CONCEPTS engineering education and technology for industry

TECHNICAL MEMORANDUM NO. 247

ADVANCED DIFFUSER PERFORMANCE FOR CENTRIFUGAL COMPRESSORS AND PUMPS

FINAL REPORT FOR THE DIFFUSER CONSORTIUM

PHASE III

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EXECUTIVE SUMMARY

A systematic examination of ten different geometric variations of the cascade airfoil diffuser, plus eleven different test points for detailed traversing of a single cascade airfoil diffuser build, has been completed yielding an extensive database to guide future cascade design. The influence of diffuser inlet radius ratio and cascade geometric radius ratio have been found to be comparatively small, although some variations have been detected. Strong effects of lift coefficient and solidity have been noted. High levels of efficiency have been obtained at elevated levels of lift coefficient and also at increased levels of solidity; however, stable operating range at low speed is superior for low levels of lift coefficient and low solidity levels. Figures ES.1a and ES.1b display some of the key effects observed. Figure ES.1a displays two samples of data showing high pressure ratio (the maximum achieved) for $C_L = 0.8$ and wide range at low speed for $C_L = 0.0$. Increased solidity at lower C_L values achieved equally high pressure ratio and an additional point of efficiency (compared to Figure ES.1b). Wide range at low solidity for low pressure ratio operation was also realized.

The flat plate equivalent cascade proved to be quite successful. It showed comparable pressure ratio and improved efficiency and operating range at all but the highest operating speed, as shown in Figures ES.2a, ES.2b, ES.3a, and ES.3b. For the highest operating speed, i.e., at the highest pressure ratio examined, the airfoil diffuser gave superior efficiency and range for most levels of design angle of attack.

Detailed traversing provided several important insights to the flow process. Although the entry conditions to the cascade diffuser changed with operating flow and speed, the basic pattern of the flow field leaving the cascade diffuser was nearly frozen for all operating conditions. Indeed, by the end of the subsequent vaneless diffuser, the yaw angle distribution was nearly constant for all operating flow and speed conditions.

Results of this investigation are quite encouraging. High performance cascade diffusers and flat plate equivalent cascades clearly form excellent candidates for diffuser systems. Recommendations are offered herein for continued work with medium and low specific speed stages but with principal emphasis on lift coefficient, solidity and vane shape (specifically, flat plates). The radius ratio parameters would be de-emphasized in subsequent work in favor of the more important variables.

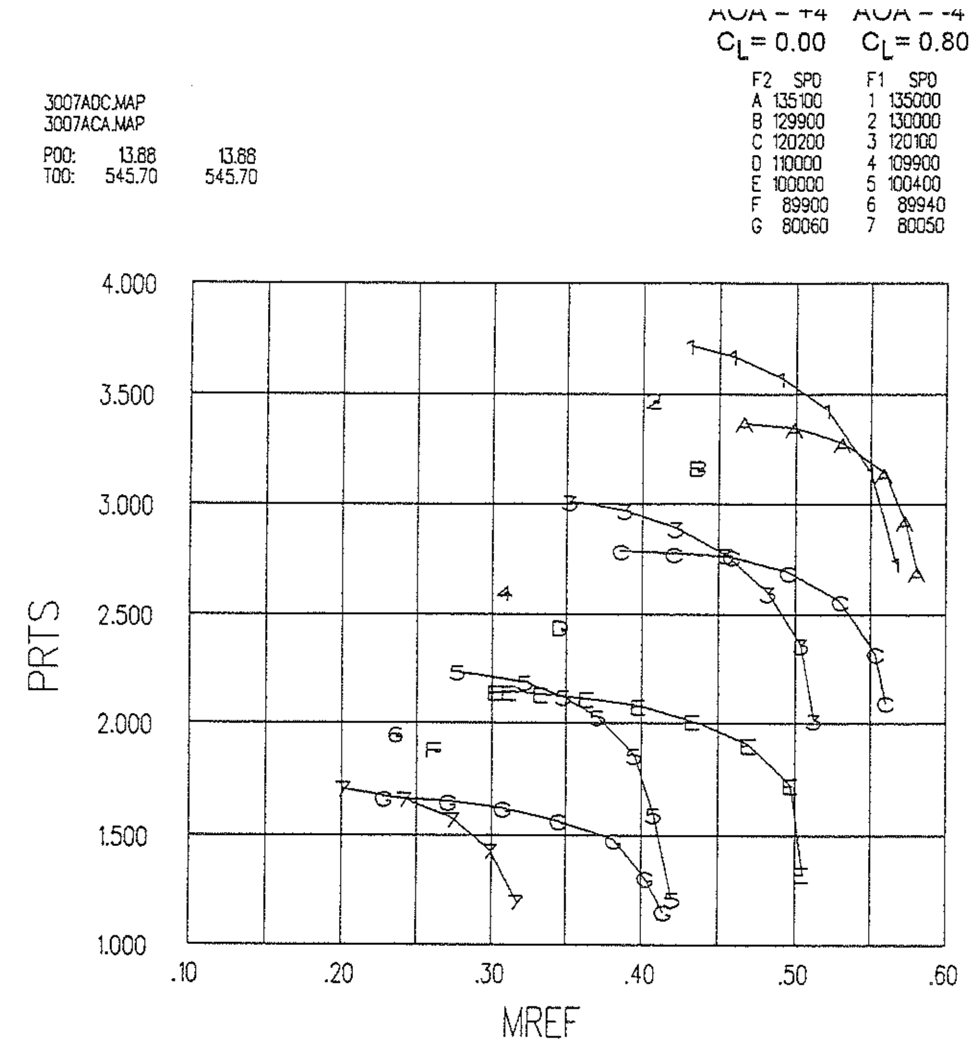

Figure ES.1a. Pressure and flow characteristics for high and low lift coefficient designs.

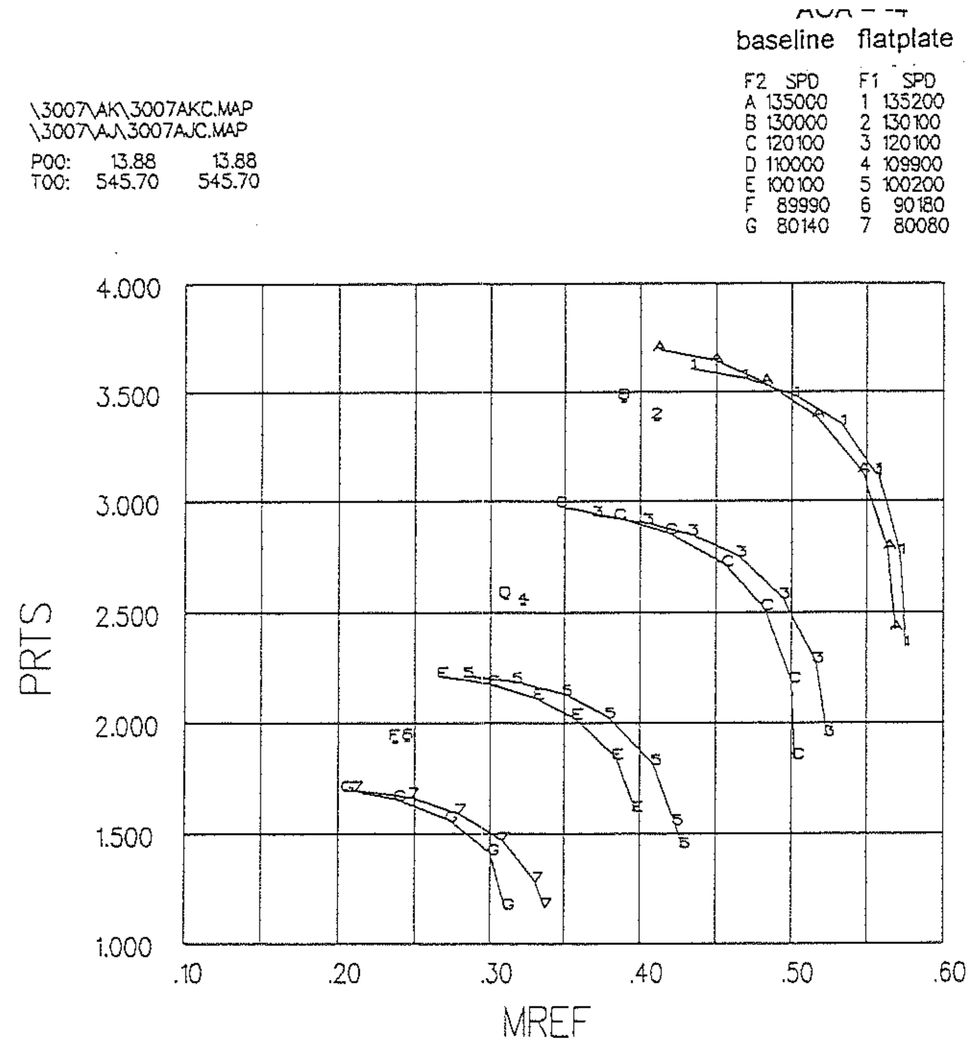

Figure ES.2a. Flat plate diffuser comparative results at AOA (design) = -4° showing pressure and flow characteristics.

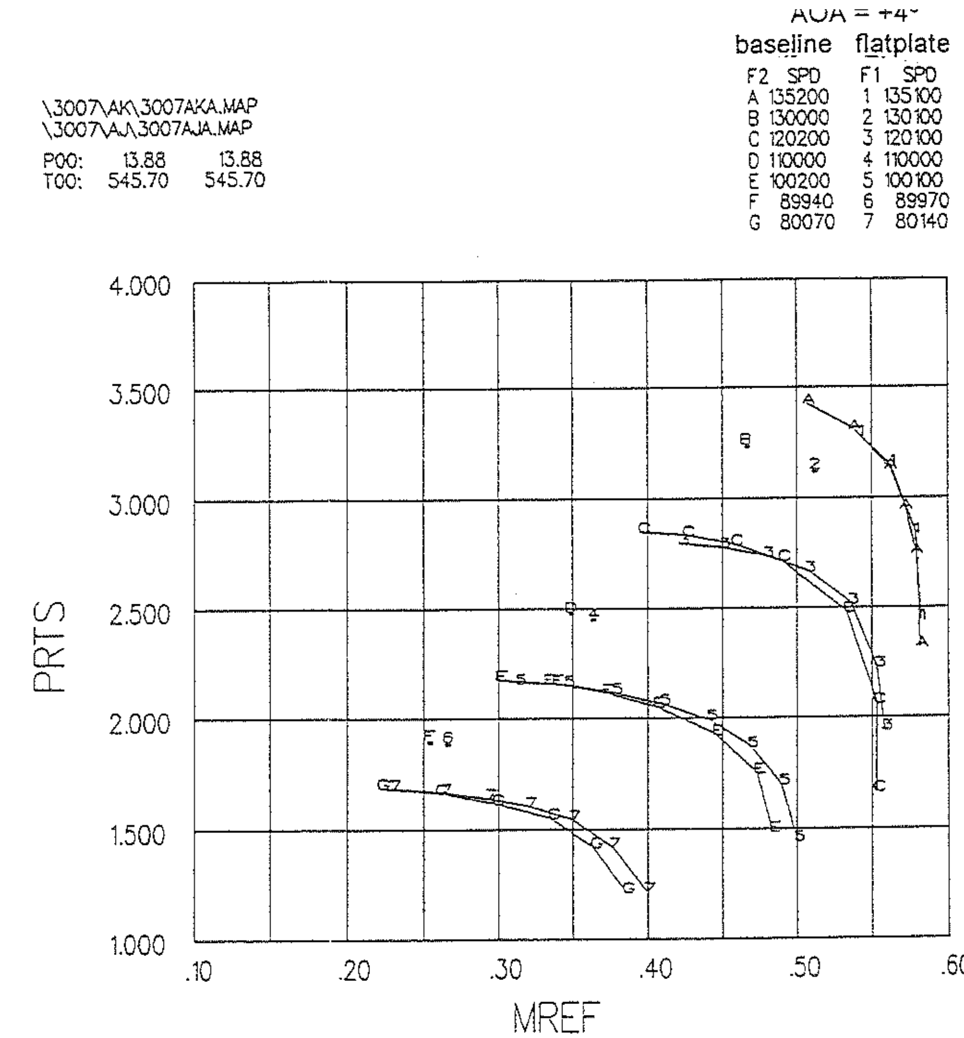

Figure ES.3a. Flat plate diffuser comparative results at AOA (design) = +4° showing pressure and flow characteristics.

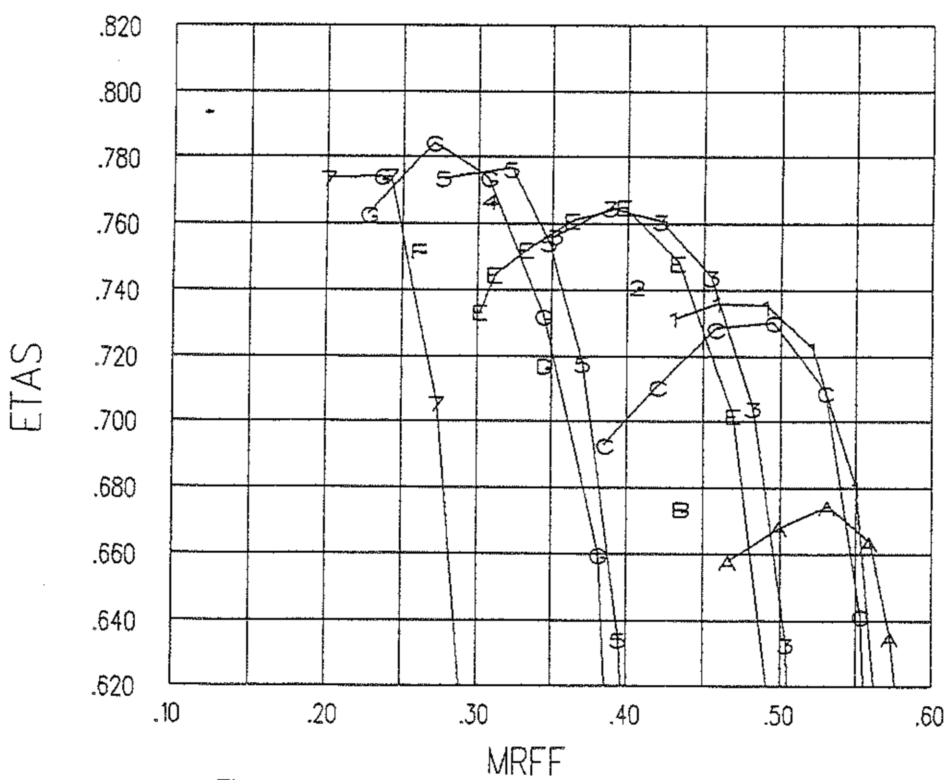

Figure ES.1b. Efficiency and flow characteristic for high and low lift coefficient designs.

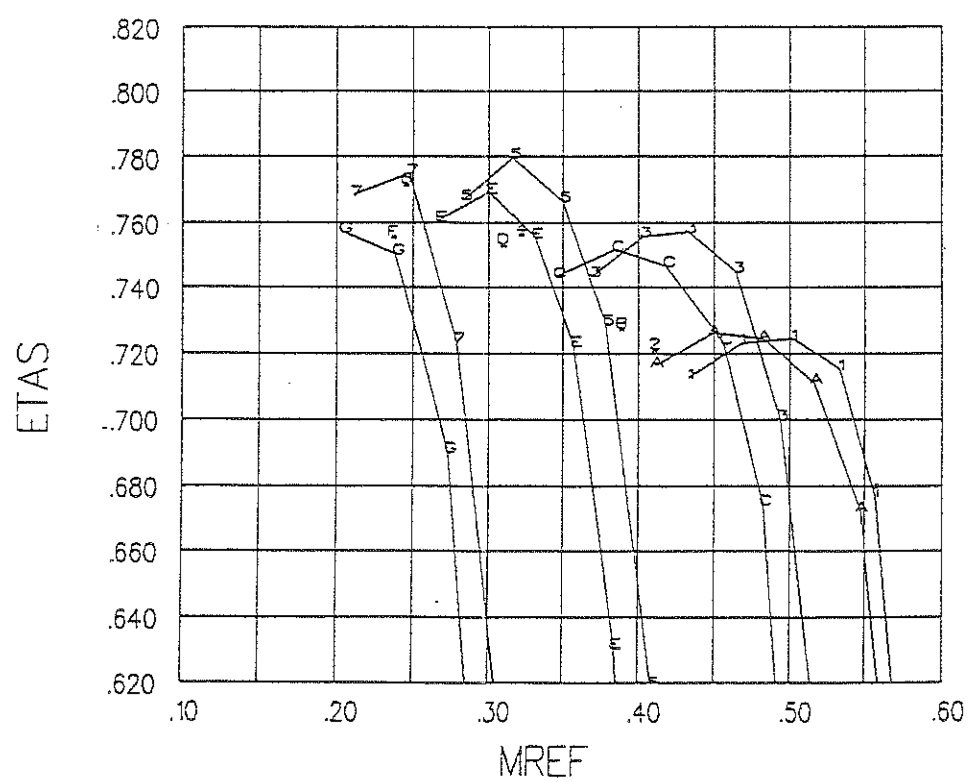

Figure ES.2b. Flat plate diffuser comparative results at AOA (design) = -4° showing efficiency characteristics.

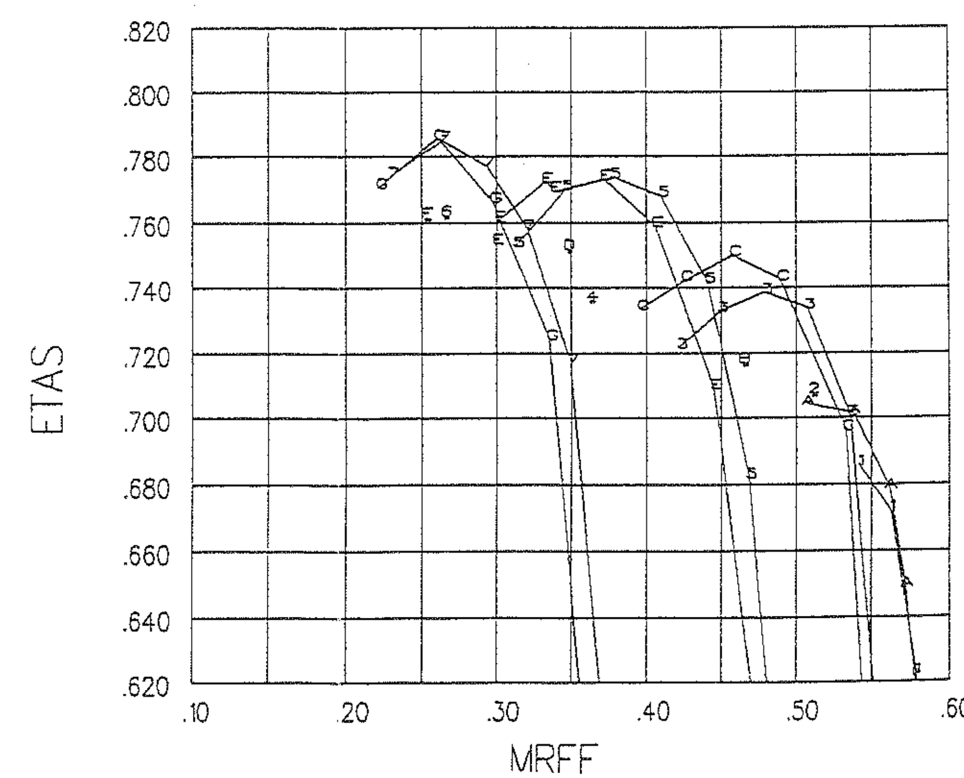

Figure ES.3b. Flat plate diffuser comparative results at AOA (design) = +4° showing efficiency characteristics.