



**Transonic data memorandum
VGK method for two-dimensional
aerofoil sections
Part 7: VGK for Windows™**

Associated software: ESDUpac W0315

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THE PREPARATION OF THIS DATA ITEM

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Mr M.D. Hodges	— Independent
Dr D.R. Philpott	— University of Hertfordshire, Hatfield
Mr G.R. Richards	— BAE SYSTEMS, Farnborough
Mr D.R. Stanniland	— Aircraft Research Association
Mr P.W.C. Wong	— Aircraft Research Association.

The construction and subsequent development of the Data Item were undertaken by

Dr F. Innes	— Senior Engineer
Dr J.N. Hammar	— Senior Engineer
Dr D.R. Philpott	— Senior Engineer.

The person with overall responsibility for the work in this subject area is Mr D.J. Mitchell.

VGK METHOD FOR TWO-DIMENSIONAL AEROFOIL SECTIONS PART 7: VGK FOR WINDOWS™

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VGK METHOD FOR TWO-DIMENSIONAL AEROFOIL SECTIONS PART 7: VGK FOR WINDOWS™

1. INTRODUCTION

This Data Item gives a guide to the use of a Windows™ version of VGK designated “Winteracter© executable VIEWpac* program W0315”. This permits the VGK aerofoil code to be run within a Windows™ interface that facilitates the construction of the relevant input files and provides graphical output of the aerofoil geometry, the computational grid and of all calculated flow parameters.

‘VGK for Windows’ has an extensive Help menu, which should be used to supplement the information given in this Data Item.

This is the seventh Data Item in a sequence dealing with the VGK aerofoil method – the other Items are listed as References 1 to 6. It describes how to run VGK within the Microsoft Windows 95™ or later operating environments. Typical computing time for a single run of VGK is of the order of several seconds at most. It is *not* necessary that a Fortran compiler be available on the computer utilised.

The VGK source code used in this Windows™ version does not differ from the source code used in the first three Data Items of the sequence (References 1 to 3). Therefore, for an explanation of the principles underlying the VGK code, see Reference 1. Sufficient information is given in the present Item to obtain results from the ‘VGK for Windows™’ program, but Reference 1 should be consulted so that the results obtained may be properly assessed. Reference 2 provides guidance for users wishing to run VGK.

VGK is the name of a CFD (computational fluid dynamics) code written in Fortran for predicting the aerodynamic characteristics of a two-dimensional single-element aerofoil in a subsonic freestream, including the effects of viscosity (boundary layers and wake) and shock waves. VGK uses an iterative approach to solve coupled finite-difference equations for the inviscid flow region and the viscous flow region (represented by integral equations). The aerofoil boundary-layers must be attached for VGK to produce results that correspond to the real flow, but the code has been calibrated against experimental data to provide a method of estimating a separation boundary – see References 2 and 3. VGK was developed over a period of years at RAE/DERA (now QinetiQ, Farnborough).

* The term VIEWpac is used here to describe the Winteracter version of an executable program. Winteracter is a trade name registered by Interactive Software Services Limited.

2. NOTATION

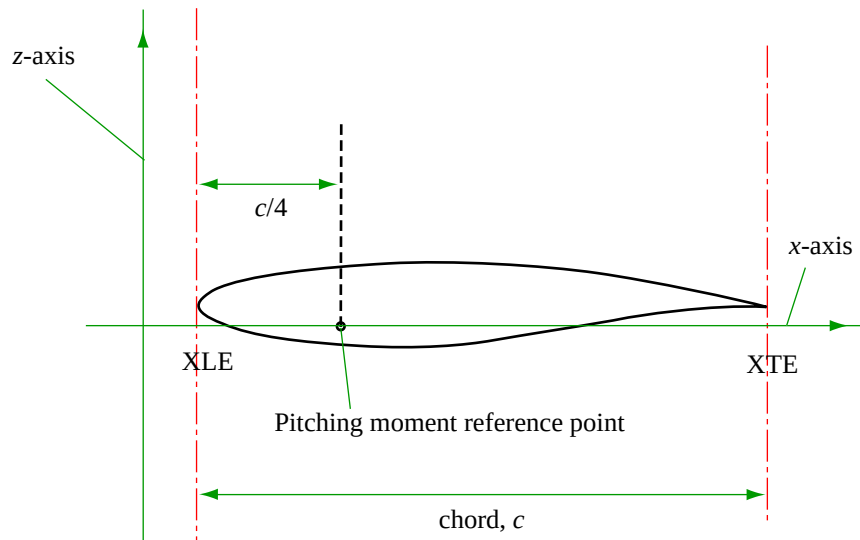
Algebraic notation is printed in italics or has Greek symbols. Notation used in VGK files is given in Roman type. Notation sequencing is based on the algebraic terms (except where none exists); some VGK notation therefore appears out of alphabetical order. All linear quantities made non-dimensional are based on aerofoil chord, c . Some items that do not appear in the text are included in the Notation. These items appear in files generated by 'VGK for Windows' or are included to facilitate the use of this Transonic Data Memorandum in conjunction with References 1 to 6.

C_D	CD	overall (<i>i.e.</i> total) aerofoil drag coefficient (see also C_{DP} , CDP)
C_{DF}	CDF	contribution to C_D determined from integration of surface shear stresses
C_{DP}	CDP	contribution to C_D determined from integration of surface pressures (denoted by C_D (CD) for inviscid flow)
C_{DV}	CDV	viscous drag coefficient, determined from momentum thickness of wake far downstream
C_{DW}	CDW	wave drag coefficient
C_{D1}	CD1	wave drag coefficient determined from 'first-order method' (see Section 3.4 of Reference 1)
C_{D2}	CD2	wave drag coefficient determined from 'improved method' (see Section 3.4 of Reference 1)
C_L	CL	aerofoil lift coefficient
C_{Lpot}	CLPOT	value of C_L determined from jump in potential at trailing-edge
C_{Lspec}		value of C_L specified to VGK (only possible for viscous runs)
C_M	CM	pitching moment coefficient $\left(= M_{1/4} / \left(\frac{\gamma}{2} p_\infty M_\infty^2 c^2 \right) \right)$
C_p	CP	pressure coefficient $\left(= (p - p_\infty) / \left(\frac{\gamma}{2} p_\infty M_\infty^2 \right) \right)$
C_p^*		pressure coefficient for local Mach number of unity
c	C	aerofoil chord (see Sketch 2.1)
c_f	CFLOC	local skin-friction coefficient
$d\zeta/d\xi$	DZ/DX	slope of aerofoil surface expressed in non-dimensional coordinates
$d^2\zeta/d\xi^2$	D2Z/DX2	second derivative of aerofoil surface expressed in non-dimensional coordinates
$\bar{H}$	HBAR	transformed boundary-layer velocity-profile shape parameter

	ISYM	integer denoting symmetrical aerofoil when equal to 1, and non-symmetrical aerofoil when equal to 0
	ITYP	integer denoting type of step in VGK calculation, when read in conjunction with NS
	IVP	control integer used by VGK, 0 for inviscid run, 4 for viscous run
j	NSG	number of radial lines in computing plane (see Sketch 3.1 of Reference 1)
k	K	number of circumferential grid lines in computing plane (see Sketch 3.1 of Reference 1)
k_c	NVISC	number of inviscid-flow iterations between each occasion viscous-flow boundary conditions are updated (in coarse mesh)
k_f	NVISC	number of inviscid-flow iterations between each occasion viscous-flow boundary conditions are updated (in fine mesh)
M	EML	local Mach number (at edge of boundary layer) based on isentropic flow relations
M_∞	EM	freestream Mach number
M_{Lsh}		value of M just upstream of shock wave
$M_{1/4}$		pitching moment about quarter-chord reference point (see Sketch 2.1)
	NL	number of (x, z) coordinate pairs specifying aerofoil lower surface (see Appendix A and Reference 2)
	NS	integer denoting either NSC or NSF (context indicates), or when equal to -1 or when $ITYP = -1$ denotes type of step in VGK calculation
	NU	number of (x, z) coordinate pairs specifying aerofoil upper surface (see Appendix A and Reference 2)
	NSC	number of iterations of inviscid-flow element using coarse mesh
	NSF	number of iterations of inviscid-flow element using fine mesh
m, n		integers denoting point in grid (see Sketch 3.1 of Reference 1)
p	P	local static pressure
p_0	P0	freestream stagnation pressure
p_∞		freestream static pressure
R	RE	Reynolds number based on chord length
	RES	maximum residual in inviscid-flow element

R_θ	RTHETA	local Reynolds number based on momentum thickness and local flow conditions
	VRES	residual corresponding to trailing-edge location in viscous-flow element
	XLE	value of x coordinate at leading edge
	XM	relaxation factor applied to supersonic flow regions
	XS	relaxation factor applied to subsonic flow region
	XTE	value of x coordinate at trailing edge
r		radial coordinate in computing plane (see Sketch 3.1 of Reference 1)
x		'chordwise' coordinate in physical plane (see Sketch 2.1)
z		'normal' coordinate in physical plane (see Sketch 2.1)
α	ALP	aerofoil incidence, <i>i.e.</i> angle between x -axis and freestream direction, positive nose-up (in degrees)
α_c		aerofoil chord-line incidence, <i>i.e.</i> angle between chord-line and freestream direction, positive nose-up (see Section 6.1 of Reference 1)
$\Delta\theta_L$	DD22	increment in non-dimensional momentum thickness at transition on lower surface
$\Delta\theta_U$	DD21	increment in non-dimensional momentum thickness at transition on upper surface
δ	DELTA	non-dimensional local boundary-layer thickness
δ^*	DELSTAR	non-dimensional local boundary-layer displacement thickness
ε	EP	artificial-viscosity parameter (see Section 3.1 of Reference 1)
γ		ratio of specific heat capacities (taken as 1.4)
λ	QCP	partially-conservative parameter (see Section 3.1 of Reference 1)
θ	THETA	non-dimensional local boundary-layer momentum thickness
θ_c	T	angular coordinate in computing plane (see Sketch 3.1 of Reference 1)
ω_c	GVISCC	relaxation factor associated with viscous effects using coarse mesh
ω_f	GVISCF	relaxation factor associated with viscous effects using fine mesh
ξ	X	non-dimensional chordwise coordinate in physical plane: $\xi = 0$ at leading-edge and $\xi = 1$ at trailing-edge
ξ_{sh}	X(SHOCK)	value of ξ corresponding to shock location

ξ_{TL}	XTL	value of ξ corresponding to boundary-layer transition location on lower surface
ξ_{TU}	XTU	value of ξ corresponding to boundary-layer transition location on upper surface
ζ	Z	non-dimensional normal coordinate



Sketch 2.1 Aerofoil axes and notation

3. WINTERACTER[®] EXECUTABLE VIEWPAC PROGRAM W0315

This version of the VGK CFD code, supplied in the file named W0315v##.exe*, contains the Fortran code that is described in Reference 1, compiled and linked using the Salford Software FTN95[™] compiler and wrapped in a 32-bit Winteracter[®] Windows[™] interface. By executing the file W0315v##.exe within the Microsoft Windows[™] operating environment, the user is running the VGK method for two-dimensional aerofoil sections. Various other files are required to run this version of the VGK program. These are provided with the W0315v##.exe executable file and are as follows:

- quietvgk.exe – effectively replaces the compiled executable program created by compiling and linking files vgk1.for, vgk2.for...vgk5.for. This program runs the analysis in the background when the user selects the ‘Analyse’ option presented in the main menu window.
- salflibc.dll – a dynamic link library file used by FTN95(Win 32)[™], the Salford Software Fortran 95 compiler, for use on PCs running the Windows 95[™] or later operating systems.
- swiss.chr – a file containing the 8-bit Swiss font character set (equivalent to Postscript Helvetica) used for presentation of text in the windows of the ‘VGK for Windows[™]’ program.
- HELP_0315.CNT – a list of the contents of the help file.
- HELP_0315.HLP – the help file for ‘VGK for Windows[™]’.

* The symbols ## refer to an encoded version number of the program: for example, if the version number is 1.1 then ## is equal to 11. Thus, the full name of Version 1.1 of the executable program W0315 will be W0315v11.exe and this name must be used when accessing the file.