PROPRIETARY REPORT

ADVANCED DIFFUSER PERFORMANCE FOR CENTRIFUGAL COMPRESSORS AND PUMPS

FINAL REPORT FOR THE ADVANCED DIFFUSER CONSORTIUM

PHASE V

RANGE AND PERFORMANCE ENHANCEMENT THROUGH DIFFUSER OPTIMIZATION FOR THE $N_S = 85$ CENTRIFUGAL COMPRESSOR STAGE

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CONCEPTS ETI, INC.
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ERRATA

Technical Memorandum No. 565 by Daniel V. Hinch, David Japikse, and Tsukasa Yoshinaka entitled "Advanced Diffuser Performance for Centrifugal Compressors and Pumps, Phase V", Final Report for the Advanced Diffuser Consortium, November 3, 1997.

Page 44, Section 3.3.2, 4th paragraph, 3rd sentence, should read:

The same general trend is true...........

TECHNICAL MEMORANDUM NO. 565

RANGE AND PERFORMANCE ENHANCEMENT THROUGH DIFFUSER OPTIMIZATION FOR THE N_S = 85 CENTRIFUGAL COMPRESSOR STAGE

Phase V

Final Report
Advanced Diffuser Consortium

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November 3, 1997

EXECUTIVE SUMMARY

This phase of the Advanced Diffuser Consortium centered around testing and CFD analysis for the medium specific speed (N_s = 85) centrifugal impeller/diffuser configuration developed in the previous phase of the consortium. Specifically, channel diffusers and low solidity airfoil (LSA) diffusers were designed, fabricated, and rig tested. A coupled CFD analysis was then performed on the impeller and the best performing diffuser.

Data from previous phases of the Advanced Diffuser Consortium was used to select appropriate geometrical parameters for designing the series of channel and LSA diffusers. Channel diffusers had not previously been run in the medium specific speed rig, while LSA diffusers were run in the previous phase with less than optimal results. Design details and guidelines are clearly described in the report. Diffuser hardware was fabricated in the Concepts ETI, Inc. (CETI) machine shop and run in the medium specific speed rig for a total of eight builds.

Some highlights of the test results are shown in Figs. ES1 and ES2. These figures show total-to-static pressure ratio and total-to-static efficiency, respectively, for the best performing channel and LSA diffuser. As seen in Fig. ES1, the two diffusers show nearly identical performance (range and pressure ratio) at 100% speed. This trend is striking considering the channel diffuser is made up of 26 relatively long channels with a well-defined throat at the inlet, while the LSA diffuser is made up of nine airfoils with no inlet throat due to the low solidity design. Figure ES2 shows that the performance of the channel diffuser is higher than that for the LSA diffuser (by about 2.5 points at design flow). Overall the range for both designs is very good, with typical range values at 100% speed being around 27%. Full details of the test results and data reduction for each build are included in this report.

After the testing was completed, coupled CFD was run on the impeller and the best performing channel diffuser. Coupled CFD has the advantage of not only providing realistic inlet conditions to the diffuser, but also allowing the presence of the diffuser to be felt by the impeller. The coupled results were compared with uncoupled results (impeller alone) so that the effects of the coupling could be determined. The results show that the diffuser has a noticeable impact on the performance of the impeller, changing the impeller loading near the exit and changing the impeller exit conditions, including exit swirl. The overall changes in the impeller performance due to coupling were compared to test data; the trends were found to be similar. An analysis of the diffuser flow field from the coupled results showed previously unseen flow structures in the diffuser.

The goals of Phase V of the Advanced Diffuser Consortium have been met. Increased performance (range, pressure ratio, and efficiency) has been demonstrated in the medium specific speed rig for two types of diffusers, while a new analysis/design tool, coupled CFD, has been shown to be very useful in understanding the effects of impeller/diffuser coupling. Areas for further improvement have been identified, including using coupled CFD to better understand impeller/diffuser interaction, and the application of a new type of diffuser, the hybrid diffuser, to further increase performance levels.

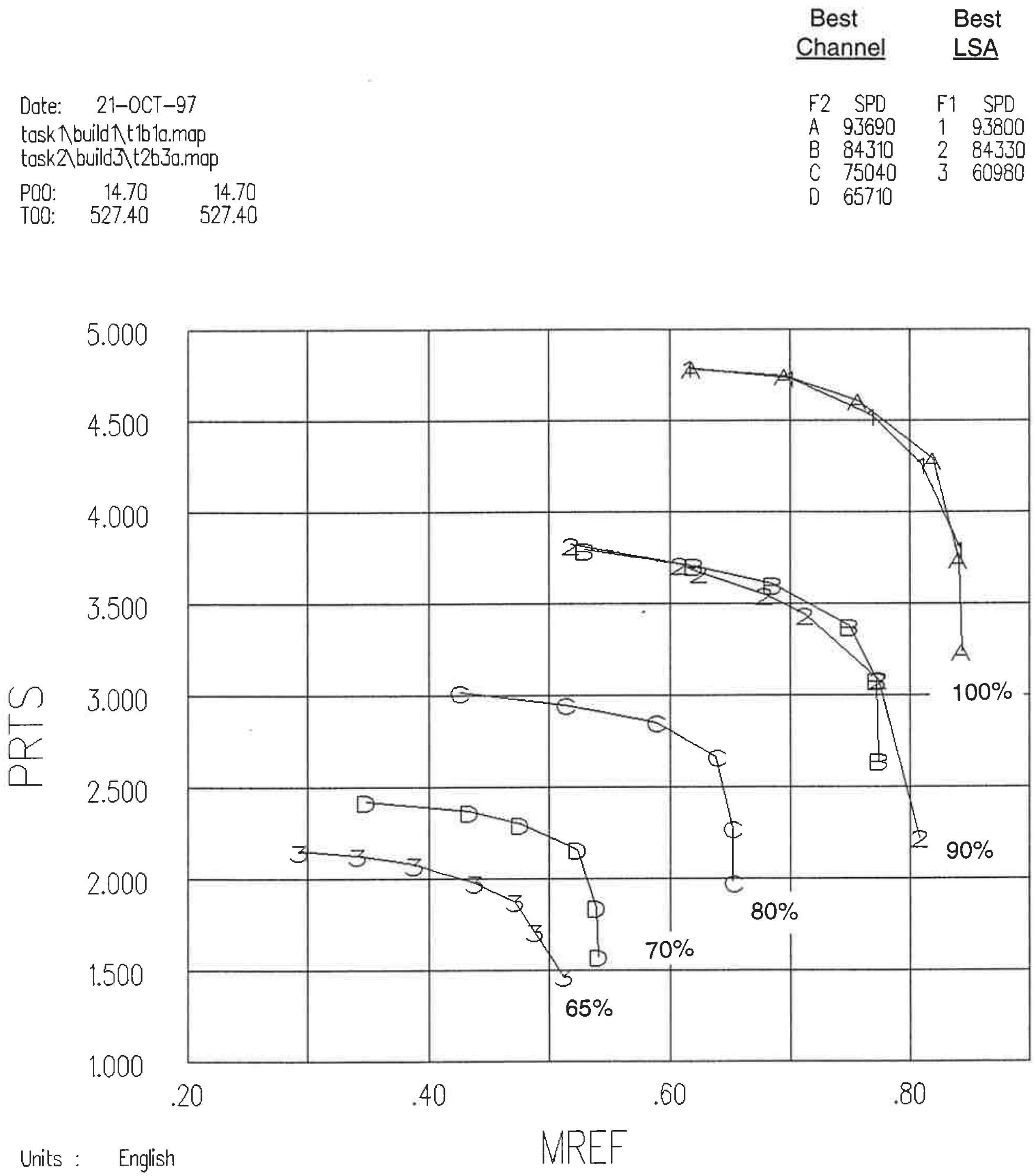

Figure ES1. A comparison of stage total-to-static pressure ratio for the best channel diffuser and the best LSA diffuser. The performance of the stage with these two diffusers is remarkably similar.

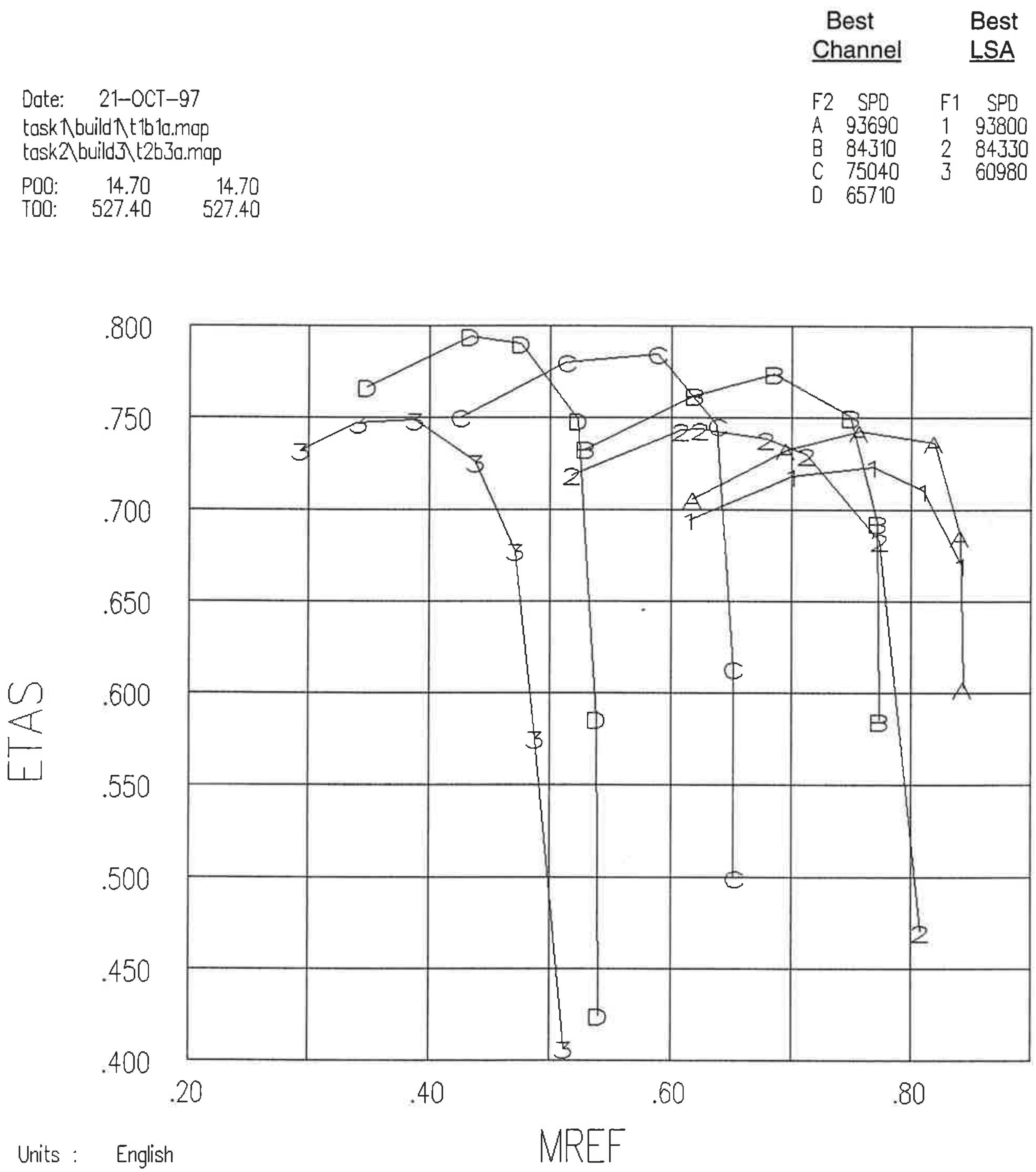

Figure ES2. A comparison of stage total-to-static efficiency for the best channel diffuser and the best LSA diffuser. The channel diffuser shows higher efficiency levels.