65	1.73	1.06	7	4

NOTES
1. Maximum outlet pressure = 5 bar
2. Minimum outlet pressure = 4 bar

Appendix A.10: Proposal Appendix A; Item 10

Calculation of the maximum elevations where 2 bars pressure is available at a firefighting branch when supplied through British standard 45 mm, 51 mm and 70 mm hose connected to a BS EN 1028-1 specification fire appliance pump.

A series of calculations were carried out assuming the hoses were connected directly to the pump outlet. In all instances 25 m hoses lengths were used. For consistency, straight vertical hose runs have been assumed. Where there has been excess hose to achieve the elevation the excess hose has been assumed to run horizontally.

Examples: Where the branch elevation is 147 m, six lengths of 25 m hose with a 3 m horizontal run has been used. For an 80 m elevation, four lengths of 25 m hose with a 20 m horizontal run has been used.

Table A.10.1 Branch elevations for 70 mm ND Hose, 2 bar branch pressure

Branch no	46		53		45	
Pump pressure	Branch pressure	Branch elevation	Branch pressure	Branch elevation	Branch pressure	Branch elevation
bar	bar	m	bar	m	bar	m
16.6	2.11	147	2.13	142	2.01	138
10	2.11	80	2.08	77	2.06	75
7	2.07	50	2	49	2.07	46

Table A.10.2 Branch elevations for 51 mm ND Hose, 2 bar branch pressure

Branch no	46		53		45	
Pump pressure	Branch pressure	Branch elevation	Branch pressure	Branch elevation	Branch pressure	Branch elevation
bar	bar	m	bar	m	bar	m
16.6	2.09	145	2	125	2.02	109
10	2.06	79	2.12	68	2.03	57
7	2	50	2.08	42	2.04	34

Table A.10.3 Branch elevations for 45 mm ND Hose, 2 bar branch pressure

Branch no	46		53		45	
Pump pressure	Branch pressure	Branch elevation	Branch pressure	Branch elevation	Branch pressure	Branch elevation
bar	bar	m	bar	m	bar	m
16.6	2.02	143	2.03	110	2.03	85
10	2.07	77	2.03	58	2.03	49
7	2.01	49	2.03	35	2.53	25

Appendix A.11: Proposal Appendix A; Item 11

Calculation of the maximum elevations where 4 bars pressure is available at a firefighting branch when supplied through British standard 45 mm, 51 mm and 70 mm hose connected to a BS EN 1028-1 specification fire appliance pump.

The method described in Appendix A.10 has also been used for Item 11. The branch pressure has been increased to 4 bar.

Table A.11.1 Branch elevations for 70 mm ND Hose, 4 bar branch pressure

Branch no	46		53		45	
Pump pressure	Branch pressure	Branch elevation	Branch pressure	Branch elevation	Branch pressure	Branch elevation
bar	bar	m	bar	m	bar	m
16.6	4.23	125	4.14	118	4	110
10	4.05	60	4.14	54	4.06	49
7	4.01	30	4.05	26	4.06	25

Table A.11.2 Branch elevations for 51 mm ND Hose, 4 bar branch pressure

Branch no	46		53		45	
Pump pressure	Branch pressure	Branch elevation	Branch pressure	Branch elevation	Branch pressure	Branch elevation
bar	bar	m	bar	m	bar	m
16.6	4.07	123	4.05	97	4.24	75
10	4.03	58	4.03	45	4.05	28
7	4.06	28	4.03	22	4.18	11

Table A.11.3 Branch elevations for 45 mm ND Hose, 4 bar branch pressure

Branch no	46		53		45	
Pump pressure	Branch pressure	Branch elevation	Branch pressure	Branch elevation	Branch pressure	Branch elevation
bar	bar	m	bar	m	bar	m
16.6	4.02	119	4.35	75	4.54	50
10	4.05	55	4.01	30	4.19	25
7	4.08	26	4.05	14	3.89	0

Appendix A.12: Proposal Appendix A; Item 12

Calculation of the maximum elevations where 2 bars pressure is available at a firefighting branch when supplied through British standard 45 mm, 51 mm and 70 mm hose connected to a High pressure pump - specification to be supplied.

The calculations have been undertaken using the HFS-3000 submersible pump performance, see Appendix D, for details. The calculation method is identical to that used for Appendix A.6.

Table A.12 The maximum branch elevation to deliver 2.0 bar branch pressure

Hose ND mm	Branch elevation m
45	101
51	112
70	121

NOTES
1. Pump: HFS-3000 submersible pump;
2. Pump speed 2100 r/min;
3. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length;
4. Riser 100 mm ND
5. Outlet to branch hose: as detailed in table;
6. Branch No 53 (k = 230);
7. Riser equivalent length: 20 m + Fittings + Height;
8. Branch elevation – riser outlet height = 0 m
9. Branch elevations calculated to nearest floor level.

Appendix A.13: Proposal Appendix A; Item 13

Calculation of the maximum elevations where 4 bars pressure is available at a firefighting branch when supplied through British standard 45 mm, 51 mm and 70 mm hose connected to a High pressure pump - specification to be supplied.

The calculations have been undertaken using the HFS-3000 submersible pump performance, see Appendix D, for details. The calculation method is identical to that used for Appendix A.10.

Table A.13 The maximum branch elevation to deliver a 4.0 bar branch pressure

Hose ND mm	Branch elevation m
45	56
51	78
70	96

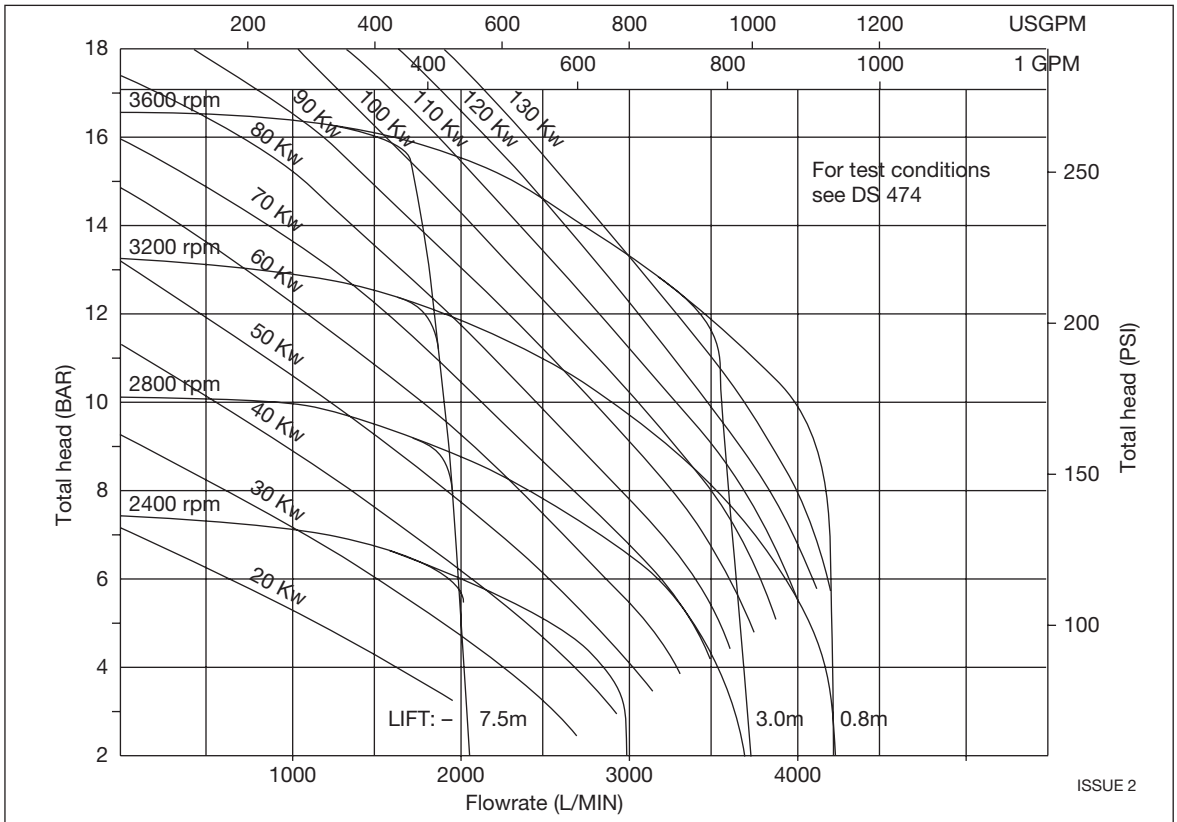
NOTES
1. Pump: HFS-3000 submersible pump;
2. Pump speed 2100 r/min;
3. Pump to riser inlet hoses: 2 parallel 70 mm ND × 25 m length;
4. Riser 100 mm ND
5. Outlet to branch hose: as detailed in table;
6. Branch No 53 (k = 230);
7. Riser equivalent length: 20 m + Fittings + Height;
8. Branch elevation – riser outlet height = 0 m
9. Branch elevations calculated to nearest floor level.

Appendix B – Typical equivalent lengths of fittings and valves

Typical equivalent lengths of fittings and valves Extracted from BS 5306: Part 2, Table 37				
Fittings and valves	**Equivalent length of medium grade steel pipe (in m) to BS 1387 (C value 120)**			
		Nominal Diameter (mm)		
		100 m		**150 m**
90° Screwed elbow		3.04		4.30
90° Welded elbow (r/d = 1.5)		1.43		2.00
45° Screwed elbow		1.61		2.30
Standard screwed tee or cross (flow through branch)		6.10		8.61
Gate valve (flanged fitting)		0.81		1.13
Butterfly valve (flanged fitting)		4.56		6.38
Globe valve – straightway (flanged fitting)		34.48		48.79
Equivalent lengths can be converted as necessary for pipes of other C values by multiplying by the following factors				
C value	100	110	130	140
Factor	0.714	0.850	1.160	1.330
NOTE: Equivalent length data may also be obtained from suppliers data sheets.				

Appendix C – Pump performance curves – Godiva WT30/10

Appendix C.1: Godiva WT30/10 Pump curves



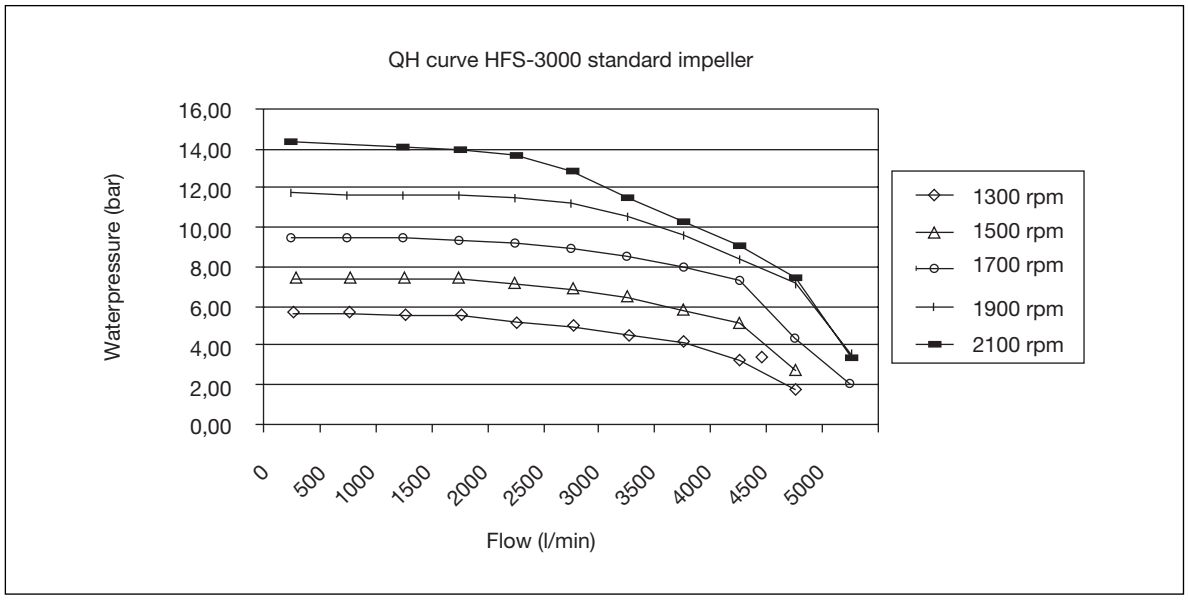
Appendix C.2: Godiva WT30/10 Pump performance numeric data

Godiva WT30/10 3600rpm	
FLOW	
10	
0	16.6
500	16.6
1000	16.45
1500	16.25
2000	15.55
2500	14.6
3000	13.4
3500	11.95
4000	10.1
4500	0
LIFT	
2	
1900	7.5
3100	3.0
Godiva WT30/10 3200rpm	
FLOW	
10	
0	13.25
500	13.15
1000	12.95
1500	12.6
2000	11.91
2500	10.98
3000	9.76
3500	8.2
4000	5.71
4500	0
LIFT	
2	
1900	7.5
3100	3.0

Godiva WT30/10 2800rpm	
FLOW	
9	
0	10.1
500	10
1000	10
1500	9.43
2000	8.92
2500	7.75
3000	6.56
3500	4.4
3700	0
LIFT	
2	
1900	7.5
3100	3.0
Godiva WT30/10 2400rpm	
FLOW	
7	
0	7.38
500	7.38
1000	7.2
1500	6.75
2000	6
2500	5.1
3000	0
LIFT	
1	
1900	7.5

Appendix D: Pump performance curves – HFS-3000 Submersible pump

Appendix D.1 HFS 3000 standard impeller pump performance curves



Appendix D.2 HFS-3000 HiFlow impeller pump performance curves