



Improving Optical Access for the Mach-6 Quiet-Flow Ludwig Tube

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10/22/2018
Final Report

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REPORT DOCUMENTATION PAGE					Form Approved OMB No. 0704-0188	
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1. REPORT DATE (DD-MM-YYYY) 19-10-2018		2. REPORT TYPE Final Report			3. DATES COVERED (From - To) 30 Sep. 2017-29 Sep. 2018	
4. TITLE AND SUBTITLE Improving Optical Access for the Mach-6 Quiet-Flow Ludwig Tube				5a. CONTRACT NUMBER		
				5b. GRANT NUMBER FA9550-17-1-0416		
				5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) Steven P. Schneider				5d. PROJECT NUMBER		
				5e. TASK NUMBER		
				5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Purdue University Aerospace Sciences Lab 1375 Aviation Drive West Lafayette, IN 47907					8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Office of Scientific Research					10. SPONSOR/MONITOR'S ACRONYM(S) AFOSR	
					11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for Public Release						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT This grant funded procurement of (1) a second 7x14-inch rectangular window, similar to the first one, using an existing extra plexiglas window insert, and (2) a second porthole window assembly for the 7x14-inch opening, with a pair of 5-inch conformal plexiglas windows. The two windows were received in March 2018. Initial attempts at testing the windows showed some slight mistakes in the construction that prevented full installation into the BAM6QT. It should be possible to correct the problems in house, using the department machine shop. Once the issues are fixed, the windows will be pressure-tested and then be available for use in the BAM6QT.						
15. SUBJECT TERMS hypersonic wind tunnels, laminar turbulent transition, quiet flow						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT unlimited	18. NUMBER OF PAGES 3	19a. NAME OF RESPONSIBLE PERSON Steven P Schneider	
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (Include area code) 765-494-3343	

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Final Report for AFOSR DURIP Grant FA9550-17-1-0416

Improving Optical Access for the Mach-6 Quiet Flow Ludwig Tube

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19 October 2018 Revision 2

Introduction

This is a brief final report for the subject equipment grant. This grant funded procurement of (1) a second 7x14-inch rectangular window, similar to the first one, using an existing extra plexiglas window insert, and (2) a second porthole window assembly for the 7x14-inch opening, with a pair of 5-inch conformal plexiglas windows.

This grant was awarded 30 Sept. 2017 for \$59.3K. Since TriModels built the existing 7x14-inch rectangular window, and the existing porthole window assembly, and since TriModels has a good reputation, a sole-source purchase order to TriModels for the new hardware was placed in late October 2017. The old extra 7x14-inch plexiglas window insert was shipped to TriModels, who assembled it into a new casing. Some minor issues with the exact dimensions of the old and new windows were resolved during TriModels design and build process. The new windows are nominally identical to the old ones, so they are interchangeable. The two new window assemblies were delivered the first week of March 2018. They were unloaded from their crates and stored in a labeled drawer. Due to tunnel scheduling and other obligations the spare windows were not immediately fit and pressure tested. Additionally, the student who helped with this project was at JHU-APL on an internship during the summer. Due to this, the initial measurements and fit-testing were not completed until October. A critical need for the windows has not yet arisen but many uses are expected.

7x14-inch Rectangular Window:

A schematic of the window is shown below in order to clarify the discussion's terminology.

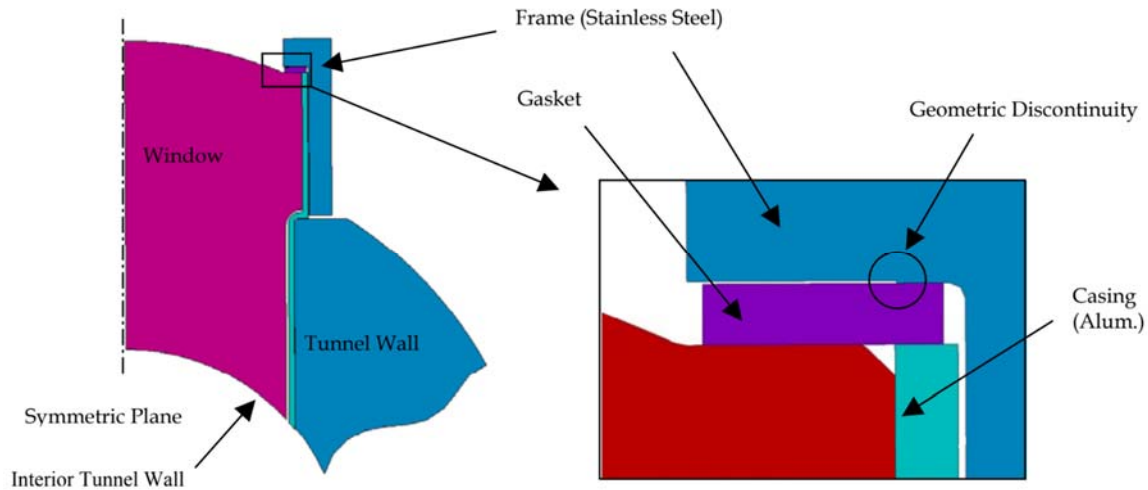


Figure 1 - Cross-section schematic of the 7 x 14 Plexiglas window. Taken from Kwon and Schneider (AIAA 2002-0309)

The larger field-of-view window was the first one to be unpackaged. The window was shipped in two separate pieces. A stainless-steel outer frame is slip-fit over the aluminum casing with a gasket in between the two. The inner casing protects the Plexiglas window and is sealed with a combination of plaster, flowable RTV, and a thicker RTV. However, the inner casing is bulging at the center of the 14-inch side and does not slip fit easily into the frame. The casing is building, probably due to shifting and curing of plaster, as has been observed previously. This issue is being resolved by Robin Snodgrass of Purdue AAE's machine shop. Precise measurements will be made and the outer surface of the aluminum casing will be machined down to the appropriate size prior to pressure-testing.

Upon further inspection, the larger Plexiglas window also has a couple of regions where the sealant was not fully adhered. This can be seen in Figure 1. The RTV will be replaced.

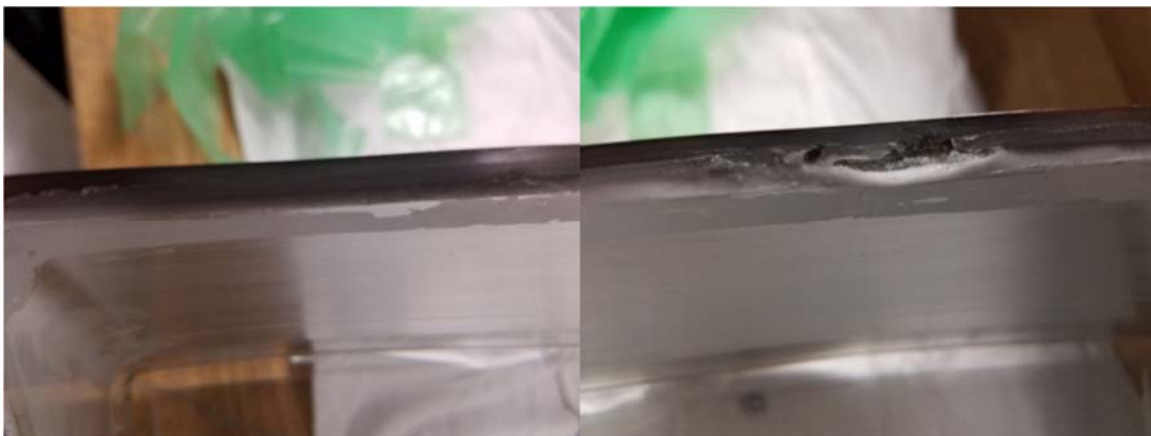


Figure 2 - Left: Correctly sealed RTV. Right: Incorrectly Sealed RTV.

Porthole Window:

The porthole window was shipped in a single assembly. Initial measurements of the window showed that some surfaces were oversized. The surface that slip fits into the BAM6QT nozzle opening measured approximately 0.005 inches larger than our current porthole window. As a result, the window would not easily slide into place. No further attempts will be made to install the window until our machine shop can make precise measurements and confirm or repair the oversize dimensions.

Window Status:

Two windows were received from Trimodels Inc. in March, 2018. Initial attempts at testing the windows showed some slight mistakes in the construction that prevented full installation into the BAM6QT. It should be possible to correct the problems in house, using the department machine shop. Once the issues are fixed, the windows will be pressure-tested and then be available for use in the BAM6QT.

Near-Term Use for Windows: FLDI Measurements

These new windows will be very useful in many different ways for a variety of projects. The 5-inch plexiglas inserts can be replaced with an infrared-clear insert for IR camera imaging; two such IR inserts are now feasible to enable view from two IR cameras. If any one window fails, there is a replacement already available.

The first use of these windows is expected to be for Focused Laser Differential Interferometry measurements. Focused laser differential interferometry (FLDI) is an optical measurement technique that utilizes common-path interferometry to measure density fluctuations in a flow. It is sensitive enough to pick up density changes due to sound and can provide high-frequency measurements that can be off the surface of a model. The FLDI is unique in that no seeding or other interference in the flow is required. Additionally, the focusing of the laser beams helps to lessen the influence of the tunnel wall boundary layer in the overall measurement, providing better spatial resolution than its non-focusing counterpart.

The rectangular windows will be essential for the FLDI. Part of the requirements of the interferometer is to have optical access across the span of the tunnel, which these windows provide. The large rectangular window in particular will be useful for obtaining FLDI measurements. Its greater size provides more options for the placement of the laser beams with respect to the model, allowing measurements to be taken in areas that would otherwise be unavailable to us. The newly available porthole window pair can be installed in the tunnel while the newly available pair of rectangular windows can be used to test the FLDI apparatus outside the tunnel. The pairs of windows can then be swapped out.