Progress Toward the Development of an Airfoil Icing Analysis Capability

Mark G. Potapczuk
Colin S. Bidwell
NASA *Lewis Research Center*
Cleveland, Ohio

Brian M. Berkowitz
Sverdrup Technology, Inc.
Mayfield Heights, Ohio

Progess Toward the Development of an Airfoil Icing Analysis Capability

M.G. Potapczuk

C.S. Bidwell

NASA *Lewis Research Center, Cleveland, Ohio*

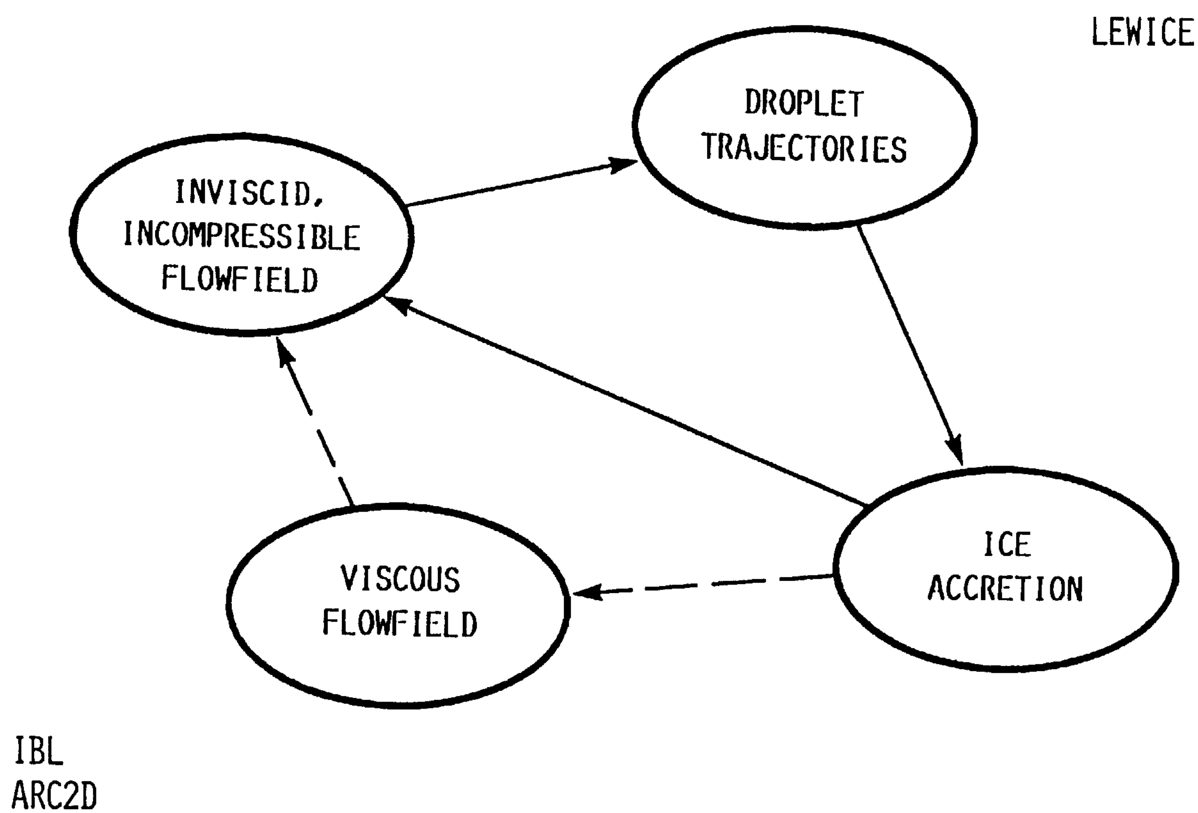
B.M. Berkowitz

Sverdrup Technology, Inc., Middleburg Hts., Ohio

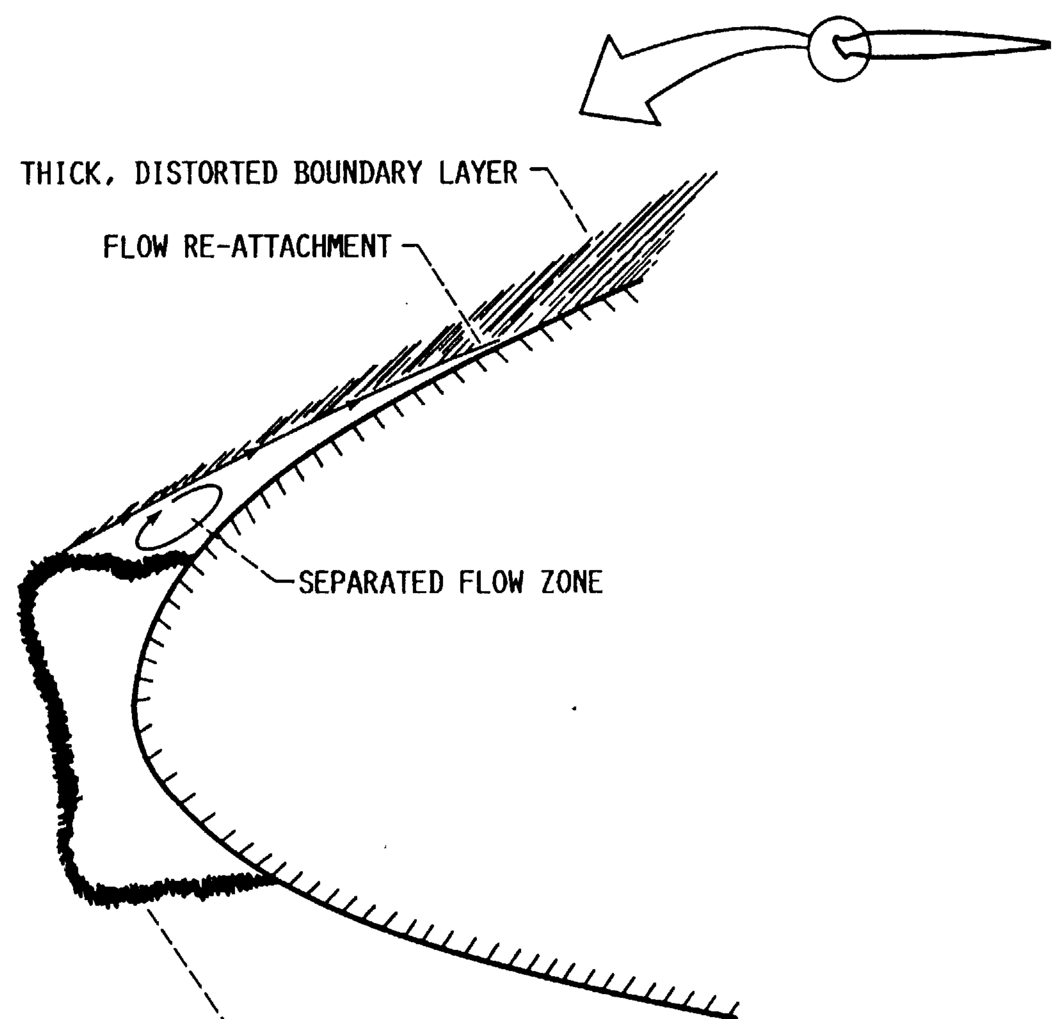
The NASA-Lewis aircraft icing analysis program is composed of three major sub-programs. These sub-programs are ice accretion simulation, performance degradation evaluation, and ice protection system evaluation. These topics cover all areas of concern related to the simulation of aircraft icing and its consequences. The motivation for these activities is twofold, reduction of time and effort required in experimental programs and the ability to provide reliable information for aircraft certification in icing, over the complete range of environmental conditions. In addition to the analytical activities associated with development of these codes, several experimental programs are underway to provide verification information for existing codes. These experimental programs are also used to investigate the physical processes associated with ice accretion and removal for improvement of present analytical models. The NASA-Lewis icing analysis program is thus striving to provide a full range of analytical tools necessary for evaluation of the consequences of icing and of ice protection systems.

Recently, two of these tools were used to produce a computational evaluation of the ice accretion process and resulting performance changes for a NACA0012 airfoil. The ice accretion code, LEWICE, provided the ice shape geometry at several points in time during the simulated icing encounter. The predicted shapes are a function of several environmental input parameters, including airspeed, temperature, water droplet size and distribution, liquid water content, and duration of the encounter. These ice shape geometries are then used as input for a Navier-Stokes analysis code, ARC2D, which calculates the flowfield and determines changes in performance characteristics of the airfoil. Presently, there is no direct link between the two codes and all interfacing is done by the user. One of the objectives of the icing analysis program is to combine codes such as these into a comprehensive icing analysis method. Work in this area is currently underway via a number of grant supported activities.

STEPS IN AIRFOIL ICING ANALYSIS METHODOLOGY

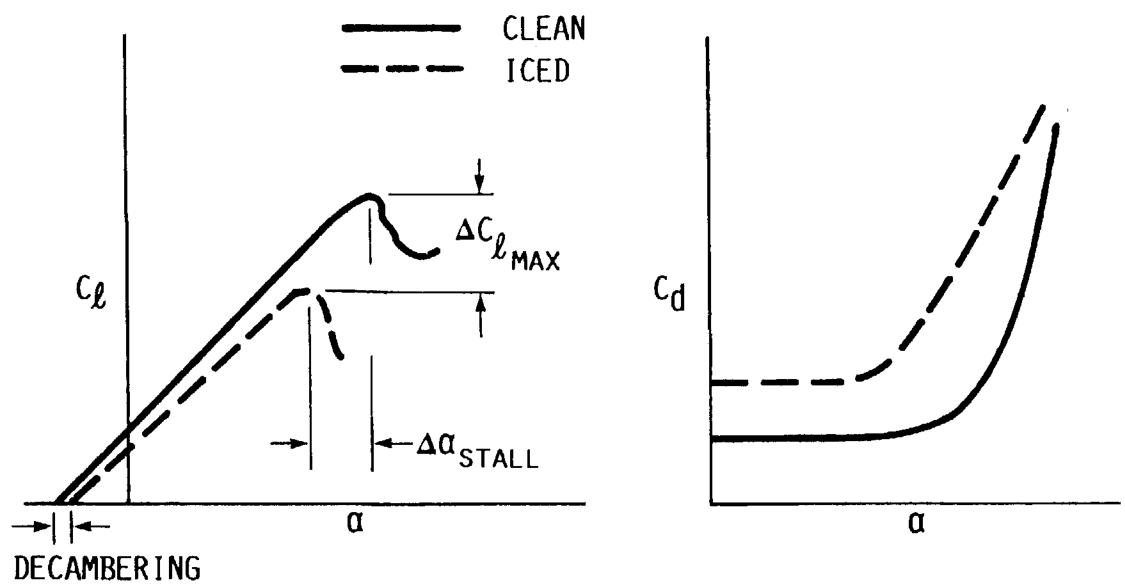


KEY ASPECTS OF AIRFOIL ICING



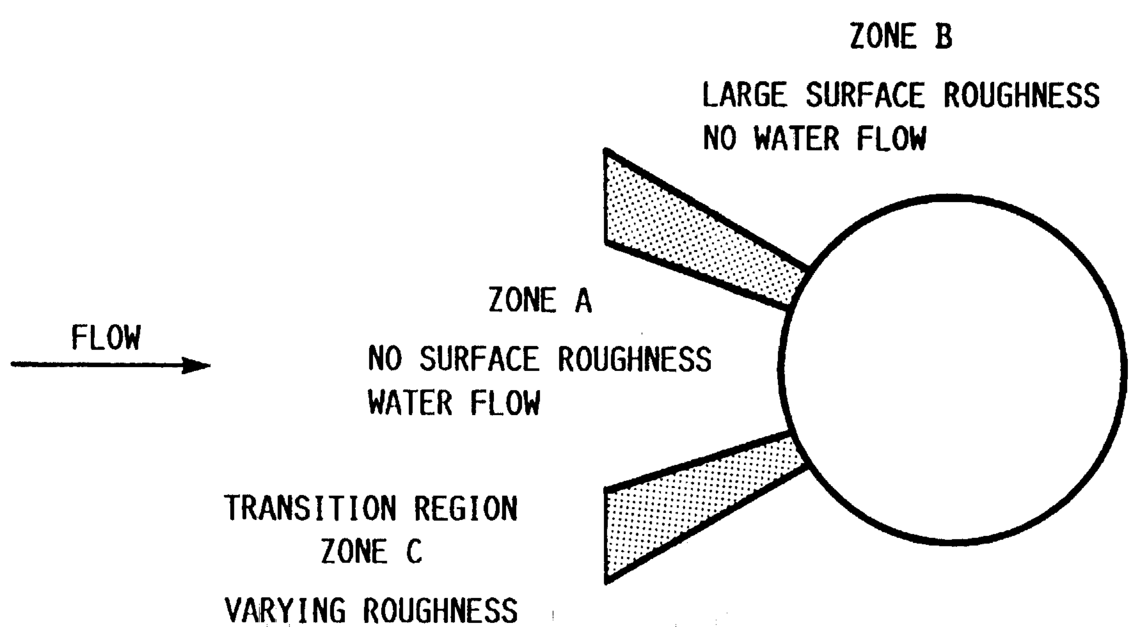
CD-88-38177

AERODYNAMIC PERFORMANCE DEGRADATION DUE TO ICING



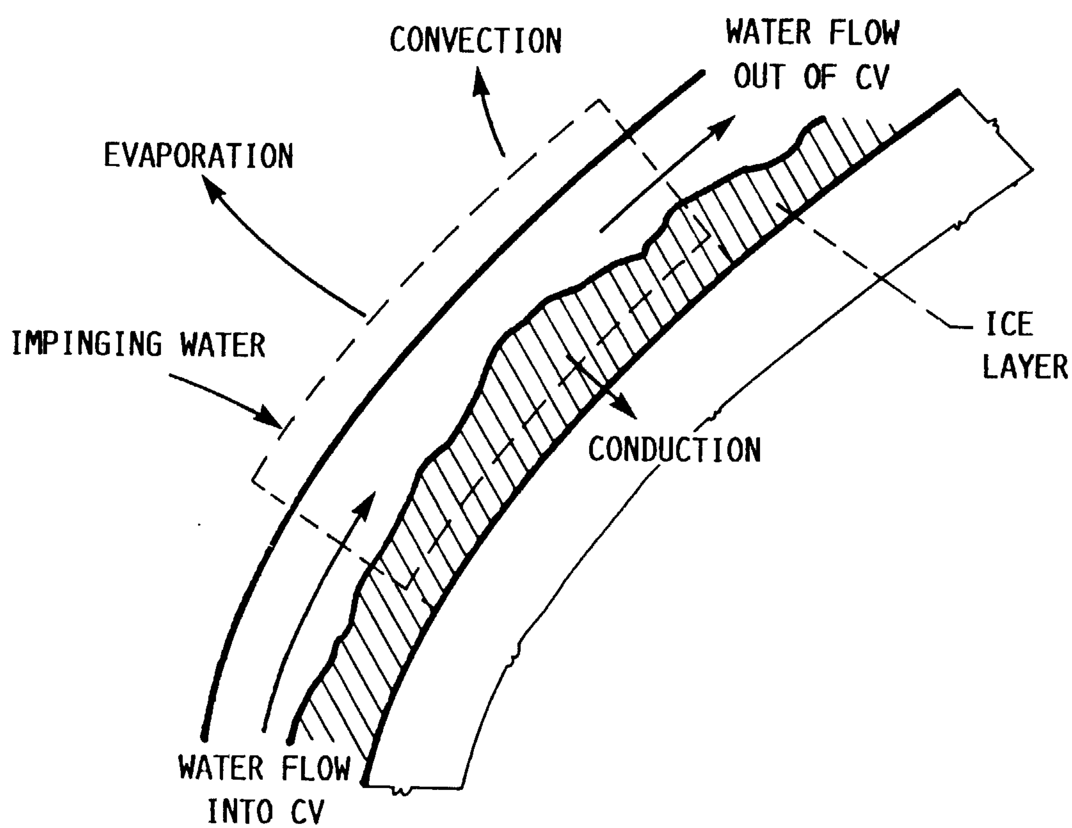
CD-88-38176

MULTIZONE MODEL OF ICE ACCRETION PROCESS



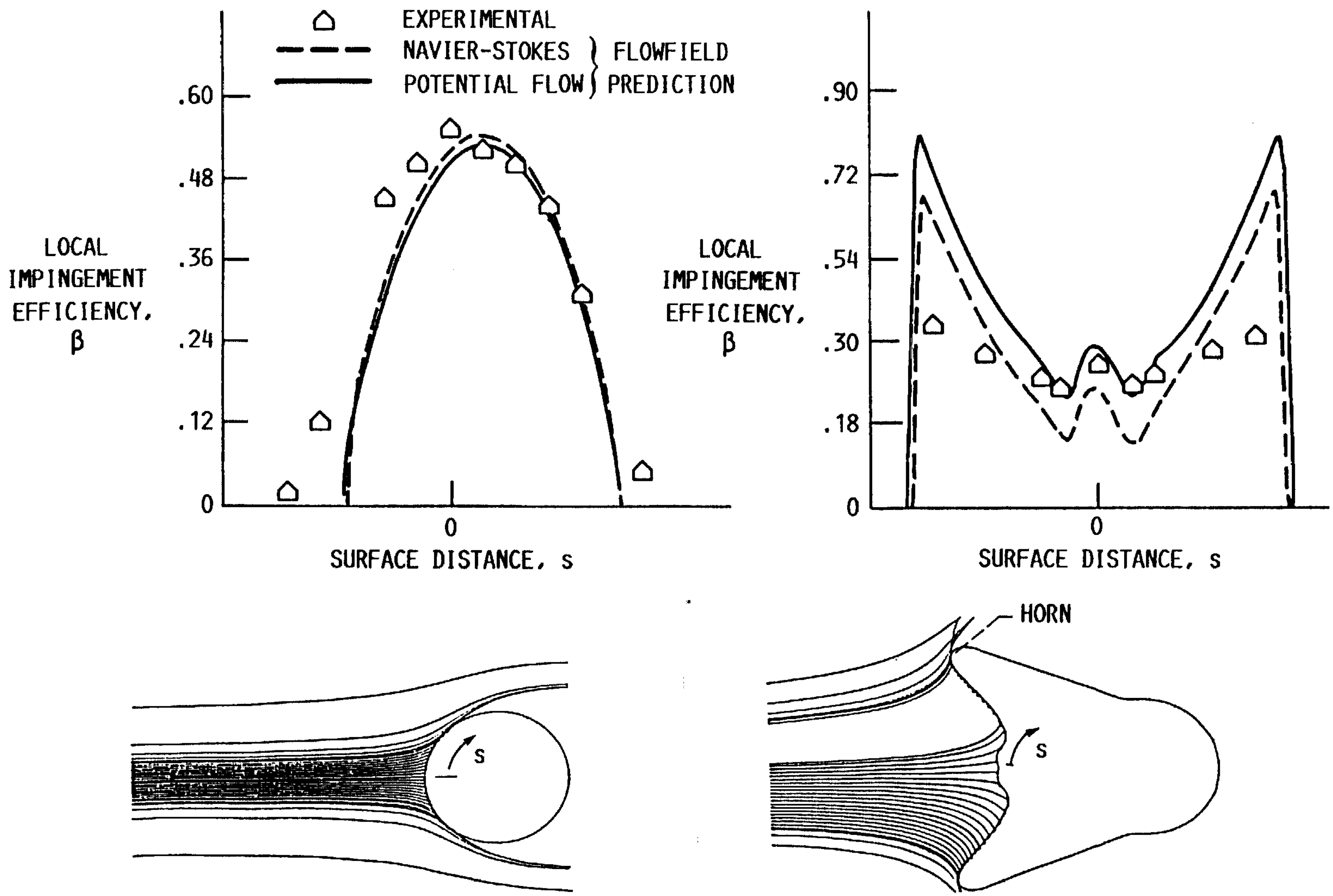
CD-88-38184

CONTROL VOLUME ANALYSIS OF ICE ACCRETION PROCESS



CD-88-38180

COLLECTION EFFICIENCY COMPARISONS

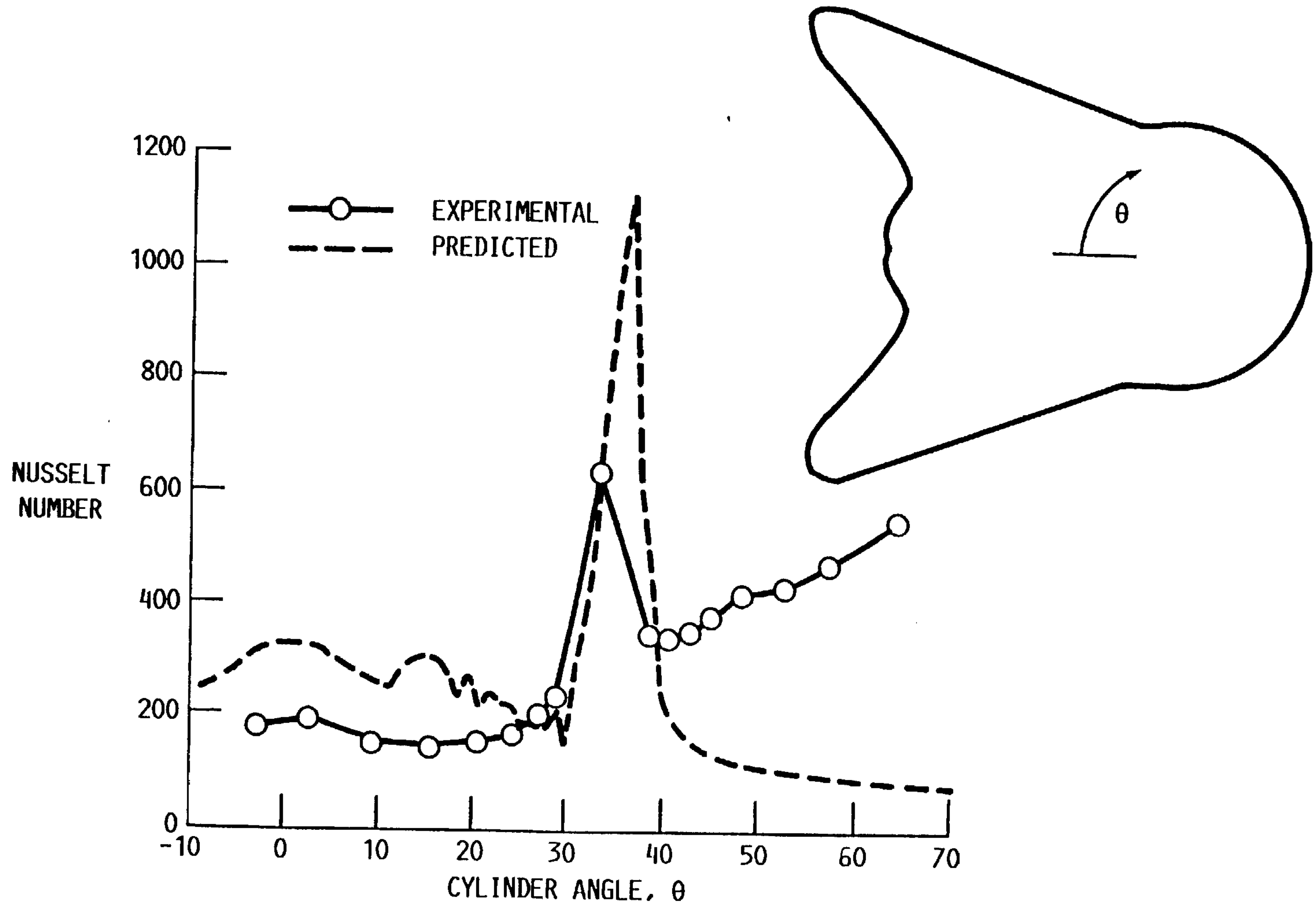


CLEAN CYLINDER.

"ICED" CYLINDER.

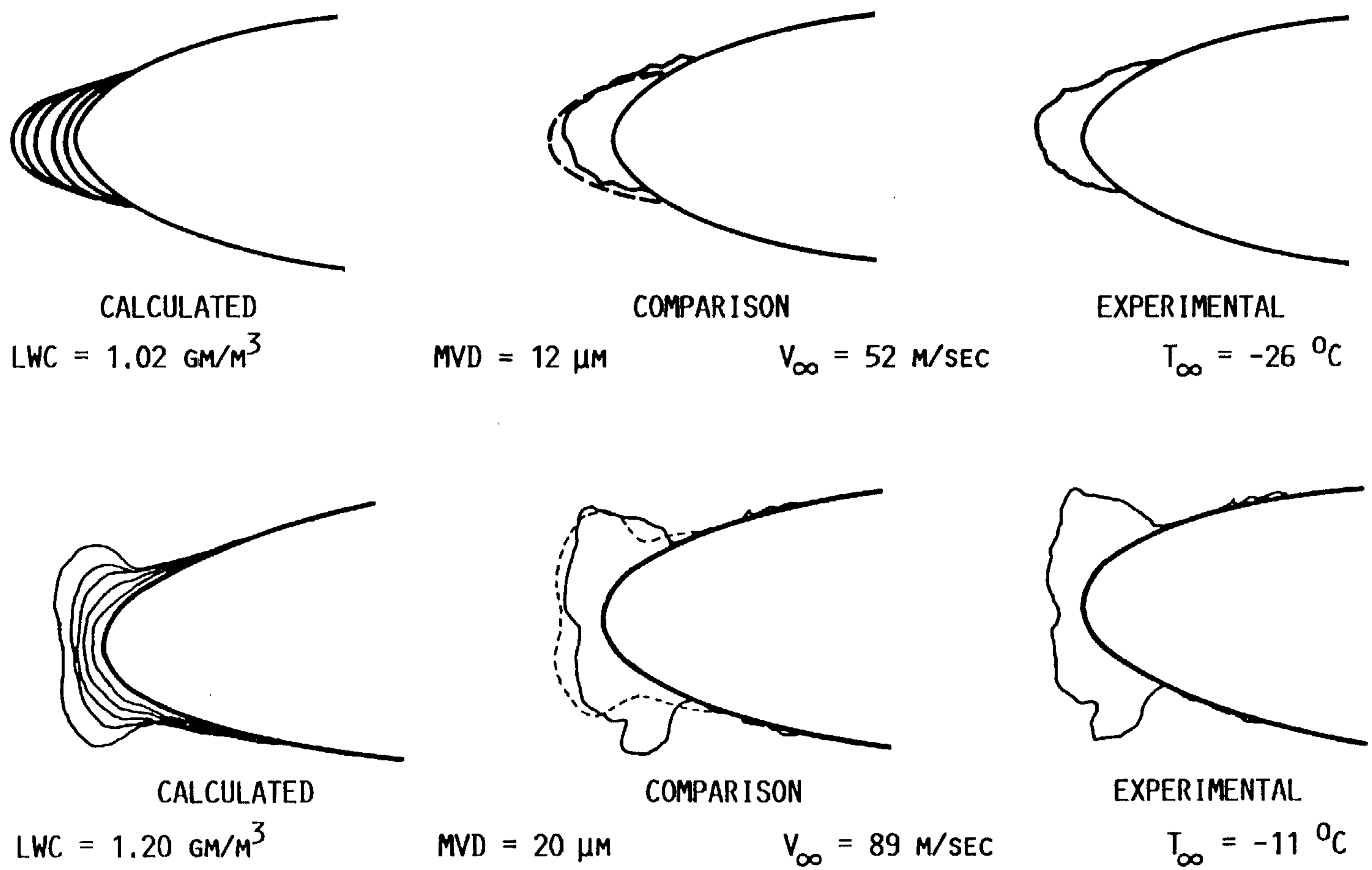
CD-88-38179

COMPARISON OF CALCULATED AND MEASURED HEAT TRANSFER COEFFICIENTS ON SMOOTH SURFACE "ICED" CYLINDER MODEL



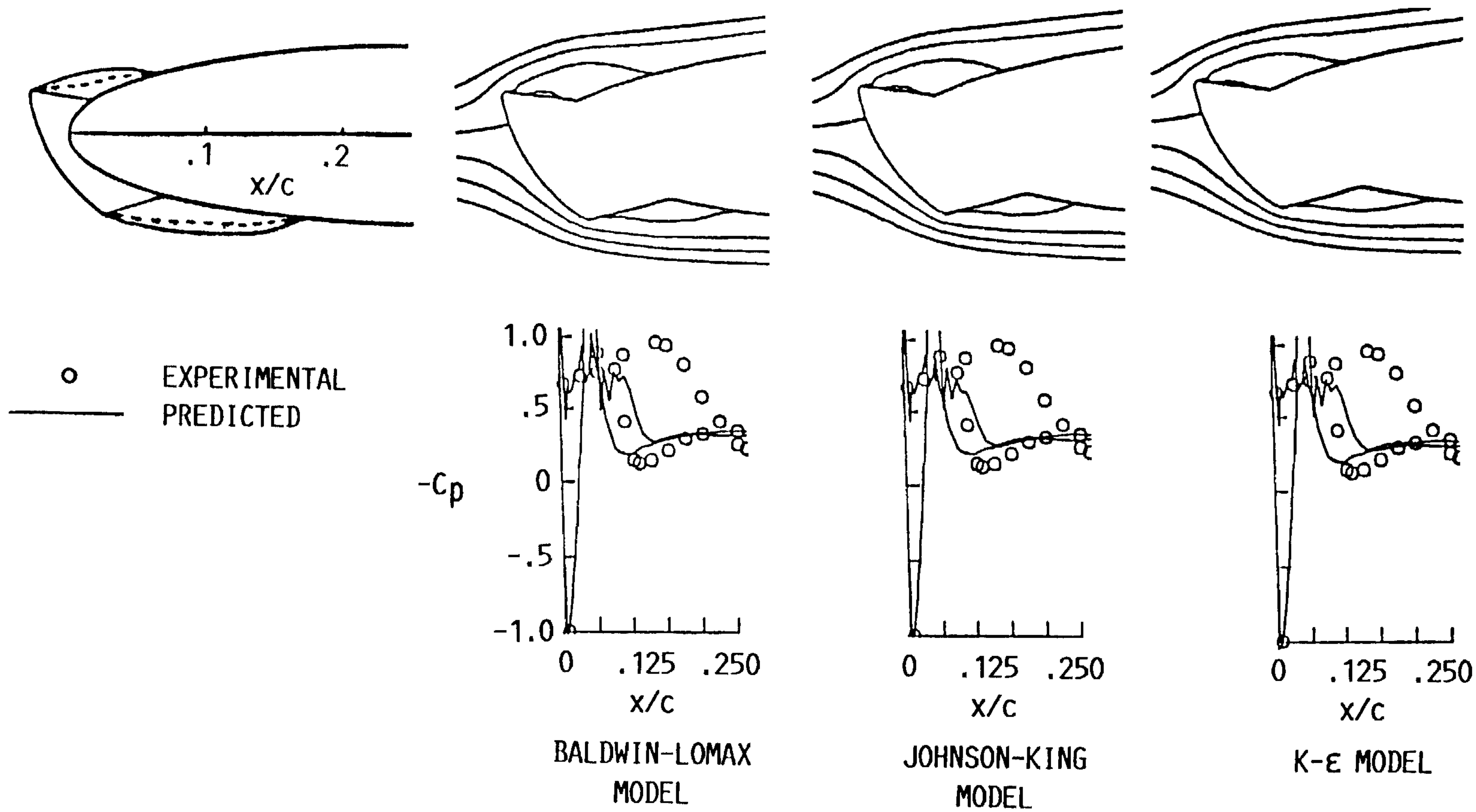
CD-88-38182

COMPARISON OF ICE SHAPE PREDICTIONS WITH AIRFOIL ICING DATA



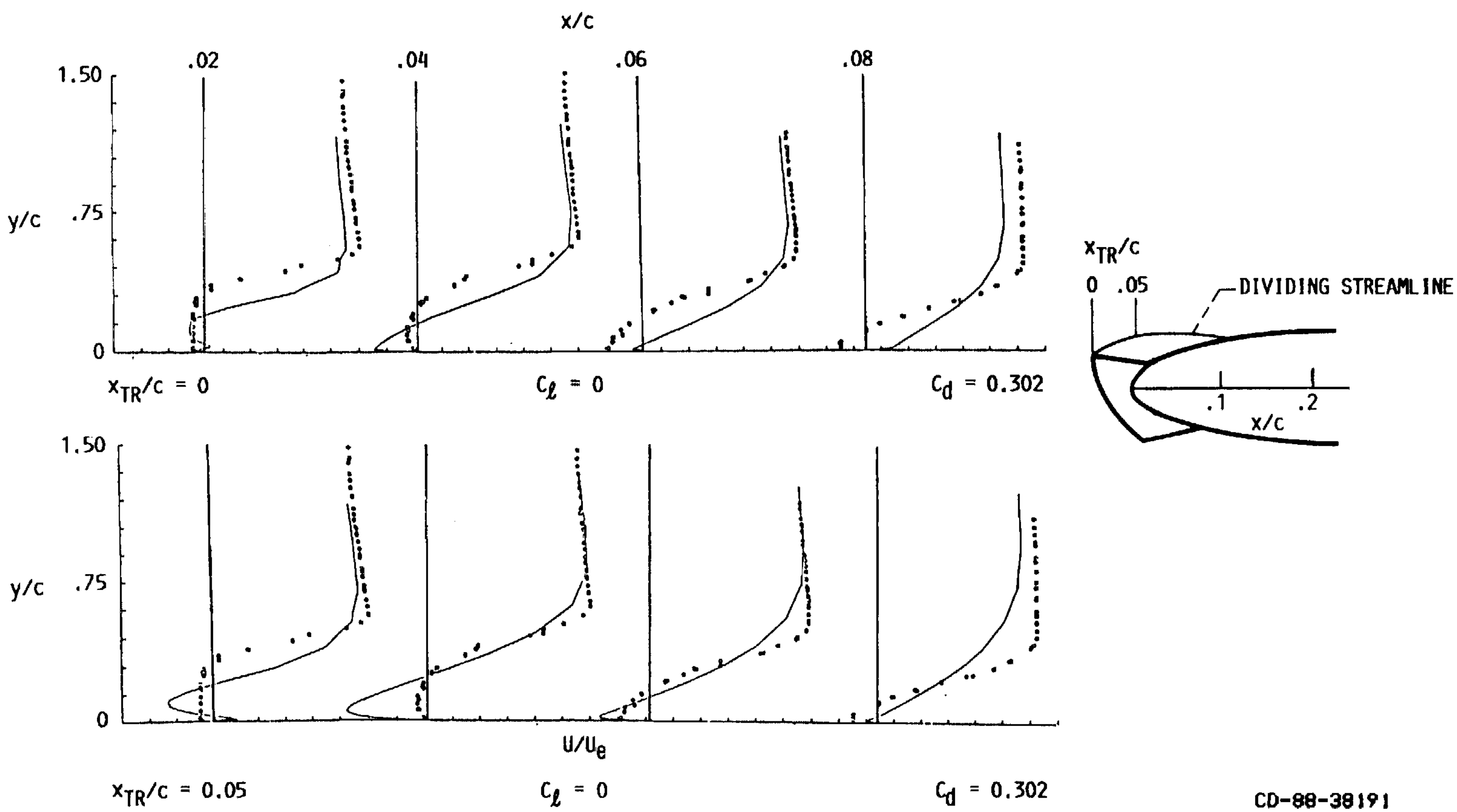
CD-88-38181

EFFECT OF TURBULENCE MODEL ON NAVIER-STOKES PREDICTIONS OF LEADING EDGE PRESSURE DISTRIBUTIONS, $\alpha = 0^0$

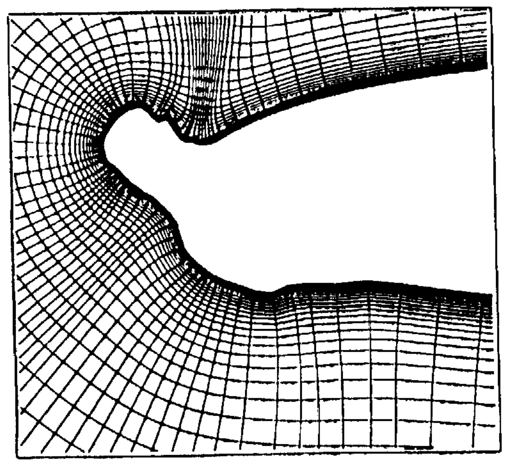


CD-88-38189

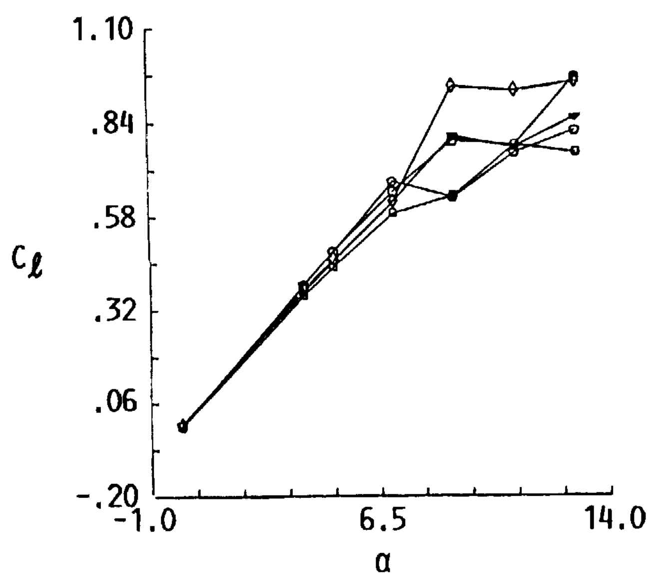
EFFECT OF BOUNDARY LAYER TRANSITION SPECIFICATION ON NAVIER-STOKES PREDICTED VELOCITY PROFILES IN SEPARATION-REATTACHMENT ZONE, $\alpha = 0^0$

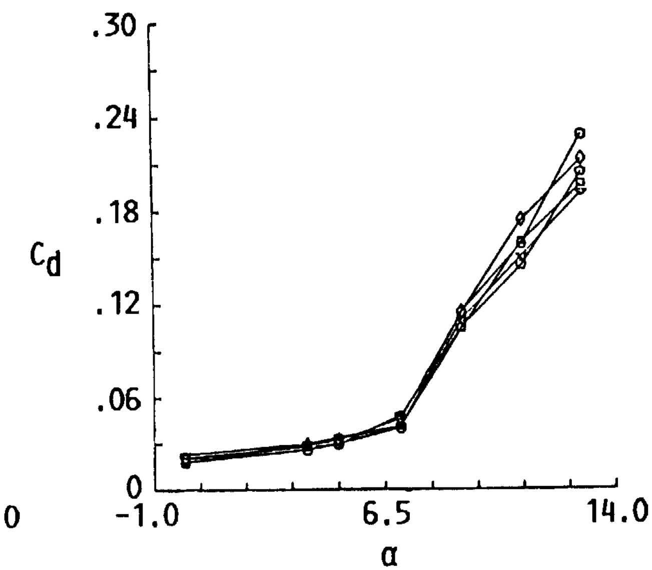


RESULTS OF GRID GENERATION STUDY



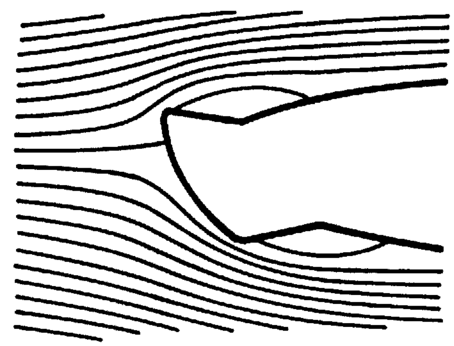
	GRID SPACING: ALONG SURFACE	GRID SPACING: NORMAL TO SURFACE	GRID CODE
◇	DENSE L.E.	NORMAL	HYPGRID
○	EVEN	NORMAL	HYPGRID
▽	DENSE L.E.	DENSE	HYPGRID
△	EVEN	DENSE	HYPGRID
□	EVEN	NORMAL	GRAPE

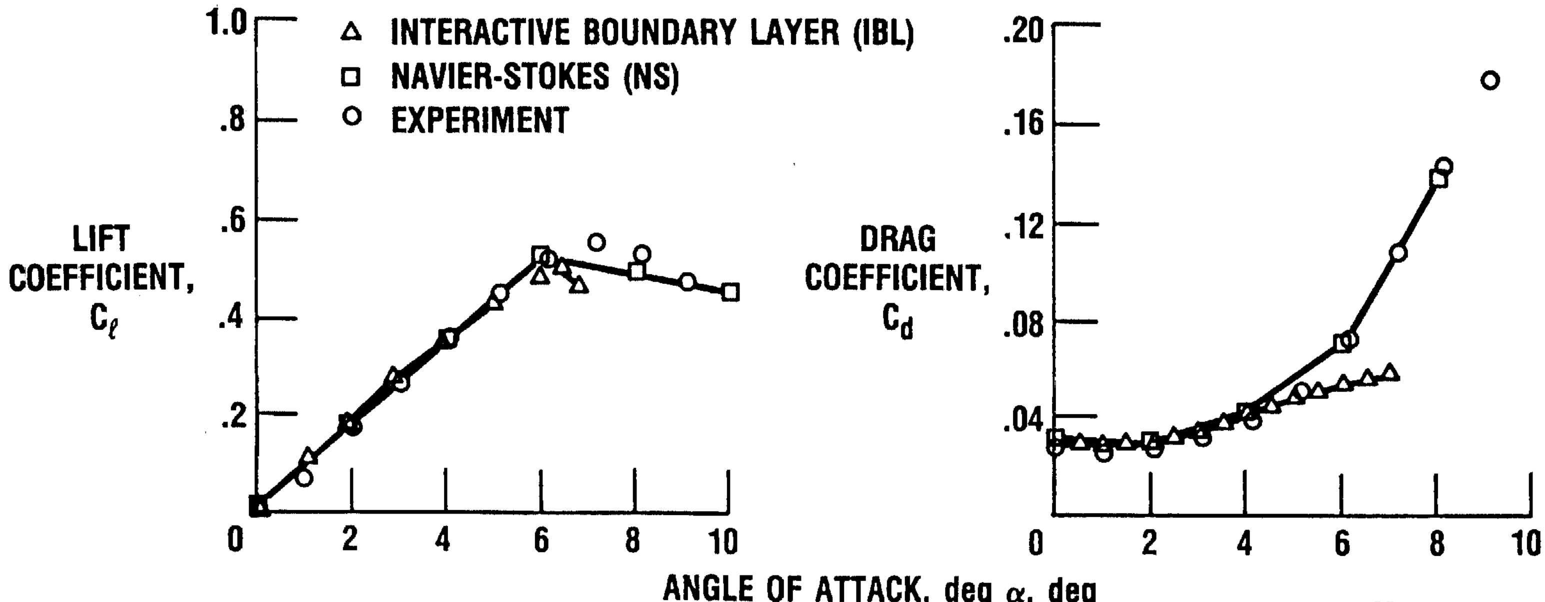




CD-88-38188

COMPARISON OF ICED AIRFOIL CODE PREDICTIONS WITH EXPERIMENTAL MEASUREMENTS





CD-88-38186

CONCLUDING REMARKS

- First generation airfoil icing capability exists

- Code validation activities are ongoing
    - Droplet trajectories / impingement
    - Ice accretion
    - Aerodynamic performance

- Supporting analytical/experimental efforts underway to improve physical modeling in codes
    - Movies/photographs of ice accretion
    - Ice surface roughness

- Extension to 3D icing analysis has been initiated