NON-CIRCULAR CROSS SECTIONS

FluidFlow3 offers a choice of three geometries for flow conduits, circular pipe, rectangular duct and annulus. These are selected form the Input Editor.

When a Rectangular /Square geometry is selected, the Input Inspector displays two additional fields, one for the Rectangular Width and one for Rectangular Height; when an Annulus geometry is selected the two fields are Annulus Inner Diameter and Annulus Outer Diameter.

RECTANGULAR DUCTS

In rectangular ducts, the non-uniform wall shear stress results in secondary flow paths within the duct cross-section and we therefore need a mechanism which compensates for these varying wall stresses.

For many non-circular cross-sections a satisfactory procedure for calculating head loss due to friction is to replace the pipe diameter, D, used in the friction and Reynolds numbers equations by the hydraulic diameter, D_e, where

$$D_e = 4 * \frac{\text{Cross Sectional Area}}{\text{Wetted Perimeter}}$$

For a rectangular duct with height/length dimensions a and b, this becomes:

$$D_e = 4 * \frac{a*b}{2(a+b)}$$

The procedure used by FluidFlow3 is as follows:

STEP	CALCULATION	
1	Calculate the actual cross-sectional area of the duct:	$A_{ac} = (a * b)$
2	Calculate the actual velocity of flow:	$u_{ac} = Q / A_{ac}$
3	Calculate the hydraulic diameter:	$D_e = 4 * \frac{a*b}{2(a+b)}$
4	Calculate Reynolds number, R_e:	$R_e = u_{ac} * D_e$ / kinematic viscosity
5	Calculate relative roughness:	$= k / D_e$
6	Determine friction factor from R_e and k / D_e	
7	Calculate the head loss:	$H_L = f * L * u_{ac}^2 / 2*g* D_e$

Note: FluidFlow3 calculates and uses the actual velocity, ie volumetric flow divided by actual duct area. This means that a correct velocity head is used for the calculation of friction loss and head loss across any fittings in a rectangular duct. This would not be the case if you calculated D_e by the above equation and then entered it into the pipe database as a circular pipe diameter, because the equivalent cross-sectional area of the pipe would be different from that of the duct, and hence the velocity would be incorrectly calculated.