**Table 2 Contributions to the vertical velocity at $r = 0$**

| $z$ | $\frac{\partial \phi_0}{\partial z}$ | $\frac{\partial \phi_1}{\partial z}$ | $\frac{\partial \phi_2}{\partial z}$ |
|---|---|---|---|
| 0.2 | −0.200 | 0.064 | −0.002 |
| 0.4 | −0.400 | 0.112 | 0.012 |
| 0.6 | −0.600 | 0.128 | 0.034 |
| 0.8 | −0.800 | 0.096 | 0.062 |

is appreciable may be seen from the contribution of the first two perturbations given in Tables 1 and 2.

### References

[1] Shaprio, A. H., *Compressible Fluid Flow* (Ronald Press Co., New York, 1953), Vol. I, Chap. 12, p. 365.

[2] Prandtl, L. and Tietjens, O. G., *Fundamentals of Hydro- and Aeromechanics* (Dover Publications, Inc., New York, 1957), Chap. X, p. 142.

# Comparison of Stability Data Obtained in Free-Flight and Steady-State Facilities

DAVIS H. CRAWFORD*
*NASA Langley Research Center, Hampton, Va.*

TESTS in gases with values of the specific heat ratio $\gamma$ different from that of 1.400 are being performed with increasing frequency. Helium is useful to alleviate the gas liquefaction problem inherent in the use of air or carbon dioxide for hypersonic flow. Carbon dioxide is useful to simulate entry into planetary atmospheres, composed for the large part of carbon dioxide, and to simulate the imperfect gas effects characterized by a change in $\gamma$ but is more subject to the problem of liquefaction than is air.

To circumvent this liquefaction problem at high Mach numbers, a free-flight method of testing has been evolved which allows the stability of a vehicle to be determined from an observation of its dynamic response along a short trajectory when fired through a test gas[1]. Reference 2 contains experimental stability results obtained in air, argon, helium, and carbon dioxide by this method which show that the stability of blunt, flared vehicles is greatly affected by the specific heat ratio $\gamma$ of the test gas. (It should be noted that an inquiry into the source of these data disclosed that, whereas most of the data came from free-flight tests, part of the test data at $\gamma = \frac{5}{3}$ was obtained from sting mounted models.) The Reynolds number range of these tests varied from two to five million based on the stream conditions ahead of the model and the model length.

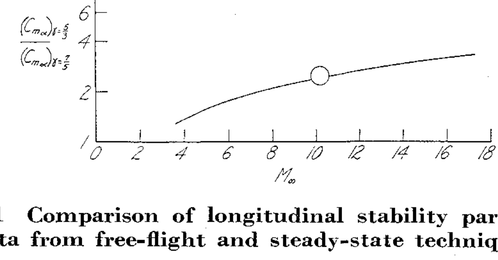


**Fig. 1 Comparison of longitudinal stability parameter data from free-flight and steady-state techniques.**

An identical model has been tested recently in the steady-state Langley 11-in. hypersonic tunnel in both air and helium at a Mach number of approximately 10.1 and a Reynolds number of approximately $0.6 \times 10^6$. Although this Reynolds number is approximately $\frac{1}{3}$ the lowest Reynolds number of Ref. 2, unpublished Langley data have shown that $C_{m_\alpha}$ is affected less than 25% by this Reynolds number variation. The ratio of these steady-state stability results is plotted on Fig. 1 together with the ratio of the faired data from Ref. 1. The agreement between these sets of data confirms the wide variation in $C_{m_\alpha}$ as a function of $\gamma$ and lends credence to the accuracy of free-flight techniques.

### References

[1] Seiff, A., "A free-flight wind tunnel for aerodynamic testing at hypersonic speeds," NACA Rept. 1222 (1955).

[2] Seiff, A., "Recent information on hypersonic flow fields," *Proceedings of the NASA-University Conference on the Science and Technology of Space Exploration*, NASA SP-11, Vol. 2, pp. 269–282 (November 1962).

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* Aerospace Engineer, Aero-Physics Division. Member AIAA.

# Flame Stabilization in Laminar Boundary Layers

T. P. TORDA* AND S. N. BUSENBERG†
*Illinois Institute of Technology, Chicago, Ill.*

### Nomenclature

$a$ = rate of consumption of combustible component
$C, C_1, C_2, C_3, C_4$ = const
$c_p$ = heat capacity at constant pressure
$D$ = diffusion coefficient
$e$ = temperature ratio, $e = (T - T_0)/(T_\infty - T_0)$
$f$ = Blasius function, $f = f(\eta)$
$K$ = concentration ratio, $K = (k - k_0)/(k_\infty - k_0)$
$k_i$ = mass fraction of species $i$ in mixture
$p$ = pressure
$Pr$ = Prandtl number, $Pr = c_p\mu/\lambda$
$q$ = reaction enthalpy per unit mass
$R$ = molar gas constant
$r$ = displacement ratio, $r = x/x^*$
$Sc$ = Schmidt number, $Sc = \mu/\rho D$
$T$ = temperature
$U$ = velocity in the streamwise direction in the Howarth plane
$u$ = velocity in the streamwise direction in the physical plane
$V$ = velocity in the normal direction in the Howarth plane
$v$ = velocity in the normal direction in the physical plane
$X$ = streamwise displacement in the Howarth plane
$x$ = streamwise displacement in the physical plane
$Y$ = normal displacement in the Howarth plane
$y$ = normal displacement in the physical plane
$\eta$ = Blasius variable, $\eta = Y(U_\infty/\nu_\infty X)^{1/2}$
$\zeta$ = dimensionless variable, $\zeta = X/U_\infty\tau$
$\lambda$ = heat conduction coefficient
$\mu$ = dynamic viscosity
$\nu$ = kinematic viscosity
$\xi$ = characteristic stay-time, $\xi = X/U_\infty$
$\rho$ = density
$\tau$ = reaction time factor

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* Professor, Department of Mechanical and Aerospace Engineering. Associate Fellow Member AIAA.

† Department of Mathematics.