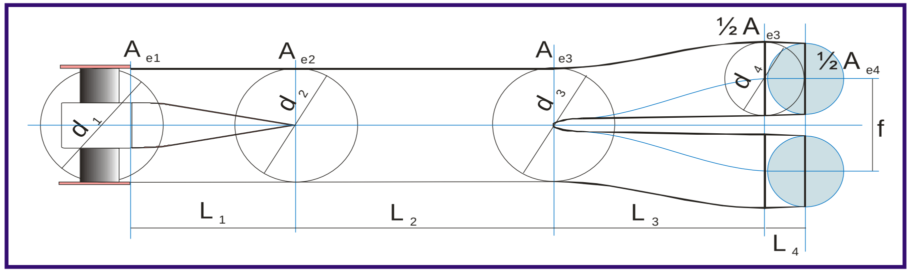
Winchester Models

Drag and Loss calculation for extension piping in EDF installations



The picture above shows the principal lay-out and dimensional parameters, which can be accomodated in the calculation. The air flow is from left to right. On the left is the exit from the fan, followed by a section which either reduces the pipe diameter or the air flow velocity, depending on the ratio of d1 to d2. The length of this section is L1.
L2 is basically a straight duct, which follows L1 and leads to the exit nozzle. L3 is the length of a bifurcated section if this is required. The cross section areas are designated with A 1 to A 4 and the appropriate diameters with d1 to d4.
The individual dimensions of the parameters must be inserted in the green fields. Dimensions are given in metric.
A very important factor in the calculations is the static thrust of the EDF, measured in the basic condition, i.e. without any extension or thrust tube. A1 is the area of the fan annulus (FSA) which is provided by the manufacturer.
The other areas are derived from the chosen diameters or "equivalent".

Ae1 =	94	cm^2	d1 =	120	mm	L1 =	160	mm
Ae2 =	113.1	cm^2	d2 =	120	mm	L2 =	450	mm
Ae3 =	113.1	cm^2	d3 =	120	mm	L3 =	220	mm
Ae4 =	78.5	cm^2	d4 =	100	mm	L4 =	50	mm

1/2 Ae3 = 47 cm^2 d (1/2Ae3) 77.4 mm **for bifurcated duct only**

static thrust = 50 N Velocity pressure Ae1 = 5319.1 Pa [N/m^2] Velocity = 94.2 m/s

Losses in this context are calculated as pressure losses in the air flow caused by friction and flow separation as well as conversions of velocity into static pressure and visa versa.
The first step is the calculation of the losses of the pipe section which follows immediately after the fan housing.
One can either reduce the diameter of the pipe to conserve the same cross section area as the fan annulus, which usually results in the minimum of losses. Keeping the same diameter over the whole pipe length constitutes a diffusion of the air flow and causes a loss of pressure as shown below. If Ae1 and Ae2 are of the same value the diffusion factor below will be 1.

Diffusion factor = Ae1/Ae2 = 1.20 Velocity in Ae2 = 78.1 m/s Velocity pressure = 3662.3
Diffusion static pressure rise = 1656.8 Pa [N/m^2] Diff.n loss = 331.4 Pa [N/m^2]

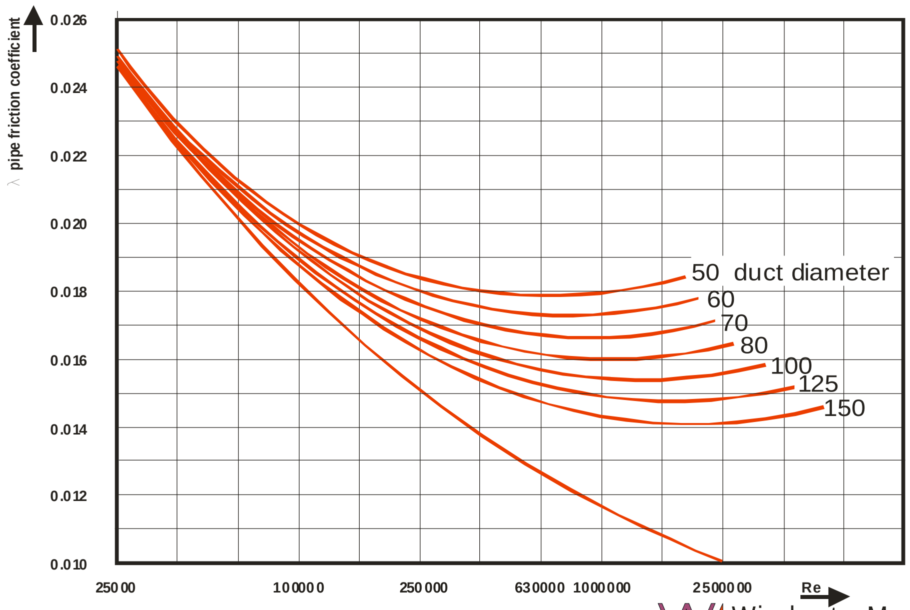
Friction loss for diffuser = 177.3 Pa [N/m^2] Re-No.: = 656270 Lambda from table = 0.015

Friction loss for main pipe = 343.3 Pa [N/m^2] Re-No.: = 656270 Lambda from table = 0.015

Flow division loss =	58.6	Pa [N/m^2]	"zeta" division=		0.016		
Friction loss for bifurcated ducts =	434.2	Pa [N/m^2]	Re-No.: =	466460	Lambda from table =	0.017	

Total pressure loss for exhaust ducting with straight pipe and bifurcation =	1344.8	Pa [N/m^2]
Remaining total pressure for velocity conversion =	3974.3	Pa [N/m^2]
Maximum possible exit velocity =	81.4	m/s
Contraction ratio (max pipe cross section to nozzles) =	0.96	
Static thrust after loss deductions (for the same power input as without duct!)	**43.1**	N

In this case the static thrust loss is around 14%. To regain the same thrust as without duct a power increase of around 20% is required



Pipe flow resistance coefficient λ
in respect of Re number

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