

## INTRODUCTION

*FluidFlow3* is particularly useful for the design of fixed fire protection and other spray/sprinkler systems. Performance data for sprinklers and nozzles can be stored in *FluidFlow3*'s database either in tabular or equation format and each sprinkler shown on *FluidFlow3*'s schematic flowsheet of the system. A fire protection system may have hundreds of sprinklers although not all in operation at the same time – *FluidFlow3* can simulate this. Pump data can be saved into the pumps database.

*FluidFlow3*'s advanced flowsheet representation of the system layout provides both a schematic representation of the pipe layout in isometric format and allows entered data and calculated values to be viewed simultaneously. Equipment operating outside specified limits is shown on the flowsheet coloured red and warnings describe the condition. Consequently, sprinklers operating above or below design limits can be immediately identified. *FluidFlow3*'s capability to display component data by displaying on the flowsheet allows the hydraulically most remote nozzle to be quickly determined.

Individual sprinklers or groups of sprinklers can be switched on or off thus enabling deluge systems to be modelled. Pipe blockages and breaks can be easily simulated.

Pump performance can be instantly displayed, the duty point being shown on the pump curve. NPSH is automatically checked.

If entering each and every one of the nozzles in a large fire protection system seems a bit daunting, *FluidFlow3* has a solution in the form of its 'copy' and 'paste' commands. A group of nozzles can be selected and then copied repeatedly.

*FluidFlow3* can simulate any type of pipe flow system such as ringmains, hydrants and foam solution systems to the point of aeration.

## LARGE SYSTEMS

Building a large sprinkler or deluge system containing many hundreds of nozzles in one go would not be an effective method of developing such a model. It would be difficult to check for data entry errors (eg a pipe length of 100mm instead of 100m, or the incorrect elevation of a nozzle). The model would be better developed in sections or sub-models, each sub-model checked for errors and then the sub-models merged.

*FluidFlow3* allows this to be done very effectively.

A sub-model, say a complete deluge system downstream of the deluge valve, could be developed and checked for data accuracy by specifying a reasonable inflow based on the desired performance of the nozzles. Decisions can then be made on the performance of the sub-model, viz:

- Nozzle performance – pressure and flow.
- Pipe sizes – are velocities too high, are there any bottlenecks.
- Variations of pressure around the system - are more inlets from the ringmain required.

Once the sub-model is thought to be correct it can be saved to its own unique filename. Other sub-models could be developed and saved in a similar fashion.

When all sub-models are satisfactory, they can be merged one by one to create the full model. The ringmain pipework can then be included.

Including all the deluge systems sub-models makes for a large model, difficult to navigate and taking relatively longer to solve.

The calculated values of flow and pressure for each sub-model represents the hydraulic characteristic of the deluge system as a whole. For instance, if a flow through a deluge system of 10,000 l/min occurred with a total pressure drop of 6.0 bar, then these two values hydraulically define the deluge system.

*FluidFlow3* has a method of utilising this information to create a single “generic fitting” or “flowsheet component” with these hydraulic characteristics (a “black box”). The software then applies dynamic similarity laws to the entered data for such a component to modify the pressure drop according to the actual flowrate calculated by the software in any particular case study.

The various deluge sub-model “black boxes” can then be connected to the ringmain to create a very simple model of the whole system. The advantage of using this representation of a firewater system is that its performance can then be quickly studied under different conditions, ie different pumps and different numbers of deluge systems operating simultaneously. In other words, without actually including the deluge systems’ pipework and nozzles it is possible to investigate their performances under any selected operational scenarios. Sizing of the pumps and ringmain pipework can be quickly achieved.

For final analysis and report the complete deluge system sub-models can be included.

## **EXISTING SYSTEMS**

Existing fixed fire protection systems may need review. Often, accurate details of the physical condition of the system and its performance are not available and the engineer has a difficult task in developing a model which reflects actual conditions.

*FluidFlow3* is extremely useful in this regard. Its graphical interface allows for “what-if” scenarios to be rapidly simulated and the results viewed on the flowsheet. For instance, on a first run of a model of an existing system its unlikely that model results will agree with site data, especially if the site data is anecdotal and/or the flow and pressure measuring system cannot be guaranteed. Despite this (or perhaps because of this!) the model will still be very useful. The reason for discrepancies can be studied. Are pipes corroded? If so, this can be simulated in the model by roughening pipes using *FluidFlow3*’s global pipe-change command. Are the pumps performing correctly – wear on the impellers can be simulated by trimming the impellers in the model. Are there bottlenecks in the system – *FluidFlow3* may identify these by warning that velocities in parts of the system are above a user-defined maximum. Is the fluid vapourising? Are there problems of NPSH.

The gradual “tuning” of a model to site conditions results in a good understanding of the existing system and results in a useful base-model on which to build system extensions or upgrade.

## **NFPA RULES**

### **Introduction**

NFPA 15 “Standard for Water Spray Fixed Fire Systems for Fire Protection” is the industry-accepted standard for the design and testing of Firewater Protection systems. However, in the particular area of hydraulic design it makes no allowance for modern computer simulations in terms of both the possible benefits and/or limitations that such a method of analysis might provide.

Fixed fire protection systems involve large numbers of pipes, valves and fittings. It is unlikely that any current hydraulic design would be carried out using the manual calculation method described in Appendix A of NFPA 15.

Section 1.2 of the standard states...

*“Nothing in this standard is intended to restrict new technologies or alternate arrangements providing the level of safety prescribed by the standard is not lowered.”*

Given the accuracy of a computer simulation over a hand-calculated design, and even taking into account the differences between a computer simulation and a calculation carried out in accordance with Appendix A of NFPA 15 described below, it is argued that the computer simulation increases the probability of achieving adequate firewater coverage during system operation and does not lower the level of integrity or safety of the system.

## **Design Criteria**

There are a number of design criteria described in NFPA 15, which need to be compared with the *FluidFlow* method. These are:

- Pressure loss formula for pipes.
- Pressure loss formula for valves and junctions.
- Velocity head.

### Pressure Loss Formula for Pipes

NFPA 15 utilises the Hazen-Williams formula for calculating the pressured drop due to flow in a straight pipe. The Hazen-Williams formula utilises a coefficient C that varies depending on the roughness and size of the pipe. The value of C can vary for new steel pipes between 120 and 140 depending on size.

Figure A-7-2 (e) in NFPA 15 provides a head drop nomograph for varying flows through steel pipes of different diameters. The Figure states that the value of C is constant for all diameters at C=120.

By contrast, the Pipe Friction Handbook by the Australian Pump Manufacturers Association Ltd provides values of C, which vary with pipe diameter. Values for new steel pipe closer to 140 are given. Since the range in value of C between 120 and 140 can make a significant difference in pressure loss, this inconsistency is significant.

An alternative method of calculating the pressure loss due to flow in a pipe is the Darcy-Weisbach equation (sometimes referred to as the Moody diagram method). This approach relies on knowledge of the absolute roughness of a pipe to determine a friction coefficient. Outside the water and fire protection industries, the Darcy equation is universally used and the method highly accurate.

*Fluid Flow3 can work in either method.*

A comparison between test values from Figure A-7-2 (e) in Appendix 'A' and the same calculation in *FluidFlow* using either method gave almost identical results for C values of 120.

### Pressure Loss Formula for Valves and Junctions

NFPA Table A-7-2 (g) gives equivalent lengths for various valves and pipe fittings. The equivalent length method utilises the concept of a length of straight pipe which produces the same pressure loss as the valve or fitting it is simulating. A drawback with this method is that a different equivalent length is required for each “size” of fitting, i.e. there is one equivalent length for a bend in a 100mm pipe and a different equivalent length for a the same type of bend in a 150mm pipe. Other drawbacks with the equivalent length method are:

- Table A-7-2 (g) requires that the equivalent lengths be corrected for values of C different from 120.
- Elbows are referred to as “standard” and no account is given for longer radius bends if used.
- The method does not take into account fittings with changing diameters, for instance a tee junction with a branch diameter different from the barrel diameter.
- Values are generic, it they do not necessarily apply to a particular manufacturer’s valve or junction.
- The list of valves and fittings is extremely limited, i.e. only a generic “swing check” valve is given and the table actually notes that the given value is to be considered “average”.

Modern computer simulation techniques utilising a schematic flow sheet representation of a pipe network can provide a more accurate and sophisticated modelling of valves and junctions, for instance the  $f_t$  method described in Crane or the methods developed by Idelchik and Miller which take into account unequal tees, wyes and bends of different  $r/D$  values.

*FluidFlow3 can utilise Crane, Miller or Idelchick method and manufacturers’ actual data can be used where available.*

### Velocity Head

Water flowing in a pipe has an energy component due to its velocity – a kinetic energy. If this velocity is reduced, the kinetic energy is converted to pressure energy. Theoretically this additional pressure energy would be available to discharge slightly more flow through a nozzle than would be the case if the velocity head was ignored. NFPA 15 states that velocity head can be either included in a calculation or ignored.

*FluidFlow does not allow for velocity head.*

Velocity head becomes significant only if the velocity of flow is quite high, say well above 3.5 m/s. High velocities are to be avoided because of increased frictional resistance. In a *FluidFlow* simulation, a maximum pipe velocity can be set such that a warning is enunciated for every pipe where the velocity exceeds the set maximum. This feature allows the design engineer to conveniently monitor the whole system for excessive velocities.

## **WARNINGS**

*FluidFlow3* has a large number of in-built and user-defined warnings designed to assist the user in developing a network model to operate within user-defined limits. These are particularly applicable to the design of fixed fire protection systems.

Warnings do not necessarily mean that the system won’t operate in reality or that there is some mistake or inadequacy in design; rather they alert the engineer to the performance of a component outside a generally accepted or user-defined range of operation.

If a warning enunciates in relation to a component, that component flags red on the flowsheet and a warning description appears in the Data Inspector.

Warnings relevant to the design of fixed fire protection systems are:

- Pump operating outside a user-specified minimum and maximum flow.
- Inadequate NPSH.
- Sprinkler or nozzle operating outside a user-specified minimum and maximum pressures.
- Pipe velocity outside user-specified minimum and maximum values.

## REPORTS

*FluidFlow3* has a number of reporting routines which will enhance the overall design process.

1. The flowsheet can be output to printer or plotter. Colour definition of pipes provides an excellent display of the system.
2. *FluidFlow3*'s own report generator can create tabular reports containing user selections of all input and calculated data. For instance, a report could contain just data about sprinklers and their performance; a quick review of the data would ensure adequate flow to the hydraulically most remote nozzle.
3. *FluidFlow* generates its own bill of materials.
4. *FluidFlow*'s unique link to Microsoft's Excel provides unlimited options for the manipulation of system data. For instance, a sprinkler report could be generated within Excel listing all sprinklers by name and calculating quantities of each. Additional data could then be added, such as price, manufacturer etc. Pipe data – lengths, size – could be exported and quantities and total weights and internal volume calculated.
5. *FluidFlow3* can export reports in HTML, Word and PDF format.

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