Pipework design made easy

Pipework design is not a exact science but the cardinal sin is to undersize, it's expensive to rectify! On the other hand you can use the "Victorian" philosophy and over engineer, this may be gratefully received by future engineers wishing add appliances to existing pipework but is not good news in a competitive environment when you could lose the job.

So where do we start?

First what defines an undersized pipe?

> Practically the noticeable effect is that the appliance will not work in an extreme case or at least not give the right performance and a customer complaint. In general this means that the gas pressure at the appliance is too low. The first response is to blame the gas supply, it's not me, it's the gas suppliers fault; easily checked by taking the pressure at the meter with the appliance running at full rate, if you have around 21 mbar, its NOT the supply. So if this exonerates the gas supplier, then it's probably down to pipe size, too higher flow through too smaller pipe or longer distance, back to pipe design.

Pipe sizing

You could guess, but even using our experience it's not a very good technique, we need something more accurate.
There are a variety of sizing techniques,

- Use the formulae and calculate yourself
- Tables from handbooks
- Slide rules
- Computer programs

There are different pipe sizes, materials and different formulae etc. The actual pipe internal diameter makes a lot of difference, so we need a means of calculation that caters for our pipe size and material. Different calculation can give different results depending on assumptions made by the writer or compiler of the calculation. As in most situations it is better to err on the high side since at the end of the day what we want is a guide for design, what designs are fitted exactly as planned? More often that not, the pipe route is changed to miss obstacles or to suit customer preferences.

The main parameter for pipe design is the pressure drop (pd), so what pressure drop is acceptable?

The main guide comes from The Institution of Gas Engineers and Managers publication UP/2 "Gas Installation Pipework, Booster and Compressors on Industrial and Commercial Premises" which recommends that the pressure drop for a low pressure system should not exceed 1 mbar (note this says should not must). This is a low-pressure drop (when you think we can only read a water gauge to ½mabr accuracy).

So why is the figure so low?

> Well, if we start at the appliance CE marked appliances have to work safely at a burner pressure of 12.5 mbar and be rated at a 17.5 mbar inlet pressure at the isolation valve. With 21 mbar at the meter this does not leave much to play with. Significantly, pipe fittings and components such as valves and meters, often forgotten about, have a major affect on pressure drop and cannot be ignored.

For gas fittings most pressure drop calculations use an "equivalent length" adjustment, every fitting has a length factor to add to the pipe length to account for the frictional resistance of the elbow, bend or tee etc. Valves also have a frictional loss, manufacturers usually can provide a flow/pressure drop chart for their valves: ball valves are the same bore as the pipe when fully open and therefore have a very low pressure drop, plug valves have higher pressure drops and butterfly valves higher still. A butterfly valve the same size as the pipe could use most of our 1-mbar allowance.
If a secondary meter is fitted, such as for sub-let buildings, its pressure drop may well exceed the 1 mbar without taking into account any pipe losses.

How rigid is the 1 mbar parameter? The IGEM UP/2 recommendation represents good engineering practice but we are allowed "engineering judgement" the main requirement is that the appliance operates safely and to its specification. It may be that if it is CE marked it should be OK with 17.5 mbar and provided this is met by our pipe design we will be OK apply our judgement and allow slightly more than the 1 mbar. **Deviations from accepted standards does however need recording with plant details in a technical file to assist others when they need to service plant etc.**

The effect of multi appliances

So far we have looked at a single appliance, once we get to a pipe network with several appliances the situation gives more variables to juggle with. With one appliance the flow rate used in pipe design is the gas rate of that appliance. When we have multiple numbers of appliances do we use the total of the maximum rates of all the appliances?
Well, it would be the worse case and the pipe should not be undersized! However there is a significant cost penalty, once more we need a bit of guidance.

The critical factor is whether we can reasonably expect all the appliances to be at maximum rate at the same time.
Two boilers for space heating which were designed to cover the worse winter condition, may very well work together at start up.
Three boilers with one as stand-by will probably not work together.
Boilers with air heaters and radiant heaters may not come on together the time to get a water system to occupancy temperature is longer than direct space heating, so when the space heaters come on the boiler could well be at the control point turned down or modulating.

A heating system and a commercial catering load off the same pipework would be even more spread out, with the catering load peaking at lunch time and even then all appliances may not be on.
For a block of apartments with individual boiler and cookers, it is unlikely all will be on together, the more apartments the more unlikely.

We are allowed by UP/2 to consider these different scenarios in our pipe design and this is called "diversity"
The next question is how much to allow, the best way is to look carefully at each usage and make an engineering judgement, for a large system such as hospital, factory etc a 60% diversity could be starting point, remember, different pipe runs with any pipework network may have different diversities.

Design Procedure

If we now go back to our starting point of the pressure drop allowance, diversity offers us a chance to be realistic and treat the 1mbar flexibly. As in most aspects of life reason should prevail, there is no substitute for experience; pipework is more an art than a science. What we need is to be able to take as many variables into account for pipework hardware and apply our judgement to the load practicalities.

Making a pipe layout drawing.

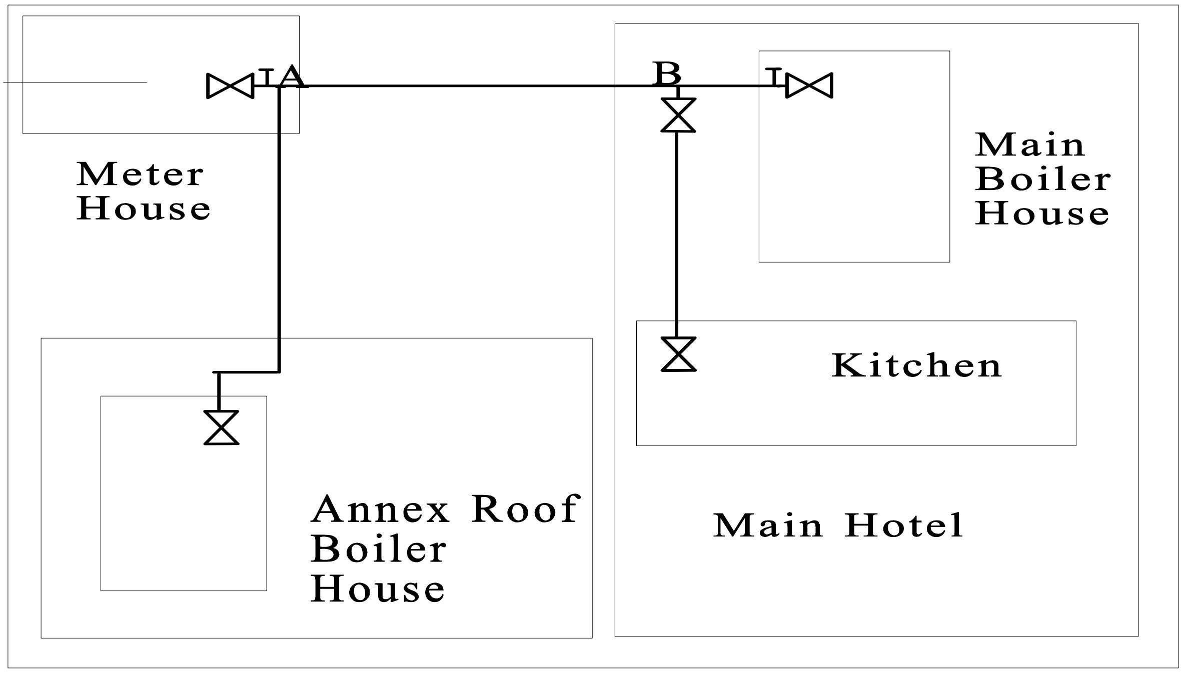
In producing the layout on a plan, there must be some thought given to the location and accessibility of the Emergency Control (or section isolation) Valves. High level positions will not be acceptable for Emergency Control Valves unless they can be easily accessed or operated remotely, e.g. by a chain wheel. In like manner it is important to consider how the system will be tested and purged for commissioning and decommissioning in order to get valves and purge points correctly located.

The location of buried sections of pipework outside buildings needs detailed consideration and can be dependent upon whether steel or PE is the chosen material.

Steel pipework can corrode due to impressed currents from power cables or even nearby electric railway systems. Try to keep as far away from power systems as is possible if you are laying steel pipes. PE pipe can be affected by certain chemicals and solvents in the soil although this is rare except on chemical works. If there is any doubt the suppliers or manufacturers should be consulted.

The route of buried pipes should be straight and if possible marked along the road/footpath with marker boxes. The use of verges or other soft ground can greatly reduce installation costs but unless buried to an adequate depth there is the risk of accidental damage by traffic that might move over its surface or from other service work by contractors. As with above ground pipes, it is important to use valves at Tees or along the route to permit easier soundness testing and subsequent works.

A typical pipe diagram of a Hotel could look like:



The Table below is a useful way of listing and showing the flow rates and pressure drops for EACH length of pipe with the same diameter. From this table the worst pressure drop leg can be found.

Pipe section	Pipe Material	Pipe size (mm)	Pipe length (m)	Flow Rate (m^3/h)	Pressure Drop (mbar)
Natural Gas					
Meter - A	Steel	100	2	130	0.03
A to B	PE 11	125	8	110	0.09
Total Meter - B					0.12
B to Kitchen	Steel	80	35	30	0.11
Kitchen pipework	Copper	54	10	30	0.35
Total to kitchen					0.46
B to Boiler house	Steel	80	20	80	0.45
Boiler house Pipework	Steel	65	8	80	0.42
Total boiler house pipework					0.87
A to Annex	Steel	50	50	20	0.68
Riser to roof	Steel	50	10 (height)	20	-0.48
Total to rooftop					0.22
	There is a pressure gain with height for natural gas				
	Use riser tab on GEA pipe loss calculator				

Worse pressure drop (index leg) is to the boiler house 0.12 + 0.87 = 0.99 mbar