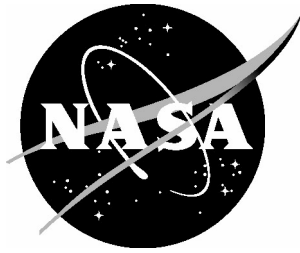# Model-Scale Aerodynamic Performance Testing of Proposed Modifications to the NASA Langley Low Speed Aeroacoustic Wind Tunnel

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March 2005

Model-scale Aerodynamic Performance Testing of Proposed Modifications to the NASA Langley Low Speed Aeroacoustic Wind Tunnel

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Tests were performed on a 1/20th-scale model of the Low Speed Aeroacoustic Wind Tunnel to determine the performance effects of insertion of acoustic baffles in the tunnel inlet, replacement of the existing collector with a new collector design in the open jet test section, and addition of flow splitters to the acoustic baffle section downstream of the test section. As expected, the inlet baffles caused a reduction in facility performance. About half of the performance loss was recovered by addition the flow splitters to the downstream baffles. All collectors tested reduced facility performance. However, test chamber recirculation flow was reduced by the new collector designs and shielding of some of the microphones was reduced owing to the smaller size of the new collector. Overall performance loss in the facility is expected to be a 5 percent top flow speed reduction, but the facility will meet OSHA limits for external noise levels and recirculation in the test section will be reduced.

Introduction

The NASA Langley Low Speed Aeroacoustic Wind Tunnel (LSAWT) is a low-speed, open-circuit, open jet acoustic wind tunnel equipped with a jet engine simulator (JES) for study of jet noise. LSAWT currently has a top speed of Mach 0.32. The jet engine simulator is equipped to produce two flow streams representing engine core and fan bypass flow. The jet flow streams are independently heated and throttled so that the engine cycle of all existing and some proposed engines can be simulated. The jet flow is surrounded by the wind tunnel flow to simulate forward flight effects at realistic landing and takeoff speeds. The combined flow traverses an open jet test section surrounded by an anechoic chamber where microphones record noise produced by the simulated jet. As such, it is a valuable tool in the pursuit of jet noise suppression technology. A typical nozzle test is shown in figure 1.

However, as with all facilities, it can be improved. Three areas of improvement currently planned for the LSAWT are the addition of inlet noise suppression, installation of flow splitters to the existing downstream noise suppression baffles, and replacement of the existing flow collector. A sketch of the LSAWT tunnel circuit illustrating these potential areas of improvement is shown in figure 2.

Noise abatement treatment is needed in the LSAWT inlet to reduce noise that escapes from the test section and propagates to the area outside of the facility. In some cases, this radiated noise can reach levels that are significantly above OSHA limits. Noise treatment required to reduce exterior noise levels to acceptable limits under all envisioned circumstances has been defined and the baffles are currently in final design. The baffles will occupy about half the cross sectional area of the tunnel inlet. Blockage from the baffles will result in a reduction of facility speed. Measurement of the extent of that performance loss was required.

Inside the test section, the open jet flow is captured by the collector. The existing collector is rather large for the room and may partially shield some of the microphones in the downstream side of the test section, so it would be desirable to have a physically smaller collector. In addition, the current collector causes a complex recirculation pattern in the room that buffets acoustic treatment on the walls and ceiling and may affect background noise levels measured by the microphones. An effort to design a better collector resulted in a smaller design that, according to CFD predictions,

reduced the recirculation flow and was more aerodynamically efficient. It was hoped that this increase in aerodynamic efficiency would reduce facility performance losses due to blockage from the inlet baffles. Measurement of performance effects of a new collector design was required.

Downstream of the test section, the high speed diffuser exits into a wide angle diffuser, which leads to the downstream noise baffles. The cross sectional area transition from the wide angle diffuser to the baffle section is abrupt, approximately fifty percent of cross sectional area. The original design incorporated a series of flow straighteners in the wide angle diffuser that reduced the abruptness of the area change and spread the flow more evenly across the baffle section. The flow splitters were purchased but never installed. It was hoped that installation of the baffle splitters would improve the overall tunnel circuit efficiency enough to make up for the loss caused by insertion of the inlet baffles, but confirmation of that with experimental measurements was required.

An effort to measure the separate and combined effects of adding inlet baffles, a new collector geometry, and downstream baffle flow splitters was conducted using a $1/20^{th}$-scale model of the Low Speed Aeroacoustic Wind Tunnel to assess changes in the overall tunnel performance.

Symbols

$p(n)$	corrected pressure at port n, psfg
p_0	standard barometric pressure, 14.769 psia
p_m	measured barometric pressure, psia
p_s	corrected static pressure, psf
p_s'	measured static pressure, psf
p_t	corrected total pressure, psf
p_t'	measured total pressure, psf
x	gap between collector trailing edge and diffuser throat, expressed in full-scale dimension, inch
x_{mic}	microphone location from upstream wall of test section chamber at model-scale, inch
t	ambient temperature, ^oR
t_0	standard temperature, 518.6 ^oR
ρ	ambient density
ρ_0	standard density, 0.0023769 slug/ft^3

Test Description

Facility
The Hampton University Low Speed Wind Tunnel was originally built as a $1/20^{th}$-scale pilot tunnel for the Low Speed Aeroacoustic Wind Tunnel. After construction of the full-size LSAWT, the pilot tunnel was loaned to Hampton University, where it has been modified for use as an educational laboratory facility. The open circuit tunnel is powered by a constant volume squirrel cage fan. The facility is shown in figure 3.

The Hampton University Low Speed Wind Tunnel was configured as a $1/20^{th}$ scale LSAWT for this test with the addition of a liner for the tunnel inlet that correctly scaled the inlet and provided means for mounting solid models representing the inlet acoustic baffles (figure 4). Additionally, the test section was fitted with a model of the Jet Engine Simulator (figure 5), a contraction nozzle representative of current LSAWT geometry (figure 6), and models of both the existing collector and proposed new collector designs (figure 7). Model flow splitters representative of the originally design for the downstream acoustic baffle flow splitters was employed (figure 8).

Model configuration
The LSAWT model was tested in a matrix of configurations, each of which was identified by a configuration designation of the form CiXjBkSl, where

i	equals	1	baseline collector
		2	5 degree collector
		3	10 degree collector
		4	12.5 degree collector
		5	15 degree collector
j	equals	x	in full-scale inches (two digit designation)
k	equals	0	no inlet acoustic baffles
		1	inlet acoustic baffles
l	equals	0	no baffle flow splitters
		1	baffle flow splitters

C4X12B1S1 is the configuration with the 12.5 degree collector located at x = 14 inches, with both the inlet baffles and downstream baffle flow splitters installed. Subsets of this naming

convention are also used for data identification in plotting, for example data identified as C4 refers to the 12.5 degree collector.

Instrumentation
The model LSAWT was equipped with static pressure taps at representative locations in the tunnel circuit, as shown in figure 9. The pressure ports locations are described in the figure legend. The static pressure ports were connected to a 48 channel manual scanni-valve, which was, in turn connected to a 1.0 psi range differential pressure transducer. The signal from the pressure transducer was displayed on a digital display. Prior to the test, the pressure transducer and display were calibrated as a system and found to be within +/- 0.0032 psi compared to the reference transducer. The accuracy of the data, then is within 0.46 psf.

Ambient conditions were monitored using an absolute pressure transducer that measured barometric pressure, and a thermometer for room temperature. Ambient measurements were used to correct data for changes in air density.

Data Acquisition Process
Test data were obtained by measuring and recording ambient temperature and barometric pressure, starting the model LSAWT, and allowing the fan to reach a steady run condition. Static pressure measurements were then obtained for the circuit by cycling through the channels for the pressure ports on the manual scanni-valve and recording the readings on a data sheet. After completion of data acquisition, the drive fan was turned off, and after the fan had stopped, ambient conditions were again recorded. The model LSAWT was then re-configured for the next run.

Data Reduction Process
Data were copied from each data sheet into a spreadsheet for initial data analysis. At the conclusion of the test, the data were transferred electronically into text data files that were processed as a batch to produce the final data presented herein.

The data were corrected to nominal density as described in reference 1. First the ambient conditions measured before and after the run were averaged, and the averaged quantities were used to calculate the ambient density.

$$\rho = \rho_0 \ (p_m/p_0) \ (t_0/t)$$

Pressure data were then corrected by applying a correction factor based on the density ratio.

$$p_s = p_s' \ (\rho_0/\rho)$$

$$p_t = p_t' \ (\rho_0/\rho)$$

Results

Data Quality of Survey Measurements
Flow survey results are plotted in figures 10-16. Data from tests are denoted with symbols while the line represents an average of the data. For figures 10-13, data obtained in the first test entry is denoted with filled in symbols, while data obtained in the second test entry is denoted by open symbols. The rest of the configurations were tested only during the second test entry, hence all data symbols are open.

In figure 10, the current configuration of the LSAWT was represented. With the exception of the static pressures in the test chamber $p(12)$, $p(13)$, and $p(14)$, all the pressure repeated within 0.8 psf, while the test section static pressures were within 2.5 psf. This level of repeatability was typical of all data obtained in both test entries. Figure 11 shows similar data for flow splitters added to the existing configuration. Note the better repeatability for $p(12)$ - $p(14)$ for this case.

In figure 12, inlet baffles were added to the configuration from figure 11. Note that there are two sets of data on this plot, one from each of the test entries. Within test entries, data is very repeatable, however, between test entries, there are relatively large differences from $p(4)$ through $p(14)$. The difference is attributable to a procedure change in sealing of the test section model between test entries. A significantly better seal was achieved in the second test entry, resulting in reduced seepage into the test chamber. Hence static pressures inside the chamber were reduced, as was the static pressure at the entrance to the diffuser, $p(6)$. The lower static pressure at the beginning of the diffuser propagates through the circuit from $p(6)$ through $p(10)$. The larger difference for $p(11)$ cannot be explained by this reasoning and it is assumed that the port 11 pressure tap was not consistent between test entries, hence $p(11)$ will not be used for cross-entry comparisons. Within test entry data sets, the pressure repeat to within +/-0.6 psf, and the static pressure data is closer than was

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shown by the existing configuration data in figure 10, with the exception of one outlier point that was 3.3 psf higher than the lowest value for p(13) in run 70.

Figure 13 shows pressure survey data from the 5 degree collector configuration at x = 10, 12, and 14 in. Data sets from the first test entry as compared to the second test entry show the same trends as noted for figure 12. Data repeatability within test entry sets is consistent within confidence bounds previously noted.

Figures 14-16 contains circuit survey data for the 10, 12.5 and 15 deg collectors at x = 10, 12, and 14 in. Data for these collectors was only obtained during the second test entry. Comparisons between collector configurations will be performed only using data from the second test entry, while assessments of impact on tunnel circuit performance due to addition of the flow splitters to the downstream baffles and the inlet baffles will be conducted using only data from the first test entry.

Addition of Flow Splitters to the Downstream Acoustic Baffles and Inlet Acoustic Baffles
In figure 17.a., the average survey data presented in figures 10 - 12, are plotted to show the impact of addition of flow splitters for the downstream acoustic baffles and new inlet acoustic baffles to the current LSAWT configuration, which is the baseline for this comparison. The differences are small. In order to emphasize the pressure differences between configurations, data from the baseline was subtracted from data for the other two configurations and are plotted in figure 17.b.

Addition of the flow splitters for the downstream acoustic baffles has no significant effect on the static pressures measured from the inlet to the plenum. However, there is a decrease of approximately 2.25 psf in the static pressure measured at the nozzle throat, indicating an increase of flow speed of about 4 ft/s. Surprisingly, the effects of the flow splitters on the diffuser and downstream baffle sections are small. It is not until the beginning of the fan section than any further significant effects are shown, and those indicate a slight increase in flow speed in those sections. The test chamber static pressures decreased by about 1 psf, which are also indicative of an increase of flow speed in the test chamber. The flow splitters for the downstream acoustic baffles increase the flow

speed in the test chamber by about 4 ft/s at the M=0.2 operating condition, or about 1.7%, while there is minimal impact elsewhere in the tunnel circuit.

The effect of adding inlet baffles to the configuration including flow splitters for the downstream baffles is also shown in figure 18. Unlike the flow splitters, the inlet baffles do affect the tunnel circuit upstream of the plenum. Not surprisingly, the effect is static pressure decrease (approximately 0.5 psf) indicative of the higher velocities in that section of the circuit due to the reduction of open cross sectional area (approximately 50%) in the tunnel inlet. The static pressure at the nozzle exit is shown to increase by 1 psf, which shows a net increase in the static pressure of approximately 3.2 psf due to the addition of the inlet baffles. This translates into a net flow speed loss at the test chamber nozzle of about 2.6 ft/s or a loss of 1.1% of the test section flow speed when compared to the existing configuration.

Manufacturers of acoustic baffles predict (reference 2,3) a total pressure loss of 1.0 psf for an approach speed to the inlet of 10 ft/s, which corresponds to a test section speed of M=0.2 The baffle losses are projected by the manufacturers to rise to 2.1 psf at an approach speed to the inlet of 15 ft/s, which represents a test section speed of M=0.3. These are considerably smaller than the losses measured in the model, which may be indicative of Reynolds numbers effects on the drag of the baffle elements. Model results will be used as a worst-case estimate of facility performance loss due to inlet baffle installation.

Since the primary purpose of the current facility modification is to reduce noise radiated from the facility to the outside to a level below OSHA noise exposure limits, this performance loss is simply the cost required to meet required noise standards. However, it should be noted that the installation of inlet acoustic baffles, without the mitigating effects of also installing flow splitters to the downstream acoustic baffles will result in a flow speed reduction of 6.1 ft/s at the M=0.2 flow condition, which is a 2.7% reduction in flow speed in the test section. Projection of this worst case loss figure for baffle installation to the facility top speed would suggest a reduction of the top speed attainable in the facility to M = 0.31 from the currently attainable M=0.32. Addition of the downstream baffle splitters should mitigate this loss to a top speed of

M=0.313. In short, even using the worst case model results leads to an estimate of only a small decrease in the top speed attainable by the facility due to installation of the inlet baffles, and this loss is mitigated by installation of the downstream baffle splitters. Manufacturer specifications for baffle total pressure loss suggest that facility top speed reduction may be less than those estimated using model measurements.

Effects of Collector Design
Installation of the inlet baffles will cause a facility performance loss that is partially mitigated by installation of the downstream baffle splitters. It is desirable to further mitigate that performance loss, or at least minimize any additional performance penalty due to installation of a new collector.

The existing collector works well, but there is room for improvement. In the current configuration, there is excessive recirculation flow in the test chamber due to flow spillage by the existing collector. At higher test speeds, the recirculation flow buffets the acoustic wedges in the area adjacent to and behind the collector lip. The recirculation flow may also affect background noise measured by microphones mounted in the downstream portion of the test chamber. A new collector should reduce the recirculation flow in the test cell.

In addition to recirculation, the existing collector is suspected of partially shielding microphones placed in the downstream portion of the test chamber. So a replacement collector design should be smaller than the existing collector. An ideal replacement collector would improve tunnel circuit aerodynamic performance, eliminate recirculation, and be much smaller than the existing collector.

The new collector design is based on the collector design employed in the NASA Langley Research Center 14- by 22-Foot Subsonic Tunnel, as reported in reference 4. A CFD study was initiated to refine a collector design that would reduce recirculation in the test chamber. This tool was used to develop the 5 degree collector design, with a chord length of each of the collector sides of 60 inches, as opposed to the existing collector with 72 inch sides. Each of the collector walls is inclined 5 degrees, and the optimum placement was found locating the collector trailing edge 12 inches

away from the high speed diffuser throat. Streamlines for the existing collector is shown in figure 18.a. showing a dual vortex recirculation zones. In figure 18.b., streamlines for the 5 degree collector is shown and the dual recirculation pattern has been transformed to a single vortex recirculation pattern.

During the phase 1 test entry, it was discovered that the CFD-optimized 5 degree collector (C2) did not adequately capture the flow from the open jet test section. Apparently, CFD under predicted the expansion of the open jet and the shear layer that was supposed to meet the collector lip instead passed outside of the collector lip. In addition, the 5 degree collector also increased circuit performance loss. As a result, three new collector models were built with wall inclinations of 10, 12.5 and 15 degrees and were tested in a phase 2 test entry. For clarity, only data obtained in the phase 2 test entry will be used in this section. It was discovered, using a flow tuft wand, that the 15 degree collector worked very well for reduction of recirculation, as did the 12.5 degree collector. The 10 degree collector produced modest recirculation reduction, while the 5 degree collector produced generally poor results. Further, it was discovered that the recirculation reduction was a strong function of the position of the collector with best results over a gap range of 10 to 14 inches.

Delta pressure plots, similar to that presented in figure 17.b., are presented for the new collector designs in figures 19 – 23. In this case, the configuration using the existing collector with inlet baffles and flow splitters is used as the baseline configuration that was subtracted from the average flow survey pressure data. The figures show that the effect of each collector design is a strong function of the collector gap.

Quantitatively, the flow collector designs will be examined on flow speed at the contraction exit, high speed diffuser pressure recovery, and fan static pressure rise required to produce the flow.

Test section flow speed can be measured using two methods in the current experimental configuration: using the static pressure at the entrance and exit of the contraction and using dynamic pressure measured by using the total pressure probe on the JES model and the static pressure at the throat of the contraction. Data from the three pressure ports are plotted for the

new collector designs, referenced to data obtained using the existing collector, in figures 24-26. Test section dynamic pressure as calculated by static pressure change in the contraction is presented in figure 27 and test section dynamic pressure as calculated using the difference between the total pressure probe and the contraction throat static pressure is presented in figure 28.

Trends shown in figures 27 and 28 are the same, although the absolute amplitudes are different by about 0.2 psf. In both cases, it is noted that all the new collector designs reduce test section dynamic pressure, and hence test section speed, as compared to the existing collector. Interestingly, the 12.5 and 15 degree collectors (C4 and C5, respectively) produce the least reduction in test section speed over a gap range from 6 to 12 inches. Interestingly, the 10 degree collector produces the greatest reduction of test section dynamic pressure for a gap range of 8 to 14 inches. These results suggest that either the 12.5 or 15 degree collectors incur the least speed reduction while still improving test section recirculation.

Another measure of merit for wind tunnel circuit performance is the pressure recovery in the high speed diffuser. In the current experimental configuration, this parameter is measured using the wall static pressure at the entrance to the diffuser (p(6)) and at the exit of the diffuser (p(7)). Data from posts 6 and 7 are presented in figures 29 and 30, for all the new collector designs, as referenced to results for the current collector, as a function of collector gap. Pressure recovery measurements in the high speed diffuser are presented in figure 31.

It is interesting to note that the static pressure at the diffuser entrance is actually reduced for the 12.5 and 15 degree collectors at a gap of 12 inches, which implies that the flow entering the diffuser is actually faster than in the case of the existing diffuser. At the same condition, figure 27 and 28 showed that the flow at the exit of the contraction was reduced by both the 12.5 and 15 degree collectors. This apparent contradiction could be due to the flow around the outside of the collector, which acts to reduce the secondary recirculation vortex, is injected instead into the diffuser and energizes the boundary layer, acting as a flow injector.

In figure 31, pressure recover in the diffuser is shown to be reduced slightly by all of the new collector configurations relative to the existing collector. However, the pressure recovery decrease is generally less for the 12.5 degree collector than the 15 degree collector for a gap range of 6 to 14 inches, except for a gap of 10 inches where the 15 degree collector is marginally better.

The driving force that produces flow in an open circuit wind tunnel is the static pressure rise produced by the drive fan. The model-scale experiment did not simulate this drive mechanism exactly, instead relying on a constant volume squirrel cage fan well downstream of the LSAWT drive fan location. As a result, it was possible to measure the static pressure difference at the entrance and exit to the drive system section. The difference in pressure between these two sections represents the pressure rise required to produce the flow conditions measured elsewhere in the circuit. Pressure data from the entrance (p(10)) and exit (p(11)) to the drive section are plotted in figures 32 and 33 for each of the collector configurations are a function of collector gap. Static pressure rise is presented in figure 34. It is interesting to note in figure 34 that the pressure rise requirement is reduced for most of the collector configurations for the entire collector gap range. If the fan section is able to produce the same pressure rise as the current facility, then the reduction in pressure rise represents a margin of fan power to reduce the adverse effects noted in the prediction of test section dynamic pressure shown in figure 27 and 28. Interestingly, at a collector gap of 12 inches, the pressure rise reduction shown in figure 34 is approximately equal for all the new collector configurations.

Given the qualitative flow results, either the 12.5 or 15 degree collectors do the best job reducing test chamber recirculation. Additionally, the inflow to the diffuser for those two collector designs at a collector gap of 12 inches indicates that flow into the diffuser is increased, which is consistent with redirection of recirculation flow into the diffuser. The test section dynamic pressure is reduced by about 2.5 psf for both the 12.5 and 15 degree collectors at a gap of 12 inches, some of which may be recovered by a margin in pressure rise shown in figure 34. The 12.5 degree collector is also smaller than the 15 degree collector at the inlet face, so shielding of test articles in the test section should be reduced.

It is recommended that the new collector for LSAWT use the 12.5 degree design and be located at a collector gap of 12 inches. Such a choice will incur a test section dynamic penalty on the order of 2.5 psf, which reflects a reduction in test section Mach number of about 0.005 at the M=0.2 test condition.

The reduction of test section speed incurred by the change in collector design and the insertion of the inlet acoustic baffles, reduced by the installation of flow splitters for the downstream acoustic baffles will be about 5 psf for the M=0.20 condition, and will reduce the test section flow to M = 0.19, or 5 percent reduction in flow speed. Projecting the flow losses to a test section speed of M=0.32 results in a dynamic pressure loss of about 12.8 psf, which will reduce the test section flow to M = .306, a reduction of about 4.5 percent.

Conclusions and Recommendations

Measurements conducted on a 1/20th scale model of LSAWT at a nominal flow speed of M = 0.2 suggest the following flow speed reductions due to installation of inlet baffles, flow splitters on the downstream baffles and a new collector: Baffle flow splitters will improve diffuser performance. Test section flow speed increased by about 1 percent. Installation of inlet baffles will reduce flow speed by about 2.5 percent. Combined with the flow splitters on the downstream acoustic baffles, the net performance loss is about 1.8 percent in flow speed. Using the manufacturer's flow loss data instead of the model measurements result in a minimal change in flow speed. The recommended new collector design will reduce tunnel performance by 2.5 percent but will also significantly reduce test section recirculation, which will reduce flow impingement on microphones resulting in a decrease of measured background noise, and reduce microphone shielding.

If all three improvements are implemented, LSAWT tunnel speed should be expected to be reduced by about 5 percent and result in a test section maximum Mach number of 0.306.

Acknowledgements

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4. G. S. Manuel, John K. Molloy and P. S. Barna, "Effect of Collector Configuration on Test-Section Turbulence Levels in an Open-Jet Wind Tunnel," NASA TM-4333 , July 1992.
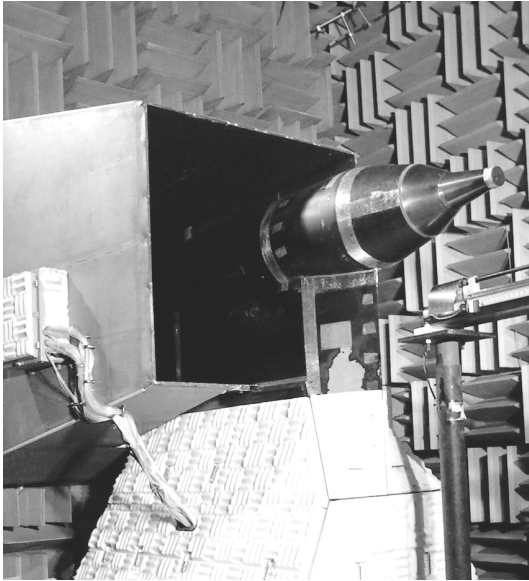
Figure 1. Typical LSAWT test setup.

Figure 2. Sketch of LSAWT circuit.

Figure 3. Hampton University Low Speed Wind Tunnel.

Figure 4. Inlet baffles model installed in tunnel inlet.
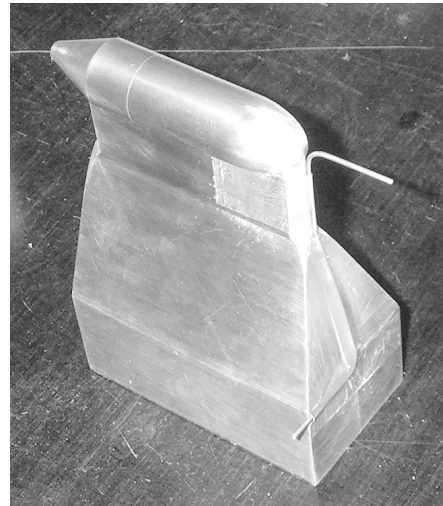
Figure 5. Model of Jet Engine Simulator.

Figure 6. Jet Engine Simulator model installed in test section with collector nozzle.

8
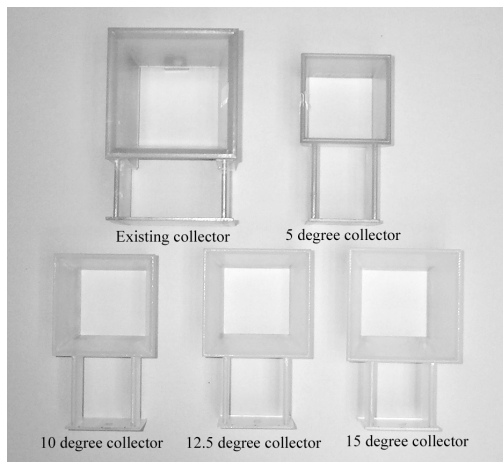
Figure 7. Collector models.

Figure 8. Flow splitters for downstream baffle section installed in model.

Inlet
Baffles

1

2

3

12 5 13

4

Jet Engine
Simulator

Collector

14

6

7

Flow
Splitters 8

9 10 11
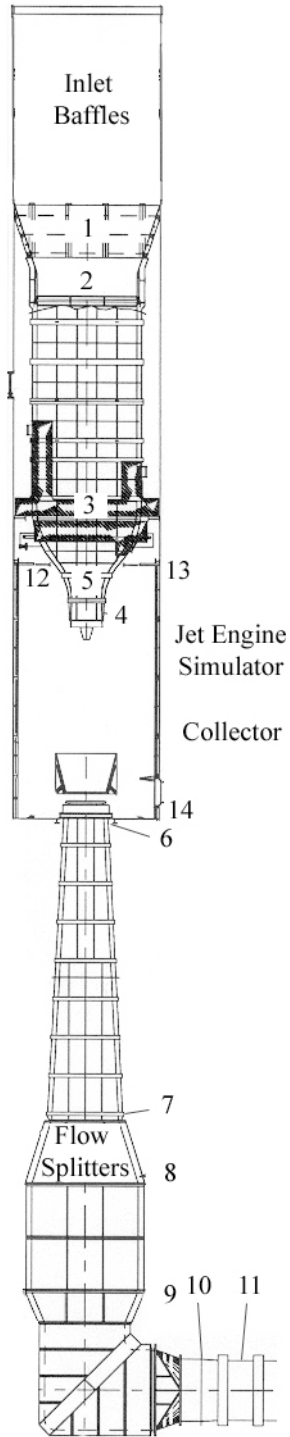
Port Number	Scanni-valve Channel	Port Location
1	0	Inlet Lip
2	1	Before Honeycomb
3	2	Plenum
4	3	End of Contraction
5	4	Contraction Total Pressure
6	5	Diffuser Throat
7	6	Diffuser Exit
8	7	Entrance Downstream Baffles
9	8	Exit Downstream Baffles
10	9	Entrance Motor Section
11	10	Exit Motor Section
12	11	Test Section Static
13	18	Upstream TS Static
14	19	Downstream TS Static

Figure 9. Sketch of LSAWT circuit showing pressure port locations.
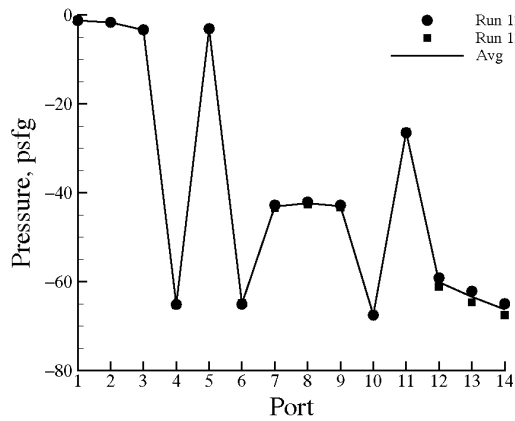
Figure 10. Existing LSAWT configuration pressure survey results.

Figure 11. Existing LSAWT configuration with addition of downstream baffle flow dividers pressure survey results.
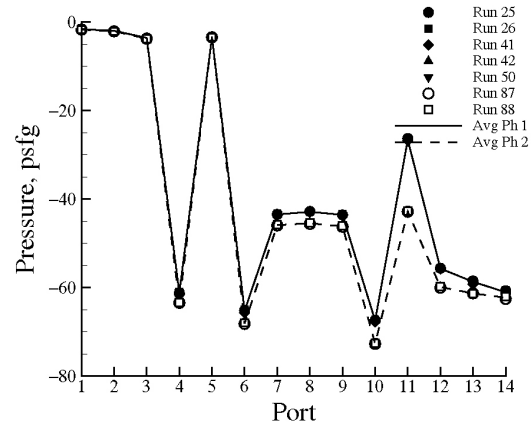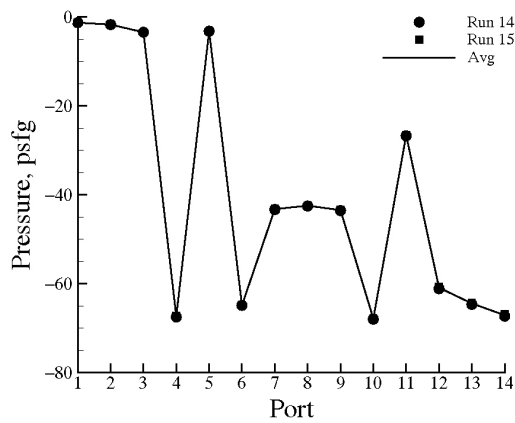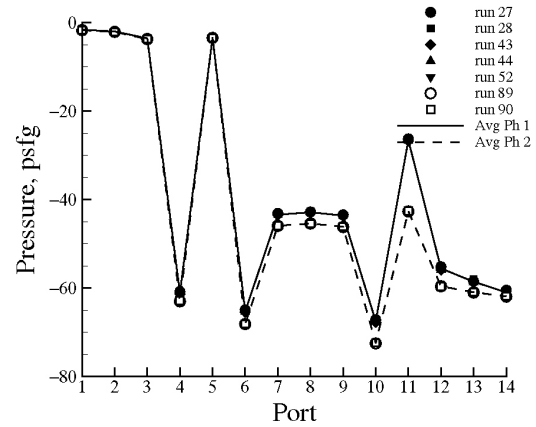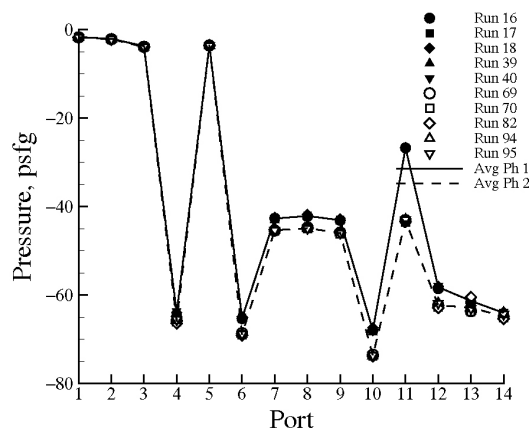
Figure 12. Existing LSAWT configuration with addition of downstream baffle flow dividers and inlet acoustic baffles pressure survey results.

a. X = 10 in.
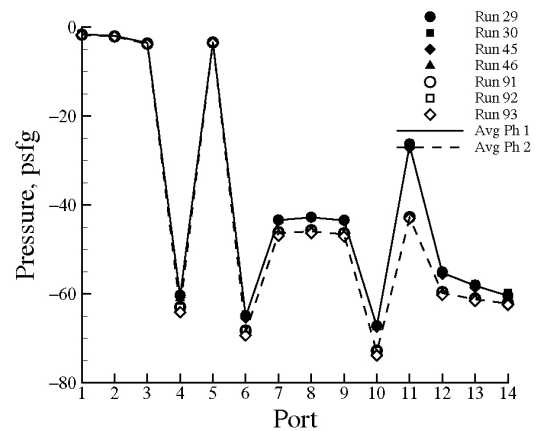
b. X = 12 in.

c. X = 14 in.

Figure 13. Five degree collector with inlet baffles and downstream baffle flow dividers pressure survey results.

11
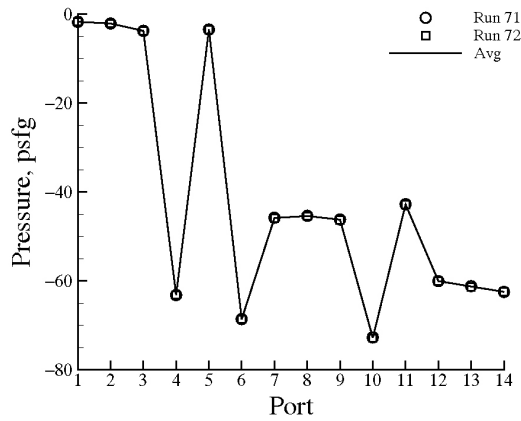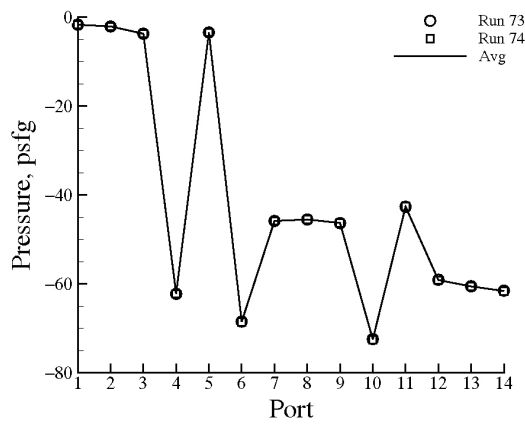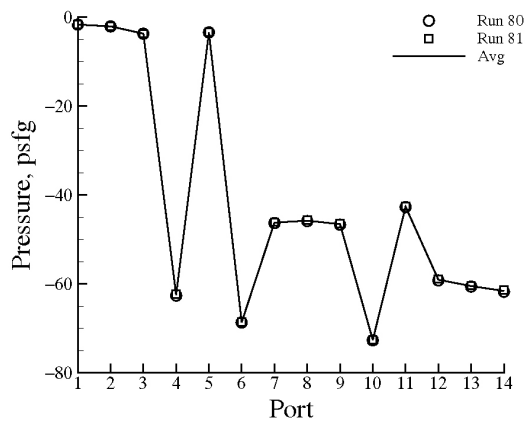
a. x = 10 in.

b. x = 12 in.

c. x = 14 in.

Figure 14. Ten degree collector with inlet baffles and downstream baffle flow dividers pressure survey results.
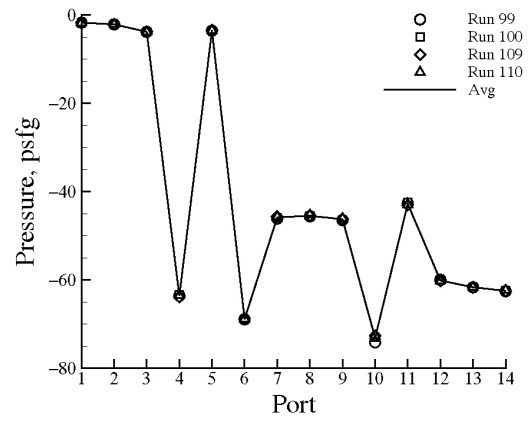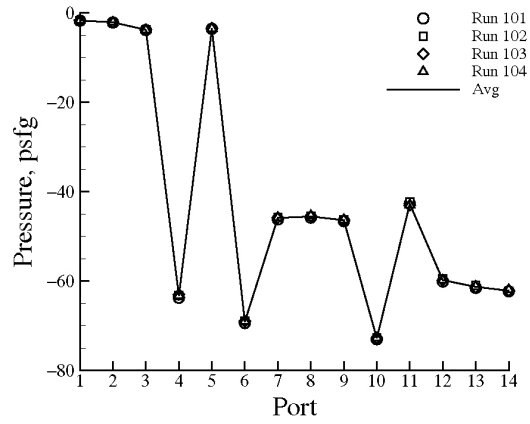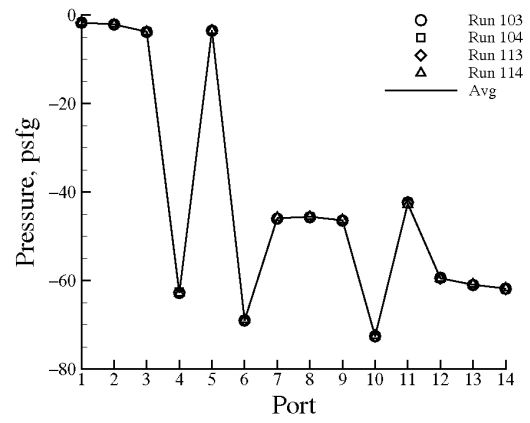
a. x = 10 in.

b. x = 12 in.

c. x = 14 in.

Figure 15. 12.5 degree collector with inlet baffles and downstream baffle flow dividers pressure survey results.

12
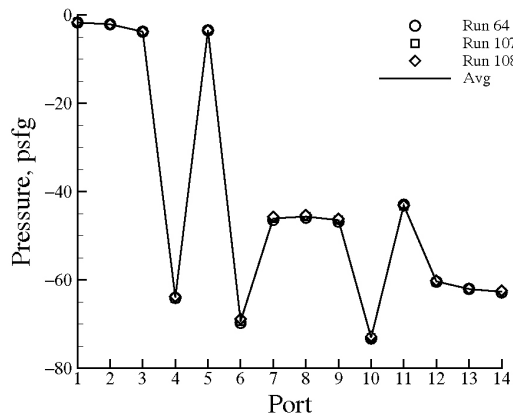
a. x = 10 in.
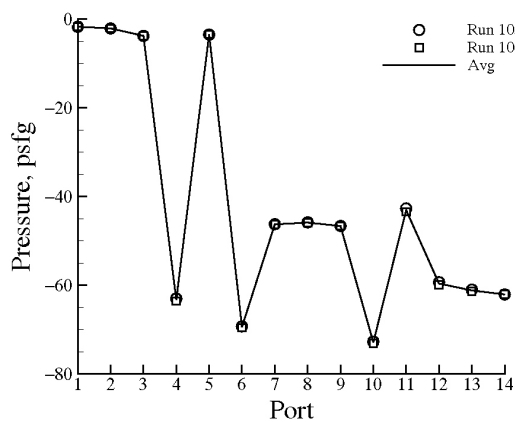
b. x = 12 in.
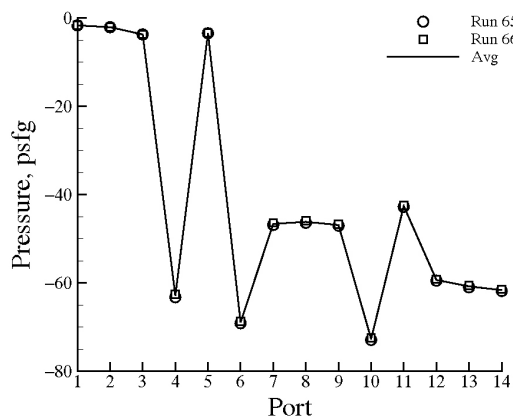
c. x = 14 in.

Figure 16. Fifteen degree collector with inlet baffles and downstream baffle flow dividers pressure survey results.
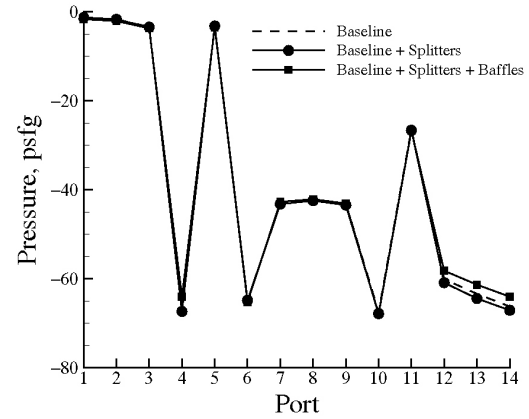
a. Pressure survey
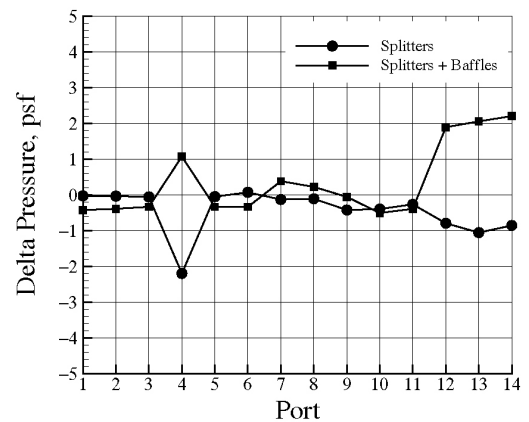
b. Delta pressures

Figure 17. Effect of adding downstream flow splitter baffles and inlet baffles to LSAWT.
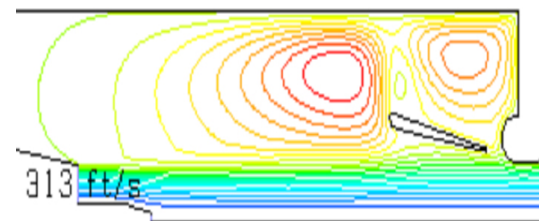
a. Existing configuration
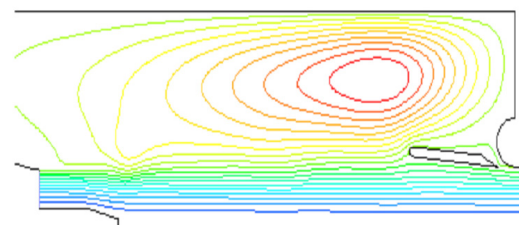
b. 5 degree collector configuration.

Figure 18. Streamline pattern calculated for the LSAWT test section.
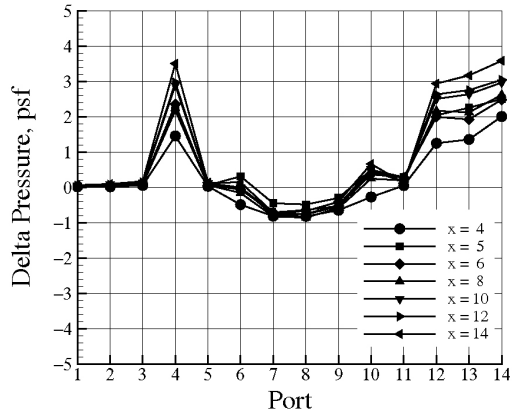
Figure 19. Effect of five degree collector on circuit performance in phase 1 testing.
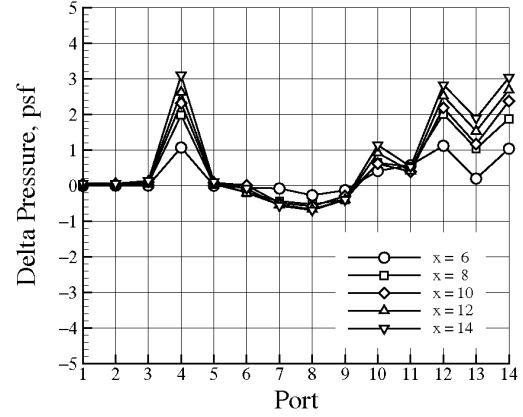
Figure 22. Effect of 12.5 degree collector on circuit performance.
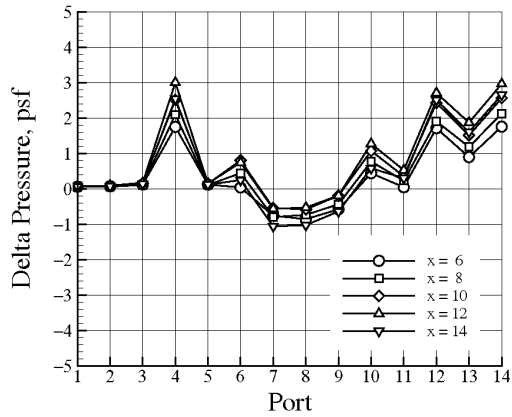
Figure 20. Effect of five degree collector on circuit performance in phase 2 testing.
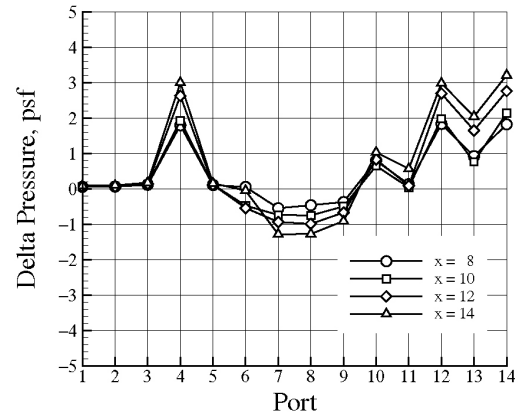
Figure 23. Effect of fifteen degree collector on circuit performance.
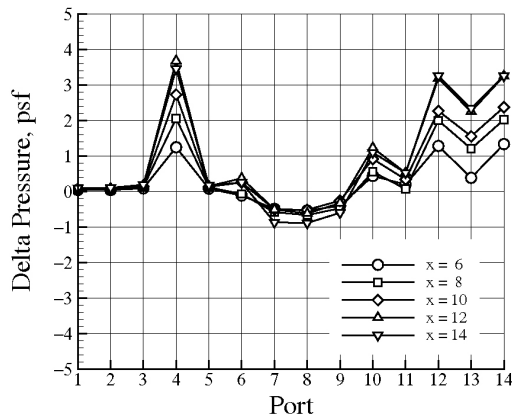
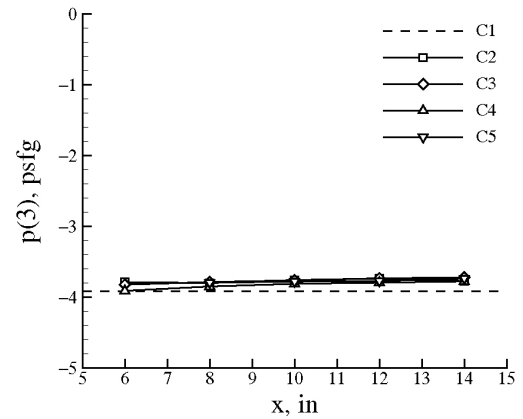Figure 21. Effect of ten degree collector on circuit performance.

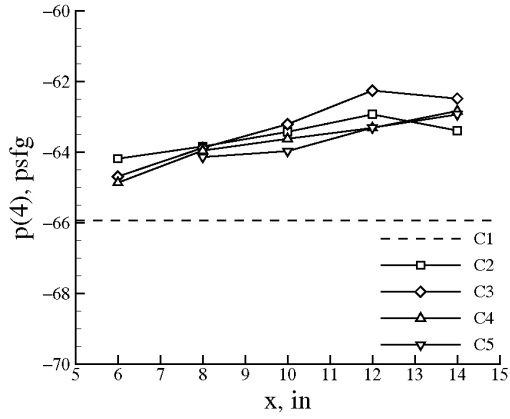Figure 24. Effect of collector configuration and gap on p(3).

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Figure 25. Effect of collector configuration and gap on p(4).

Figure 26. Effect of collector configuration and gap on p(5).

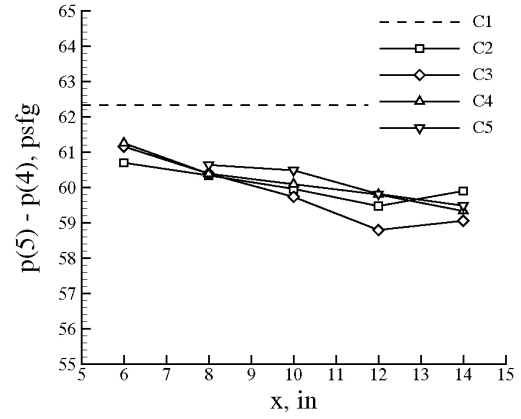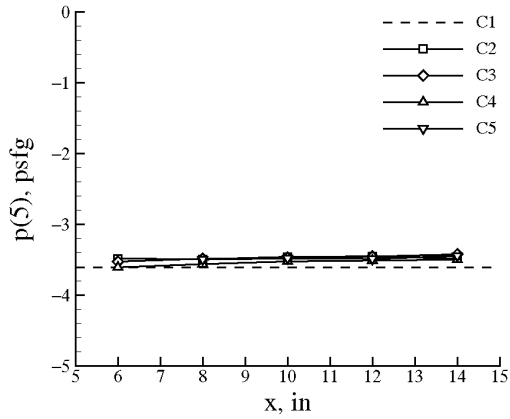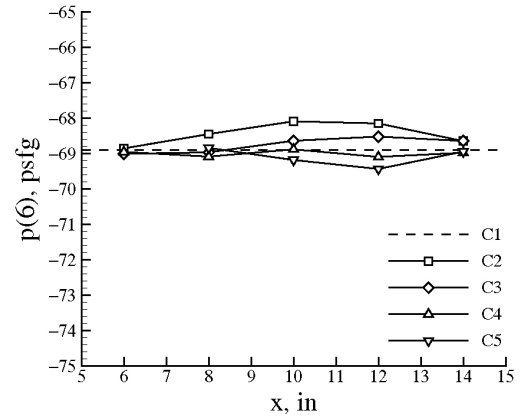Figure 27. Contraction pressure drop as a function of collector geometry and gap.

Figure 28. Dynamic pressure as calculated between p(5) and p(4) as a function of collector geometry and gap.

Figure 29. Effect of collector configuration and gap on p(6).

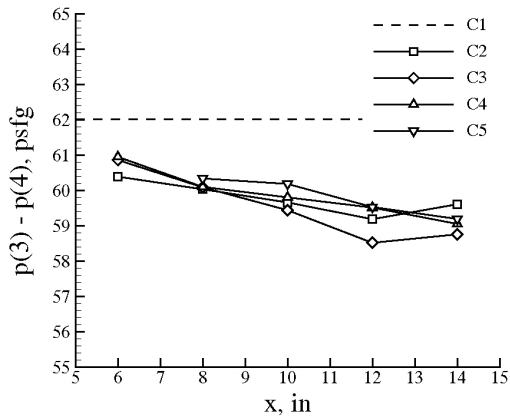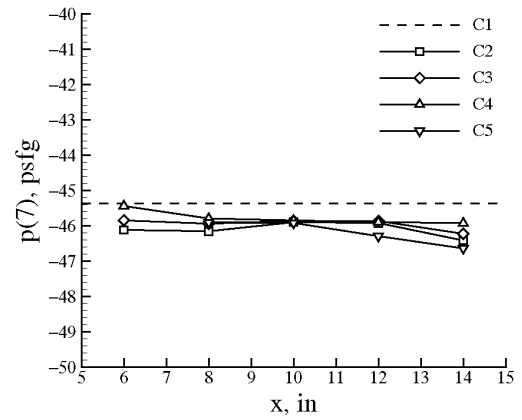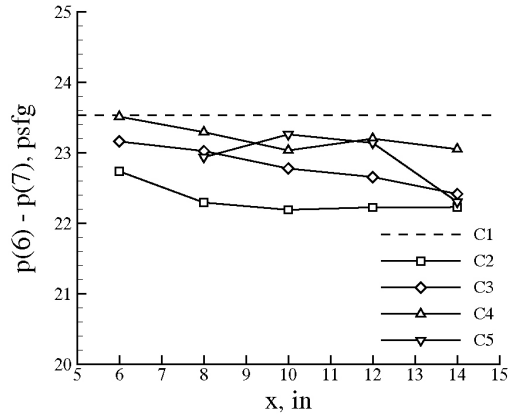Figure 30. Effect of collector configuration and gap on p(7).

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Figure 31. Effect of collector configuration and gap on pressure recovery in the high speed diffuser.
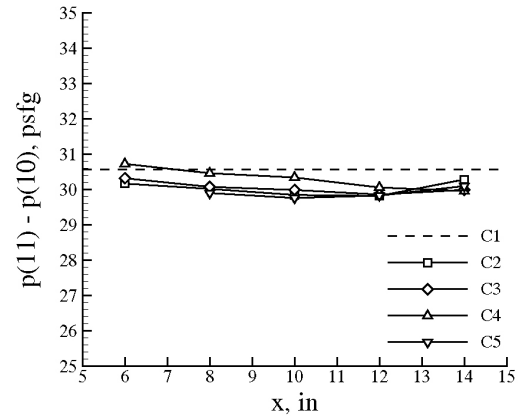

Figure 34. Effect of collector geometry and gap on pressure rise required for dynamic pressure shown in figures 27 and 28.
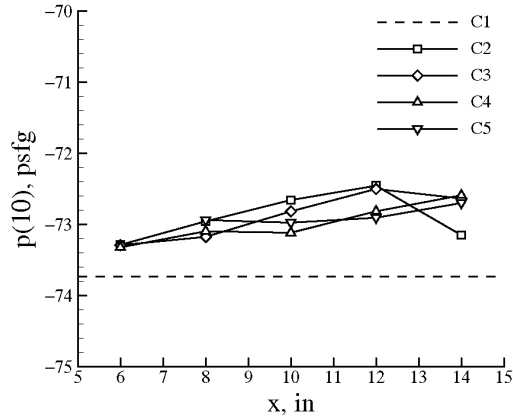

Figure 32. Effect of collector configuration and gap on p(10).
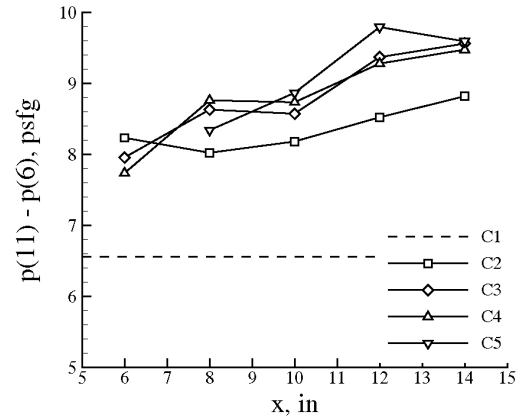

Figure 35. Effect of collector configuration and gap on pressure recovery from the diffuser entrance to the fan section.
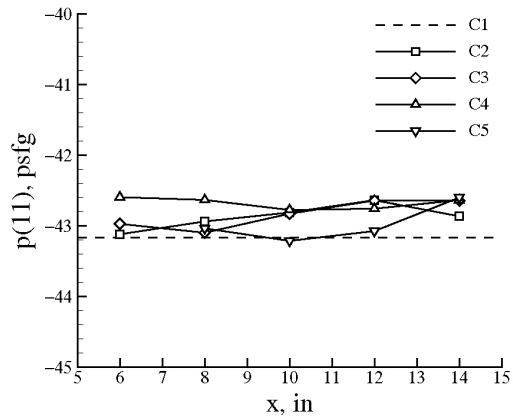

Figure 33. Effect of collector configuration and gap on p(11).

REPORT DOCUMENTATION PAGE		Form Approved OMB No. 0704-0188

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1. REPORT DATE (DD-MM-YYYY) 01- 03 - 2005	2. REPORT TYPE Technical Memorandum	3. DATES COVERED (From - To)

4. TITLE AND SUBTITLE Model-Scale Aerodynamic Performance Testing of Proposed Modifications to the NASA Langley Low Speed Aeroacoustic Wind Tunnel	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S) Booth, Earl R., Jr.; and Coston, Calvin W., Jr.	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER 23-781-30-12

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) NASA Langley Research Center Hampton University Hampton, VA 23681-2199 Hampton, Virginia 23668	8. PERFORMING ORGANIZATION REPORT NUMBER L-19093

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Washington, DC 20546-0001	10. SPONSOR/MONITOR'S ACRONYM(S) NASA
	11. SPONSOR/MONITOR'S REPORT NUMBER(S) NASA/TM-2005-213534

12. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified - Unlimited Subject Category 71 Availability: NASA CASI (301) 621-0390

13. SUPPLEMENTARY NOTES
Booth: Langley Research Center; Coston: Hampton University An electronic version can be found at http://ntrs.nasa.gov

14. ABSTRACT
Tests were performed on a 1/20th-scale model of the Low Speed Aeroacoustic Wind Tunnel to determine the performance effects of insertion of acoustic baffles in the tunnel inlet, replacement of the existing collector with a new collector design in the open jet test section, and addition of flow splitters to the acoustic baffle section downstream of the test section. As expected, the inlet baffles caused a reduction in facility performance. About half of the performance loss was recovered by addition the flow splitters to the downstream baffles. All collectors tested reduced facility performance. However, test chamber recirculation flow was reduced by the new collector designs and shielding of some of the microphones was reduced owing to the smaller size of the new collector. Overall performance loss in the facility is expected to be a 5 percent top flow speed reduction, but the facility will meet OSHA limits for external noise levels and recirculation in the test section will be reduced.

15. SUBJECT TERMS
Jet noise testing; Model-scale facility performance; Wind tunnel performance

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON STI Help Desk (email: help@sti.nasa.gov)
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include area code)
U	U	U	UU	21	(301) 621-0390

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