Fulton Heating Solutions, Inc.

Engineering Guide

Condensing Hydronic Boilers

Common Combustion Air Duct Sizing

It is acceptable to manifold the combustion air intake duct from multiple boilers into a common air header. The sizing of this common header will vary depending on several factors including boiler capacity, length of the run, number of fittings, and whether or not the flue gas exhaust is also combined into a common flue header.

COMBINED COMBUSTION AIR INTAKE WITH INDIVIDUAL FLUE GAS EXHAUST VENTS

For systems utilizing individual flue gas exhaust vents per boiler, with a combined combustion air intake, the diameter of the common combustion air intake duct can be calculated using a simplified total equivalent cross-sectional area approach.

N	=	Number of Boilers
D_i	=	Individual Boiler Combustion Air Intake Diameter (inches)

Solve for the common combustion air intake diameter (D_c) in inches, and round up only to the nearest available diameter:

$$D_c = 2 \times \sqrt{N \left(\frac{D_i}{2}\right)^2}$$

COMBINED COMBUSTION AIR INTAKE WITH COMBINED FLUE GAS EXHAUST VENT

For venting systems that intend to combine flue gas exhausts as well as combustion air intakes, it is imperative that the common combustion air intake duct is sized for negligible (≤0.01"WC) pressure losses. The reason for this is to prevent the occurrence of reverse flue gas flow through idle boilers. Reverse flue gas flow is a subset of undesired flue gas recirculation (FGR) that can not only cause operational issues with boiler combustion systems, but can become a safety hazard to the occupants of the building.

One valid method is an iterative approach evaluating the delta-P performance for various diameters (D_c). The method detailed below uses the Weymouth Formula for compressible flow in 3" and larger pipes. Contact your local Fulton Representative with any questions, Fulton Applications Engineering is available to assist with this analysis.

The following parameters must be known:

L	=	Total Equivalent Length (feet)
D_i	=	Individual Boiler Combustion Air Intake Diameter (inches)
E	=	Excess Air of the Burners (%) *Note: typical condensing boiler burners range from 25-55%*
H	=	Higher Heating Value of Natural Gas (BTU/ft^3)
Q	=	Input Rate of the Burner (BTU/hr)
f	=	Dimensionless Darcy Friction Factor

$$\Delta p = 0.00000411 \times f \times \left(\frac{L}{D_c^{\,5}}\right) \times \left(9.48 \times \left(\frac{Q}{H}\right) \times \left(1 + \left(\frac{E}{100}\right)\right)\right)^2$$

The friction factor (f) can be determined using two methods, a Moody Diagram or by calculation using the Swamee-Jain expression which approximates the friction factor based on the absolute roughness (ε) of the vent material in inches, the diameter (D_c) and the Reynolds number (Re):

$$f = 0.25 \left(\log\left(\frac{\varepsilon}{3.7\,D_c} + \frac{5.74}{Re^{0.9}}\right)\right)^2$$

Check with the intake duct material supplier for the specific absolute roughness (ε) value. Approximations with a 30% safety margin for joints are 0.005 inches for galvanized and 0.0025 inches for PVC (ASHRAE Fundamentals, 1985, pg 33.5 Table 1).

Reynolds number (Re) for volumetric flow is expressed as the following per the North American Combustion Handbook, Vol 1:

$$Re = 15.28\left(\frac{\rho\, Q}{\mu\, D_c}\right)$$

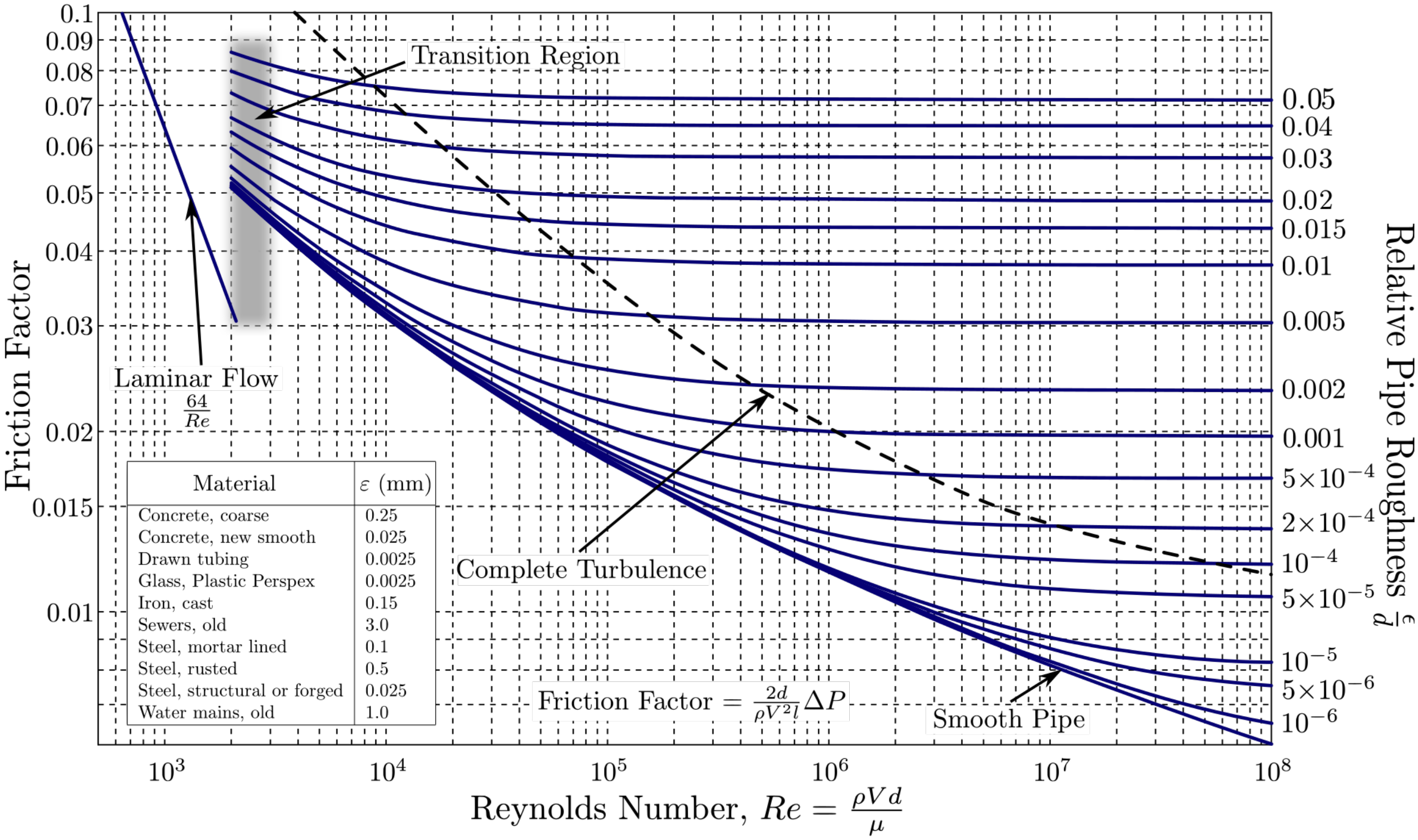
Density (ρ) is assumed to be dry air calculated as below where R is specific gas constant 53.25 ft lb/lb °R, T is absolute temperature in °R, p_0 is 14.7 psi, 0.3047 is m/ft conversion, and h is elevation in feet:

$$\rho = \frac{p_0 \, (1 - h \times 6.875 \times 10^{-6})^{5.25588}}{R \times T}$$

Dynamic viscosity (μ) is calculated using Sutherland's formula (Crane, 1988) and μ_0 and T_0 are Standard Temperature Pressure (STP) therefore 0.0000003797 lbs s /ft^2 and 530°R respectively:

$$\mu = \mu_0 \left(\frac{0.555\, T_0 + 120}{0.555\, T + 120} \right) \left(\frac{T}{T_0} \right)^{\frac{3}{2}}$$

Alternatively, a Moody Diagram (S. Beck and R Collins, University of Sheffield) can be used to determine friction factor:



Note: It is ultimately the responsibility of the designer and installer of the venting system to fully validate the system to ensure reverse flue gas flow cannot occur under any operating condition. Adhere to the boiler installation instructions, all national and local codes, and ensure carbon monoxide detectors (by others) are interlocked with the boilers.