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Pressure drop in ducts across round-wire gauzes normal to the flow

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THE PREPARATION OF THIS DATA ITEM

The work of the permanent professional staff of the Engineering Sciences Data Unit on this particular Item, which supersedes Item No. Aero 02.00.01, was monitored and guided by the Fluid Mechanics Steering Group which had the following constitution:

Chairman	
Mr W.F. Wiles	— Rolls-Royce (1971) Ltd, Hucknall
Members	
Mr E.C. Firman	— Central Electricity Research Laboratories
Mr B.H. Fisher	— Consulting Structural Engineer
Dr G. Hobson	— English Electric - AEI Turbine Generators Ltd
Dr J.M. Ilsley	— Kellogg International Corporation
Mr T.V. Lawson	— University of Bristol
Mr J.R.C. Pederson	— British Aircraft Corporation Ltd, Stevenage
Mr C. Scruton	— Independent.

The Steering Group has benefited from the participation of members from several engineering disciplines. In particular, Mr B.H. Fisher has been appointed to represent the interests of structural engineering as the nominee of the Institution of Structural Engineers, Mr E.C. Firman has been appointed to represent the interests of mechanical engineering as the nominee of the Institution of Mechanical Engineers, and Dr J.M. Ilsley has been appointed to represent the interests of chemical engineering as the nominee of the Institution of Chemical Engineers.

The Item was accepted for inclusion in the Aerodynamics Sub-series by the Aerodynamics Committee which had the following constitution:

Chairman	
Prof. G.M. Lilley	— University of Southampton
Vice-Chairmen	
Prof. D.W. Holder	— University of Oxford
Mr W.F. Wiles	— Rolls-Royce (1971) Ltd, Hucknall

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PRESSURE DROP IN DUCTS ACROSS ROUND-WIRE GAUZES NORMAL TO THE FLOW

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PRESSURE DROP IN DUCTS ACROSS ROUND-WIRE GAUZES NORMAL TO THE FLOW

1. NOTATION AND UNITS

Three coherent systems of units are given below.

		SI	British	
A	cross-sectional area of duct in which gauze is placed	m^2	ft^2	ft^2
a	speed of sound	m/s	ft/s	ft/s
D	drag force on gauze	N	pdl	lbf
d	wire diameter	m	ft	ft
K_r	reference pressure drop coefficient in incompressible flow for $Re \geq 2000$	—	—	—
K_s	static-pressure drop coefficient, $\Delta p_s / (\frac{1}{2} \rho V^2)$	—	—	—
K_t	total-pressure drop coefficient, $\Delta p_t / (\frac{1}{2} \rho V^2)$	—	—	—
M	Mach number just upstream of gauze	—	—	—
n	wire mesh (number of wires per unit length)	$1/\text{m}$	$1/\text{ft}$	$1/\text{ft}$
p	static pressure of fluid upstream of gauze	N/m^2	pdl/ft^2	lbf/ft^2
Δp_s	static-pressure drop across gauze	N/m^2	pdl/ft^2	lbf/ft^2
Δp_t	total-pressure drop across gauze	N/m^2	pdl/ft^2	lbf/ft^2
R	gas constant	J/kg K	$\text{ft pdl/lb}^\circ\text{R}$	ft lbf/slug K
Re	Reynolds number based on wire diameter, $\rho V d / \mu$	—	—	—
T	static temperature of fluid upstream of gauze	K	$^\circ\text{R}$	K
V	mean flow velocity upstream of gauze	m/s	ft/s	ft/s
α	orthogonal porosity, $(1 - nd)^2$	—	—	—
β	solidity, $1 - \alpha$	—	—	—
γ	ratio of specific heat capacity at constant pressure to that at constant volume	—	—	—
λ_1	factor to account for effect of $Re < 2000$ on pressure drop coefficient	—	—	—

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λ_{2s}	factor to account for effect of compressibility on static-pressure drop coefficient	—	—	—
λ_{2t}	factor to account for effect of compressibility on total-pressure drop coefficient	—	—	—
μ	dynamic viscosity of fluid upstream of gauze	N s/m ²	pdl s/ft ²	lbf s/ft ²
ρ	density of fluid upstream of gauze	kg/m ³	lb/ft ³	slug/ft ³

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2. INTRODUCTION

This Data Item presents information on the pressure drop in ducts across round-wire gauzes (or screens) normal to a fluid flow. The pressure drop is dependent upon the gauze geometry, and the velocity, density, Reynolds number and Mach number of the flow.

The data are presented in the form of non-dimensional pressure drop coefficients and apply to the flow of liquids and gases. For liquids, the effect of compressibility (or Mach number) can be ignored.

The pressure drop attributable to a gauze placed normal to a flow in a duct is given by

$$\Delta p_s = K_s \frac{1}{2} \rho V^2 \quad (2.1)$$

$$\text{or} \quad \Delta p_t = K_t \frac{1}{2} \rho V^2, \quad (2.2)$$

$$\text{where} \quad K_s = K_r \lambda_1 \lambda_{2s} \quad (2.3)$$

$$\text{and} \quad K_t = K_r \lambda_1 \lambda_{2t}. \quad (2.4)$$

In this Item, K_r is a reference pressure drop coefficient, applicable to incompressible flow ($M = 0$) at Reynolds numbers exceeding 2000, to which correction factors, λ_1 (Figure 2) and λ_{2s} or λ_{2t} (Figures 3 and 4), are applied to account for the effects of Reynolds numbers below 2000 and compressibility, respectively.

3. POROSITY

Figure 1 shows the reference pressure drop coefficient, K_r , as a function of porosity for $Re = 2000$ and $M \approx 0$. This Figure is based on data (mainly for air) from Derivations 8 to 12, 14 to 21, 23 to 27 and 29.

4. EFFECT OF REYNOLDS NUMBER

Figure 2 shows the increase of pressure drop coefficient with decreasing Re below 2000. The Figure is based on the same Derivations as Figure 1, and gives the correction factor, λ_1 , to be applied to values of K_r from Figure 1 for $Re < 2000$. Above $Re = 2000$, the factor λ_1 may be taken as unity. The data show a considerable scatter about the mean correlation curve of Figure 2, but scatter bands of ± 10 per cent and ± 15 per cent include about 80 per cent and 95 per cent of the data respectively.

5. EFFECT OF MACH NUMBER

The effect of duct Mach number on static- and total-pressure drop is shown in Figures 3 and 4. These Figures give the correction factors, λ_{2s} and λ_{2t} , which, used in Equations (2.3) and (2.4) in conjunction with values of K_r and λ_1 , give the static- and total-pressure drop in Equations (2.1) and (2.2) respectively. Note that for incompressible flow, i.e. $M \approx 0$, $\lambda_{2s} = \lambda_{2t} = 1$, and $\Delta p_s = \Delta p_t = K_r \lambda_1 \frac{1}{2} \rho V^2$. The curves of Figure 4 have been derived from the static-pressure drop data of Figure 3 using isentropic flow relations. The information is based on data for air taken from Derivations 13, 22 and 27 to 29.