ESDU 92042
Issued December 1992
With Amendment B
March 2007
Supersedes ESDU 84029 and 88002
Re-issued June 2011

Ejectors and jet pumps:
Computer program for design and performance for compressible gas flow

Associated software: ESDUpac A9242

Endorsed by
The Institution of Chemical Engineers
The Institution of Mechanical Engineers

ESDU DATA ITEMS

Data Items provide validated information in engineering design and analysis for use by, or under the supervision of, professionally qualified engineers. The data are founded on an evaluation of all the relevant information, both published and unpublished, and are invariably supported by original work of ESDU staff engineers or consultants. The whole process is subject to independent review for which crucial support is provided by industrial companies, government research laboratories, universities and others from around the world through the participation of some of their leading experts on ESDU Technical Committees. This process ensures that the results of much valuable work (theoretical, experimental and operational), which may not be widely available or in a readily usable form, can be communicated concisely and accurately to the engineering community.

We are constantly striving to develop new work and review data already issued. Any comments arising out of your use of our data, or any suggestions for new topics or information that might lead to improvements, will help us to provide a better service.

THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item was monitored and guided by the Internal Flow Panel, which first met in 1979 and had the following membership:

Chairman

Dr J.A. Eaton	— University College Galway, Ireland

Members

Mr D.A. Campbell	— Rolls-Royce Ltd, Derby
Mr J. Campbell	— Ove Arup and Partners
Dr C.J. Clark	— BP International Ltd
Dr D.J. Cockrell	— University of Leicester
Prof. D.H. Freeston*	— Auckland University, New Zealand
Dr M.E. Gill	— W.S. Atkins Science and Technology
Mr A.J. Green	— BHR Group Ltd
Dr A. Johnson	— Schlumberger Cambridge Research Ltd
Prof. J.L. Livesey	— University of Salford
Dr M. Moore	— Independent
Mr J.A. Ward	— AEA Technology, Harwell.

* Corresponding Member

This Item supersedes and incorporates the methods of ESDU 84029 and 88002. The work on ESDU 84029, for the design and performance of ejectors and jet pumps with compressible air flows, was monitored and guided in 1984 by the following Working Party†:

Mr J. Campbell	— Babcock Power Ltd
Dr D.J. Cockrell	— University of Leicester
Mr J.S. Drabble	— Royal Aircraft Establishment (Pyestock)
Dr R.S. Silvester	— British Hydromechanics Research Association
Mr A.W. Wakefield	— Wakefield and Imberg
Mr R. Whitaker	— British Aerospace (Warton).

The initial assessment of the available information on compressible air flows in ejectors and jet pumps and the subsequent development of ESDU 84029 was undertaken (under contract to ESDU) by†

Ms A.E. Gibson	— Atkins Research and Development
Dr S.J. Murray	— Atkins Research and Development.

(*Continued on inside back cover*)

† Affiliations at the time are given

EJECTORS AND JET PUMPS
COMPUTER PROGRAM FOR DESIGN AND PERFORMANCE FOR COMPRESSIBLE GAS FLOW

ESDU 92042 describes a computer program for the design of gas ejectors and jet pumps to meet given requirements and for prediction of performance.

Two design methods are provided. A 'quick' method is based on data from a range of typical single nozzle ejectors and requires a minimum of input data. A detailed design method is also provided (based on a one-dimensional flow theory given in the Appendix) which enables a more detailed assessment of the effects of internal losses to be made. This method may also be applied to multi-nozzle or annular nozzle designs. The performance prediction method is also based on the one-dimensional theory and calculates the flow conditions throughout the ejector given the dimensions, loss factors and entry flow conditions. The use of the program is illustrated by three worked examples. The program is provided to run within ESDUview, a user-friendly environment for personal computer users. An executable version of this program is available.

CONTENTS

EJECTORS AND JET PUMPS
Computer Program for Design and Performance for Compressible Gas Flow

1. NOTATION AND UNITS

Any consistent system of units may be used in the equations in this Item.*

		Units	
		SI	*British*
A	cross-sectional area	m^2	ft^2
A_{ME}	area ratio: A_4/A_e	–	–
A_R	area ratio: A_4/A'_e	–	–
A_R*	area ratio: A_4/A_{th}	–	–
a	sonic velocity	m/s	ft/s
C_D	primary-nozzle discharge coefficient	–	–
d	diameter	m	ft
i	defines user estimated parameter	–	–
K	mixing duct momentum loss factor	–	–
L	length of mixing duct	m	ft
L_d	length of contraction or diffuser	m	ft
M	Mach number: V/a	–	–
$\dot{m}$	mass flow rate	kg/s	slug/s†
n	number of user estimates of parameter, number of nozzles	–	–
PP	primary parameter: $C_D(p'_{te}/p''_{te})/A_R$	–	–
p_t	absolute total pressure	‡kPa	lbf/ft^2
R	gas constant (for air, $R \approx 287$ J/kg K, 3090 ft lbf/slug K)	J/kg K	ft lbf/slug K†
r_m	mass flow ratio: $\dot{m}''/\dot{m}'$	–	–
S	length of mixing duct entry	m	ft
SP	secondary parameter: $(p''_{te}/p_4)(A_R - 1)/A_R$	–	–

For footnotes see end of Notation Section.

Issued December 1992
With Amendment B – March 2007
Re-issued June 2011 – 54 pages

T_t	absolute total temperature	K	K
V	stream velocity	m/s	ft/s
γ	ratio of specific heat capacity at constant pressure to that at constant volume (for air, $\gamma \approx 1.4$)	–	–
η_d	contraction or diffuser total-pressure recovery: p_{t5}/p_{t4}	–	–
η_i	secondary flow inlet efficiency: p''_{te}/p_{t0}	–	–
ϕ_d	contraction or diffuser wall angle	degrees	degrees
ϕ_m	mixing duct wall equivalent angle	degrees	degrees

* For many parameters ESDUpac A9242 uses non-consistent, but more commonly-used, units to simplify the use of the program. The units required by the program are shown in Tables 5.1, 5.2, 5.3 and 5.4 and are displayed on-screen when running ESDUpac A9242 in ESDUview (see Section 4).

† 1 slug = 32.174 lb mass.

‡ 1 kPa = 1000 N/m^2

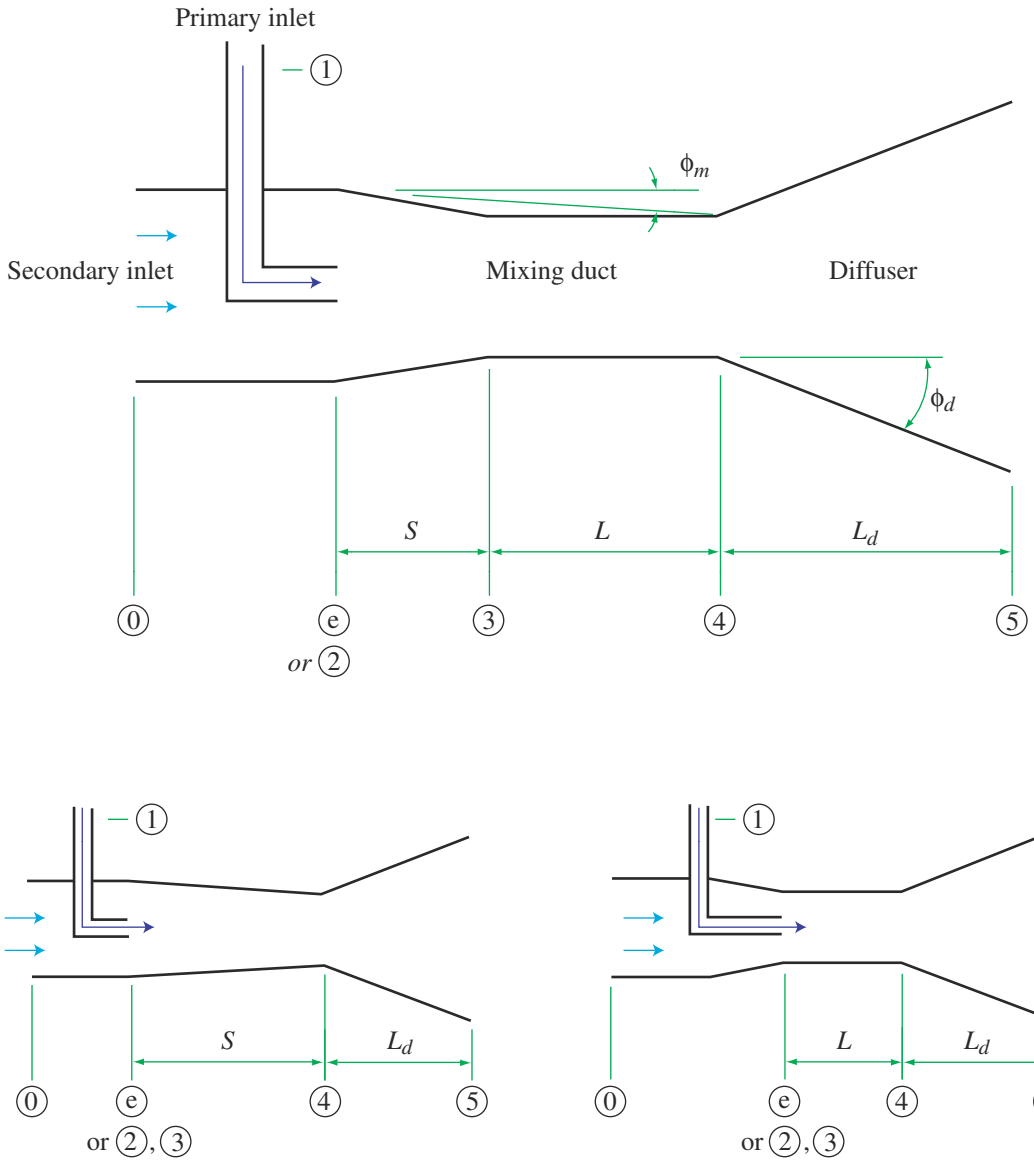
Subscripts

e	primary nozzle exit plane
th	primary nozzle throat
max	upper limit of parameter
0	secondary flow entry plane
1	primary nozzle entry plane
3	mixing duct entry plane
4	mixing duct exit plane
5	contraction or diffuser exit plane

The reference planes are defined in Sketch 1.1. Note that, for constant area mixing, planes 2 and 3 are coincident and are referred to by subscript e.

Superscripts

$'$	refers to primary stream or primary nozzle
$''$	refers to secondary stream or secondary inlet



(i) Convergent mixing duct.
In this case, the mixing duct length, L, is effectively zero

(ii) Parallel sided mixing duct.
In this case, the mixing duct entry length, S, is effectively zero

Sketch 1.1 Ejector configuration and typical cases.