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Cassini/Titan IV Acoustic Blanket Development and Testing

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CASSINI/TITAN IV ACOUSTIC BLANKET DEVELOPMENT AND TESTING

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BIOGRAPHY

William O. Hughes develops and directs the launch vehicle vibroacoustic environment activities at NASA Lewis Research Center. He has defined acoustics and vibration requirements, specifications and test plans for over 10 years. Mr. Hughes previously worked at Analex Corporation, U.S. Steel Research and Raytheon. He received his B.S. (1977) in Physics from Penn State University and his M.E. (1981) in Mechanical Engineering from Carnegie-Mellon University.

Anne M. McNelis is a structural dynamics engineer at NASA Lewis Research Center. For the past three years, she has performed vibroacoustic analysis to develop acoustic and random vibration test specifications. Ms. McNelis previously worked for Bailey Controls Company. Her B.S. degree is in Systems and Control Engineering from Case Western Reserve University.

ABSTRACT

NASA Lewis Research Center recently led a multi-organizational effort to develop and test verify new acoustic blankets. These blankets support NASA's goal in reducing the Titan IV payload fairing internal acoustic environment to allowable levels for the Cassini spacecraft. To accomplish this goal a two phase acoustic test program was utilized. Phase One consisted of testing numerous blanket designs in a flat panel configuration. Phase Two consisted of testing the most promising designs out of Phase One in a full scale cylindrical payload fairing. This paper will summarize this highly successful test program by providing the rationale and results for each test phase, the impacts of this testing on the Cassini mission, as well as providing some general information on blanket designs.

KEYWORDS

Acoustics, Acoustic Blankets, Blankets, Cassini, Payload Fairing, Spacecraft Acoustic Environment, Spacecraft Acoustic Testing, Titan IV, Vibroacoustics

INTRODUCTION

New and improved acoustic blankets were recently developed and tested to support NASA's Cassini mission. Acoustic blankets are utilized in the payload fairing (PLF) of expendable launch vehicles (ELVs) to reduce the fairing's interior acoustics and the subsequent vibration response of the spacecraft and its components.

The Cassini spacecraft will be launched in October 1997, by a Titan IV/Centaur launch vehicle, to explore Saturn and its moons. The electric power source for the Cassini mission are three mission critical Radioisotope Thermoelectric Generators (RTGs). The RTG design was previously vibration qualified for the Space Shuttle launch environment and utilized on the Galileo and Ulysses spacecraft missions.

However analysts at the Jet Propulsion Laboratory (JPL), the spacecraft designer, predicted that acoustically driven vibration levels for the Cassini RTGs would exceed the RTGs' previous qualification vibration levels. This exceedence is primarily due to RTG mounting differences along with differences in the launch vehicle and spacecraft.

To avoid an extremely costly requalification of the RTGs, a major acoustic blanket development and test effort was initiated and funded by NASA Lewis Research Center (LeRC), the launch vehicle integrator for the Cassini mission. If successful, the new acoustic blankets would provide a lower acoustic and vibration environment for the Cassini's RTGs than the environment obtained when using the standard Titan IV acoustic blankets.

Besides NASA LeRC and JPL, other organizations involved in this joint effort included Lockheed Martin Astronautics (LMA, formerly Martin Marietta Technologies Incorporated, MMTI), McDonnell Douglas Aerospace (MDA), Aerospace Corporation, Analex Corporation, Cambridge Collaborative Incorporated and the Riverbank Acoustical Laboratory (RAL).

ACOUSTIC TEST PROGRAM OVERVIEW

Acoustic blanket design technology for aerospace applications has seen little development in the past twenty-five years. Developing an acoustic blanket to meet the needs of the Cassini mission necessitated developing advanced blanket technology. Not only did the blanket have to reduce the acoustic field significantly, but it had to do so in the difficult frequency range of 200 to 250 Hz. Typically acoustic blankets are most effective at frequencies of 400 Hz and above.

Specifically, our goal was to design and test a new acoustic blanket which would reduce the expected acoustic environment for the Cassini RTGs by 3 dB at 200 and 250 Hz, when compared with the baseline Titan IV blanket system environment.

The approach taken was to develop a two-phase acoustic test program that would provide confidence that the new blanket would result in an optimal, feasible system that had a high probability of performing well in the flight configuration.

Phase One consisted of evaluating new blanket designs by acoustic testing of flat panel blanket samples. Flat panel testing had the advantage that numerous designs could be quickly evaluated at a relatively low cost. By proper interpretation of the absorption and transmission loss test data obtained, the leading candidate designs could then be chosen for further testing in Phase Two.

Phase Two would test the leading candidate blanket designs and the baseline Titan IV blanket design in a full scale cylindrical payload fairing. Although this type of testing is expensive, the effect of the blankets on reducing the PLF's interior acoustics would be measured with the appropriate flight-like boundary conditions and geometry, for only the few promising candidates.

This two phase test approach was chosen because it was considered inadvisable and risky to test an unproven new design in an expensive full scale test. Likewise the geometry and size of the flight payload fairing made it unwise to base blanket selection solely on the basis of testing of flat panel samples.

The two phase test program which was followed is illustrated in flow-chart format in Figure 1.

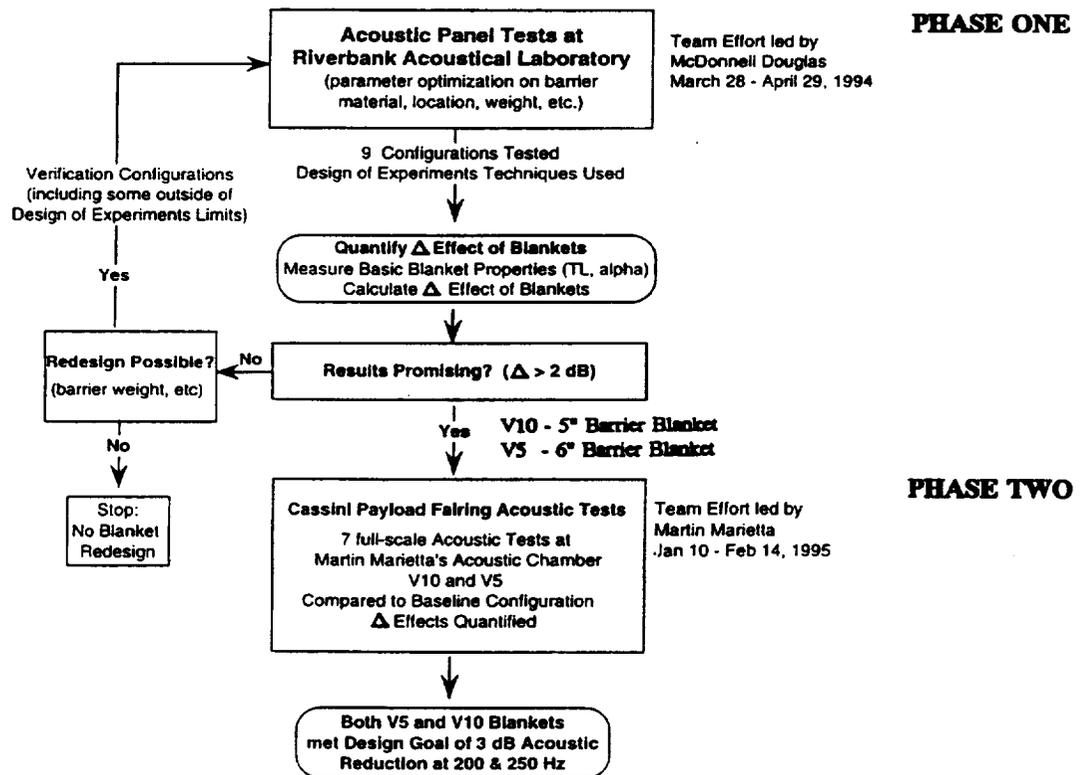


Figure 1. Overview of the Two Phase Acoustic Blanket Test Program

FLAT PANEL TESTING DEVELOPMENTAL SERIES OVERVIEW

The testing of the new blanket designs in a flat panel configuration occurred in March-April 1994 at the Riverbank Acoustical Laboratory (RAL), Geneva, Illinois. Absorption values for the blankets were obtained from reverberation time tests per ASTM C423. Blanket transmission loss (TL) values were obtained from testing per ASTM E90. Figure 2 illustrates the TL test configuration. Utilizing the absorption and TL test data, analytical predictions were made to calculate the effect of each new blanket design in reducing the PLF's interior acoustics, at the frequencies of interest.

A total of 19 different blankets (18 new designs and the Titan IV baseline blanket) were tested for absorption and TL characteristics. These designs are illustrated in Figure 3. Additionally, a isogrid panel sample, from a Titan IV PLF wall, had its TL measured separately and was also used for all the blanket TL testing. (The Titan IV PLF is a cylindrical aluminum isogrid structure, consisting of a geometric pattern of machined out triangular pockets.) Each blanket tested was an 8 foot by 9 foot rectangular sample. As a material constraint, all blanket materials utilized in the new designs had to be already qualified for spaceflight.

Testing was divided into two series of tests known as the development tests and the verification tests. The development test series will be explained first. As part of the development tests, the isogrid panel and the Titan IV baseline blanket were tested. Also the Design of Experiments (DOE) technique was utilized to maximize the amount of meaningful test information while running a minimum number of tests. From this DOE technique it was expected that one could determine the influence of various factors on the response and determine which combination of these factors would optimize the response. Each development test was run twice to check for reasonable measurement repeatability and insure that the test was recording meaningful data and not just background variation.

The Titan IV baseline blanket is 3 inches thick, with a 0.6 pounds per cubic foot density fiberglass batting, with no internal barrier. It was believed that blanket improvements could be obtained by optimizing both the absorption (i.e. thicker blanket) and TL (i.e. heavier blanket) characteristics for our Cassini mission critical frequencies of 200 - 250 Hz. Therefore in order to reach our acoustic goal either a thicker (four inches) blanket and/or a blanket with an internal barrier would be needed.

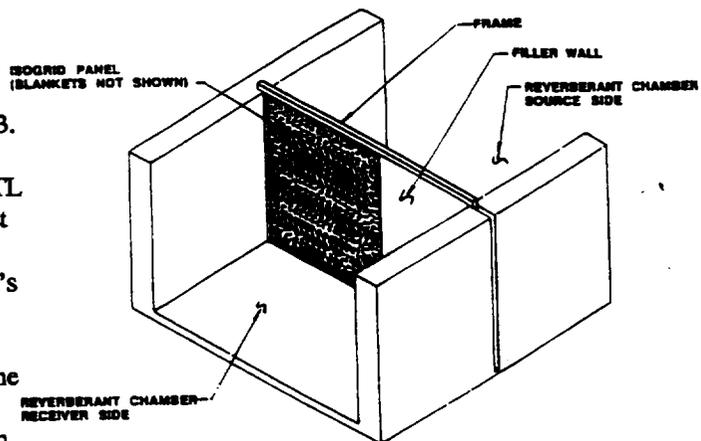


Figure 2. Transmission Loss Test Configuration for Flat Panel Testing (Chamber walls are cut away to show isogrid panel and filler wall) (From Reference 1.)

The DOE part of the development tests looked at three main parameters of a 4 inch thick blanket design. First, the density of the blanket's fiberglass batting was varied from 0.6 to 2.4 pounds per cubic foot (pcf). Second, the density of the internal barrier was varied from 0.0 (no internal barrier) to 0.44 pounds per square foot (psf). Third, the location of the internal barrier was varied from 0 to 3 inches from the isogrid panel.

FLAT PANEL TESTING DEVELOPMENTAL SERIES RESULTS

The results from the developmental test series were surprising and somewhat disappointing. With regards to the absorption data it was discovered that the Titan IV baseline blanket was already optimized for our frequencies of interest. The absorption peak of the Titan IV baseline blanket was previously thought to occur between 400 and 500 Hz. The flat panel test of the baseline blanket showed this peak to be at 250 Hz. Increasing the blanket (batting) thickness, such as in DOE 1, improved the absorption at 125 Hz, but actually made the absorption worse at 200 - 250 Hz, as shown by Figure 4. Thus our new intent was to try to keep our baseline blanket absorption values and to reach our goal by increasing the TL at 250 Hz.

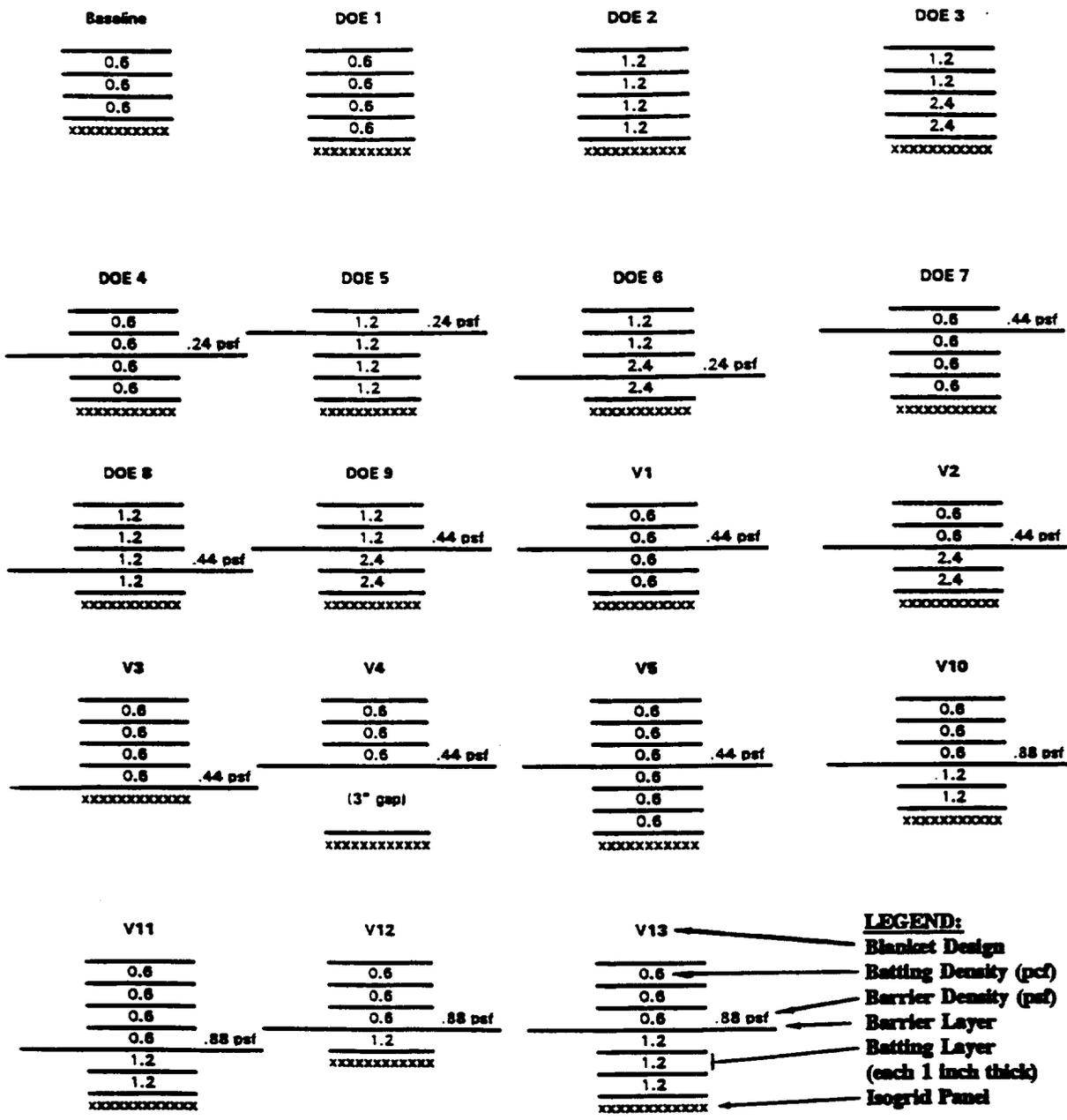


Figure 3. Blanket Designs Tested in Phase One

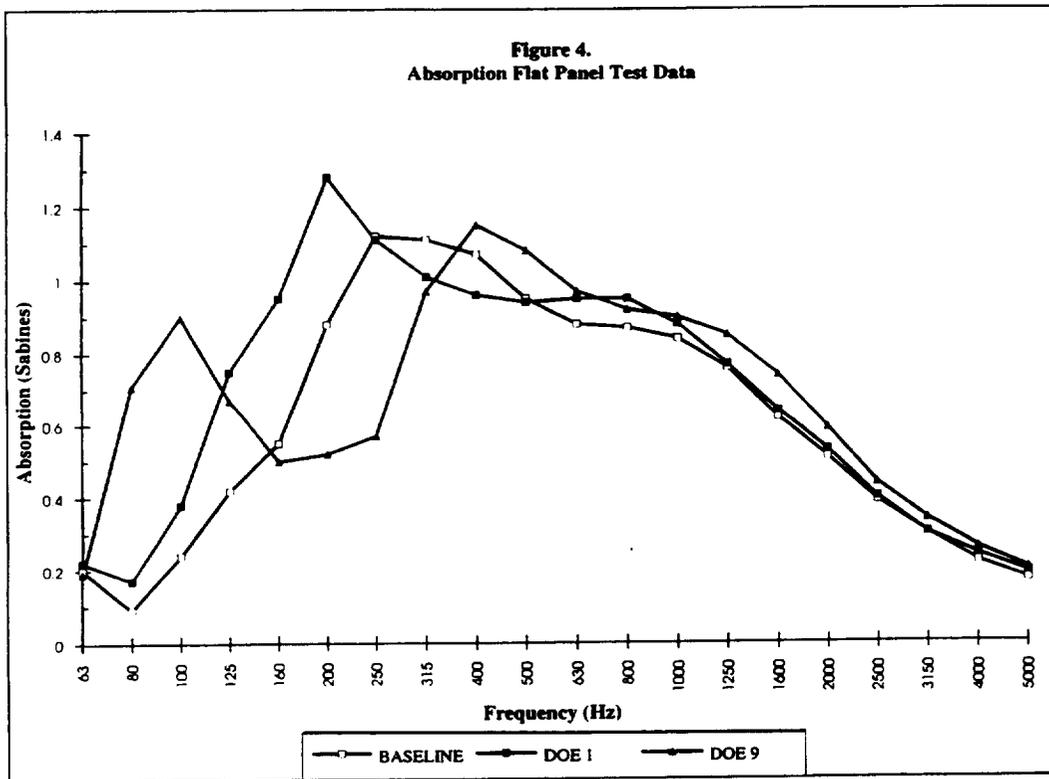
FLAT PANEL TESTING VERIFICATION SERIES OVERVIEW

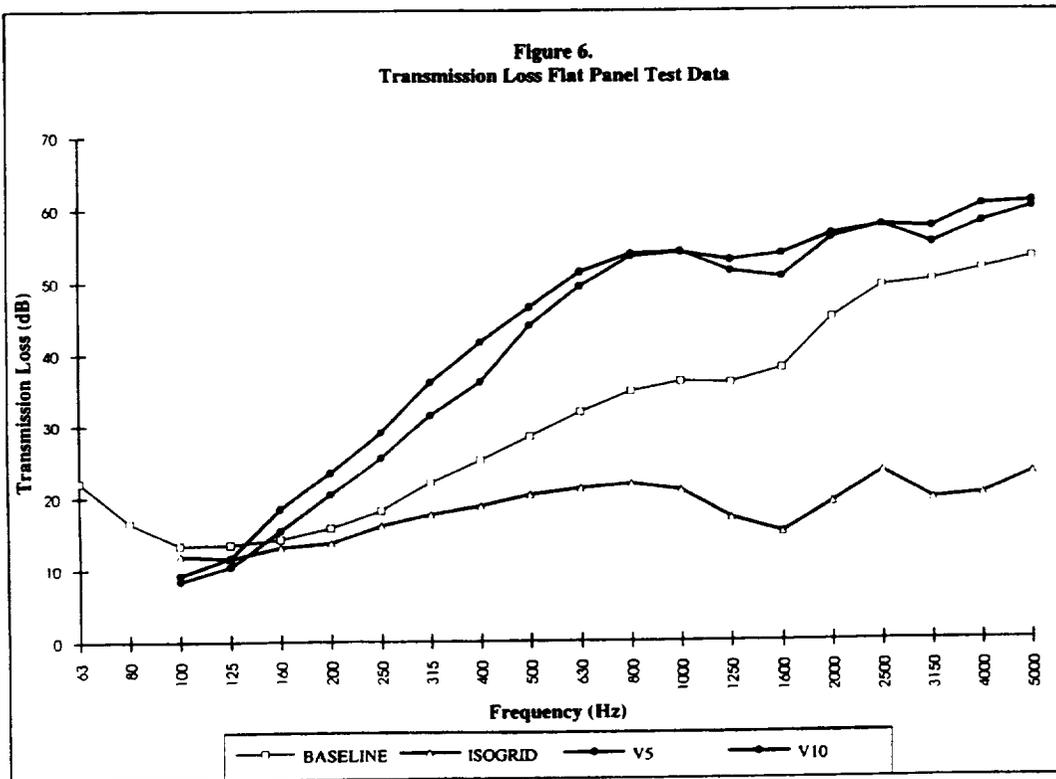
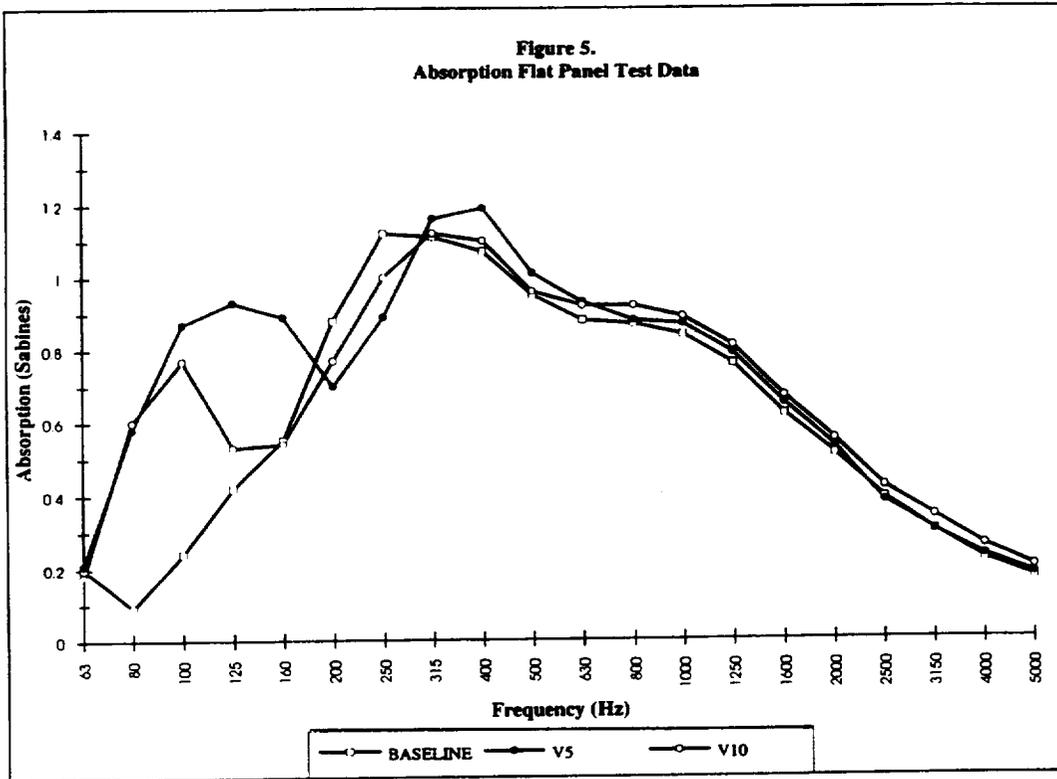
To maintain this baseline absorption required a minimum of 3 inches of fiberglass batting on the inboard side (side opposite PLF isogrid wall) of the barrier. The presence of an internal barrier not only increases the TL but it affects the blanket absorption characteristics by creating a double peak (and a valley between the peaks) in the absorption spectrum. Thus it also became important to avoid shifting the absorption valley into the critical frequency range of interest. Figure 4 illustrates these points.

With regards to TL, it was found that the barrier needed to be either heavier or placed further away from the PLF isogrid wall. Analysis of the test data showed that a 4 inch blanket would not meet our goals. Both the absorption and TL required significant thickness and therefore even thicker blankets would be needed to reach our goal.

The original intent of the verification series was to test verify the optimum blanket candidates as identified by the DOE technique. Although much useful information was obtained in the developmental series, there was no design tested which met our goals nor did the DOE analysis point to any combination of the tested blanket parameters which would meet our goals. The name "verification series" remained but this series now became an effort to use the previous test data to analytically brainstorm to a solution within the allowable budget, blanket materials and test facility time constraints.

A few verification blanket designs were tested with mixed, but non-satisfactory, results. As indicated earlier a thicker blanket would be needed. Relief came from the LMA Cassini Project Office who indicated that a 5 inch thick and even a 6 inch thick blanket would be allowable and still meet the necessary mission clearance requirements.





FLAT PANEL TESTING VERIFICATION SERIES RESULTS

Configuration V5 was the first 6 inch thick blanket tested. V5 also had a heavy internal barrier (0.44 psf) and was the first new blanket design which showed significant promise in meeting the original test goal.

Configuration V10 was the first test configuration to have the "super" heavy barrier (0.88 psf) and was 5 inches thick. Although this blanket would weigh about 6 times the Titan IV baseline blanket, this weight was allowed by the Cassini program.

Thinner (4 inches) and thicker (6 inches) variations of the super heavy barrier were also tested in configurations V12 and V11, V13 respectively.

From all 19 new blanket configurations tested, V10, V11 and V13 configurations, all with the super heavy barrier, were analyzed to reduce the PLF's acoustic the best at 200 - 250 Hz. V5 was the only configuration without the super heavy barrier which was analyzed to meet our goal.

Figure 5 illustrates the flat panel absorption test data for the Titan IV baseline, V5 and V10 blankets. Similarly, Figure 6 illustrates the TL test data for these same blankets and the isogrid panel by itself.

It should be noted that the impact of the increased TL values seen in the flat panel test results is severely lessened when predicting PLF acoustic noise reduction. This is because the flight PLF does not have 100% full blanket coverage, but is instead only partially covered to allow for access, doors, split rails, wiring harnesses, etc.

Using the measured absorption and TL flat panel test data, MDA performed acoustic analysis using their PLFNOISE software to predict the noise reduction which would be obtained for the Titan IV PLF with the appropriate flight blanket coverage. Based on this analysis, it was decided to choose V10 as the leading blanket candidate for further testing in the full scale PLF configuration. V5 was also chosen for this additional testing because its results also looked promising and its design (barrier weight) was significantly different from V10.

A complete summary of the flat panel test results may be found in Reference 1.

FULL SCALE PLF TESTING OVERVIEW

Having chosen the most promising blanket candidates (V10 and V5) out of Phase One testing, Phase Two testing could now begin. Phase Two testing was a full scale test series with a cylindrical PLF, which would simulate the flight boundary conditions and geometry. Phase Two testing occurred in January-February 1995 at LMA's Reverberant Acoustic Laboratory (RAL), Denver, Colorado.

The test hardware consisted of a 60 foot high section of a Titan IV PLF, along with a Cassini spacecraft simulator and a Centaur simulator. The lower portion of the spacecraft simulator was a high fidelity developmental test model (DTM) supplied by JPL. Included in this was one RTG dynamic simulator and two RTG mass simulators. The upper portion of the spacecraft simulator and the large High Gain Antenna (HGA) at the top of the spacecraft were simulators provided by LMA to represent the proper geometry and volume effects. Figure 7 is a photograph which shows the Cassini spacecraft simulator and the aft section of the Titan IV PLF in LMA's acoustic chamber. Figure 8 is a photograph which shows the acoustic blankets mounted on the interior isogrid wall of the Titan IV PLF.

Phase Two testing consisted of a series of seven acoustic tests to determine the acoustic environment and the RTG vibration environment for three different blanket configurations (3" baseline, 5" V10 and 6" V5). Figure 9 shows the test matrix.

In the test matrix, the term "full coverage" does not imply 100% blanket coverage but is meant to convey that the tested configuration had similar blanket coverage to that expected for the actual Cassini flight. Partial coverage was a test condition equal to 75% of the full coverage. Two partial coverage tests were done, one for the baseline and one for a barrier blanket, to improve our understanding and prediction of the effects of blanket coverage on the PLF's interior acoustics. The results of these tests are outside the scope of this paper.

The test matrix also shows testing with and without TVAs. TVAs are tuned vibration absorbers which were attached to the lower portion of the spacecraft in an attempt by JPL to reduce the vibration of the RTGs. Again these results are outside this paper's scope of interest, however JPL's Cassini program office has decided not to utilize the TVA design for the Cassini flight.

**Figure 7. Cassini Spacecraft Simulator in Aft Section of Titan IV PLF
(From Reference 2.)**

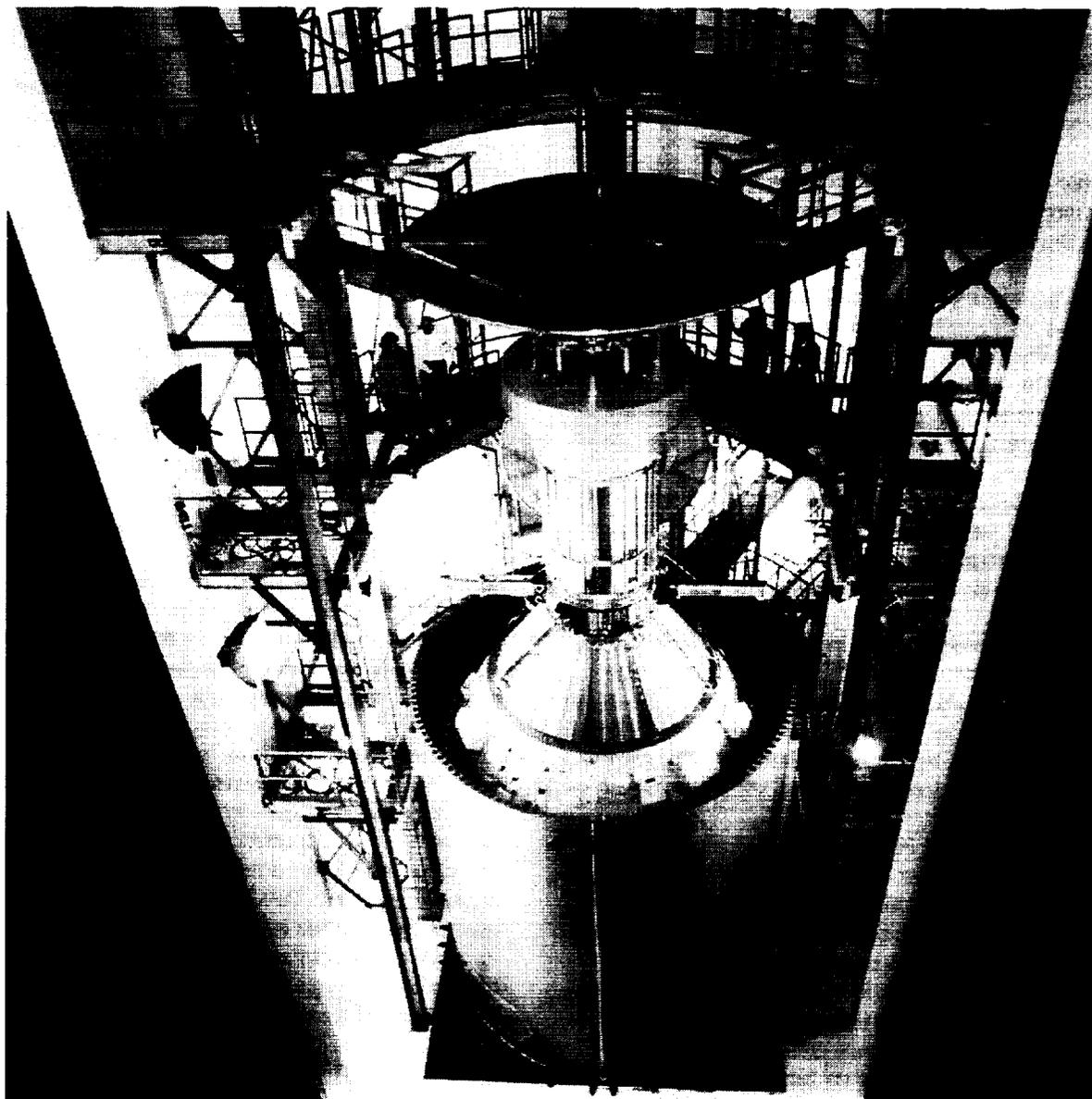
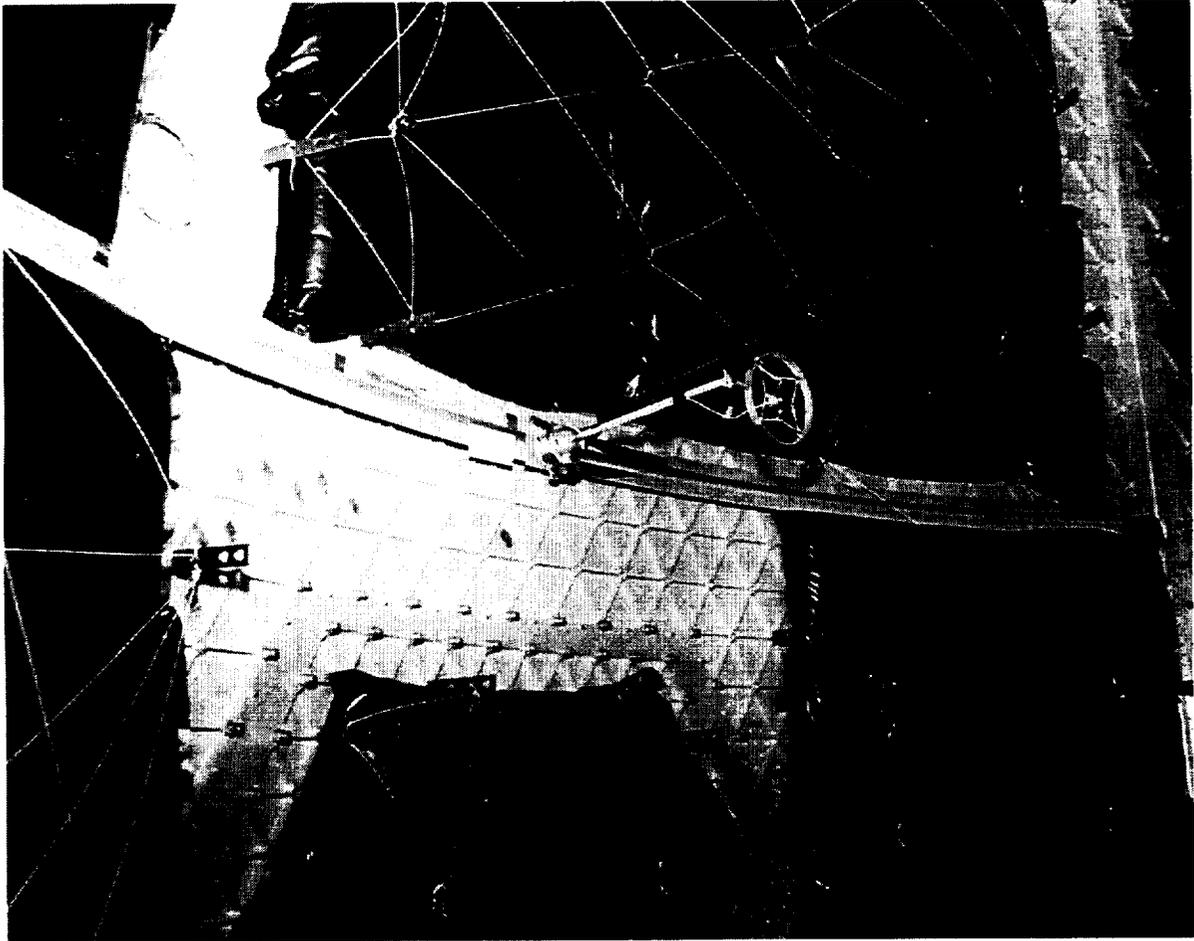


Figure 8. Interior View of Acoustic Blankets Mounted on Titan IV PLF's Isogrid Wall (From Reference 2.)



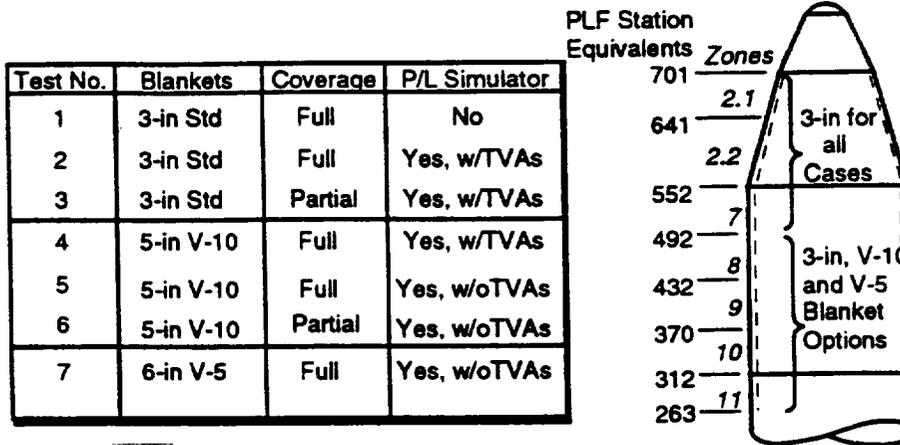


Figure 9. Test Matrix for Full Scale PLF Testing (From Reference 2.)

The Phase Two test program was designed to measure the delta effect of the environments using new barrier blankets when compared to the environment using the baseline blankets. Since the reverberant acoustic field of the test chamber is different than the traveling acoustic wave at a launch pad, it was felt that delta measurements would be most meaningful as opposed to the absolute measurements.

To properly quantify this delta effect a number of microphones were utilized to measure the PLF's interior acoustic field, as shown in Figure 10. A large number of these microphones were located in Zones 9 and 10 of the PLF, which was the region of high interest for the RTGs. Other microphones were located to measure the acoustic field in other zones of the PLF and to reflect past and future Titan IV flight locations and past test locations by JPL. One of the microphones is visible in Figure 8. A small number of accelerometers were mounted on the simulators to ensure that the simulators were behaving normally. Although not shown here, JPL and MDA also had a large amount of instrumentation to measure the vibration response of the Cassini spacecraft and PLF respectively.

FULL SCALE PLF TESTING RESULTS

The results from the full scale PLF testing were very successful. Referring again to the test matrix of Figure 9, the key tests were Tests 2, 4 and 7. Test 2 established the baseline measurements using the Titan IV baseline blanket, whereas Tests 4 and 7 would allow the calculation of the delta effect of the new blanket designs above the baseline. (Tests 4 and 5 are essentially repeats from an acoustic point of view. The

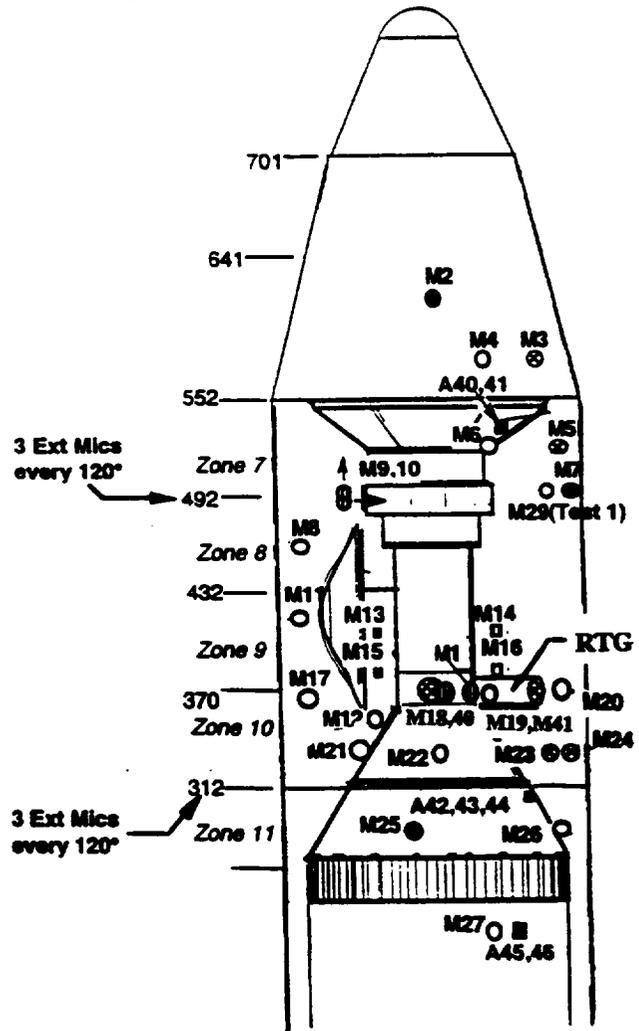


Figure 10. Full Scale PLF Test Instrumentation (From Reference 2.)

presence of the TVAs might affect the spacecraft vibration response but does not affect the PLF's interior acoustics. Tests 1 and 2 were used to confirm that the presence of the spacecraft simulator did not cause anything abnormal to occur within the PLF.)

The acoustic excitation on the external side of the PLF simulated the Titan IV flight external specification and was based on the average of six control microphones. The test to test repeatability of this external excitation was extremely good (range of 0.4 dB over all 7 tests at 200 and 250 Hz). However to account for even these small variations all test data was adjusted to represent the level which would be obtained if the acoustic excitation was exactly the Titan IV external specification.

Figure 11 illustrates the main results of Phase Two testing. The external specification is the desired PLF external specification. Test 2 data shows the average of 10 microphones in zones 9 and 10. This represents the average PLF interior level in the RTG region when the Titan IV baseline blankets are utilized. Similarly the Test 4 and Test 7 data represent the same microphone average when the V10 and V5 blankets are substituted for the baseline blankets in zones 8, 9, 10 and 11. From Figure 11 one can see that the new blankets were very successful in reducing the PLF interior acoustics to

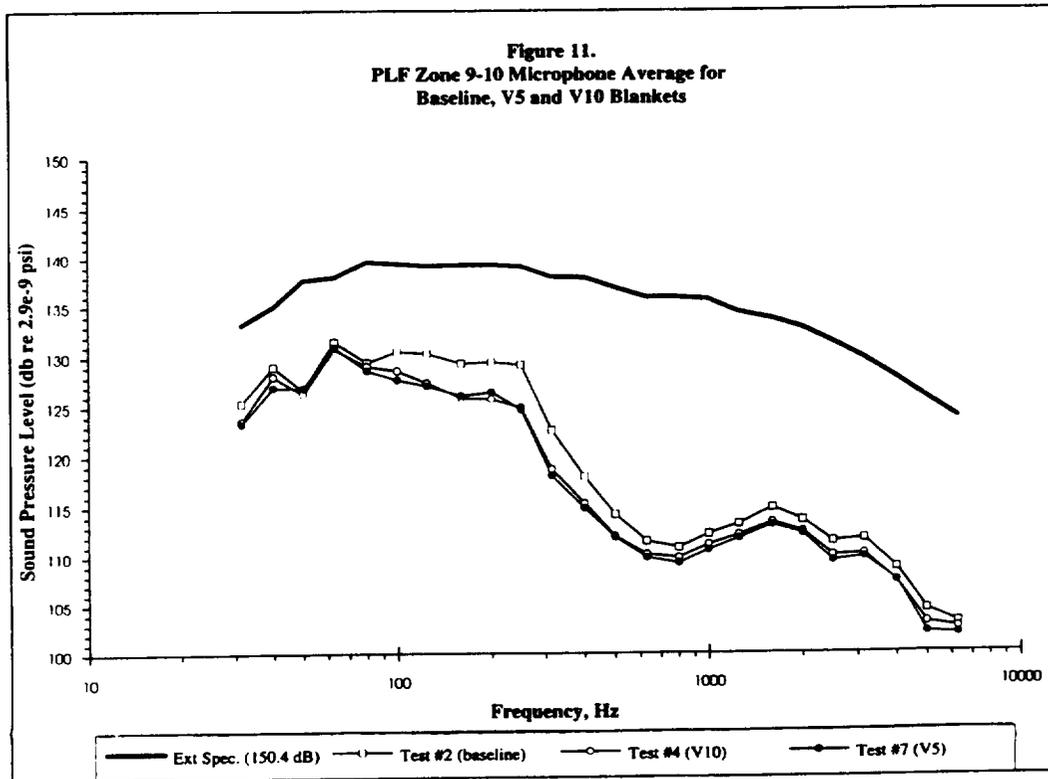
levels below those provided by the baseline blankets. Also whereas this improvement is largest at 200 to 400 Hz, it is a positive improvement at all frequencies.

Figure 12 illustrates the delta improvement for the V10 and V5 blankets. This figure shows that both the V10 and the V5 blankets were successful in reducing the RTG acoustic environment by 3 dB at 200 and 250 Hz. For the V10 blanket this improvement is 3.5 dB at 200 Hz and 4.0 dB at 250 Hz. For the V5 blanket the improvement is 3.2 dB at 200 Hz and 4.6 dB at 250 Hz.

Similar values are reached when the test data is evaluated at the P95/50 statistical levels, instead of at the mean value.

Of course, the ultimate goal was to reduce the RTG vibration response to prevent a vibration requalification test of the RTG. The analysis of the RTG response is outside the scope of this paper, but an indication of the vibration reduction achieved is shown in Figure 13. This figure shows the acceleration PSD (power spectral density) response at the base of the RTG dynamic simulator for the baseline blanket and for the (6") V5 blanket. One can see substantial improvement, particularly in the 200 and 250 Hz frequencies.

A complete summary of the full scale cylindrical PLF testing may be found in References 2 and 3.



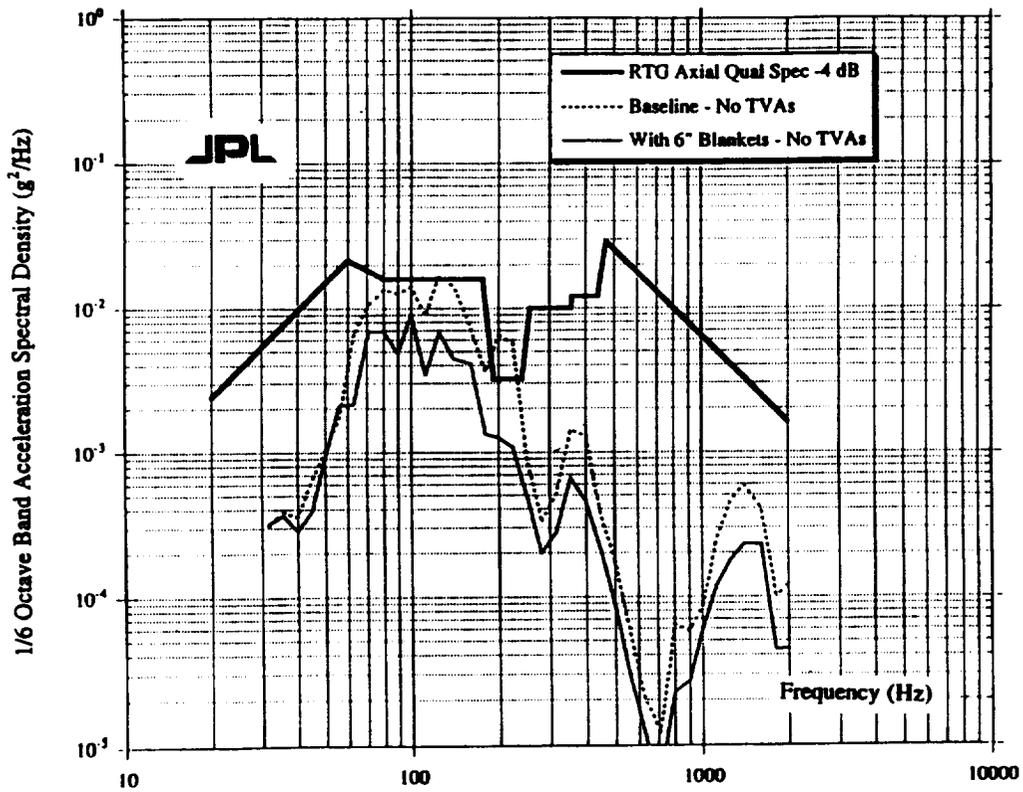
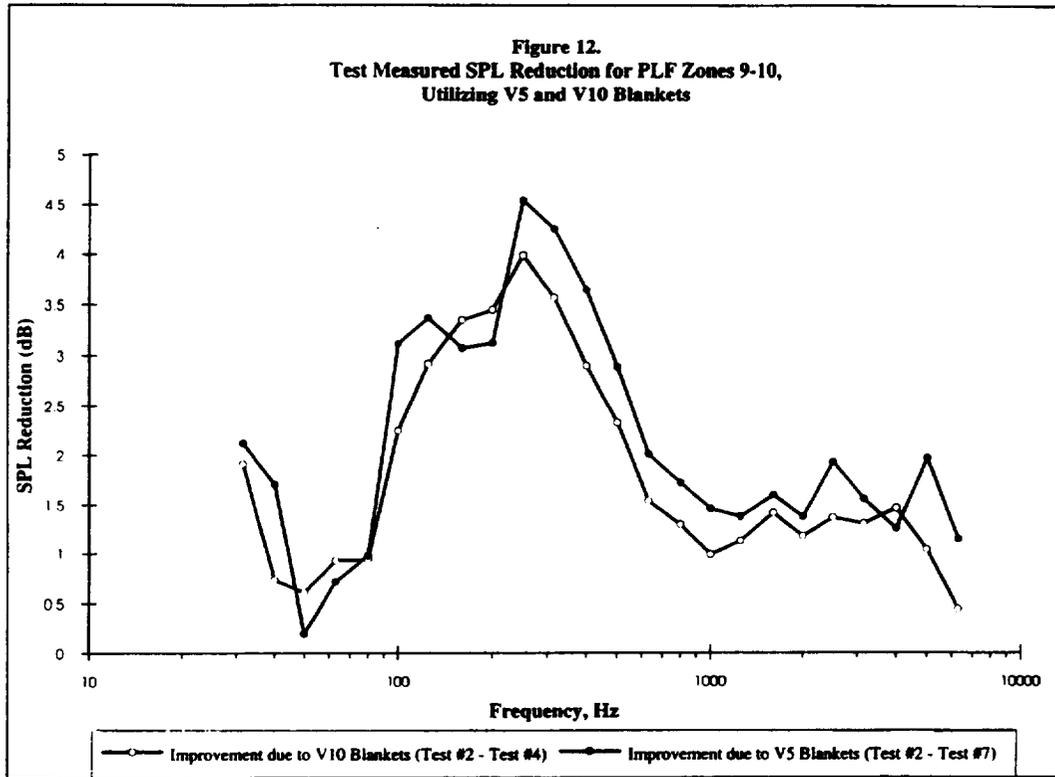


Figure 13. Axial Vibration Reduction Measured at RTG Base (From Reference 3.)

BLANKET SELECTION FOR CASSINI MISSION

The technical assessment of the Phase Two test data is that both of the new barrier blankets (V5 and V10) exceeded the goal of reducing the acoustic environment by more than 3 dB and significantly reduced the RTG vibration response, at the 200 and 250 Hz critical frequencies. No detrimental effects were seen at any frequency or in other PLF zones.

The technical assessment of the test data is also that both of the new barrier blankets had similar acoustic performances and that other programmatic considerations could lead to the selection of the final blanket design for the Cassini mission.

NASA LeRC's Cassini Project Office has selected the V5 (6" thick blankets) for the upcoming Cassini mission. Factors weighed in the decision, in addition to the acoustic improvement, were the added weight of the barrier blanket systems, and contamination, separation, thermal, venting, and clearance factors. With most of these considerations being near equal, the weight of the blanket system became the deciding factor and the "lighter" V5 blanket was chosen over the heavier V10 blanket. The V5 blanket is still approximately four times the weight of the Titan IV baseline blanket.

Because of the success of this blanket developmental test program, vibration requalification of the RTGs for the Cassini mission will not be necessary. The utilization of the new V5 blankets to reduce the acoustic excitation and the subsequent vibration of the RTGs eliminates the need to manufacture additional RTG units for a requalification test program, thus saving approximately \$20-25 million in manufacturing cost and \$5 million in testing cost.

LESSONS LEARNED

The two phase test approach used to solve the Cassini mission's problem was extremely successful. Numerous candidates were quickly evaluated in the flat panel testing and when they were found to be unsatisfactory, additional candidates outside the original limits were found to be promising. These promising candidates were then tested in the full scale PLF testing and found to exceed the original goals of the blanket test program. If the initial proposed new blankets were not first tested as flat panel samples but instead tested only in the full scale test and there found to be unsatisfactory, a large amount of time, money and effort would have been wasted in performing the full scale tests on these blankets.

Knowing that there is a difference between a small flat panel sample and a flight cylindrical PLF, is it possible to use the results from a flat panel test to predict the results in a full scale PLF test?

Analytical software codes, such as PLFNOISE and VAPEPS, can predict acoustic levels within the PLF using the blanket characteristics along with the PLF structural and geometric properties. To obtain even quicker predictions during the flat panel testing, a relatively simple method was developed by Cambridge Collaborative and NASA LeRC. This method enables one to predict the delta improvement of a new blanket design over a baseline blanket design for a PLF configuration using the flat panel sample test data.

Using dynamic power balance and assuming steady state conditions and that the energy absorbed by the blanket is much greater than the energy absorbed by the unblanketed PLF isogrid wall and by the spacecraft, then the following equation can be derived:

$$\Delta_{\text{Improvement (dB)}} = 10 \log_{10} \left(\frac{\alpha_{\text{new blanket}}}{\alpha_{\text{baseline blanket}}} \right) + 10 \log_{10} \left(\frac{\tau_{\text{baseline blanket}} + \frac{1-S^*}{S^*}}{\tau_{\text{new blanket}} + \frac{1-S^*}{S^*}} \right)$$

where,

Δ = Improvement (dB) of New Blanket above Baseline Blanket
 α = Measured Blanket Absorption Coefficient

τ = Blanket Transmission Coefficient = $10^{\left(\frac{-\Delta_{TL}}{10}\right)}$

Δ_{TL} = Measured Transmission Loss (dB)

Δ_{TL} = TL of Blanket with PLF Isogrid - TL of PLF Isogrid

$S^* = \left(\frac{\text{Blanketed Surface Area for PLF}}{\text{Total Surface Area for PLF}} \right)$

This equation also assumes that no acoustic energy is lost structurally through damping or vibration mechanisms and that the power balance is valid within each frequency band.

The delta improvement is due to two factors. The first factor is the change due to the new absorption characteristics. The second factor is the change due to the new transmission loss characteristics. As stated earlier, in developing the new Cassini blanket, we had to minimize our decrease in the first factor (keep the baseline absorption) and maximize our increase in the second factor (increase transmission loss).

The measured data from the flat panel tests for the Titan IV baseline, V5 and V10 blankets can be used with this equation to predict the improvement expected for V5 and V10 blankets. This prediction can then be compared with the actual improvement (SPL reduction) measured in the full scale PLF tests for the V5 and V10 blankets in the PLF zones 9 - 10.

Figure 14 shows the predicted versus test data improvement over the baseline blanket for the V5 blanket. In this case, the prediction methodology results in an underprediction at all frequencies. The shape of the prediction spectrum does follow the actual test spectrum well, with both the predicted and actual test data peaking at 250 Hz.

A similar comparison for the improvement due to the V10 blanket is shown in Figure 15. This comparison is better, however now the prediction tends to be a slight overprediction at the frequencies of greatest interest (200-250 Hz). Again, the shape of the prediction spectrum follows the actual test spectrum well, with both spectrums peaking at 250 Hz.

It is not clearly understood why the prediction methodology results in an underprediction for V5 and an overprediction for V10. The answer may lie in the inherent assumptions of the methodology. Or it may be because the V10 blanket results depend more on the transmission loss factor than the V5 blanket results and that the flanking paths may have differed slightly in the Phase One and Phase Two test setups.

Nevertheless these comparisons, showing reasonable magnitude and frequency correlation with test data, gives us confidence that this prediction methodology may be used to give a first order approximation on how a blanket design would perform in a full scale PLF test.

PREDICTING BLANKET PERFORMANCE

All predictions given are delta improvements above the Titan IV baseline blanket (3 inches thick, with no barrier). That is, the interior acoustics (sound pressure level, SPL) of the PLF will be reduced when the predicted delta improvement is positive.

Figure 16 shows the effect of increasing the blanket batting thickness and introducing a barrier that is centered in the blanket. Refer to Figure 3 for details of the blanket designs. The DOE 1 curve shows that adding one more inch (4 inches) of batting results in a small improvement. A 0.24 psf barrier has been introduced in this 4 inch thick blanket in DOE 4. This results in an improvement around 500 Hz, but is actually less than DOE 1 (no barrier) below 315 Hz. Increasing the barrier density up to 0.44 psf for the 4 inch thick blanket further improves the blanket performance as shown by the V1 prediction. Finally, for V5, the barrier remains 0.44 psf, but now the blanket thickness is 6 inches, with 1 inch being added on each side of the barrier. This helps improve both the absorption and transmission loss and results in substantial improvement.

Figure 17 shows the effect of the location of the barrier. The V1 curve shows the prediction when the 0.44 psf barrier is centered in the 4 inch blanket. Moving the 0.44 psf barrier one inch toward the PLF's interior, results in the prediction given by the DOE 7 curve. Some increase in transmission loss is more than offset by the reduction in absorption for this design from 225 to 630 Hz. The curve predicted for when the 0.44 psf barrier is moved one inch outward toward the PLF isogrid wall is shown in the DOE 8 curve. (The batting density has also changed.) At the frequencies of interest (200 - 250 Hz) the transmission loss factor is now significantly smaller and the increase of the absorption does not overcome this, resulting in a negative change. If the barrier is left in this position but is made heavier (0.88 psf) the transmission loss factor improves and the absorption factor remains the same. This is shown in the V12 prediction curve. (Again, the batting density has changed.)

The flat panel test data obtained in Phase One testing is valuable information. The prediction methodology illustrated in this section is one way of using this data to understand some of the concepts of blanket design which were learned during this program.

For all the blanket predictions, the flat panel data presented in Reference 1 are used. When a blanket was

Figure 14.
Predicted versus Test Measured SPL Reduction for PLF Zones 9-10, Utilizing V5 Blankets.

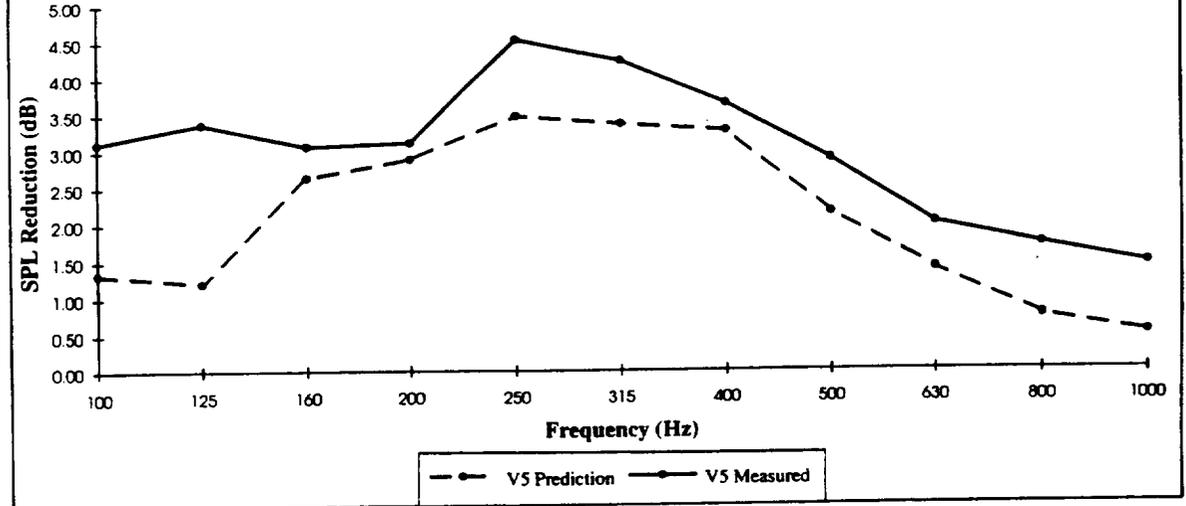
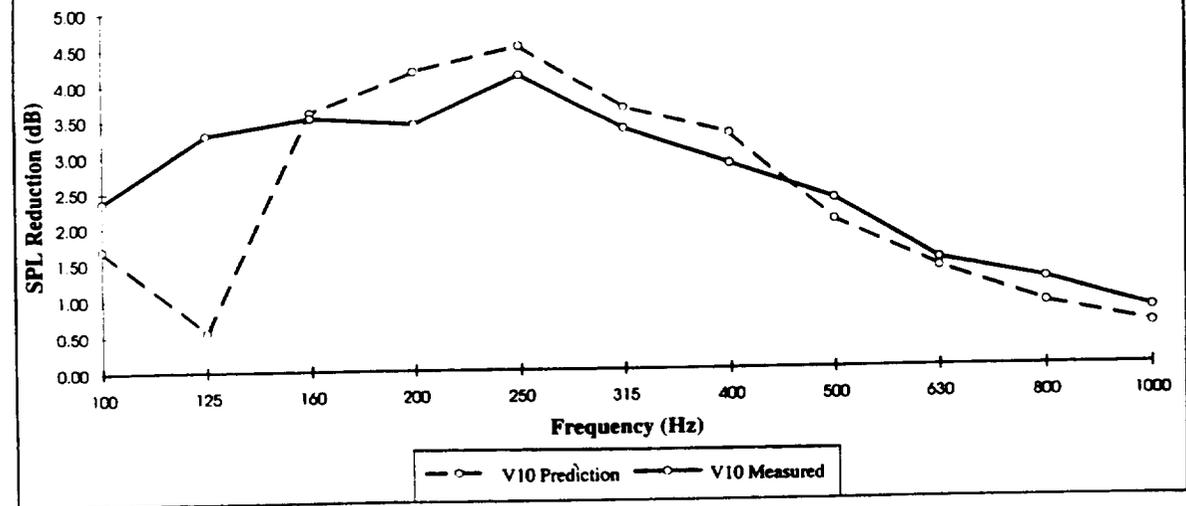
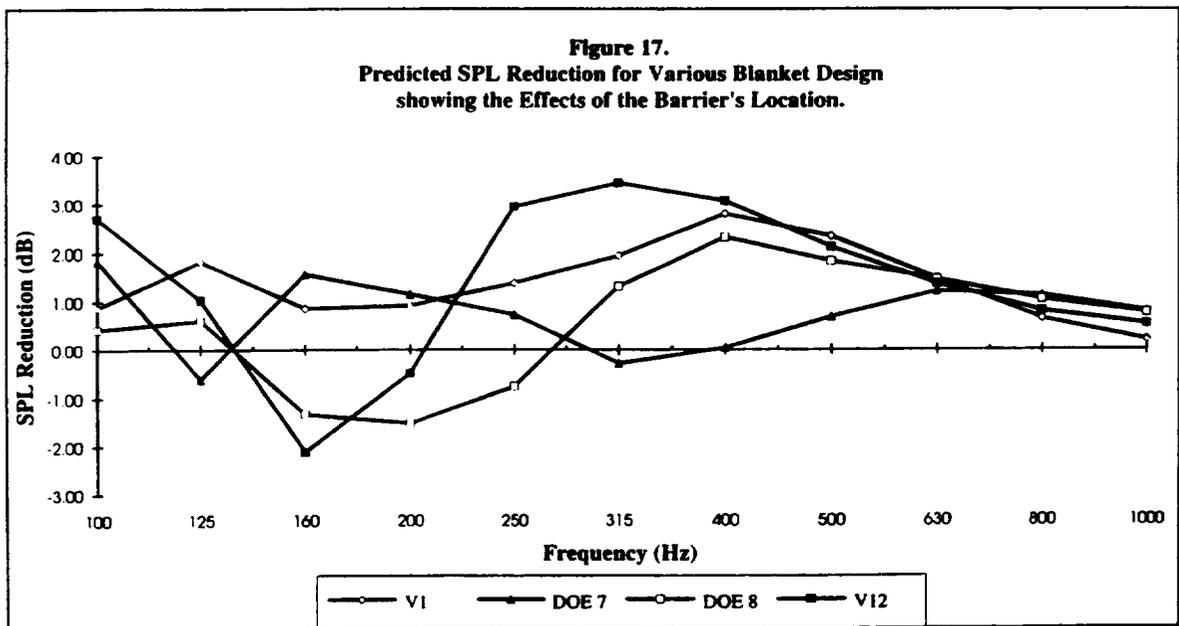
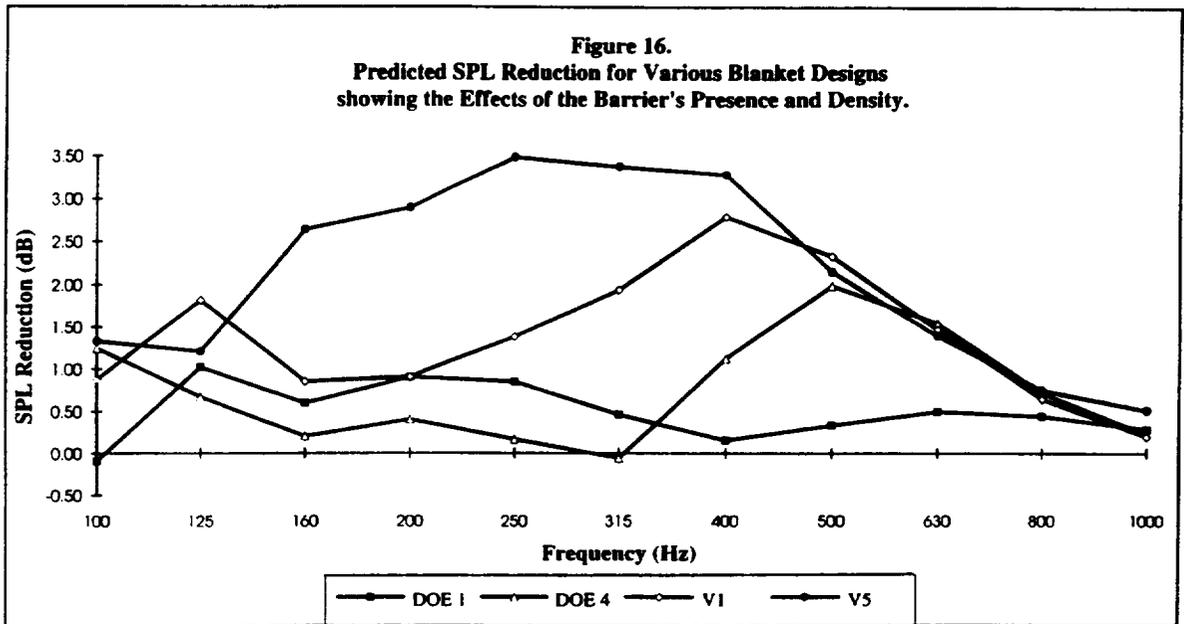


Figure 15.
Predicted versus Test Measured SPL Reduction for PLF Zones 9-10, Utilizing V10 Blankets.





retested, a straight numerical average of the data from the two runs were used in the prediction. A value of 0.765 was used for S^* in all predictions, which is typical of the Cassini flight blanket coverage in the PLF zones of interest.

CONCLUSIONS

A multi-organizational effort, led by NASA Lewis Research Center, to develop and test verify new acoustic blankets has been successfully completed. Two flight viable blanket candidates, configurations V5 and V10 have been found which meet the goal of reducing the PLF's interior acoustics in the zones of interest by 3 dB or more at the Cassini mission critical frequencies of 200 and 250 Hz. The V5 blankets have been selected by the Cassini program to be utilized for this mission. Because of this success, the Cassini's RTGs do not have to be vibration requalified, resulting in \$25 - 30 million dollars in savings for NASA.

The two phase test program followed in this effort was critical in meeting the objectives of the test program. In Phase One, numerous blanket candidates were quickly evaluated by flat panel testing to arrive at potential blanket candidates. In Phase Two, these select blanket candidates were then tested in a full scale cylindrical payload fairing to determine their performance in a realistic flight environment.

A wealth of acoustic test data was obtained during this test program. A methodology for using flat panel test data to obtain a first order prediction of the performance of an acoustic blanket in a PLF has been discussed. The information presented in this paper may be utilized for other space missions and their own special applications which may differ from the Cassini mission's. The barrier blanket technology developed for this program may also have non-space applications for creating quieter acoustic environments for automobiles, ships, airplanes, homes, offices and industrial settings.

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