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Advanced Subsonic Technology (AST) Separate-Flow High-Bypass Ratio Nozzle Noise Reduction Program Test Report

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PREFACE

In 1995, NASA GRC initiated efforts to meet the US industry's rising need to develop jet noise technology for separate flow nozzle exhaust systems. Such technology would be applicable to long-range aircraft using medium to high by-pass ratio engines. With support from the Advanced Subsonic Technology Noise Reduction program, these efforts resulted in the formulation of an experimental study, the Separate Flow Nozzle Test (SFNT). SFNT's objectives were to develop a data base on various by-pass ratio nozzles, screen quietest configurations and acquire pertinent data for predicting the plume behavior and ultimately its corresponding jet noise. The SFNT was a team effort between NASA GRC's various divisions, NASA Langley, General Electric, Pratt&Whitney, United Technologies Research Corporation, Allison Engine Company, Boeing, ASE FluiDyne, MicroCraft, Eagle Aeronautics and Combustion Research and Flow Technology Incorporated.

SFNT found several exhaust systems providing over 2.5 EPNdB reduction at take-off with less than 0.5% thrust loss at cruise with simulated flight speed of 0.8 Mach. Please see the following SFNT related reports: Saiyed, et al. (NASA/TM—2000-209948), Saiyed, et al. (NASA/CP—2000-210524), Low, et al. (NASA/CR—2000-210040), Janardan et al. (NASA/CR—2000-210039), Bobbitt, et al. (NASA/CR—201-210706) and Kenzakowski et al. (NASA/CR—2001-210611.).

I wish to thank the entire SFNT team of nearly 50 scientists, engineers, technicians and programmers involved in this project. SFNT would have fallen well short of its goals without their untiring support, dedication to developing the jet noise technology.

Naseem Saiyed
SFNT Research Engineer

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LIST OF SYMBOLS and NOMENCLATURE FOR NAMING TEST NOZZLE CONFIGURATIONS

The Advanced Subsonic Technology (AST) separate-flow nozzle jet noise reduction test program, designated as the SFNT program by NASA Lewis Research Center, was a co-operative team project involving NASA Lewis Research Center (LeRC), the General Electric Aircraft Engine Company (GEAE), the Pratt & Whitney Aircraft Company (P&W), the Allison Engine Company (AEC), the Boeing Commercial Aircraft Company and the United Technologies Research Center (UTRC). GEAE provided six (6) baseline axisymmetric separate-flow nozzle models with bypass ratios (BPR) of 5, and 8, with internal and external plugs and eleven (11) different jet noise suppression configurations consisting of various chevrons, vortex generator doublets and a "tongue" mixer (designed by AEC). P&W supplied nine (9) jet noise suppression configurations representing four (4) jet noise suppression concepts (i.e. offset centerline fan nozzle, flipper-tabbed fan and core nozzles, scarfed fan nozzle, core half and full mixers with 10- and 20-mini-lobes, respectively). All nine of P&W's suppressor configurations were for the baseline external plug, BPR 5 (model 3) nozzle only. The majority of the suppression devices provided by GEAE and P&W were also for the model 3, external plug, BPR=5 nozzle. GEAE and P&W's nozzles were designed and fabricated by the same model hardware company, Aero Systems Engineering (ASE). The model nozzles were interchangeable on the primary and on the fan streams. P&W's primary nozzles could be tested with GEAE's fan nozzles, and vice versa.

The participants of the SFNT program adopted a common nomenclature for describing the test nozzle configurations. The nozzle configuration is to be identified by a three "digit" alphanumeric code (i.e. # X Y where # is the nozzle model number, X is the designation for the core nozzle, and Y is the designation for the fan nozzle). A listing of the various nozzle configurations and the corresponding alphanumeric codes is given below.

For Example : Nozzle Configuration # X Y

Model (#)

1 = Coplanar (BPR=5)	2 = Internal Plug (BPR=5)	3 = External Plug (BPR=5)
4 = Internal Plug (BPR=8)	5 = External Plug (BPR=8)	6 = Modified Plug (BPR=5)

(X) - Core Nozzle Designation

B= Baseline Axisymmetric Nozzle (GE)
C12= 12 Chevrons (GE)
C8= 8 Chevrons (GE)
I= 12 Inward Facing Chevrons (GE)
A= 12 Alternating Facing Chevrons (GE)
Di= 64 Internal VG Doublets (GE)
Dx= 20 External VG Doublets (GE)
T24= 24 Flipper Tabs (P&W)

(Y) - Fan Nozzle Designation

B= Baseline Axisymmetric Nozzle (GE)
C= 24 Chevrons (GE)
Di= 96 Internal VG Doublets (GE)
T24= 24 Flipper Tabs (P&W)
T48= 48 Flipper Tabs (P&W)
Omax= Maximum Offset Centerline Nozzle (P&W)
S= Scarfed Nozzle (P&W)

T48= 48 Flipper Tabs (P&W)
Hm= 10-minilobe Half Mixer (P&W)
Tm= Tongue Mixer (AEC)
Fm= 20-minilobe Full Mixer (P&W)

Ct= 24 Chevrons with O-ring boundary trip (GE)
Cv= 24 Chevrons with external VG(GE)

As stated earlier, the majority of the jet noise suppression devices tested were for model 3 (BPR=5, external plug). Combinations of different primary and fan nozzles were tested. For example, a 24-tabbed primary nozzle was tested in conjunction with a baseline fan nozzle and the resulting test configuration is identified as 3T24B, where "3" is the model number, "T24" is the 24-flipper tabs primary nozzle and "B" is the baseline fan nozzle. Other combinations of primary and fan jet noise suppression nozzles that were tested are identified by the same basic notations described in this nomenclature.

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1.0 SUMMARY

Prior to the current program, NASA and industry-supported jet noise research was targeted primarily at reducing jet noise from either subsonic mixed-flow long duct nozzle systems or supersonic low-bypass turbojet nozzle systems. There had been little research effort at reducing jet noise from the high bypass ratio (HBPR), non-mixed, separate-flow, short duct exhaust systems that are typical of today's large turbofan engines that power such aircraft as the Boeing 747, 757, 767 and 777. Part of the reason for this lack of research effort on these separate-flow systems is that jet noise has not typically been the dominant noise source in these HBPR engines. However, the requirement to provide ever higher thrusts to power new and growth versions (i.e. higher takeoff gross weight) of the aircraft, means that today's HBPR engines have to operate at even higher jet temperatures and pressure ratios and to generate higher jet velocities and thus higher jet noise levels. In 1995, upon recommendations from industry's and NASA's AST Steering Committee and Technical Working Group, the NASA Separate-Flow Nozzle Jet Noise (SFN) Reduction Test Program was conceived and launched. NASA's Lewis Research Center recognized that for engine thrust growth to continue without an increase in aircraft noise levels or a major costly engine/nacelle redesign, jet noise reduction through the use of jet noise external suppression devices for these separate-flow jet exhaust systems needed to be developed. These jet noise suppression devices have to be lightweight, have low thrust loss and be easy to incorporate into existing separate-flow nozzle exhaust systems. The goal of this effort was to demonstrate a Three (3) decibel reduction in jet noise (relative to the 1992 technology) for nonmixed separate-flow nozzle exhaust systems.

NASA awarded Pratt & Whitney (P&W) contract NAS3-27727, (AST Task Order 14.2) to design, build and test separate-flow exhaust nozzle scale models in the bypass ratio range of 5 to 8, employing a range of potential jet noise external suppression devices. The Boeing Commercial Airplane Company was subcontracted by P&W to help specify possible test configurations with noise reduction potential and to supply phased microphone array measurements to demonstrate that phased array techniques could be used for (1) jet noise source location visualization without intrusion into the jet plume, and (2) explanation of how the different suppression devices affect the jet noise sources. The United Technologies Research Center (UTRC) was also subcontracted to analyze, using Computational Fluid Dynamics (CFD) analyses, the flow fields of the some of the nozzle concepts selected and designed by P&W. P&W provided nine (9) jet noise suppression devices consisting of: a 24-flipper tabbed primary nozzle, a 48-flipper tabbed primary nozzle, a 24-flipper tabbed fan nozzle, a 48-flipper tabbed fan nozzle, a scarfed fan nozzle, and two offset- centerline fan nozzles with different amounts of offset, a 10-mini-lobed primary half mixer and a 20-mini-lobed primary full mixer.

These scaled model suppression devices, together with other model nozzle devices from the General Electric Aircraft Engine Company (GEAE), provided under a separate NASA/GEAE contract, were tested in the NASA Lewis Nozzle Acoustic Test Rig (NATR) under static and simulated flight conditions. Far-field acoustic data were taken and the noise results analyzed.

The noise results indicated that inward-facing chevrons on primary nozzles and flipper-tabs on primary nozzles achieved Effective Perceived Noise Level (EPNL) suppressions close to the SFN program goal of 3 EPNdB (at mixed jet velocity condition of 1200 ft/sec). Adding fan

nozzle chevrons to the above primary nozzle devices provided only small additional EPNL benefits. The results also indicated that primary nozzle devices effected the low-frequency and high-frequency components of the baseline nozzle's far-field Sound Pressure Noise (SPL) spectra. The fan nozzle devices effected the high-frequency component of the baseline nozzle's SPL spectra and in almost all cases, the fan devices actually increased the levels of these high-frequency noise. Other test nozzle devices, i.e. vortex generator doublets (GEAE), scarfed fan nozzle, offset-centerline fan nozzle, min-lobed mixers, tongue mixer (Allison), neutral chevrons (GEAE), and combination nozzles consisting of two of these concepts did not achieve the desired 3 EPNdB goal.

The Boeing's phased-array results showed that phased-array technology could be used successfully to provide qualitative images of the jet noise sources of the separate-flow nozzle without intrusion into the jet exhaust plume. The phased-array tests showed that at low to mid frequencies, there were two distinct jet noise sources. The first source is located near the nozzle exit and the second source is downstream at several nozzle diameters. The tests also showed that the primary and fan mixer nozzle devices generally increased the upstream and decreased the downstream jet source region's sound intensities. The best noise suppression devices are the primary inward-facing chevrons and flipper-tabbed primary nozzles, which tended to decrease the downstream source region with only minimum increase in the upstream source region.

NASA Lewis' plume survey data showed the primary tabbed nozzles produced pressure and temperature profiles that were similar to those produced by high-penetration lobed mixers. The profile is a 6-lobe pattern for the 24-flipper tabbed and a 12-lobe pattern for the 48-flipper tabbed primary nozzle. In P&W's tab design, which incorporated a "neutral" tab separating each "up" and "down" tab, the neutral tab increased the effective lobe penetration and did not add to the effective "lobe" count of the device. In the 24-tab case, the effective lobe count of the plume profile is controlled by the six "up" and six "down" tabs. In Gee's inward-facing chevron design, the effective lobe count of the plume profile is the same as the total number of chevrons.

In summary, NASA's model-scale nozzle noise tests show that it is possible to achieve a 3 EPNdB jet noise reduction with inward-facing chevrons and flipper-tabs installed on the primary nozzle and fan nozzle chevrons. These chevrons and tabs are simple devices and are easy to be incorporated into existing short duct separate-flow non-mixed nozzle exhaust systems. However, these devices are expected to cause some small amount of thrust loss relative to the axisymmetric baseline nozzle system. Thus, it is important to have these devices further tested in a calibrated nozzle performance test facility to quantify the thrust performances of these devices. The choice of chevrons or tabs for jet noise suppression would most likely be based on the results of thrust loss performance tests to be conducted by Aero System Engineering (ASE) Inc.

It is anticipated that the most promising concepts identified from this program will be validated in full scale engine tests at both Pratt & Whitney and Allied-Signal, under funding from NASA's Engine Validation of Noise Reduction Concepts (EVNRC) programs. This will bring the technology readiness level to the point where the jet noise suppression concepts could be incorporated with high confidence into either new or existing turbofan engines having short-duct, separate-flow nacelles.

2.0 INTRODUCTION

The modern high bypass ratio (HBPR) turbofan engines powering current aircraft such as the 747, 757, 767 and 777 still continue to generate significant levels of jet noise. The requirement to provide even higher thrusts to power new and growth versions of these aircraft requires these HBPR engines to operate at still higher fan pressure ratios and generate yet higher jet velocities and thus higher jet noise. Most previous jet noise suppression research had been targeted at reducing jet noise from either the subsonic mixed-flow nozzle systems or the supersonic low-bypass turbojet nozzle systems. Upon recommendations from the aerospace industry, the NASA LeRC Separate-Flow Nozzle (SFN) jet noise reduction test program was conceived and launched in 1995. The NASA Lewis Research Center recognized that to allow aircraft takeoff weight/engine thrust growth to continue without an increase in current aircraft noise levels or a major costly engine/nacelle redesign, jet noise reduction through the use of jet noise external suppression devices needed to be developed. In addition, these jet noise suppression devices should be lightweight, have low thrust losses and be easy to incorporate into existing short duct separate-flow nozzle exhaust systems. Foreign engine manufacturers, such as Rolls Royce, often have used long fan duct mixed flow nacelles with internal mixers to reduce the levels of jet noise. These exhaust systems provide noise reduction but at the expense of increased weight and cost. To replace existing separate flow nacelles with this type of suppression would require a major effort. NASA's and industry's goal for the current program was to develop new jet noise suppressor technology for separate flow nacelles that would provide a 3 decibel reduction in jet noise relative to the 1992 technology.

NASA awarded Pratt & Whitney (P&W) and General Electric Aircraft Engines (GEAE) contracts (NAS3-27727, Task Order 14.2 and NAS3-27720, AoI 14.3 respectively) to design, build and test separate-flow exhaust nozzle scale models in the bypass ratio range of 5 to 8, employing a range of potential jet noise external suppression devices. These scaled model suppression devices were to be tested in the NASA Lewis Nozzle Acoustic Test Rig (NATR) under static and simulated flight takeoff conditions. Far-field acoustic data would be taken. The Boeing Commercial Airplane Company was subcontracted by P&W to help define possible test configurations with noise reduction potential and to supply phased microphone array measurements to demonstrate that phased array technique could be used for (1) jet noise source location visualization without intrusion into the jet plume, and (2) explanation of how the different suppression devices affect the jet noise sources. After the completion of the noise tests and noise suppression data analysis, NASA and industry would select a few of the best noise suppressor nozzles for the further testing in another test facility (Aero Systems Engineering) to measure their thrust loss (performance) characteristics. This performance testing was to be conducted under a separate NASA contract.

The acoustic scale model nozzle test program involved cooperative efforts from NASA LeRC, P&W, United Technologies Research Center (UTRC), Boeing Commercial Aircraft Company (subcontractors to P&W), GEAE and Allison Engine Company (AEC) (subcontractor to GEAE). GEAE provided five (5) baseline axisymmetric separate flow nozzle models with internal and external plugs with BPR's of 5 and 8. The flow lines of these

five baseline nozzles were scaled up (1.0224 factor) from the baseline nozzles used by NASA LaRC in their AST Separate Flow Data Base and Suppression Study. The scale factor of 1.0224 was chosen so that the model nozzles could fit into the NATR test rig. GEAE also provided eleven (11) different jet noise suppression devices consisting of various chevrons, vortex generator (VG) doublets and a tongue mixer designed by the Allison Engine Company. The tongue mixer had a significantly larger effective throat area when tested with model 2 baseline fan nozzle, resulting in a BPR smaller than the desired BPR of 5. To get the correct BPR, AEC had to modify baseline model 2 core nozzle area by building a new longer internal plug that extended further out into the core nozzle throat, thus reducing the core nozzle area and flow rate. This model designated as model #6 does not have the same core nozzle area and flow rates as model 2. AEC's tongue mixer was the only core nozzle configured and tested as model 6. P&W provided nine (9) jet noise suppression devices representing four (4) different jet noise reduction concepts (i.e. offset centerline fan nozzle, scarfed fan nozzle, flipper-tabbed core and fan nozzles (with unique tab sequencing arrangements), and a 10-mini-lobed core half mixer and a 20-mini-lobed full mixer). All nine P&W's configurations were for the model 3, external plug (and BPR of 5) test nozzle.

Aero Systems Engineering (ASE) won competitive bids from both P&W and GEAE to fabricate the test model nozzle hardware. Because of this, ASE was able to coordinate the delivery of the test hardware to fit the test schedule and eliminate necessary hardware reworking since all nozzle parts can be fitted in ASE prior to their delivery to the NASA test facility.

The noise portion of the SFNT program was conducted in the NASA Lewis Research Center Nozzle Acoustic Test Rig (NATR) facility from the 20th of March to the 18th of June, 1997. Far-field noise data were acquired and NASA Lewis was responsible for the acquisition and reduction of the these data. The processed data were then provided to P&W, GEAE and Allison in a prior agreed upon electronic database format. The processed data were scaled by a model-to-engine scale factor of 8 and projected to a level 1500-ft altitude flyover flight path to obtain flight noise levels for a typically sized engine. In addition, NASA Lewis requested P&W and GEAE to make separate noise predictions for the most promising jet noise suppression devices, applied specifically to each company's jet engine products which have nozzle scale factors different than 8.

NASA selected ASE (through competitive bidding) to conduct performance (thrust loss) measurements for the baseline nozzle and a few selected devices that demonstrated significant jet noise suppression. These performance measurements are required for evaluating the nozzle performance vs noise suppression characteristics, since any device that would be considered for today's turbofan engines must have significant noise suppression and low thrust losses. ASE is scheduled to complete the performance testing and report the results by end of the first quarter of 1998.

The SFNT program required a high degree of cooperation and coordination between P&W and GEAE. A single test plan was prepared by GEAE (with inputs from P&W) and was approved by NASA. This test plan provided detailed design information on the different jet noise external suppression concepts, and specified the type of tests (i.e. acoustics, phased

microphone arrays, jet plume surveys, laser and Schlieren), data acquisition and data reduction requirements. This information is given in Reference 1. For the final test reporting, it was decided that P&W and GEAE would each prepare separate reports covering the analyses that each company was contractually obligated to perform. Thus, there will be two test reports for the SFNT program. P&W's test report is provided here and documents the independent analyses conducted by P&W of the noise data for Model 3, external plug with BPR 5 nozzle jet noise for the baseline and suppression devices. GEAE's and Allison's joint test report would document GEAE's and Allison's analyses for the same Model 3 nozzles plus the other additional nozzle models (1, 2, 4, 5 and 6). P&W's and GEAE's test reports taken together should cover the entire scope of the SFNT program.

3.0 TEST OBJECTIVES

NASA's overall test objectives for the SFNT program were five-fold. The first objective was to create a jet noise acoustic database for the separate-flow nozzle baseline exhaust system for bypass-ratios of 5 and 8. The second objective was to evaluate the noise reduction characteristics of the different noise suppression devices designed and built by P&W and GEAE for the separate-flow nozzle exhaust systems, and to demonstrate that a 3 decibel jet noise reduction would be possible with these new external suppression devices. The third objective was to conduct limited near-field acoustic measurements using a Boeing Company provided phased-array microphone system to locate the major sources of jet noise radiation associated with the different noise suppression devices. The fourth objective was to conduct jet plume (temperature and pressure) surveys on selected promising noise suppression devices and to use these data to correlate with far-field jet noise measurements. The last and fifth objective was to explore the potential use of laser sheet and Schlieren imaging tests to obtain qualitative flow visualization images of the downstream mixing jets from the separate nozzle flows.

P&W's test objective was a subset of NASA's overall objectives, and thus, was more limited in scope. P&W was to provide noise suppression devices for only one nozzle model with a bypass ratio of 5 and with an external plug (model 3). P&W was to evaluate and report on the results of the suppression devices for model 3 only, and to report on the phased-array microphone source noise location/radiation results performed by the Boeing Company under subcontract to P&W. P&W was to use the phased-array data and the jet plume survey results to help explain the noise characteristics of a few selected promising noise suppression devices, and to demonstrate that these devices could achieve 3 EPNdB jet noise suppression.

Other NASA test objectives will be addressed in a test report by GEAE under NAS3-27720, AoI 14.3.

3.1 SEPARATE-FLOW BASELINE NOZZLE SOURCE LEVELS PREDICTION

The first step in deciding what design features are important to incorporate into the jet noise external suppressor designs was to determine what are the major noise source levels in the (nonmixed) separate-flow nozzle systems of the axisymmetric baseline nozzles. In the separate-flow nozzle exhaust system where the primary and secondary jet flows are still within the subsonic Mach number range, the major noise sources could be identified as those generated from each of the two jet (primary and fan) flows and to the merged (mixed) flow. An empirical model has been developed by the Boeing Aircraft Company (Ref. 3) for predicting the relative noise levels of these three sources for the separate-flow baseline nozzle coaxial jet. Using this empirical model, predictions of the source noise levels for model #3 (BPR=5, external plug) were made for a mixed jet velocity of 1155 ft/sec (core velocity of 1585 ft/sec and fan velocity of 1070 ft/sec) which is typical for a current HBPR turbofan engine at sideline power. The predicted sound pressure level (SPL) spectra for the three noise sources (primary, secondary and mixed jet) at four different far-field angles (measured with respect to the inlet) are shown in Figure 1. The predictions show the mixed jet generated most of the low-frequency noise at almost every far-field angles except for the very aft angle (150 degrees), and the secondary jet generated most of the high-frequency noise at all far-field angles.

Figure 2 shows the predicted corresponding perceived noise level (PNL) directivities for the primary, secondary, mixed and total jet noise. As expected, the mixed jet component noise dominates, with the secondary jet noise at levels that are 5 PNdB lower. The primary jet noise is again predicted to be only important at the very aft far-field angles (greater than 150 degrees).

Based on this Boeing's coaxial jet empirical model for the baseline nozzle, it was decided that the best strategy for suppressing the separate-flow nozzle jet noise was to promote better mixing between the primary and secondary jet to achieve more uniform and lower centerline velocity for the mixed jet. The second strategy is to promote better mixing between the secondary jet's outer shear layer and the ambient free-jet. The jet noise suppression devices that P&W designed and incorporated into the model #3 (BPR=5, external plug) nozzle were focused on these two strategies.

The mixing devices P&W designed for these noise tests were delta tabs, minilobes (half and full mixers), scarfed fan nozzle and an offset centerline fan nozzle. The delta-tabs devices when placed between the core and fan nozzle act on the source noises from the primary and the mixed jet and would reduce both the low and high frequencies from these two noise sources. Similarly, the devices when placed on the fan nozzle outer diameter would act on the high frequency noise from the mixing of the fan jet shear layer and the ambient freejet. In addition, P&W also explored the use of a scarfed or scooped fan nozzle to shield the high frequency noise that is generated close to the fan nozzle exit from propagating directly to the far-field microphones. Another new concept that P&W investigated was the offset-centerline fan nozzle. The flow field of this asymmetric nozzle was predicted to be highly distorted (horse-shoe shaped flow pattern) with jet centerline velocities decaying at rates significantly

higher than that of the axisymmetric nozzle. The Computational Fluid Dynamics (CFD) analyses of some of these unusual devices is presented in Section 4.1.3.

GEAE designed chevrons and low profile vortex generators (arranged in doublets with the flat leading end of the ramps facing the flow) and AEC designed the tongue mixer. Descriptions of these and other suppression devices are presented below.

4.0 NOZZLE MODELS DESCRIPTION, TEST FACILITY, TEST METHODS, DATA ACQUISITION AND REDUCTION PROCEDURES

4.1 NOZZLE MODELS DESCRIPTIONS

4.1.1 SEPARATE-FLOW NOZZLES (SFN) BASELINE MODELS

The baseline models are scaled versions (scale factor of 1.0224) of the baseline models being tested at NASA Langley. This scale factor was chosen so that these baseline nozzles would fit into the NASA Lewis NATR test rig. The estimated hot core nozzle and fan nozzle areas for the six baseline models are summarized below :

Model #	Description	Core Nozzle Area (sq. in)	Fan Nozzle Area (sq. in)
1	Coplanar (BPR=5)	11.30	29.58
2	BPR=5, Internal Plug	11.19	28.94
3	BPR=5, External Plug	10.53	28.94
4	BPR=8, Internal Plug	7.96	32.72
5	BPR=8, External Plug	8.64	32.72
6	BPR~5, Modified Plug	7.96	28.94

4.1.1.1 Model #1, Coplanar, BPR=5, Internal Plug

Figure 3 shows a picture of the Model 1, BPR=5, coplanar baseline nozzle. The fan nozzle has the same nozzle exit plane as that of the primary nozzle. The cold dimensions are 3.753 inches for the core nozzle exit diameter and 7.246 inches for the fan nozzle exit diameter. The diameter of the internal plug (not visible in Figure 3) is 2.029 inch. Both the primary and the fan nozzle have nozzle lip wall thickness of approximately 0.005 inches. No mixing devices were tested on this model. The test purpose for this model is to provide a set of acoustic data for a coplanar baseline nozzle.

4.1.1.2 Model #2, BPR=5, Internal Plug.

Figure 4 shows a picture of the Model 2, BPR=5, internal plug baseline nozzle. The cold dimensions for the core and fan nozzle exit diameters are 3.753 inches and 9.629 inches, respectively. The internal plug diameter is 2.029 inches (same as that of model 1). The core nozzle exit plane is approximately 7.081 inches downstream of the fan nozzle exit plane.

A limited number of chevrons with and without vortex generators applied to the core and fan nozzle was tested on this model configuration.

4.1.1.3 Model #3, BPR=5, External Plug.

Figure 5 shows a picture of the Model 3, BPR=5, external plug baseline nozzle. The cold dimensions for the core and fan nozzle exit diameters are 5.156 inches and 9.629 inches, respectively. The core nozzle external plug is unique to Model 3. The plug has a maximum diameter of 3.704 inches (cold) and a boattail angle of 16 degrees. The plug protrude from the exit plane of the core nozzle by 5.355 inches. The fan nozzle exit plane is 4.267 inches upstream relative to the core nozzle exit plane. Except for the AEC's core nozzle tongue mixer, the majority of the flow mixing devices were tested on this model.

4.1.1.4 Model #4, BPR=8, Internal Plug.

Figure 6 shows a picture of the Model 4, BPR=8, internal plug baseline nozzle. The cold dimensions for the core and fan nozzle exit diameters are 3.165 inches and 9.629 inches, respectively. The core nozzle exit plane is approximately 7.60 inches downstream of the fan nozzle exit plane. No mixing devices were tested on this model. The test purpose for this model is to provide a set of acoustic data for a BPR of 8, internal plug baseline nozzle.

4.1.1.5 Model #5, BPR=8, External Plug.

Figure 7 shows a picture of the Model 5, BPR=8, external plug baseline nozzle. The cold dimensions for the core and fan nozzle exit diameters are 4.827 inches and 9.629 inches, respectively. The core nozzle exit plane is approximately 4.265 inches downstream of the fan nozzle exit plane. The centerbody (plug) for model 5 is the same as that of model 3. Only chevrons were tested with this model.

4.1.1.6 Model #6, (Modified Plug for AEC's Tongue Mixer)

Figure 8 shows a picture of the Model 6 with the internal plug modified for the AEC's core nozzle tongue mixer. The core and fan nozzles are the same as those for Model 2. No acoustic data were taken for this baseline configuration. When the core tongue mixer was tested in the original model 2 baseline configuration with a short internal plug, the core flow for the tongue mixer was significantly higher than predicted, and the resultant BPR was less than the desired value of 5. This configuration was built in an attempt to reduce the core flow for the tongue mixer so that the BPR would be closer to the desired value. Figure 9 shows a picture of the tongue mixer with the modified extended plug in the model 6 configuration.

4.1.2 MIXING ENHANCER DEVICES/CONCEPTS

The mixing devices selected for the SFN noise tests are (1) chevrons, (2) vortex generator (VG) doublets, (3) tongue mixer, (4) flipper tabs, (5) scarfed fan nozzle, (5) mini-lobed half mixer, (6) mini-lobed full mixer and (7) offset-centerline fan nozzle. Except for the tongue mixer, the exit nozzle areas of these devices are approximately the same as the nozzle exit areas of the baseline nozzles they replaced. Combinations of different core nozzle mixing devices could be tested with different fan nozzle mixing devices without changing the basic BPR of the model tested. A detailed description of the design parameters of the various mixing devices can be found in Reference 1 (SFN test plan). As presented in the nomenclature, a total of 10 mixing devices were fabricated for the core nozzle and 8 devices for the fan nozzle.

4.1.2.1 Chevrons

Chevrons are serrated continuations of the nozzle trailing edge. These serrations are deep and are relatively bigger than tabs. The chevrons, designed by GEAE, could be neutral or directed inward or alternatively inward and outward at a small angle (5 degrees) . These GEAE's supplied chevron nozzles are shown in Figures 10 through 14 for (a) a eight (8) neutral-chevrons core nozzle, (b) a twelve (12) neutral chevrons core nozzle, (c) a twelve (12) inward-chevrons core nozzle, (d) a twelve (12) alternating inward- and outward-chevrons core nozzle and (e) a twenty four (24) neutral-chevrons fan nozzle. The parameters used to describe the chevrons are given in Reference 1.

4.1.2.2 Vortex Generators (VG) Doublets

The vortex generators doublets selected by GEAE for the SFN noise test consist of tandem wedges with the flat bases of the ramps facing the flow. Figure 15 shows a picture of the arrangement of twenty (20) VG doublets installed on the outer surface near the exit plane of a core nozzle. Figures 16 and 17 show two similar VG doublets arrangements on the inner surfaces of a core nozzle and a fan nozzle. The design parameters for these vortex generators are described in Reference 1.

4.1.2.3 Tongue Mixer

The AEC' s tongue mixer design showed in Figure 18 has the shape of a 12-lobe mixer with the side walls cut off, leaving only the crowns and crests to direct the core flow inward and outward to increase mixing between the core and fan streams. This device was tested in Model 2 only. When first tested, the tongue mixer does not produce the correct bypass ratio as the baseline model and a second modified centerbody (plug) was built which reduced the core flow and raised the bypass ratio closer to that of the baseline model. A detailed description of the tongue mixer design is given in Reference 1.

4.1.2.4 Flipper Tabs

The P&W's flipper tabs are small delta tabs which are continuations of the nozzle exit trailing edge. The tabs are arranged in a repeating sequence consisting of an up tab/neutral tab/down tab/neutral tab. Twenty-four (24) and forty-eight (48) tabs configurations were provided by P&W for both the core and fan nozzles of Model 3. The inner and outer surfaces of each tab are circular arcs as measured in the streamwise directions. Figures 19 through 22 show the 24- and 48-tabs configurations for the core and the fan nozzles.

4.1.2.5 Scarfed Fan Nozzle

Figure 23 shows a picture of the P&W designed scarfed fan nozzle which has a 120-degrees circumferential segment that extend from the original nozzle exit plane. This segment or scoop can be clocked at different positions relative to the far-field microphones. As shown in Figure 24, the scarfed fan nozzle could be tested with different core nozzle suppression devices to add an additional suppression effect due to the scoop's line of sight blocking of the high frequency noise generated close to the nozzle exit plane.

4.1.2.6 Half Core Mixer Nozzle

Figure 25 shows a picture of the P&W designed half core mixer with 10 mini-lobes over a 180 degrees circumferential segment and a regular baseline circular nozzle over the remaining 180 degrees. This half mixer was tested at different clocking positions with the lobed half of the mixer facing at 0 degrees (towards), at 90 degrees and at 180 degrees (away) from the far-field microphones.

4.1.2.7 Full Core Mixer Nozzle

Figure 26 shows the P&W designed full core mixer with 20 mini-lobes over the entire circumference.

4.1.2.8 Offset Centerline Fan Nozzle

This nozzle design was selected based on recommendations from the Boeing Aircraft Company who is a subcontractor to P&W under the AST contract. The centerline position of the fan nozzle was offset by an amount described as a Cosine function (Reference 1). The nozzle retains the same circular cross-sections as the baseline nozzle at each axial distance along the centerline of the nozzle. A picture of the offset-centerline fan nozzle is shown in Figure 27. CFD flow field analyses of this unusual nozzle design is presented in Section 4.1.3. This fan nozzle was tested with the core baseline nozzle and the Half core mixer nozzle.

4.1.2.9 Core and Fan Suppression Devices Combination Nozzles

Figures 28 through 40 show pictures on various combinations of different core suppression devices tested with different fan suppression devices on Model 3. These combination nozzle configurations are denoted by a three digit code as explained in the nomenclature. For example, configuration 3T48T48 is a model 3 nozzle with a 48-flipper-tabbed core nozzle and a 48-flipper-tabbed fan nozzle. All the combination nozzles tested have approximately the same BPR as the baseline Model 3 nozzle.

Cross-section descriptions of the model hardware configurations are provided in Appendix B.

4.1.3 CFD ANAYSES FOR SELECTED NOZZLE DESIGNS

Conventional nozzle design processes apply empirical rules and CFD analyses. A key design criterion of these analyses has been to reduce the peak levels of velocity and temperature at the nozzle exit plane. UTRC/P&W uses NASTAR, its internally developed, general-purpose Navier-Stokes viscous flow analysis to design mixer/nozzle configurations. The NASTAR code is based on Rhie's method (Ref. 4) and it represents a significant extension of the pressure-correction methodology used in the TEACH family of codes (Ref. 5). The code solves the Reynolds-averaged form of the governing equations for steady, three-dimensional flows including the effects of turbulence and heat release due to chemical reaction. The governing equations are approximated using a finite-volume method. The discretized continuity and momentum equations are used to derive a pressure-correction equation that is used in place of the continuity equation. Rhie's method provides a single-cell, general curvilinear coordinate procedure that is applicable for Mach numbers ranging from incompressible flow to hypersonic flow. The results described in the current study were obtained using the two equation **(k-ε)** model for turbulence due to Jones and Launder (Ref. 6).

4.1.3.1 Model #3 Baseline (Axisymmetric) Nozzle

The first high-bypass-ratio (BPR ≈ 5) configuration analyzed was the model #3 axisymmetric baseline nozzle. All calculations described in this report have been performed at conditions representing a take-off condition (M_∞ = 0.3). By assuming that radial profiles of the flow properties were flat at the inlet plane, the flow boundary conditions specified are shown on table below.

HBPR CFD Inlet Boundary Conditions

Primary total temperature	= 1491 R
Fan total temperature	= 647 R (600 R actual)
Freestream total temperature	= 524 R
Primary total pressure	= 3183.8 psfa (22.1 psia) (24.0 psia actual)
Fan total pressure	= 3714.5 psfa (25.8 psia) (26.1 psia actual)
Freestream total pressure	= 2172.4 psfa (15.1 psia)

The baseline axisymmetric geometry was analyzed at P&W using a two-dimensional computational grid of 273 by 129, with grid clustering near the wall to allow modeling the viscous near-wall behavior by integrating directly to the wall (i.e., thereby eliminating use of wall functions).

Analyses of CFD predicted performance of nozzle exhaust systems are usually expressed in terms of lateral displays of the axial velocity (U), total temperature (To) and/or Mach number (M) at the nozzle exit plane. For the current study, cross-planar color contour plots of the axial velocity distribution at planes located downstream of the centerbody trailing edge (x/D = 0.0) and at x/D = 6.0 are shown in Figure 41. The axial distance has been

normalized by the fan nozzle trailing edge diameter (D). The high-speed region (dark red) shows little jet velocity decay over this range. Comparisons with the results from other nozzle analyses are presented below.

4.1.3.2 Model #3 Scarfed Fan Nozzle

For the three-dimensional calculations discussed here, it was necessary to use wall functions to keep the number of computational nodes manageable. These grids had law-of-the-wall y^+ values ranging from about 100 to 200 on the various surfaces; these values were within the acceptable range for using wall functions.

The design of the fan-scarfed nozzle added an extension to the lower fan nozzle trailing edge to prevent the downward radiation of noise generated from a portion of the fan nozzle and primary nozzle flows. The fan nozzle contour was generated by initially defining an axisymmetric geometry, extending the fan nozzle such that the primary nozzle was internal. The extended fan nozzle was then cut away from the upper 180 degrees (from +90 degrees to -90 degrees from top-dead center TDC). The extended fan nozzle was further sliced from the axisymmetric trailing edge at +90 degrees to the extended nozzle trailing edge at +120 degrees, thereby producing a scarfed section. The same was repeated from -90 degrees to -120 degrees. No attempt was made to fillet any corner produced by these modifications.

The three-dimensional exhaust system was analyzed by taking advantage of the vertical plane of symmetry. Figure 42 shows velocity contours from the 3D calculation. The image is an "upside down" mirror image; that is, the flow in the top half of the figure is closer to the ground. There is a small region of transonic flow under the upper fan nozzle, where the extension has been added. The region recompresses with little loss incurred. The air flows are within 2.0% and 0.2% for the primary and fan streams, respectively. The change in the primary flow is probably due to the change in "suppression" of the primary stream by the fan stream. The extended nozzle provides some relief to the primary stream that the axisymmetric nozzle does not.

4.1.3.3 Model #3 Core Half Mixer

The proposed half mixer design modifies the primary flow cowl from a completely axisymmetric surface (splitter) into a 180-degree splitter surface (oriented top-dead center) and a ten-lobed mixer (oriented bottom-dead center). The mixer consists of ten full-sized lobes and two reduced-size lobes for blending at 90 and 270 degrees to the axisymmetric splitter. Analyzing such a configuration, even after assuming one plane of symmetry, is a prodigious calculation. Therefore, an analysis of the core full mixer configuration (i.e., with lobes along the full circumference) was performed; thus, it was then possible to restrict the computational domain to planes of symmetry at the lobe crest and lobe trough. Two lobed mixers configurations were considered during the design phase, (1) a low-penetration design and (2) a high-penetration design. Analysis of these configurations were performed (1) to determine if the designs achieved the correct flow splits (bypass ratio, BPR) with no flow

problem areas (e.g., separation, supersonic flow), and (2) to assess the mixedness of the design, relative to the axisymmetric baseline.

In both situations, an analysis of a mixer lobe was performed. Symmetry was assumed and the analysis of only one-half of a lobe was required. A computational grid of dimensions 273 by 129 by 33 (1,162,000) nodes was generated using the UTRC-developed MKBLOX grid generation software system. Dimensions and grid node distributions were chosen to approximate the grid in the analysis of the baseline separate-flow system. The grid node distributions were also selected to provide a simple means of reducing the size of the grid independently in each of the coordinate directions. Therefore, it was possible to develop a grid of one-quarter the number of grid nodes by removing every other grid line in the radial and circumferential directions and to develop a grid with only one-eight the number of grid lines by removing every other line in each of the coordinate directions. In this manner, a means was provided to test both the grid independence of solutions and to reduce turnaround time for the cases. In addition, a coarser grid permitted analysis of blended configurations in which the computational domain was necessarily larger due to the absence of periodic and symmetry boundaries. For example, an analysis of the complete full mixer design was achieved by considering a full 180 degree segment. An example of a grid with one-quarter the number of grid nodes is shown for a slice through a lobe crest in Figure 43. Here, every other axial and radial grid is shown.

Inspection for regions of supersonic flow: Of concern is the fact that the core mixer designs may produce regions of supersonic flow with correspondingly large total pressure losses. All converged solutions were inspected for regions of supersonic flow. For all cases other than the high-penetration design, the maximum Mach number anywhere in the flow field was 1.03 to 1.06, depending on the case considered. Generally, these zones appeared as narrow strips of transonic flow and can probably be safely neglected because of their small extent.

For the high-penetration case, the maximum Mach number was 1.25. Color contour plots of the velocity field in both the crest and trough cut planes for this case are presented in Figure 44. The small reddish region in the crest cut indicates the limited region of sonic flow. This higher penetration mixer apparently accelerates the flow to the transonic range. Figure 45 presents similar views for the total temperature field. These displays show little attenuation of the hot primary flow as the exhaust jet mixes downstream.

Display of flow field evolution: Evolution of the flow field, as a result of the mixer, is presented in Figure 46, where color contours of the total temperature are displayed at a plane cutting the engine exhaust at the trailing edge of the centerbody (x/D = 0.). Although only a half-lobe has been analyzed, the results have been reflected about the plane of symmetry and then replicated twenty times to obtain the circumferential view shown; i.e. the mixer simulation assumed the lobe geometry was fully periodic and not restricted to a 180 segment. The flow field exhibits the classic kidney shaped pattern produced by the generation of streamwise vorticity from the convoluted surface of the mixer. Figure 47 shows a similar view for the axial velocity at x/D = 0 and at x/D = 6. The axial velocity shows little of the high speed flow seen in the axisymmetric calculation (Figure 41), and by x/D=6 additional

mixing has substantially reduced the peak velocity level. The axial velocity variable shows little of the kidney shaped patterns at x/D = 0. while the downstream plane is almost axisymmetric.

Effect of mixer design: Axial velocity and total temperature contours for the **low-penetration** design using the revised grid and the **high-penetration** design are compared at the end of the centerbody in Figure 48. These results are also displayed in the enlarged format, and only a half lobe view of each calculation is displayed. The sector angle for the high-penetration design is smaller than that of the low-penetration case. Therefore, the relatively larger contribution of shear-layer mixing for the high penetration core mixer produces substantially more mixing at this axial location.

Tests for grid independence: Computational studies were performed on the low-penetration core mixer nozzle to assess the adequacy of the computational grid used. Parametric variations were performed on a grid with every second axial and radial grid line removed. Comparisons of axial velocity and total temperature at the end of the plug were made with little qualitative difference observed. The level of mixing appears to be the same for these cases, but the distribution at this axial location differs. The results for the densest grid show greater mixing, suggesting that factors (as yet unidentified) other than numerical diffusion may be important here. The high resolution grid, however, would be needed for any performance assessment calculation.

4.1.3.4 Model #3 Fan Offset Centerline Nozzle

The fan offset centerline nozzle modifies the primary flow cowl from a completely axisymmetric surface (splitter) by displacing it vertically downward from top-dead center. Two different displacements, denoted medium and maximum were considered. Calculations were performed by assuming symmetry about the vertical axis. A computational grid of dimensions 129 by 91 by 33 (387,000) was generated using the UTRC- developed MKBLOX grid generation software system. Dimensions and grid node distributions were chosen to approximate the grid in the analysis of the baseline separate-flow system.

Effect of nozzle offset: Full color contour circumferential views of the axial velocity at the centerbody trailing edge plane (x/D=0.0) and at x/D=6.0 are shown on Figure 49. The level of peak axial velocity is reduced to the level seen in the core mixer case (Figure 47). A direct comparison of the fan offset centerline nozzle flow field to the baseline axisymmetric nozzle is shown in Figure 50. Total temperature contours are evaluated at planes distributed from x/D = 0. to 11. The effect of the offset clearly produces a crossflow structure (kidney pattern) associated with the generation of streamwise vorticity. The effect of the streamwise vorticity on the total temperature field produces an almost mixed out flow by x/D = 11.

4.2 TEST FACILITY AND TEST METHODS

The noise and microphone phased array testing part of the SFNT program were conducted in the NASA LeRC's Aeroacoustic Propulsion Laboratory (AAPL) from the 20th of March to the 18th of June. The facility was then shutdown for a previously scheduled two week period for maintenance. Nozzle exit flow plume survey testing were then conducted following the restart of the facility. The AAPL is consisted of the Nozzle Acoustic Test Rig (NATR) and the 65-foot radius Anechoic Hemispherical Dome. Far-field acoustic data were measured using a 48-foot radius microphone array centered at the test nozzle exit plane. P&W subcontracted the Boeing Aircraft Company to provide the phased array measurement equipment and to conduct the acquisition and processing of the phased array data. A detailed description of the test facility, test procedures, acoustic data acquisition and reduction has been presented in the test plan (Reference 1) and in previously published reports of References 6, 7 and 12. However, for completeness of this test report, sections of the descriptions of the test facility reproduced (verbatim) from the test plan are included below.

4.2.1 Nozzle Acoustic Test Rig (NATR)

The NATR is consisted of the 53-inch diameter free-jet duct section and the Jet Exit Rig (JER). The free-jet is driven by an annular air ejector system that entrains ambient air through a plenum and a transition bellmouth section and expels the air through a 53-inch inner diameter free-jet duct with a centerline height of 120 inches. The system can produce free-jet Mach numbers up to 0.3. Downstream of the free-jet duct exit plane is the Jet Exit Rig. The JER is the structure through which airflows are delivered to the core and fan nozzles via connections to the facility's compressed air supply systems. The core nozzle airflow is heated by a combustor using hydrogen as fuel. The fan nozzle airflow is heated by electric heaters. Exhaust gases from the free-jet and jet rig are expelled through the 43 ft high by 55 ft wide exhaust door downstream of the jet rig. A 60-inch diameter exhaust fan in the top of the dome provides air circulation. Figure 51 shows a picture of the NATR and the acoustic anechoic test arena.

4.2.2 Anechoic Test Area

The anechoic test arena is a 65-ft radius hemispherical dome. The walls of the dome and half the floor area are treated with acoustic wedges. The untreated half of the floor, occupied by the Power Lift Rig (PLR), has an acoustically treated wall installed near the NATR exit plane and extending aft along the untreated floor to shield unwanted sound reflections from the untreated floor area and other test equipment. The floor area in front of the test nozzle are treated with wedges prior to actual acoustic data acquisition. Microphones for the acoustic data acquisition are located along a 48-ft radius arc centered at the exit plane of the test nozzle. These microphones are mounted on 10-ft poles bolted to the floor. The angle locations for the microphones are from 50 to 160 degrees, at every 5 degrees interval. Figure 52 shows a picture of the 48-ft radius microphone array.

4.2.3 Facility Instrumentation

The NATR/JER instrumentation provides data on test variables such as free-jet Mach number, fan nozzle pressure ratio, core nozzle pressure ratio, fan flow temperature and core flow temperature, and airflow rates for the core and fan nozzles. The facility is not configured for nozzle thrust measurements. Four (4) total pressure/temperature rakes are installed at the charging stations of the core and fan ducts of the jet exit rig. The four radial rakes are spaced 90 degrees apart, and each rake has five (5) total pressure and five (5) total temperature sensors. The instrumentation system can display all twenty individual values and an averaged value for the total pressure and temperature. Flow venturis located in the compressed air supply lines give the flow rates of the core and fan flows.

4.2.4 Acoustic Test Matrix and Test Variables

The test matrix and the power setting parameters (i.e. core and fan nozzle temperatures and pressures) were selected to provide some common cycle points with the AST jet noise test scheduled for the NASA Langley Research Center. Further refinements were made to the test plan as the test progressed. The most significant modification was to set the fan nozzle temperature at a constant 600 degrees Rankine for all power settings (instead of varying the fan nozzle temperature from 560 to 660 for low to high power). This modification reduced significantly the amount of time required to set each test point. The second modification was to reduce the number of nozzle configurations that required testing at all three freejet Mach numbers (i.e. 0.0, 0.2 and 0.28). This reduced the number of configurations that were tested at all three Mach numbers to those of the baseline nozzles and to the most promising mixer devices. All others were tested at test points limited to the Lewis Cycle-2 (5 points at Mach number of 0.28, 1 common point at 0.2 and 1 common point at 0.0). This common point is pt. #21 of the Lewis Cycle-2. (This test point is equivalent to the sideline power of a typical aircraft powered by two HBPR engines). The effect of freejet Mach number on the jet noise reduction of the mixer devices were evaluated using pt #21 tested at three Mach numbers. The third modification to the test plan was to add a sixth cycle (Cycle-6) test points to one GE's nozzle mixer (3IC) for Escort runs 906 through 913. The test condition parameters for Cycle-1 through Cycle-6 are listed in Table 1.

4.2.5 Test Methods

NASA Lewis was responsible for the acquisition and the reduction of the noise data. Prior to the start of the noise tests, a facility shakedown was initiated and several facility associated noise sources were noted. These were 1) pipe noise from the newly designed secondary air supply system and 2) "vortex shedding" tones from the airfoil-shaped struts in the NATR airflow. These extraneous noise source were eliminated by installing a muffler in the secondary air supply system and wrapping the pipes with dense foam, and by wrapping the airfoil-shaped struts with fine wires running fore and aft from leading to trailing edges. Further descriptions of the test procedures are described below.

4.2.5.1 Acoustic Testing

Noise data were taken for the baseline nozzle Models 1 through 5 at three freejet Mach numbers (0.0, 0.20 and 0.28) and at power settings duplicating some of those to be tested at the NASA LaRC Jet Noise Facility. The data from these baseline nozzles were to be used by NASA to compare Lewis's and Langley's jet noise test facilities acoustic data acquisition and reduction systems. The power settings (core and fan nozzle pressure ratios, core and fan nozzle temperatures) for each baseline model were selected based on a composite of current turbofan engine cycles from different engine companies. Model 1 (BPR=5, Coplanar) and Model 2 (BPR=5, internal plug) were tested at power settings specified in cycles 1, 2 and 5. Model 3 (BPR=5, external plug) was tested at cycles 1 and 2. Model 4 (BPR=8, internal plug) and Model 5 (BPR=8, external plug) were tested at cycles 3 and 4. The majority of the jet noise mixer/suppression devices were for Model 3. These devices were tested at cycle 2, with the exception of 3IC which was also tested at cycle 6.
Repeat points of the baseline nozzle was taken each day for adjusting the absolute levels due to ambient temperature variations from test day to test day.

4.2.5.2 Phased-Array Microphone Testing

The following section describing the phased-array technique and beamforming comes directly from Reference 8 and is included within this document because it provides a good description of the procedure.

Beamforming is the name given to a variety of array processing algorithms that focus the array's signal-capturing abilities in a particular direction. The principle behind phased arrays is straightforward: if a signal is propagated to an array of sensors and each sensor's signal is delayed by an appropriate amount and added together with appropriately delayed signals from other sensors, the source signal is reinforced with respect to the noise. The delays that reinforce the signal are directly related to the length of time it takes the signal to propagate between sensors. As shown in Figure 53, due to different paths to each microphone it will take different amounts of time for the source signal to reach each microphone. By delaying each microphone's measured signals by an appropriate amount and adding together the delayed signals from all microphones, an enhanced signal can be obtained as shown in Figure 54.

The first question is how much delay is needed to get an enhanced signal. Delays are chosen by picking target points in space where possible noise sources might exist. The time required for a signal from an acoustic source at that target point to travel to each microphone is then calculated. This time can be calculated through classical acoustic formulas or through ray-tracing codes. Delays for each microphone signal are then calculated such that an enhanced signal would be obtained if a source was actually located at the target point. If a source was at the target point, an enhanced signal, such as that shown in Figure 54, would be calculated. However, if no noise source was at the target point, but was instead at some other point in space, then the delays do not cause the signals to add together in a constructive fashion. Instead the signals will tend to destructively add together and cause a small signal output as

shown in Figure 55. In practice all of these computations are done in the frequency domain and "time delays" between microphones are in fact phase differences, but the premise is the same. By examining many target points, the actual source locations can be found.
There are two major benefits to using phased arrays. First, by examining many target points on and around the test object, noise source locations can be found. Second, the array makes it possible to acquire acoustic data in locations where it was previously impossible due to signal-to-noise problems. It would be extremely difficult or impossible to acquire acoustic data near a source region in a jet. The flow noise on the microphone would overwhelm any acoustic signal.

Test setup

A picture of the test setup is shown in Figure 56. Three arrays were used during the testing. Two of the arrays were planar arrays which were designed and built for an earlier airframe noise test and were contained within the box below the nozzle shown in Figure 56. The microphone cables could be seen coming out of the back side of the box. The third array, a linear array, was located at the sideline position. It was designed and built for this test and was added in case there were signal-to-noise problems with the planar arrays. As it turned out, the two-dimensional planar arrays performed well and the one-dimensional linear array was barely used. A description of each array is included below.

Large 7-arm Logarithmic Spiral Array

The large 7-arm logarithmic spiral array can determine source density in three dimensions, although with poor resolution in depth because of the array's limited aperture. This array, which was designed for resolving low frequency sources (1-10 kHz), is a 63-element multi-arm spiral array with a 29-inch outer radius and 2-inch inner radius (see Figure 57). The elements are distributed, 9 each, along seven identical spiral arms so as to maintain approximately uniform area density of sensors across the array. The innermost circle of this array was replaced with the second to the innermost circle from the small planar array (described below) so that the two arrays could share some elements thereby reducing the number of sensors required for the test. This array, as well as the small 7-arm spiral array, were tested below the nozzle at approximately 90 degrees and then moved downstream and rotated towards the noise sources at approximately 120 degrees as shown in Figure 56.
More detailed information (e.g. the peak sidelobe levels or beamwidth) of logarithmic spiral arrays versus conventional arrays can be found in References 9 and 10.

Small 7 arm Logarithmic Spiral Array

The small planar array, which was designed for resolving high frequency sources (8-80 kHz), is a 49-element multi-arm spiral array with a 6-inch outer radius and 0.75-inch inner radius. The elements are distributed, 7 each, along seven identical spiral arms so as to maintain approximately uniform area density of sensors across the array (see Figure 58). Two of the outermost elements in this array were not used due to data acquisition system configuration limitations.

One-Dimensional Linear Array

A 1-D linear array was designed and tested for this test. The array remained at the sideline position at approximately 90 degrees. The 28-element linear array was 48 inches in length. It was designed to work across a broad range of frequencies (1-50 kHz) by using an element distribution strategy that guarantees non-redundant spacing (i.e., no two pairs of microphones in the array are separated by the same distance).

A picture of the array is shown in Figure 59. The microphones were mounted in a board at grazing incidence to the jet source thus reducing any microphone incidence effects. The face of the board was covered with a strip of Nomex felt to reduce any reflections from the board to the microphones.

Description of the Test Conditions for Phased-Array Testing

One hundred forty two data points were taken for three different arrays for the 31 test configurations/array locations shown in Table 2.

The nozzles were tested along Cycle-2 operating line chosen by NASA, GE and PW to have approximately the same bypass and core nozzle pressure ratios typical of current engine nozzle designs. Points 21 and 23 were typical of a sideline and a cutback condition, respectively.

Cycle-2, BPR=5 Power Settings for Phased-Array Measurements

Point (Equiv. Condition)	Fan Pressure Ratio	Fan Total Temp R	Core Pressure Ratio	Core Total Temp R
20	1.890	600	1.790	1540
21 (Sideline)	1.830	600	1.680	1500
22	1.730	600	1.510	1420
23 (Cutback)	1.600	600	1.350	1345
24	1.510	600	1.270	1300

4.2.5.3 Nozzle Exit Flow Plume Survey Testing

Flow plume survey investigations were conducted on selected nozzle configurations at limited power settings (Cycle-2, points 21 and 23). The surveys were conducted along the jet centerline and at several lateral horizontal positions for several axial distances downstream of the jet. The plume survey rake assembly itself contains four (4) rakes. The left outboard rake is spaced approximately 4.28 inches from the centerline of the rake assembly and this rake contains 41 total pressure sensors. The left inboard rake is 1.28 inches from the rake assembly centerline and this rake contains 41 total temperature sensors. The next two rakes (i.e. the right outboard and inboard rakes) contain static pressure sensors only. Figure 60 shows a picture of the Plume Survey Rake Apparatus. Typically, a plume survey is generated by traversing the rake assembly in 0.25 inches lateral increments. Further details of the procedure are described in Reference 1.

4.3 DATA ACQUISITION AND REDUCTION METHODS

4.3.1 Acoustic Data Acquisition and Reduction Method

The test plan (Reference 1) described the NASA LeRC acoustic data processing scheme that digitizes the raw data and corrects them for microphone pistonphone calibrations, actuator frequency responses, free-field and grid cap frequency responses, analogy filter roll-off, free-jet shear layer refraction corrections, atmospheric attenuation at test day condition over test distance corrections, spherical spreading attenuation corrections, and scaling the data to full-scale (scale factor of 8) and 150-ft radius. (For test points simulating flight conditions, the freejet background noise were subtracted from the measured acoustic data before corrections were applied). Figure 61 shows a flowchart of how the acoustic data is processed. NASA provided Block V data which was used for this report.

The acoustic and aerodymanic performance (mass flow rates, nozzle discharge coefficients) data along with test condition (total temperatures, total pressures and calculated jet velocities and ideal net thrust) information were also recorded in each data file which is identified by an “Escort” number and a nozzle configuration number.

4.3.1.1 150-Ft Radius (FullScale) Sound Pressure Level (SPL) Spectral Data

The first set of data were 1/3-octave band SPL spectral data scaled up to a 8-scale factor and projected to a 150-ft radius distance. These data were corrected to the acoustic standard day condition, 77 deg. F and 70 % relative humidity. These data were identified as “Pfiles” data by NASA Lewis.

4.3.1.2 1500-Ft (FullScale) Flyover SPL Spectral Data and Effective Perceived Noise Level (EPNL) Calculations

The second set of data were 1/3-octave SPL spectral data obtained by extrapolating the 150-ft-radius SPL data to a 1500-ft level flyover. These data were calculated using NASA LeRC's methods to account for relative flight velocity, Doppler effect, spherical spreading attenuation, NOY weighting, summation and tone corrections, and duration corrections.. Accompanying these 1/3-octave band SPL spectral data are the calculated Perceived Noise Level (PNL) and the Effective Perceived Noise Level (EPNL) values. These data were identified as "Tfiles" data by NASA Lewis.

4.3.2 Phased-Array Microphone Jet Noise Source Location Data Reduction Method

The microphone signals were digitized to a hard-disk in real-time using the Boeing Digital Data System 3 (DDS3). During breaks in testing (e.g., model changes), the data was uploaded and processed on the NASA LeRC LACE cluster on 11 dedicated parallel nodes. The output of the parallel processing were cross-correlation matrices that were then further processed to give beamformed SPLs at different locations defined in a grid.

A NASA LeRC supplied SGI computer with the FAST program was used for viewing the processed data and creating color postscript files of the beamformed images.

Calibration of the Arrays with and without Tunnel Flow

Phased arrays work by accurately knowing phase differences (equivalent to time-delays) between relative microphones for a signal from a given source location. Bias errors can be present in both the amplitude and phase that can blur the beamformed images. To insure the quality of the images, a phase calibration of the microphones is done for a source at a known location. Then the phase errors are determined and applied to the measured jet noise data to remove the bias errors.

In order to account for the propagation of sound through the tunnel's moving flow and through a shear layer, the beamforming program uses a ray tracing algorithm to calculate the path lengths to each microphone. To insure that this procedure works properly, a known source is placed inside the tunnel near the noise source. For this test, two deer whistles were taped on the outside of the secondary nozzle as shown in Figure 62. The tunnel was brought up to speed which caused the whistles to make noise. Beamforming was performed to show that sources could be found and that they were at the proper location.

4.3.3 Nozzle Exit Plume Survey Data Reduction Method

4.3.3.1 Jet Pressures, Temperatures and Axial Velocity Profiles

The plume measurements are static and total pressures and gas total temperatures as function of the lateral and axial locations. At a given axial location, the rake assembly traversed in 0.25 inch increments and each sweep of the survey cover the entire cross-section of the jet plume and some of the freejet flow. A map consisting of values of static pressures, total pressures and gas temperatures together with grid points lateral and axial coordinates is generated. First, jet Mach numbers are calculated from the static and total pressures, and jet velocities are then calculated from the jet Mach numbers and gas temperatures. Post-

processing of the plume survey data and creating color image postscript files of pressure, temperature and jet velocity contours were done by Dr. James Bridges of NASA Lewis.

5.0 DISCUSSIONS OF TEST RESULTS

5.1 EPNL SUMMARY FOR All SFN TEST CONFIGURATIONS

Table 4 presents a summary of the calculated Effective Perceived Noise Level (EPNL) values (for a 1500-ft-level flyover) and the corresponding Escort numbers for all the nozzle configurations tested. Also included in the summary are the ideal mixed jet velocity (Vmix) and the ideal net thrust (Fn), calculated using the mixed flow mass and momentum equations. These EPNL values are for a scaled-up nozzle of scale factor of 8. As shown in Table 4, there are several repeat runs of the model 3 baseline nozzle taken over a period of 11 weeks. The ambient test day temperatures varied from 35 to 74 deg. F. Figure 63(a) shows a correlation of the 1500-ft level flyover EPNLs (normalized by Fn, the ideal thrust) plotted against mixed jet velocities (Vmix), and Figure 63(b) shows the same correlation (with the ambient test day temperature correction) in the form of EPNLs against mixed jet **Mach** number (Vmix/C0) where Vmix is again the mixed jet velocity and C0 is the ambient speed of sound. As shown in Figure 63(b), the data scatter for the EPNL correlation when corrected for ambient test day temperature is significantly reduced. For this reason, all EPNL correlations presented in this report would be EPNLs versus mixed jet **Mach** numbers. The third order least square fit curve shown in Figure 63(b) represents the typical model 3 baseline nozzle EPNL versus mixed jet **Mach** number correlation.

5.1.1 Results for Model 3 Baseline Nozzle

All spectra reflect fullscale jet noise assuming a scale factor of 8. Figure 64 shows a comparison of the measured and Boeing's JEN6 predicted SPL spectra for the Model 3 baseline nozzle at mixed jet velocity of 1155 ft/sec. The comparison shows good agreement between measured and predicted spectra for all far-field angles, which indicates that the individual jet source levels predicted by JEN6 as described in Figure 1, are reasonably accurate, and that the noise from the mixed jet is probably the dominant noise source for the separate-flow nozzle.

5.1.1.1 Effects of Freejet Mach Number on Baseline Nozzle Noise Levels

Figure 65 shows the effect of the freejet Mach number on the EPNL versus Jet Mach number correlations for Model 3 baseline nozzle. EPNL values decrease with increasing freejet Mach numbers. Figure 66 shows the effect of the freejet Mach number on PNL directivities for a mixed jet velocity of 1155 ft/sec. The PNL directivities become flatter with increasing freejet Mach number, and the maximum PNL reductions occur near the peak noise angles between 120 and 140 degrees. Figure 67 shows the freejet Mach number effect on the corresponding SPL spectra. The freejet appears to reduce the baseline nozzle's jet noise over the entire frequency range of the jet noise spectra.

5.2 RESULTS FOR SELECTED MODEL 3 MIXER DEVICES

5.2.1 EPNL versus Mixed Jet Mach Number Correlations

Figures 68 through 78 show comparisons of the 1500-ft level flyover EPNL (freejet Mach number of 0.28) versus mixed jet Mach number correlations for most of the model 3 baseline and mixer devices tested, (i.e. 3C12B, 3C8B, 3IB, 3AB, 3DiB, 3DxB, 3BT48, 3BT24, 3BCv, 3BC, 3BOmax, 3T24B, 3T48B, 3HmB, 3FmB, 3IC, 3C12C, 3C8C, 3AC, 3T24T24, 3T24C, 3T48T48, 3T48C, 3HmC, 3HmS, and 3HmOmax). The most effective noise reduction devices are the primary Chevrons with fan baseline nozzle (3IB, 3AB) or with fan Chevron nozzle (3IC. 3AC), and the primary flipper-tabbed nozzles with fan baseline nozzle (3T24B, 3T48B) or with fan Chevron and 48-flipper-tabbed fan nozzles (3T24T48, 3T24C, 3T48T48, 3T48C). The vortex generators doublets configured nozzle (3DiB, 3DxB), the scarfed fan nozzle (3BS), the offset centerline fan nozzle (3BOmax), the half- and full-mixer core nozzles (3HmB, 3FmB) did not achieve any significant noise reduction. In general, the results show that the chevrons and flipper-tabbed devices worked best when installed on the primary/core nozzle. The same configured devices installed on the fan nozzle did not work as well.

5.2.2 EPNL Reductions/Suppressions Achieved by Model 3 Mixer Devices

Figures 79 through 89 present the respective EPNL reductions achieved by the model 3 mixer devices at freejet Mach number of 0.28. The plots show the delta EPNdB values on the Y-axes as positive values for EPNL noise reductions and negative values for actual noise increases. The figures show that some devices such as the 24 flipper-tabbed fan nozzle, the scarfed fan nozzle, the offset fan nozzle, actually increase the overall EPNL noise levels.
Devices like the vortex-generators doublets produced no significant EPNdB noise effect, while the half- and full-mixer core nozzles produced negative effects at low mixed jet velocity settings but positive effects at the higher mixed jet velocities. The devices that worked well are the primary chevrons and primary flipper-tabbed nozzles tested in combination with the baseline fan nozzle or the chevron fan nozzle. These noise reductions/suppressions generally increase with increasing mixed jet velocity with maximum reductions as much as 3 EPNdB were achieved at the highest mixed jet velocity tested (1200 ft/sec). Devices that achieved the 3 EPNdB noise goal at 1200 ft/sec (Vmix) are (i) 3IC, (ii) 3AC, (iii) 3T24C, (iv) 3T48C. Devices that nearly achieved the 3 EPNdB goal are 3T24B, 3IB, 3AB, 3T48T48, 3T48B and 3C8C.

5.2.3 Effect of Freejet Mach Number on Model 3 Mixer Devices EPNL Reductions/Suppressions

Figures 90 through 96 are plots of the EPNdB suppressions of the Model 3 mixer devices at the second highest mixed jet velocity tested (Vmix=1155 ft/sec) for three freejet Mach numbers, 0.0, 0.20 and 0.28. The results showed that there is no consistent trend of the effect of freejet Mach number on the mixer devices EPNdB noise suppression. For some devices

(3AB, 3BT24, 3HmC, 3BOmax, 3HmB, 3FmB, 3AC, 3T24T24, 3T24T48, 3T24C, 3HmS, 3T48T48, 3HmOmax and 3BS) the EPNdB suppressions decrease with increasing freejet Mach number, while other devices (3C12B, 3C8B, 3IB, 3T48B, 3IC, 3C8C and 3BT48) the EPNdB suppressions remain constant with freejet Mach numbers.

5.2.4 Effect of Freejet Mach Number on Mixer Devices' PNL Directivities

Figures 97 through 100 show the effects of the freejet Mach numbers on selected mixer devices' 1500-ft level flight PNL directivities for mixed jet velocity setting of 1155 ft/sec. The reduction of PNL with increasing freejet Mach number is not constant over the entire angle range and instead is more at the peak noise angle than at the either ends of the inlet and aft angle directivities. The resulting impact is that the overall PNL directivity is flatter as freejet Mach Mach number is increased, and it appears that the "-10 PNdB" down points are beyond the angle ranges of the acoustic data (i.e. less than 50 degrees inlet and greater than 160 degrees aft). In the term of the EPNL metrics, the mixer devices tend to have favorable lower peak PNLs but higher adverse duration correction factors relative to that of the baseline nozzle. The net impact is that the overall EPNL reduction is somewhat lower than the reduction of the peak PNL.

5.2.5 SPL Spectral Characteristics of Selected Mixer Devices (P&W's 48-Flipper Tabbed Primary and Fan Nozzles)

The noise characteristics for the 48-flipper tabbed primary and fan nozzles designed by P&W were selected for more detailed acoustic analyses in this section. The 48-flipper tabs designs were tested as (a) 48-tabbed primary nozzle with baseline fan nozzle (3T48B), (b) baseline primary nozzle with 48-tabbed fan nozzle (3BT48), (c) 48-tabbed primary with 48-tabbed fan nozzle (3T48T48) and (d) 48-tabbed primary with GE's 24-Chevrons fan nozzle (3T48C).

5.2.5.1 Comparison of PNL Directivities at typical "Cutback" Mixed Velocity Setting (Vmix=980 ft/sec, Freejet Mach=0.28)

Figure 101 shows a comparison of the PNL directivities of the 3T48B, 3BT48, 3T48T48 and 3T48C test configurations versus that of the model 3 baseline configuration (3BB). As shown earlier in Figure 85, there is little or no EPNdB reductions for these devices at this low mixed velocity setting. The 3T48B (48-tabbed primary nozzle) shows some noise reductions in the aft angles but nothing in the inlet angles. The 3BT48 (48-tabbed fan nozzle) shows an overall noise increase for almost the entire angle range. The combined 48-tabbed primary and fan nozzle (3T48T48) shows some noise reduction in the aft angles and a noise increase in the inlet angles, as one would expect to find when the noise effects of the 48-tabbed primary alone and the 48-tabbed fan alone are combined. The 3T48C (48-tabbed primary with GE's 24-chevrons fan nozzle) shows the same trend as that of the 3T48T48, except that the noise increase in the inlet angles are slightly less.

5.2.5.2 Comparisons of SPL Spectral Characteristics at typical "Cutback" Mixed Velocity Setting (Vmix=980 ft/sec, Freejet Mach=0.28)

Figure 102 compares the SPL spectra at four (4) far-field angles, 60, 90, 110 and 150 degrees. At this low mixed velocity, the 3T48B nozzle achieved about 2 dB low-frequency noise reduction but generated slightly higher high-frequency noise at 90 degrees. In contrast, the 3BT48 nozzle, shown in Figure 103, significantly reduced higher low-frequency noise but also generated significantly higher high-frequency noise. In NOY weighting, the increased level of the high-frequency noise has an adverse impact on the PNL metric, and the net result is an overall PNL increase for the 3BT48 nozzle as shown in Figure 101(b). In Figure 104, the 48-tabbed primary and fan combination nozzle (3T48T48) also generated significantly higher high-frequency noise which is characteristic of the 48-tabbed fan nozzle. Figure 105 shows the SPL spectral characteristics of the combination nozzle 3T48C where the 48-tabbed fan nozzle is replaced by the 24-chevrons fan nozzle. This nozzle has lower high-frequency noise levels, indicating that chevrons are better than tabs for the fan nozzle application.

5.2.5.3 Comparison of PNL Directivities at typical "Sideline" Mixed Velocity Setting (Vmix=1155 ft/sec, Freejet Mach=0.28)

Figure 106 shows a comparison of the PNL directivities of the 3T48B, 3BT48, 3T48T48 and 3T48C versus that of the model 3 baseline 3BB for the typical higher "sideline" mixed jet velocity setting. The trends are similar as to those noted for the "cutback" jet velocity cases. Most of the PNL reductions are in the aft angles. There are no reductions and even some slight noise increases in the inlet angles.

5.2.5.4 Comparisons of SPL Spectral Characteristics at typical "Sideline"Mixed Velocity Setting (Vmix=1155 ft/sec, Freejet Mach=0.28)

Figures 107 through 110 show the SPL spectral comparisons of the 3T48B, 3BT4B, 3T48T48 and 3T48C for the higher "sideline" mixed jet velocity setting of 1155 ft/sec.
The comparisons again show the same trends, that (1) the 48-tabbed primary nozzle achieves 2-3 dB low-frequency noise reduction with only a slight increase of high-frequency noise. and (2) the 48-tabbed fan nozzle achieves 2-3 dB low-frequency noise reduction but generates an equal amount increase of high-frequency noise.

5.2.5.5 Effect of Freejet Mach Number on SPL Spectra

The effects of freejet Mach number on SPL spectra of the 48-tabbed primary nozzle (3T48B), the 48-tabbed fan nozzle (3BT48) and the 48-tabbed primary and fan combination nozzle (3T48T48) are shown in Figures 111, 112 and 113, respectively. The two 48-tabbed fan nozzle configurations all show that in the inlet angles (60 and 90 degrees) the reduction of noise levels due to increasing freejet Mach numbers are uneven across the frequency

spectra. The high-frequency portions of the spectra (2000 Hz and above) indicate less reduction and are less sensitive to increasing freejet Mach number from 0.20 to 0.28. According to the prediction of the Boeing's JEN6 jet noise model for the baseline nozzle presented in Figure 1, these high-frequency noise are from the secondary or fan jet. One explanation for the lack of reduction in high-frequency noise is that the tabs in the fan nozzle are interacting with the freejet tunnel flow and are generating additional high-frequency noise which negate any "flight effect" benefits the fan jet may encounter.

Figures 114, 115 and 116 are cross-plots of the same SPL spectra for the three 48-tabbed primary, fan and combined nozzles to show how the SPL spectra change with the three nozzles over freejet Mach number of 0.0, 0.20 and 0.28. The changes in SPL spectra are found to be identical in all three freejet Mach numbers. The tabbed fan nozzle produce additional high-frequency noise when tested by itself or in combination with the tabbed primary nozzle. The suppression characteristics of the combined tabbed nozzle appear to be the additive sum of the individual suppression characteristics of the 48-tabbed primary nozzle and the 48-tabbed fan nozzle.

5.2.6 Comparisons of SPL Spectral Characteristics of Other Mixer Devices

Comparisons of SPL spectral characteristics of the other model 3 mixer devices tested are presented in Appendix A, Figures A-1 through A-80. Analyses of all these figures support the general conclusion that chevrons and tabs installed on the primary nozzle are the best noise suppression devices. These primary nozzle devices achieve low-frequency noise suppression without generating additional increase in high-frequency noise. The same chevrons and tabs on the fan nozzle are not effective because they generate additional increase in high-frequency noise either by interaction with the fan jet or the freejet flows.

5.3 SELECTED MICROPHONE PHASED-ARRAY TESTING RESULTS

The data was processed for each configuration and supplied to NASA LeRC in the form of color postscript files and plotable data files. These data were loaded onto a computer at NASA LeRC with the help of Dr. James Bridges for distribution to the AST partners. A small amount of analysis of the data was performed by Boeing for selected configurations and will be discussed below.

Figure 117 shows a typical output for a configuration /test condition for one array. The configuration name and array identification are in each subtitle. Below this, the run identification number, operating point, and Mach number are displayed. Each figure displays six individual contours that show the relative SPLs from the peak source level. The third octave band center frequency (fc), the peak SPL, and the location (x and y) of the peak SPL for each one-third octave band frequency are shown below each color contour.

The location "x" on the streamwise axis is always referenced to the upstream freejet tunnel nozzle exit plane which is 30 inches upstream of the primary nozzle exit plane in the model 3

baseline nozzle. Therefore, when the value of the peak SPL "x" location is given as x = 90 means that the peak SPL source is actually located at (x = 90-30 =60) inches downstream of primary nozzle exit plane. Since the cold diameter of the primary nozzle is 5.156 inches, the "x" location normalized by the primary nozzle diameter is 60/5.156 = 11.6 primary nozzle diameters. The "y" location for the peak SPL for each frequency band is referenced to the nozzle's centerline. Therefore when the value of the "y" location is given as y = -2 inches means the y-coordinate of the peak SPL is 2 inches above the jet centerline as seen by the array looking up. Y-coordinate equals 0 inches is approximately the jet centerline or axis.

An outline of the top half of the nozzle is shown in each contour as provided by Dr. James Bridges. The nozzle is always on the left hand side of the contour with the jet flow from the left to the right.

To the left of the figure, a color map shows the SPL relative to the peak levels. The peak level is shown as 0 dB while the rest of the SPL color contours as -2, -4 , -6 and -8 dB referenced to the peak SPL value printed below each of the six blocks. SPL levels are only shown to -8 dB relative to the peak because levels much below these are subject to spatial aliasing from the array. Spatial aliasing occurs in phased array beamforming analogous to frequency aliasing in time-domain, signal processing. These arrays have about 8-10 dB of resolution between the main lobe and the highest side lobes. Therefore, signals below 8-10 dB could be aliased signals from other sources, so they may not be true sources and are not shown. References 9 and 10 explain sidelobe levels and aliasing in greater detail.

5.3.1 Model 3BB Viewed with Array A

Figure 117 shows Model 3, the BPR 5 external plug, SPL source levels for operating point 21 (sideline condition) at a tunnel Mach number of 0.28 for the large, 2-D array (array A) at the 90 degree position. Notice at the lowest model scale frequency, fc=1000 Hz, there seems to be one source (11.6 primary nozzle diameter) downstream of the nozzle while at the highest frequency shown, fc=3150 Hz, there are two sources (one approximately one primary nozzle diameter and a second one 11.4 primary nozzle diameter downstream). The downstream source changes location very slightly forward (closer to the nozzle) as frequency is increased.

The upstream source becomes increasingly important as the frequency increases. The upstream source is not even visible at the lowest frequency, but is very evident at the highest frequency.

5.3.2 Model 3BB Viewed with Array B

Figure 118 shows the same configuration viewed with Array B (at higher frequencies). Array B is the name given to the high frequency, 2-D inner small-arm array at the 90 degree position. This array works well from 8 to 40 kHz. Using the B array showed only one high frequency source near the nozzle. The location of this source moves slightly forward with frequency until it appears to be located at the secondary nozzle/ambient shear layer location.

Generally, these results can be explained by considering the two source regions separately. The upstream source region near the nozzle exit, for herein named Region 1, results primarily from secondary/ambient mixing layer noise, any nozzle trailing edge, and duct noise. This source region tends to dominate at the higher frequencies.

The downstream source, conveniently named Region 2 for this document, is most likely the "classical jet noise" region where jet mixing which give rise to the "mixed" jet is responsible for the noise. This region dominates the lower frequencies in Figure 117, but is not apparent at frequencies above 10 kHz model scale in Figure 118.

Clearly the data show two separate source regions. Also, the location of the peak SPL for the two source regions does not move as drastically as has been suggested by some of the jet noise prediction theories. The sources move slightly forward (toward the nozzle) with increased frequency, but not continuously from Region 2 to Region 1. Instead each source region seems to move only slightly while the relative importance changes with frequency. A low resolution method (for instance one where the phase difference between two microphones is used to determine a source location) would show a continuous transition from the Region 1 to Region 2 as the frequency increased because only the center of the mass of the noise could be located. As frequency increases, clearly the center of mass moves forward in a gradual way. This may help explain some of the older data sets showing a smooth transition of the peak SPL region towards the nozzle exit with increasing frequency.

5.3.3 Model 3BB Viewed with Array A Point 23

Figure 119 shows the baseline, external plug configuration at the cutback condition (Pt 23). Comparing figure 119 with figure 117, it is clear that the relative importance of the two sources has changed. The upstream source, Region 1, has a higher relative SPL compared to the downstream source, Region 2, as the operating condition is lowered (lower nozzle operating point).

This observation seems to suggest that the upstream source is less affected by the nozzle Mach number than the downstream source.

5.3.4 Model 3BB Viewed with Array A Mach 0.0

Figure 120 shows the baseline, external plug configuration at a tunnel Mach number of 0.0 (static) instead of 0.28. Note the relative level of the two source regions. The downstream source, Region 2, is more important relative to Region 1 for the static condition. This also tends to suggest that Region 2 is more affected by relative Mach number of the nozzle than Region 1.

5.3.5 Model 3IC Viewed with Array A

Enhanced mixing devices generally decreased the noise in the downstream noise region, but increased the noise at the upstream region. The devices that were effective in reducing the overall PNLT noise, were the ones that reduced the downstream region without overly increasing the upstream region.

Figure 121 shows phased array data for Array A for the chevron nozzle noise suppression device. This far-field data showed that this particular noise suppression hardware gave low frequency suppression with little increase in the high frequencies. Compared to the baseline configuration, Figure 117, this configuration has reduced levels for the downstream region, Region 2, with minimally increased levels for the upstream region.

5.3.6 Model 3BB Viewed with Array D

The 2-D arrays were moved to a downstream location of approximately 120 degrees to image the jet noise sources at an angle more consistent with the peak radiation angle of a jet. Figure 122 shows the phased array output for the baseline, extended plug configuration at the 120 degree position.

Note the downstream source region has increased SPLs relative to the upstream source region. The SPLs as given with the phased array are normalized to give the values as measured at the array. Since the downstream source is closer to the array than the upstream source, an amplification of the SPL occurs as the 20*log10 of the ratio of the two distances. Also, this D-array give higher peak SPL levels compared to the A-array for the same frequency band. This observation could be explained by considering the classical case where the jet flow in the form of jet "eddies " are convected downstream along a path within the shear layer which is at an angle 60 degrees to the D-array. The amplitudes of the noise arriving at the D-array are amplified by a factor of 40 log (1-$\mathbf{M_c}$Cos60) where $\mathbf{M_c}$ is the eddy convective Mach number.

5.3.7 Selected integrated SPL Spectra

In addition to the contour plots, integrated spectra were obtained by assuming the sources at different grid points outside the array resolution were incoherent (statistically independent and their powers can be summed). The time-averaged cross-spectral matrices were used for beamforming and do not allow the correlation between sources at different locations to be determined.

Figure 123 shows the integrated (bold lines) with the array at the 90 degree position versus the far-field measured data at 90, 100, and 110 degrees. The levels are shown over a range of far-field levels because the phased array itself spans a range of angles. All the data were extrapolated to 1 foot distance at full-scale frequencies. The phased array data did not include any atmospheric absorption and therefore the levels fall off at the highest frequencies.

The data for this configuration look exceptionally good and suggest that further work should be done to determine how well phased array measurements can reproduce far-field SPL spectral data. Figure 124 shows the integrated levels compared to the far-field data for the 3IC configuration. This comparison shows significantly increased levels from 600 to 2000 Hertz full-scale for the integrated spectra. Further work is needed to explain why the integrated levels differed from the far-field levels in this area.

5.4 SELECTED PLUME SURVEY PRESSURE AND TEMPERATURE PROFILES

Post-processing of the plume survey data and creating pressures, temperatures and jet velocity contours in the form of color image postscript files were done by Dr. James Bridges of NASA Lewis. Selected results are shown in Figures 125a through 132c for eight nozzle test configurations, 3T48B, 3T24T48, 3T24T24, 3T24C, 3BT24, 3FmB and 3HmB and 3BOmax, respectively. In Figure 125b for test configuration 3T48B, the temperature profile of the 48-flipper tabbed primary nozzle with the baseline fan nozzle is a 12-lobe pattern with a high degree of lobe penetration. This lobe pattern indicates that the "up" tab acts like the "crest" of the lobe in the conventional mixer where the primary flow is forced outward into the fan flow. The "down" tab behaves like the "trough" of the lobe where the fan flow is forced inward into the primary flow. The "neutral" tabs separating the up and down tabs prevents the outward and inward flows from interfering with each other. In the 48-flipper tabbed primary nozzle case, there are 12 "up" tabs and 12 "down" tabs, and therefore, the resulting plume behaves like a 12-lobed pattern. Each "up" delta tab produces a pair of streamwise vortices that rotates in opposite direction. Looking into the up tab, the vortex shed by the right edge of the delta triangular shape, the direction of the vortex is counter-clockwise and the primary flow is pulled outward into the fan flow. On the left edge, the vortex flow direction is clockwise, and again the primary flow is pulled outward into the fan flow. The strength of this pair of vortices is approximately equal to the circulation which is given in Reference 11 as

$$\text{Circulation} = 2\ U\ H \tan(\text{alpha})$$

where U is the velocity difference between the primary and fan flow, H is the tab height, and (alpha) is the tab angle relative to the primary nozzle mean flow line. The (alpha) value in the 48-tabs design is 30 degrees and value of tan(30) is 0.557. The value of H is (3.142 x primary nozzle diameter / 4 x total number of tabs) which is equal to 0.085 inches. At the sideline condition, U is equal to (1585 - 1070 = 515 ft/sec.) Thus the computed circulation strength is 4.06 sq. ft/sec. At the apex of the 90 degrees delta tab, the net circulation is zero, since the pair of clockwise and counter-clockwise vortices have to cancel each other. For this reason, the delta tab is designed to have a sharp point at the apex. The circulation produced by the down tab has the same strength as the up tab. In general, the requirement for a good tab design is to have a small tab height (H) and a large tab turning angle (alpha). However, increasing the value of alpha beyond 30 degrees could lead to local flow separation which is detrimental to the performance of the nozzle in flow and thrust coefficients.

The 24-flipper tabbed primary nozzle test configuration has twice the tab height as the 48-tabbed configuration and hence twice the vortices strength. The plume data for this configuration is shown in Figures 126a to 126c. The plume temperature profile shows a 6-lobe pattern with twice the lobe penetration as the 48- tabs. The primary flow no longer has a hot potential core and instead it is divided into six (6) smaller jets which mix rapidly with the fan flow to form a uniform mixed jet at only a few diameters downstream.

The 48-tabbed and 24-tabbed primary nozzle configurations have some of the best noise suppression characteristics and have achieved close to 3 EPNdB. On the recommendation from P&W, NASA Lewis has selected both 48- and 24-tabbed primary nozzles for additional aero-performance testing at Aero System Engineering to quantify the flow and thrust coefficients for these type of tabbed nozzle designs.

5.5 ASSESSMENT OF EPNL BENEFITS OF APPLYING SELECTED "BEST" MIXER DEVICES TO P&W's ENGINE PRODUCTS.

On the request from NASA Lewis, P&W made some preliminary estimates of the EPNL benefits of applying the noise suppression characteristics of the most promising mixer devices to the PW4084/98 jet engine product which has a scale factor of 12. The methods used to obtain these preliminary delta EPNdB are described in the following section.

The "Pfiles" SPL spectra (from NASA Lewis for scale factor of 8) were rescaled to a factor of 12, by applying a frequency shift [to lower frequencies by a factor of 10 Log (12/8)], and adjusting the amplitude higher by 20 Log (12/8). This adjustment was applied to the baseline (3BB) as well as the selected mixer nozzles. The resized SPL jet noise spectra for each nozzle configuration were then projected to a 1500-ft altitude level flyover prediction together with other engine noise components (i.e. fan, turbine, compressor, core/combustion) to get an effective total airplane flyover noise EPNL calculated value. These calculations were done for the typical sideline and cutback conditions, corresponding to 1155 ft/sec and 982 ft/sec Vmix. The calculated total airplane EPNL value using the baseline (3BB) jet noise becomes the referenced base value from which the EPNdB suppression of the mixer devices are calculated. The results are shown below.

Nozzle	EPNdB Suppression at Sideline		EPNdB Suppression at Cutback	
Configuration	Jet Alone	Total Engine Noise	Jet Alone	Total Engine Noise
3BB	Base	Base	Base	Base
3IB	2.0	1.0	0.6	0.2
3AB	1.6	0.5	0.0	-0.3
3AC	2.5	0.9	0.8	0.0
3IC	2.7	1.3	0.8	0.3
3T24B	2.2	1.3	0.0	0.0
3T48B	1.6	1.0	0.8	0.1
3T48C	2.5	1.3	0.8	0.3

As the numbers indicated, at sideline condition the mixer devices' EPNL suppressions are somewhat reduced when applied to an actual engine product whose total engine noise signature consists of more than jet noise. At cutback condition, the mixer devices' jet alone noise suppression effectiveness are significantly reduced, and when other engine noise component source levels are added to the total engine noise signature, the net effective total engine noise suppressions become even less.

6.0 SUMMARY OF RESULTS AND CONCLUSIONS

Scaled model suppression devices, nine (9) from P&W and ten (10) other model nozzle devices from the General Electric Aircraft Engine Company (GEAE) (provided under a separate NASA/GEAE contract), were tested in the NASA Lewis Nozzle Acoustic Test Rig (NATR) under static and simulated flight takeoff conditions. Far-field acoustic data, phased-array microphone data and plume survey data were taken and the results analyzed.

The NASA's NATR noise results indicated that (1) inward-facing chevrons on primary nozzles and flipper-tabs on primary nozzles achieved the best Effective Perceived Noise Level (EPNL) suppressions close to the SFN program goal of 3 EPNdB (at mixed jet velocity condition of 1200 ft/sec). Adding fan chevrons to the above primary nozzle devices provided only some additional marginal EPNL benefit. The results also indicated that primary nozzle devices affected the low-frequency component of the baseline nozzle's far-field Sound Pressure Noise (SPL) spectra. The fan nozzle devices affected the high-frequency component of the baseline nozzle's SPL spectra and in almost all cases, the fan devices actually increased the levels of these high-frequency noise. Other test nozzle devices (vortex generators doublets (GEAE), scarfed fan, offset-centerline fan nozzle, min-lobed mixers, tongue mixer (Allison), neutral chevrons (GEAE), and combination nozzle consisting of two of these concepts) did not achieve the desired 3 EPNdB goal.

The Boeing's phased-array results showed that phased-array technology could be used successfully to provide images of the jet noise sources of the separate-flow nozzle without intrusion into the jet exhaust plume. The phased-array tests showed that at low to mid frequencies, there were two distinct jet noise sources. The first source is located near the nozzle exit and the second source is downstream at several nozzle diameters. The tests also showed that the primary and fan mixer nozzle devices generally increased the upstream and decreased the downstream jet source regions sound intensities. The best noise suppression devices are the primary inward-facing chevrons and flipper-tabbed nozzles, which tended to decrease the downstream source region with only minimum increase in the upstream source region.

The NASA Lewis's plume survey data showed the primary tabbed nozzles produced pressure and temperature profiles that were similar to those produced by high-penetration lobed mixers. The profile is a 6-lobe pattern for the 24-flipper tabbed and a 12-lobe pattern for the 48-flipper tabbed primary nozzle. In P&W's tab design which incorporated a "neutral" tab separating an "up" and a " down" tab, the neutral tab increased the effective lobe penetration and did not added to the effective "lobe" count of the device. In the 24-tab case, the effective lobe count of the plume profile is controlled by the six "up" and six "down" tabs. In GEAE's inward-facing chevron design, the effective lobe count of the plume profile is the same as the total number of chevrons.

In summary, NASA's model-scale nozzle noise tests show that it is possible to achieve a 3 EPNdB jet noise reduction with inward-facing chevrons and flipper-tabs installed on the primary nozzle. These chevrons and tabs are simple devices and are easy to be incorporated

into existing short duct separate-flow non-mixed nozzle exhaust systems. However, these devices had been known to cause some small amount of thrust loss relative to the axisymmetric baseline nozzle system. Thus, it is important to have these devices further tested in a calibrated nozzle performance test facility to quantify the thrust performances of these devices. The choice of chevrons or tabs for use in the SFN jet noise reduction would most likely be based on the outcome of these devices thrust loss performance test results.

7.0 NEW TECHNOLOGY

As mentioned in the Summary of Section 1.0, a number of jet noise reduction concepts have been developed and demonstrated in model tests during the current contract efforts at Pratt & Whitney and GEAE. It is anticipated that the most promising of these concepts will be validated in full scale engine tests at both Pratt & Whitney and Allied-Signal, under funding from NASA's Engine Validation of Noise Reduction Concepts (EVNRC) programs. This will bring the technology readiness level to the point where these jet noise suppression concepts could be incorporated with high confidence into either new or existing turbofan engines having short-duct, separate-flow nacelles.

A patent application has been filed by Pratt & Whitney (inventors: John K. C. Low and Douglas C. Mathews) for the alternating tab, or "flipper tab" concept. This device is unique in that it involves a repeating cycle of tabs in a pattern of up-neutral-down-neutral. This pattern, when repeated 12 times (48 tabs) or 6 times (24 tabs) resulted in nearly 2.5 EPNdB jet noise suppression, with relatively low flow blockage.

8.0 REFERENCES

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Table 1. Power Settings Test Matrix for SFN Noise Test.

Test Point Number	Fan Nozzle Pressure Ratio	Fan Total Temp. (deg. Rankine)	Core Nozzle Pressure Ratio	Core Total Temp. (deg. Rankine)
Cycle-1, BPR=5				
10	1.75	600	1.56	1491
11	1.63	600	1.45	1390
12	1.51	600	1.33	1300
13	1.39	600	1.24	1240
14	1.27	600	1.15	1190
Cycle-2, BPR=5				
20	1.89	600	1.79	1540
21	1.83	600	1.68	1500
22	1.73	600	1.51	1420
23	1.60	600	1.35	1345
24	1.51	600	1.27	1300
25	1.42	600	1.20	1260
26	1.28	600	1.12	1200
Cycle-3, BPR=8				
30	1.56	600	1.35	1385
31	1.46	600	1.26	1339
32	1.36	600	1.17	1280
33	1.27	600	1.11	1235
34	1.17	600	1.05	1185
Cycle-4, BPR=8				
40	1.62	600	1.60	1580
41	1.57	600	1.52	1520
42	1.52	600	1.44	1460
43	1.44	600	1.33	1400
44	1.34	600	1.22	1320
45	1.25	600	1.15	1270
46	1.18	600	1.09	1220
Cycle-5, BPR=5 (Higher Core Temperature Variation Relative to Cycle-2)				
50	1.83	600	1.68	1640
51	1.60	600	1.35	1450
52	1.42	600	1.20	1300
Cycle-6, (Higher BPR than Cycle-2)				
60	1.92	600	1.62	1470
61	1.86	600	1.54	1440
62	1.76	600	1.43	1380
63	1.62	600	1.28	1300
64	1.52	600	1.22	1270

Table 2: Phased Array Test Configurations/Array-Microphone Positions

Test Config.	Model	Core Nozzle	Fan Nozzle	Array Ang.	Clock Ang.	Test Points
1	1	Base	Base	90	N/A	088-101
3IB	3	12 In-Flip Chevs.	Base	90	N/A	102-106
3IC	3	12 In-Flip Chevs.	24 Chevs.	90	N/A	107-111
3BB	3	Base	Base	90	N/A	112-119
3AB	3	12 Alt-Flip Chevs.	Base	90	N/A	120-124
3T24T48	3	24 Flip Tabs	48 Flip Tabs	90	N/A	125-129
3T48T48	3	48 Flip Tabs	48 Flip Tabs	90	N/A	130-138
3T48B	3	48 Flip Tabs	Base	90	N/A	139-143
3HmB(0)	3	Half Mixer	Base	90	0	144-147
3HmB(90)	3	Half Mixer	Base	90	90	148-150
3HmB(180)	3	Half Mixer	Base	90	180	151-153
3T24B	3	24 Flip Tabs	Base	90	N/A	154-158
3T24T24	3	48 Flip Tabs	24 Flip Tabs	90	N/A	159-163
3BOmax(0)	3	Base	Max. Offset	90	0	164-166
3BOmax(180)	3	Base	Max. Offset	90	180	167-169
3C12B	3	12 Chevs.	Base	90	N/A	170-172
2BB	2	Base	Base	120	N/A	173-175
2BB	2	Base	Base	120	N/A	176-180
3BB	3	Base	Base	120	N/A	181-185
3T24B	3	24 Flip Tabs	Base	120	N/A	186-188
3T24T24	3	24 Flip Tabs	24 Flip Tabs	120	N/A	189-191
3IC	3	12 In-Flip Chevs.	24 Chevs.	120	N/A	192-196
3HmB(0)	3	Half Mixer	Base	120	0	197-199
3HmB(90)	3	Half Mixer	Base	120	90	200-202
3HmB(180)	3	Half Mixer	Base	120	180	203-205
3T24B	3	24 Flip Tabs	Base	120	N/A	206-207
3T24T24	3	24 Flip Tabs	24 Flip Tabs	120	N/A	208-209
3BOmax(0)	3	Base	Max. Offset	120	0	210-214
3BOmax(180)	3	Base	Max. Offset	120	180	215-219
3BS(0)	3	Base	Scarf	120	0	220-224
3BS(180)	3	Base	Scarf	120	180	225-229

Table 3. AAPL Separate-Flow Nozzle Plume Survey Test Summary

Escort No.	Test Date	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Nozzle	Fan Nozzle	Clock Position	Cycle/ Point No.	Vpri (fps)	Vfan (fps)	Ideal Vmix (fps)	Freejet Mach No
1335	5/20/97	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1577	1069	1153	0.28
1341	5/20/97	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 21	1588	1072	1160	0.28
1353	5/21/97	3C12C	3010100	3	5	External	12 Chevrons	24 Chevrons	0	C2/Pt 21	1589	1070	1159	0.28
1367	5/22/97	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 21	1591	1072	1157	0.28
1383	5/22/97	3IC	3030100	3	5	External	12 In Chev.	24 Chevrons	0	C2/Pt 21	1590	1072	1158	0.28
1396	5/22/97	3T24C	3079199	3	5	External	24 Flip Tabs	24 Chevrons	0	C2/Pt 21	1600	1071	1165	0.28
1405	5/23/97	3C8B	3020000	3	5	External	8 Chevrons	Baseline	0	C2/Pt 21	1595	1071	1161	0.28
1421	5/23/97	3IB	3030000	3	5	External	12 In Chev.	Baseline	0	C2/Pt 21	1590	1073	1159	0.28
1433	5/23/97	3AB	3040000	3	5	External	12 Alt. Chev.	Baseline	0	C2/Pt 21	1590	1071	1160	0.28
1446	5/23/97	3HmB	3090009	3	5	External	Half Mixer	Baseline	90	C2/Pt 21	1587	1075	1160	0.28
1457	5/27/97	3FmB	3110000	3	5	External	Full Mixer	Baseline	0	C2/Pt 21	1585	1071	1155	0.28
1468	5/27/97	3T48B	3080000	3	5	External	48 Flip Tabs	Baseline	0	C2/Pt 21	1594	1072	1158	0.28
1480	5/27/97	3T24B	3070000	3	5	External	24 Flip Tabs	Baseline	0	C2/Pt 21	1595	1069	1154	0.28
1496	5/27/97	3T24T24	3070300	3	5	External	24 Flip Tabs	24 Flip Tabs	0	C2/Pt 21	1580	1072	1157	0.28
1503	5/28/97	3BT24	3000300	3	5	External	Baseline	24 Flip Tabs	0	C2/Pt 21	1584	1069	1160	0.28
1519	5/28/97	3BOmax	3000509	3	5	External	Baseline	Offset Noz.	90	C2/Pt 21	1591	1070	1160	0.28
1528	5/28/97	3T24T48	3070400	3	5	External	24 Flip Tabs	48 Flip Tabs	0	C2/Pt 21	1596	1071	1160	0.28
1550	5/29/97	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C2/Pt 21	1592	1066	1124	0.28
1560	5/30/97	1BB	1000000	1	5	Coplanar	Baseline	Baseline	0	C2/Pt 21	1578	1070	1150	0.28
1576	5/30/97	6TmB	6100000	6	5	Ext/Int	Tongue Mixer	Baseline	0	C2/Pt 21	1585	1069	1162	0.28
1587	5/30/97	6BB	7000000	7	13	Ext/Intl	Baseline	Baseline	0	C2/Pt 21	1601	1072	1106	0.28

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
87	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 14	692	0.0	13940	76.9
88	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 13	825	0.0	-	83.4
89	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 12	933	0.0	-	88.9
90	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 11	1022	0.0	-	93.5
91	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 10	1102	0.0	-	97.5
92	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 13	824	0.28	-	74.3
93	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt12	932	0.28	-	79.0
94	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 11	1020	0.28	-	83.6
95	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 10	1104	0.28	-	88.8
97	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 13	829	0.2	-	78.0
98	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 12	932	0.2	-	82.8
99	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 11	973	0.2	-	87.9
100	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C1/Pt 10	1100	0.2	-	92.8
101	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 21	1147	0.2	-	95.1
102	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 24	909	0.2	-	81.6
103	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 25	835	0.2	-	78.1
104	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 26	697	0.2	-	72.3
105	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 24	909	0.28	-	77.4
106	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 23	980	0.28	-	80.7
107	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 22	1082	0.28	-	86.7
108	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 21	1156	0.28	-	91.4
109	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 20	1200	0.28	-	94.0
111	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 20	1193	0.0	-	101.9
112	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 21	1159	0.0	-	100.1
113	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 22	1080	0.0	-	96.1
114	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 23	978	0.0	-	90.8
115	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 24	915	0.0	-	87.6
116	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C2/Pt 26	697	0.0	-	76.8
117	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C5/Pt 52	840	0.0	-	83.7
118	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C5/Pt 51	987	0.0	-	91.8
119	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C5/Pt 50	1165	0.0	-	101.1
120	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C5/Pt 50	1164	0.28	-	97.3
121	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C5/Pt 51	988	0.28	-	82.0
122	3/20/97	48.0	1BB	1000000	1	5	Internal	Baseline	Baseline	0	C5/Pt 52	842	0.28	-	74.7

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
198	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 24	911	0.28	17519	76.9
199	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 23	983	0.28	21328	80.1
200	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 22	1077	0.28	27149	85.6
201	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 21	1152	0.28	32004	90.8
202	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 20	1197	0.28	35016	93.2
204	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 21	1156	0.2	35597	94.8
205	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 24	918	0.2	-	80.9
206	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 25	838	0.2	10325	77.4
208	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 26	697	0.2	10072	71.6
209	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 26	697	0.0	14802	75.9
211	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 23	982	0.0	31145	90.1
212	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 22	1081	0.0	38085	95.2
213	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 21	1150	0.0	43735	99.7
217	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 20	1203	0.0	47458	101.4
218	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 10	1097	0.0	39562	96.5
219	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 11	1019	0.0	33769	92.7
220	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 12	924	0.0	27449	87.7
221	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 13	822	0.0	21466	82.6
222	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 14	699	0.0	15113	76.2
223	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 14	700	0.2	10334	72.2
224	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 13	833	0.2	16161	77.6
225	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 12	928	0.2	21114	82.0
226	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 11	1021	0.2	26429	87.3
227	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 10	1101	0.2	31513	91.9
228	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 10	1100	0.28	28082	87.6
229	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 11	1023	0.28	23460	82.8
230	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 12	928	0.28	18305	78.0
231	3/25/97	58.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 13	826	0.28	13464	73.6
232	3/25/97	48.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C5/Pt 52	839	0.28	14014	74.6
233	3/25/97	48.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C5/Pt 51	984	0.28	21278	81.1
234	3/25/97	48.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C5/Pt 50	1161	0.28	31648	92.2
236	3/25/97	48.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C5/Pt 51	984	0.0	30846	90.6
237	3/25/97	48.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C5/Pt 52	831	0.0	21599	82.6

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
244	3/25/97	40.0	2BD	2000200	2	5	Internal	Baseline	96 Int. VG Doublet	0	C2/Pt 20	1203	0.28	35197	94.5
246	3/25/97	40.0	2BD	2000200	2	5	Internal	Baseline	96 Int. VG Doublet	0	C2/Pt 21	1155	0.28	31943	91.0
247	3/25/97	40.0	2BD	2000200	2	5	Internal	Baseline	96 Int. VG Doublet	0	C2/Pt 22	1076	0.28	26913	85.6
248	3/25/97	40.0	2BD	2000200	2	5	Internal	Baseline	96 Int. VG Doublet	0	C2/Pt 23	979	0.28	21027	80.2
249	3/25/97	40.0	2BD	2000200	2	5	Internal	Baseline	96 Int. VG Doublet	0	C2/Pt 24	913	0.28	17462	80.4
251	3/25/97	40.0	2BD	2000200	2	5	Internal	Baseline	96 Int. VG Doublet	0	C2/Pt 23	984	0.0	31282	90.2
252	3/25/97	40.0	2BD	2000200	2	5	Internal	Baseline	96 Int. VG Doublet	0	C2/Pt 22	1081	0.0	38269	95.2
304	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 26	695	0.0	15006	75.9
305	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 24	909	0.0	26787	86.0
306	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 23	984	0.0	31676	89.6
307	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 22	1081	0.0	38739	94.6
308	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 21	1158	0.0	44473	98.3
309	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 20	1202	0.0	47886	100.5
310	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 21	1158	0.2	35938	94.1
311	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 24	911	0.2	21132	80.4
312	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 25	837	0.2	16416	77.3
313	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 26	696	0.2	10234	72.0
314	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 24	910	0.28	17636	76.6
315	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 23	982	0.28	21598	80.1
316	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 22	1077	0.28	27354	85.0
318	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 21	1159	0.28	32493	89.7
319	3/27/97	64.4	2C12B	2010000	2	5	Internal	12 Chevrons	Baseline	0	C2/Pt 20	1204	0.28	35864	92.3
323	3/27/97	65.6	2C12Ct	2010800	2	5	Internal	12 Chevrons	24 Chev.(BL trip)	0	C2/Pt 24	913	0.28	17948	78.0
324	3/27/97	65.6	2C12Ct	2010800	2	5	Internal	12 Chevrons	24 Chev.(BL trip)	0	C2/Pt 23	982	0.28	21811	81.1
325	3/27/97	65.6	2C12Ct	2010800	2	5	Internal	12 Chevrons	24 Chev.(BL trip)	0	C2/Pt 22	1083	0.28	28050	86.0
326	3/27/97	65.6	2C12Ct	2010800	2	5	Internal	12 Chevrons	24 Chev.(BL trip)	0	C2/Pt 21	1160	0.28	32899	90.1
327	3/27/97	65.6	2C12Ct	2010800	2	5	Internal	12 Chevrons	24 Chev.(BL trip)	0	C2/Pt 20	1204	0.28	36014	92.8
330	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 24	918	0.2	20904	80.7
331	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 21	1161	0.2	36741	93.3
332	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 25	838	0.2	16605	77.4
333	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 26	697	0.2	10347	72.1
334	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 24	917	0.28	18031	76.8
335	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 23	984	0.28	21869	79.9
336	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 22	1084	0.28	27980	84.8
337	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 21	1162	0.28	33167	89.5

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
339	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 20	1203	0.28	35843	91.8
340	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 20	1198	0.0	48249	100.0
341	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 22	1079	0.0	39056	94.2
342	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 21	1158	0.0	45014	98.4
343	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 23	981	0.0	31937	89.6
344	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 24	913	0.0	27271	86.1
345	3/27/97	63.0	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 26	700	0.0	15379	76.1
347	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 26	700	0.0	15164	76.0
348	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 24	914	0.0	26781	85.8
349	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 23	979	0.0	31144	89.1
350	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 22	1076	0.0	38250	94.3
351	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 21	1154	0.0	44068	98.4
352	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 20	1198	0.0	47373	100.6
353	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 20	1198	0.28	35212	92.7
354	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 21	1154	0.28	32037	89.7
355	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 22	1078	0.28	27257	84.7
356	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 23	979	0.28	21277	79.7
357	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 24	911	0.28	17550	76.8
359	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 21	1157	0.2	35759	93.9
360	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 24	911	0.2	21152	80.3
361	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 25	834	0.2	16228	77.1
362	3/28/97	67.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 26	698	0.2	10241	71.9
369	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 13	827	0.28	14052	74.5
370	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 12	928	0.28	19185	79.2
371	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 11	1020	0.28	24258	84.0
372	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 10	1103	0.28	29274	88.4
373	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 10	1103	0.2	32282	92.7
374	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 11	1022	0.2	27122	89.1
375	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 12	929	0.2	21692	83.0
376	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 13	827	0.2	16309	77.9
377	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 14	704	0.2	10823	73.1
378	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 14	700	0.0	15757	77.1
379	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 13	825	0.0	22316	83.0

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tumb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
380	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 12	927	0.0	28457	88.6
381	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 11	1021	0.0	34796	93.4
382	4/1/97	46.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 10	1102	0.0	40560	97.5
383	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1199	0.0	48133	102.3
384	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.0	44938	99.8
385	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1080	0.0	39340	95.8
386	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	980	0.0	32109	90.6
387	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	911	0.0	27469	87.6
388	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 26	697	0.0	15599	76.8
389	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 26	702	0.2	10731	72.7
390	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 25	837	0.2	16813	78.2
391	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	910	0.2	20673	81.5
392	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1155	0.2	36277	95.6
395	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1157	0.28	33039	91.7
396	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1198	0.28	35684	94.1
397	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1080	0.28	27891	86.6
399	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	978	0.28	21212	80.7
400	4/1/97	47.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	910	0.28	17918	77.4
408	4/1/97	44.0	3BCvg	3000900	3	5	External	Baseline	24 Chev. (24 vgs)	0	C2/Pt 24	912	0.28	18496	78.4
409	4/1/97	44.0	3BCvg	3000900	3	5	External	Baseline	24 Chev. (24 vgs)	0	C2/Pt 23	980	0.28	22330	81.6
410	4/1/97	44.0	3BCvg	3000900	3	5	External	Baseline	24 Chev. (24 vgs)	0	C2/Pt 22	1082	0.28	28598	86.9
411	4/1/97	44.0	3BCvg	3000900	3	5	External	Baseline	24 Chev. (24 vgs)	0	C2/Pt 21	1156	0.28	33376	91.3
412	4/1/97	44.0	3BCvg	3000900	3	5	External	Baseline	24 Chev. (24 vgs)	0	C2/Pt 20	1198	0.28	36537	93.9
415	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 26	692	0.0	15425	76.2
416	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 24	912	0.0	27980	86.4
417	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 23	981	0.0	32525	90.0
418	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 22	1079	0.0	39686	94.9
419	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 21	1153	0.0	45173	98.8
420	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 20	1198	0.0	48734	101.2
426	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 24	912	0.2	21110	81.3
427	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 21	1152	0.2	36449	94.2
428	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 25	831	0.2	19394	77.7
429	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 26	700	0.2	10746	72.7
430	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 24	911	0.28	18064	77.2

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
431	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 23	983	0.28	22132	80.4
432	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 22	1080	0.28	28243	85.9
433	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 21	1155	0.28	33116	90.5
434	4/2/97	60.0	3BC	3000100	3	5	External	Baseline	24 Chevrons	0	C2/Pt 20	1197	0.28	36066	94.0
438	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 26	695	0.0	15568	77.1
439	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 24	916	0.0	27549	87.7
440	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 23	982	0.0	31942	90.8
441	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 22	1083	0.0	39125	95.6
443	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 21	1156	0.0	44305	98.7
444	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 20	1197	0.0	47182	100.2
445	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 20	1200	0.28	35300	93.3
446	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 21	1156	0.28	32256	90.7
447	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 22	1083	0.28	27718	86.4
448	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 23	982	0.28	21711	80.7
449	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 24	916	0.28	18106	77.1
450	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 24	914	0.2	20753	81.5
451	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 21	1156	0.2	35827	94.8
452	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 25	835	0.2	16559	77.5
453	4/2/97	59.0	3BS(0)	3000700	3	5	External	Baseline	Scarfed Fan Noz.	0	C2/Pt 26	699	0.2	10638	70.8
456	4/2/97	52.0	3BS(90)	3000709	3	5	External	Baseline	Scarfed Fan Noz.	90	C2/Pt 24	914	0.28	18179	78.2
457	4/2/97	52.0	3BS(90)	3000709	3	5	External	Baseline	Scarfed Fan Noz.	90	C2/Pt 23	982	0.28	21905	81.6
458	4/2/97	52.0	3BS(90)	3000709	3	5	External	Baseline	Scarfed Fan Noz.	90	C2/Pt 22	1082	0.28	27916	87.2
459	4/2/97	52.0	3BS(90)	3000709	3	5	External	Baseline	Scarfed Fan Noz.	90	C2/Pt 20	1199	0.28	35433	95.3
460	4/2/97	52.0	3BS(90)	3000709	3	5	External	Baseline	Scarfed Fan Noz.	90	C2/Pt 21	1155	0.28	-	92.5
461	4/2/97	52.0	3BS(90)	3000709	3	5	External	Baseline	Scarfed Fan Noz.	90	C2/Pt 21	1156	0.2	35919	96.7
462	4/2/97	52.0	3BS(90)	3000709	3	5	External	Baseline	Scarfed Fan Noz.	90	C2/Pt 21	1155	0.0	44044	101.2
463	4/2/97	47.0	3BS(180)	3000718	3	5	External	Baseline	Scarfed Fan Noz.	180	C2/Pt 24	913	0.28	17999	79.2
464	4/2/97	47.0	3BS(180)	3000718	3	5	External	Baseline	Scarfed Fan Noz.	180	C2/Pt 23	984	0.28	21988	82.2
465	4/2/97	47.0	3BS(180)	3000718	3	5	External	Baseline	Scarfed Fan Noz.	180	C2/Pt 22	1084	0.28	28103	88.2
467	4/2/97	47.0	3BS(180)	3000718	3	5	External	Baseline	Scarfed Fan Noz.	180	C2/Pt 20	1201	0.28	35578	95.0
468	4/2/97	47.0	3BS(180)	3000718	3	5	External	Baseline	Scarfed Fan Noz.	180	C2/Pt 21	1160	0.2	35942	96.1
469	4/2/97	47.0	3BS(180)	3000718	3	5	External	Baseline	Scarfed Fan Noz.	180	C2/Pt 21	1158	0.0	-	100.4
477	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 24	915	0.28	18203	79.0
478	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 23	984	0.28	21943	81.9
479	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 22	1079	0.28	27612	86.4

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
480	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 21	1157	0.28	32572	90.6
481	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 20	1198	0.28	35160	92.4
483	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 24	917	0.2	20778	83.3
484	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 21	1157	0.2	35925	93.6
485	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 25	841	0.2	16739	78.4
486	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 26	702	0.2	10567	73.1
487	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 26	697	0.0	15358	76.3
488	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 24	912	0.0	27317	86.2
489	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 23	984	0.0	31994	89.4
490	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 22	1081	0.0	38768	94.0
491	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 20	1198	0.0	47547	99.1
492	4/3/97	64.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 21	1156	0.0	44146	97.2
493	4/3/97	65.0	3HmB(90)	3090009	3	5	External	Core Half Mixer	Baseline	90	C2/Pt 24	915	0.28	17922	77.9
494	4/3/97	65.0	3HmB(90)	3090009	3	5	External	Core Half Mixer	Baseline	90	C2/Pt 23	986	0.28	21905	81.2
495	4/3/97	65.0	3HmB(90)	3090009	3	5	External	Core Half Mixer	Baseline	90	C2/Pt 22	1081	0.28	27684	86.1
497	4/3/97	65.0	3HmB(90)	3090009	3	5	External	Core Half Mixer	Baseline	90	C2/Pt 21	1158	0.28	32379	90.4
498	4/3/97	65.0	3HmB(90)	3090009	3	5	External	Core Half Mixer	Baseline	90	C2/Pt 20	1197	0.28	35068	92.8
499	4/3/97	65.0	3HmB(90)	3090009	3	5	External	Core Half Mixer	Baseline	90	C2/Pt 21	1157	0.2	35974	94.2
500	4/3/97	65.0	3HmB(90)	3090009	3	5	External	Core Half Mixer	Baseline	90	C2/Pt 21	1157	0.0	44348	98.2
501	4/3/97	64.0	3HmB(180)	3090018	3	5	External	Core Half Mixer	Baseline	180	C2/Pt 24	914	0.28	18076	77.5
502	4/3/97	64.0	3HmB(180)	3090018	3	5	External	Core Half Mixer	Baseline	180	C2/Pt 23	982	0.28	21630	80.7
503	4/3/97	64.0	3HmB(180)	3090018	3	5	External	Core Half Mixer	Baseline	180	C2/Pt 22	1081	0.28	27622	86.1
504	4/3/97	64.0	3HmB(180)	3090018	3	5	External	Core Half Mixer	Baseline	180	C2/Pt 20	1200	0.28	35223	93.0
505	4/3/97	64.0	3HmB(180)	3090018	3	5	External	Core Half Mixer	Baseline	180	C2/Pt 21	1157	0.28	32330	90.6
506	4/3/97	64.0	3HmB(180)	3090018	3	5	External	Core Half Mixer	Baseline	180	C2/Pt 21	1152	0.2	35589	94.4
507	4/3/97	64.0	3HmB(180)	3090018	3	5	External	Core Half Mixer	Baseline	180	C2/Pt 21	1151	0.0	43732	98.2
508	4/3/97	60.0	3HmS(0)	3090700	3	5	External	Core Half Mixer	Scarfed Fan Noz.	0	C2/Pt 24	908	0.28	17833	77.2
509	4/3/97	60.0	3HmS(0)	3090700	3	5	External	Core Half Mixer	Scarfed Fan Noz.	0	C2/Pt 23	981	0.28	21690	80.9
510	4/3/97	60.0	3HmS(0)	3090700	3	5	External	Core Half Mixer	Scarfed Fan Noz.	0	C2/Pt 22	1081	0.28	27672	86.3
511	4/3/97	60.0	3HmS(0)	3090700	3	5	External	Core Half Mixer	Scarfed Fan Noz.	0	C2/Pt 21	1153	0.28	31812	89.9
512	4/3/97	60.0	3HmS(0)	3090700	3	5	External	Core Half Mixer	Scarfed Fan Noz.	0	C2/Pt 20	1202	0.28	35164	92.2
513	4/3/97	60.0	3HmS(0)	3090700	3	5	External	Core Half Mixer	Scarfed Fan Noz.	0	C2/Pt 21	1158	0.0	43541	97.5
514	4/3/97	60.0	3HmS(0)	3090700	3	5	External	Core Half Mixer	Scarfed Fan Noz.	0	C2/Pt 21	1158	0.2	35477	93.7
516	4/3/97	60.0	3HmS(0)	3090700	3	5	External	Core Half Mixer	Scarfed Fan Noz.	0	C2/Pt 20	897	0.0	28315	94.2

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
525	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 24	913	0.28	18312	78.2
526	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 23	981	0.28	22016	80.9
527	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 22	1079	0.28	27965	85.5
528	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 21	1156	0.28	32969	89.4
529	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 20	1195	0.28	35450	91.2
530	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 21	1157	0.2	36218	92.7
531	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 24	915	0.2	20879	81.1
532	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 25	833	0.2	16488	77.6
533	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 26	696	0.2	10394	72.2
534	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 26	690	0.0	15090	75.5
535	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 24	912	0.0	27679	85.4
536	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 23	981	0.0	32251	88.6
538	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 22	1080	0.0	39330	93.2
539	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 20	1198	0.0	48347	98.1
540	4/4/97	67.0	3Hm(0)C	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 21	1156	0.0	-	96.4
545	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	914	0.28	18018	76.6
546	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	982	0.28	21718	80.0
547	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1077	0.28	27275	85.4
548	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1157	0.28	32458	90.5
549	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1198	0.28	35133	93.3
550	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1158	0.2	35927	94.7
551	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	918	0.2	20755	80.9
552	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 25	842	0.2	16749	77.7
553	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 26	698	0.2	10378	71.7
554	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 26	692	0.0	14937	75.6
555	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	910	0.0	27102	86.1
556	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	985	0.0	32061	92.1
557	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1079	0.0	38669	94.9
558	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1161	0.0	44756	99.1
559	4/4/97	74.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1202	0.0	47874	101.3
591	4/8/97	42.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	918	0.28	18309	78.1
592	4/8/97	42.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	981	0.28	21776	81.2
593	4/8/97	42.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1077	0.28	27558	87.0
594	4/8/97	42.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1152	0.28	32372	91.5
595	4/8/97	42.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1199	0.28	35545	94.4
596	4/8/97	42.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1152	0.2	35876	95.6
597	4/8/97	42.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.0	44352	99.9

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
599	4/8/97	39.8	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 24	915	0.28	18463	79.5
600	4/8/97	39.8	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 23	980	0.28	22020	83.6
601	4/8/97	39.8	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 22	1077	0.28	27819	87.0
602	4/8/97	39.8	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 21	1154	0.28	32703	91.1
603	4/8/97	39.8	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 20	1197	0.28	35564	93.2
605	4/8/97	39.8	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 21	1151	0.2	35585	94.3
606	4/8/97	39.8	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 21	1153	0.0	43863	97.6
612	4/8/97	47.5	3HmC(0)	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 24	918	0.28	18702	79.3
613	4/8/97	47.5	3HmC(0)	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 23	976	0.28	21866	81.9
614	4/8/97	47.5	3HmC(0)	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 22	1080	0.28	28031	87.1
615	4/8/97	47.5	3HmC(0)	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 21	1155	0.28	32890	90.8
616	4/8/97	47.5	3HmC(0)	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 20	1197	0.28	36079	93.1
617	4/8/97	47.5	3HmC(0)	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 21	1159	0.2	36435	94.1
620	4/8/97	47.5	3HmC(0)	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 21	1155	0.0	44533	97.4
621	4/8/97	47.5	3HmC(0)	3090100	3	5	External	Core Half Mixer	24 Chevrons	0	C2/Pt 20	1196	0.28	35864	92.9
623	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 24	909	0.28	18423	79.8
624	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 23	981	0.28	22135	82.1
625	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 22	1081	0.28	28340	86.9
626	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 21	1154	0.28	33199	90.8
627	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 20	1193	0.28	35880	93.1
628	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 21	1153	0.2	36547	94.1
629	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 21	1150	0.0	44331	97.2
630	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 21	1154	0.0	45183	97.8
631	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 21	1158	0.2	36973	94.1
632	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 21	1153	0.28	33102	91.0
634	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 22	1080	0.28	28312	87.0
636	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 20	1193	0.28	35840	92.9
637	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 23	977	0.28	22115	82.4
638	4/8/97	29.0	3HmC(45)	3090105	3	5	External	Core Half Mixer	24 Chevrons	45	C2/Pt 24	914	0.28	18560	79.4
639	4/9/97	35.5	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	916	0.0	27765	87.7
640	4/9/97	35.5	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1157	0.0	45077	100.4
641	4/9/97	35.5	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1152	0.2	36307	95.7
642	4/9/97	35.5	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1151	0.28	32692	92.0
643	4/9/97	35.5	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1194	0.28	35823	94.4
644	4/9/97	35.5	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1077	0.28	28080	87.2
645	4/9/97	35.5	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	978	0.28	21928	81.5
646	4/9/97	35.5	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	912	0.28	18246	78.2
647	4/9/97	35.5	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1151	0.28	32768	94.1

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
651	4/9/97	36.1	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 24	913	0.28	18306	79.0
652	4/9/97	36.1	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 23	984	0.28	22176	82.1
653	4/9/97	36.1	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 22	1081	0.28	28053	87.3
654	4/9/97	36.1	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 21	1154	0.28	32670	91.5
655	4/9/97	36.1	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 20	1198	0.28	35688	93.4
657	4/9/97	36.1	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 20	1196	0.28	35561	93.5
659	4/9/97	36.1	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 21	1156	0.0	44864	97.4
660	4/9/97	36.1	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 21	1155	0.2	36120	94.9
663	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 24	904	0.28	18112	80.4
664	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 23	981	0.28	21759	83.2
665	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 21	1161	0.28	32830	91.8
666	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 21	1163	0.28	33093	91.9
667	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 22	1086	0.28	28221	88.3
668	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 20	1201	0.28	35846	93.5
669	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 21	1159	0.2	36251	94.4
670	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 21	1155	0.0	44274	96.6
671	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 20	1203	0.0	48218	98.3
672	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 22	1083	0.0	39067	93.8
673	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 23	983	0.0	31918	89.7
675	4/9/97	29.0	3HmOmax(0)	3090500	3	5	External	Core Half Mixer	Max CL Offset	0	C2/Pt 24	913	0.0	27367	86.9
679	4/10/97	40.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	919	0.28	18761	78.5
680	4/10/97	40.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	980	0.28	22078	81.6
681	4/10/97	40.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1080	0.28	28129	86.8
682	4/10/97	40.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1159	0.28	33327	92.1
683	4/10/97	40.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1197	0.28	36000	94.9
684	4/10/97	40.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1162	0.2	37119	96.3
685	4/10/97	40.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.0	44692	100.2
686	4/10/97	44.6	3BOmax(90)	3000509	3	5	External	Baseline	Max CL Offset	90	C2/Pt 24	914	0.28	18302	80.3
687	4/10/97	44.6	3BOmax(90)	3000509	3	5	External	Baseline	Max CL Offset	90	C2/Pt 23	982	0.28	22133	83.8
688	4/10/97	44.6	3BOmax(90)	3000509	3	5	External	Baseline	Max CL Offset	90	C2/Pt 22	1083	0.28	28235	90.3
689	4/10/97	44.6	3BOmax(90)	3000509	3	5	External	Baseline	Max CL Offset	90	C2/Pt 21	1161	0.28	33274	95.1
690	4/10/97	44.6	3BOmax(90)	3000509	3	5	External	Baseline	Max CL Offset	90	C2/Pt 20	1202	0.28	36040	97.5
691	4/10/97	44.6	3BOmax(90)	3000509	3	5	External	Baseline	Max CL Offset	90	C2/Pt 21	1156	0.2	36144	98.5
692	4/10/97	44.6	3BOmax(90)	3000509	3	5	External	Baseline	Max CL Offset	90	C2/Pt 21	1163	0.0	45239	101.6
693	4/10/97	38.1	3BOmax(180)	3000518	3	5	External	Baseline	Max CL Offset	180	C2/Pt 24	913	0.28	18319	80.0
694	4/10/97	38.1	3BOmax(180)	3000518	3	5	External	Baseline	Max CL Offset	180	C2/Pt 23	985	0.28	22253	84.9
695	4/10/97	38.1	3BOmax(180)	3000518	3	5	External	Baseline	Max CL Offset	180	C2/Pt 22	1083	0.28	28210	91.1

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
696	4/10/97	38.1	3BOmax(180)	3000518	3	5	External	Baseline	Max CL Offset	180	C2/Pt 21	1158	0.28	32949	96.2
697	4/10/97	38.1	3BOmax(180)	3000518	3	5	External	Baseline	Max CL Offset	180	C2/Pt 20	1198	0.28	35511	98.9
698	4/10/97	38.1	3BOmax(180)	3000518	3	5	External	Baseline	Max CL Offset	180	C2/Pt 21	1154	0.2	36070	99.3
699	4/10/97	38.1	3BOmax(180)	3000518	3	5	External	Baseline	Max CL Offset	180	C2/Pt 21	1158	0.0	44165	103.0
700	4/10/97	34.9	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 24	919	0.28	18704	79.1
701	4/10/97	34.9	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 23	982	0.28	21958	81.8
702	4/10/97	34.9	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 22	1085	0.28	28235	87.4
703	4/10/97	34.9	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 21	1161	0.28	33158	91.5
704	4/10/97	34.9	3BOmax(0)	3000500	3	5	External	Baseline	Max CL Offset	0	C2/Pt 20	1202	0.28	35896	93.5
705	4/10/97	38.9	3BT48	3000400	3	5	External	Baseline	48 Flipper Tabs	0	C2/Pt 24	917	0.28	17739	79.1
706	4/10/97	38.9	3BT48	3000400	3	5	External	Baseline	48 Flipper Tabs	0	C2/Pt 23	986	0.28	21369	81.9
707	4/10/97	38.9	3BT48	3000400	3	5	External	Baseline	48 Flipper Tabs	0	C2/Pt 22	1086	0.28	27326	86.5
708	4/10/97	38.9	3BT48	3000400	3	5	External	Baseline	48 Flipper Tabs	0	C2/Pt 21	1160	0.28	32137	90.8
709	4/10/97	38.9	3BT48	3000400	3	5	External	Baseline	48 Flipper Tabs	0	C2/Pt 20	1207	0.28	35173	93.8
710	4/10/97	38.9	3BT48	3000400	3	5	External	Baseline	48 Flipper Tabs	0	C2/Pt 21	1164	0.2	35360	94.6
711	4/10/97	38.9	3BT48	3000400	3	5	External	Baseline	48 Flipper Tabs	0	C2/Pt 21	1157	0.0	42877	98.7
723	4/11/97	45.2	3BT24	3000300	3	5	External	Baseline	24 Flipper Tabs	0	C2/Pt 24	917	0.28	17363	80.6
724	4/11/97	45.2	3BT24	3000300	3	5	External	Baseline	24 Flipper Tabs	0	C2/Pt 23	985	0.28	20923	83.4
725	4/11/97	45.2	3BT24	3000300	3	5	External	Baseline	24 Flipper Tabs	0	C2/Pt 22	1081	0.28	26665	87.3
726	4/11/97	45.2	3BT24	3000300	3	5	External	Baseline	24 Flipper Tabs	0	C2/Pt 21	1161	0.28	31628	91.5
727	4/11/97	45.2	3BT24	3000300	3	5	External	Baseline	24 Flipper Tabs	0	C2/Pt 20	1205	0.28	34567	93.8
728	4/11/97	45.2	3BT24	3000300	3	5	External	Baseline	24 Flipper Tabs	0	C2/Pt 21	1161	0.2	34564	95.5
729	4/11/97	45.2	3BT24	3000300	3	5	External	Baseline	24 Flipper Tabs	0	C2/Pt 21	1162	0.0	42522	98.3
730	4/11/97	49.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	913	0.28	18189	78.3
731	4/11/97	49.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	984	0.28	22156	81.3
732	4/11/97	49.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1080	0.28	27998	87.1
733	4/11/97	49.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1202	0.28	36168	94.4
734	4/11/97	49.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.28	32749	91.8
735	4/11/97	49.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.2	36249	95.9
736	4/11/97	49.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1153	0.0	44153	99.7
737	4/11/97	43.0	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 24	913	0.28	18223	77.8
738	4/11/97	43.0	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 23	985	0.28	22235	80.9
739	4/11/97	43.0	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 22	1080	0.28	27899	86.0
740	4/11/97	43.0	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 21	1160	0.28	32993	90.7
741	4/11/97	43.0	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 20	1204	0.28	35890	93.2
742	4/11/97	43.0	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 21	1156	0.2	36059	94.8
743	4/11/97	43.0	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 21	1161	0.0	44912	99.2

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
744	4/11/97	43.0	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 24	915	0.2	20955	81.7
745	4/11/97	43.0	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 25	838	0.2	16834	78.4
746	4/11/97	43.0	3C12B	3010000	3	5	External	12 Chevrons	Baseline	0	C2/Pt 26	692	0.2	10332	72.7
751	4/14/97	50.1	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	915	0.28	18375	77.9
752	4/14/97	50.1	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	984	0.28	22185	80.9
753	4/14/97	50.1	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1083	0.28	28010	86.8
754	4/14/97	50.1	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1159	0.28	33053	94.1
755	4/14/97	50.1	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1195	0.28	35414	95.6
756	4/14/97	50.1	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.2	36278	95.6
757	4/14/97	50.1	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.0	44490	99.8
758	4/14/97	49.5	3C8B	3020000	3	5	External	8 Chevrons	Baseline	0	C2/Pt 24	915	0.28	18311	77.6
759	4/14/97	49.5	3C8B	3020000	3	5	External	8 Chevrons	Baseline	0	C2/Pt 23	982	0.28	22006	80.5
760	4/14/97	49.5	3C8B	3020000	3	5	External	8 Chevrons	Baseline	0	C2/Pt 22	1078	0.28	27856	85.8
761	4/14/97	49.5	3C8B	3020000	3	5	External	8 Chevrons	Baseline	0	C2/Pt 21	1160	0.28	33202	90.0
762	4/14/97	49.5	3C8B	3020000	3	5	External	8 Chevrons	Baseline	0	C2/Pt 20	1201	0.28	35813	92.5
763	4/14/97	49.5	3C8B	3020000	3	5	External	8 Chevrons	Baseline	0	C2/Pt 21	1162	0.2	36561	94.1
764	4/14/97	49.5	3C8B	3020000	3	5	External	8 Chevrons	Baseline	0	C2/Pt 21	1158	0.0	44585	98.5
765	4/14/97	48.0	3IB	3030000	3	5	External	12 Inward Chev.	Baseline	0	C2/Pt 24	915	0.28	18368	77.6
766	4/14/97	48.0	3IB	3030000	3	5	External	12 Inward Chev.	Baseline	0	C2/Pt 23	982	0.28	21963	80.3
769	4/14/97	48.0	3IB	3030000	3	5	External	12 Inward Chev.	Baseline	0	C2/Pt 22	1080	0.28	27961	84.7
770	4/14/97	48.0	3IB	3030000	3	5	External	12 Inward Chev.	Baseline	0	C2/Pt 21	1157	0.28	32871	89.3
771	4/14/97	48.0	3IB	3030000	3	5	External	12 Inward Chev.	Baseline	0	C2/Pt 20	1198	0.28	35734	91.6
772	4/14/97	48.0	3IB	3030000	3	5	External	12 Inward Chev.	Baseline	0	C2/Pt 21	1153	0.2	36076	93.2
773	4/14/97	48.0	3IB	3030000	3	5	External	12 Inward Chev.	Baseline	0	C2/Pt 21	1154	0.0	44594	97.7
774	4/14/97	48.0	3AB	3040000	3	5	External	12 Alternating Chev.	Baseline	0	C2/Pt 24	915	0.28	18806	78.6
775	4/14/97	48.0	3AB	3040000	3	5	External	12 Alternating Chev.	Baseline	0	C2/Pt 23	988	0.28	22656	81.5
776	4/14/97	48.0	3AB	3040000	3	5	External	12 Alternating Chev.	Baseline	0	C2/Pt 22	1085	0.28	28553	85.9
777	4/14/97	48.0	3AB	3040000	3	5	External	12 Alternating Chev.	Baseline	0	C2/Pt 21	1163	0.28	33643	89.8
778	4/14/97	48.0	3AB	3040000	3	5	External	12 Alternating Chev.	Baseline	0	C2/Pt 20	1207	0.28	36455	92.0
779	4/14/97	48.0	3AB	3040000	3	5	External	12 Alternating Chev.	Baseline	0	C2/Pt 21	1168	0.2	37308	93.6
780	4/14/97	48.0	3AB	3040000	3	5	External	12 Alternating Chev.	Baseline	0	C2/Pt 21	1164	0.0	44951	96.5
785	4/15/97	58.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	914	0.28	18198	78.1
786	4/15/97	58.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	979	0.28	21780	80.6
787	4/15/97	58.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1079	0.28	27761	86.1
788	4/15/97	58.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1158	0.28	32883	90.8
789	4/15/97	58.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1198	0.28	35424	93.7
791	4/15/97	58.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1154	0.2	35953	94.8

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
792	4/15/97	58.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.0	44436	99.4
797	4/15/97	56.9	3DIB	3050000	3	5	External	64 Int. Doublet VGs	Baseline	0	C2/Pt 24	912	0.28	18382	77.4
798	4/15/97	56.9	3DIB	3050000	3	5	External	64 Int. Doublet VGs	Baseline	0	C2/Pt 23	979	0.28	21829	80.9
799	4/15/97	56.9	3DIB	3050000	3	5	External	64 Int. Doublet VGs	Baseline	0	C2/Pt 22	1079	0.28	27749	86.0
800	4/15/97	56.9	3DIB	3050000	3	5	External	64 Int. Doublet VGs	Baseline	0	C2/Pt 21	1153	0.28	32680	91.0
801	4/15/97	56.9	3DIB	3050000	3	5	External	64 Int. Doublet VGs	Baseline	0	C2/Pt 20	1198	0.28	35551	93.6
803	4/15/97	56.9	3DIB	3050000	3	5	External	64 Int. Doublet VGs	Baseline	0	C2/Pt 21	1156	0.2	35969	94.9
804	4/15/97	56.9	3DIB	3050000	3	5	External	64 Int. Doublet VGs	Baseline	0	C2/Pt 21	1159	0.0	44730	99.4
805	4/15/97	59.3	3IB	3030000	3	5	External	12 Inward Chevrons	Baseline	0	C2/Pt 24	910	0.28	18024	77.0
806	4/15/97	59.3	3IB	3030000	3	5	External	12 Inward Chevrons	Baseline	0	C2/Pt 23	978	0.28	21850	79.9
807	4/15/97	59.3	3IB	3030000	3	5	External	12 Inward Chevrons	Baseline	0	C2/Pt 22	1074	0.28	27385	84.0
808	4/15/97	59.3	3IB	3030000	3	5	External	12 Inward Chevrons	Baseline	0	C2/Pt 21	1152	0.28	32632	88.5
809	4/15/97	59.3	3IB	3030000	3	5	External	12 Inward Chevrons	Baseline	0	C2/Pt 20	1196	0.28	35305	90.7
810	4/15/97	59.3	3IB	3030000	3	5	External	12 Inward Chevrons	Baseline	0	C2/Pt 21	1156	0.2	36112	92.5
811	4/15/97	59.3	3IB	3030000	3	5	External	12 Inward Chevrons	Baseline	0	C2/Pt 21	1157	0.0	44605	97.0
812	4/15/97	58.1	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 24	911	0.28	18232	77.2
813	4/15/97	58.1	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 23	981	0.28	22098	79.9
814	4/15/97	58.1	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 22	1080	0.28	28231	84.1
815	4/15/97	58.1	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 21	1153	0.28	32996	88.1
816	4/15/97	58.1	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 20	1198	0.28	36097	90.5
817	4/15/97	58.1	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 21	1157	0.2	36778	92.2
818	4/15/97	58.1	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 21	1150	0.0	44777	96.2
819	4/15/97	53.6	3C12C	3010100	3	5	External	12 Chevrons	24 Chevrons	0	C2/Pt 24	909	0.28	18233	77.4
820	4/15/97	53.6	3C12C	3010100	3	5	External	12 Chevrons	24 Chevrons	0	C2/Pt 23	979	0.28	22079	81.5
822	4/15/97	53.6	3C12C	3010100	3	5	External	12 Chevrons	24 Chevrons	0	C2/Pt 22	1085	0.28	28560	85.4
823	4/15/97	53.6	3C12C	3010100	3	5	External	12 Chevrons	24 Chevrons	0	C2/Pt 21	1160	0.28	33565	89.9
826	4/15/97	53.6	3C12C	3010100	3	5	External	12 Chevrons	24 Chevrons	0	C2/Pt 20	1197	0.28	36116	92.1
827	4/15/97	53.6	3C12C	3010100	3	5	External	12 Chevrons	24 Chevrons	0	C2/Pt 21	1160	0.2	36898	93.7
828	4/15/97	53.6	3C12C	3010100	3	5	External	12 Chevrons	24 Chevrons	0	C2/Pt 21	1157	0.0	44958	98.1
832	4/16/97	51.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	909	0.28	17702	77.3
834	4/16/97	51.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	992	0.28	22393	80.7
835	4/16/97	51.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1081	0.28	27550	86.0
836	4/16/97	51.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1162	0.28	32779	91.1
837	4/16/97	51.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1201	0.28	35196	93.2

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
838	4/16/97	48.7	3C8C	3020100	3	5	External	8 Chevrons	24 Chevrons	0	C2/Pt 24	914	0.28	18553	77.5
839	4/16/97	48.7	3C8C	3020100	3	5	External	8 Chevrons	24 Chevrons	0	C2/Pt 23	982	0.28	22131	80.0
840	4/16/97	48.7	3C8C	3020100	3	5	External	8 Chevrons	24 Chevrons	0	C2/Pt 22	1079	0.28	27982	84.8
841	4/16/97	48.7	3C8C	3020100	3	5	External	8 Chevrons	24 Chevrons	0	C2/Pt 21	1159	0.28	33051	88.8
843	4/16/97	48.7	3C8C	3020100	3	5	External	8 Chevrons	24 Chevrons	0	C2/Pt 20	1200	0.28	35985	91.2
845	4/16/97	48.7	3C8C	3020100	3	5	External	8 Chevrons	24 Chevrons	0	C2/Pt 21	1158	0.2	36468	92.9
846	4/16/97	48.7	3C8C	3020100	3	5	External	8 Chevrons	24 Chevrons	0	C2/Pt 21	1157	0.0	44643	97.5
847	4/16/97	47.8	3AC	3040100	3	5	External	12 Alternating Chev.	24 Chevrons	0	C2/Pt 24	914	0.28	18491	77.7
848	4/16/97	47.8	3AC	3040100	3	5	External	12 Alternating Chev.	24 Chevrons	0	C2/Pt 23	988	0.28	22671	80.6
849	4/16/97	47.8	3AC	3040100	3	5	External	12 Alternating Chev.	24 Chevrons	0	C2/Pt 22	1085	0.28	28410	85.0
850	4/16/97	47.8	3AC	3040100	3	5	External	12 Alternating Chev.	24 Chevrons	0	C2/Pt 21	1162	0.28	33493	88.9
851	4/16/97	47.8	3AC	3040100	3	5	External	12 Alternating Chev.	24 Chevrons	0	C2/Pt 20	1205	0.28	36191	90.8
852	4/16/97	47.8	3AC	3040100	3	5	External	12 Alternating Chev.	24 Chevrons	0	C2/Pt 21	1167	0.2	37214	92.3
853	4/16/97	47.8	3AC	3040100	3	5	External	12 Alternating Chev.	24 Chevrons	0	C2/Pt 21	1161	0.0	45428	95.8
859	4/17/97	43.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	914	0.28	18091	78.1
860	4/17/97	43.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	981	0.28	21782	81.3
861	4/17/97	43.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1077	0.28	27622	87.0
862	4/17/97	43.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1154	0.28	22453	91.0
863	4/17/97	43.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1197	0.28	35379	94.2
864	4/17/97	40.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 24	911	0.28	17825	79.2
865	4/17/97	40.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 23	981	0.28	22038	82.7
866	4/17/97	40.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 22	1080	0.28	27767	87.3
867	4/17/97	40.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 21	1155	0.28	32544	91.3
868	4/17/97	40.0	3HmB(0)	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 20	1198	0.28	35622	93.1
871	4/17/97	42.0	3HmB(45)	3090005	3	5	External	Core Half Mixer	Baseline	45	C2/Pt 24	912	0.28	18107	79.5
872	4/17/97	42.0	3HmB(45)	3090005	3	5	External	Core Half Mixer	Baseline	45	C2/Pt 23	983	0.28	21949	82.3
873	4/17/97	42.0	3HmB(45)	3090005	3	5	External	Core Half Mixer	Baseline	45	C2/Pt 22	1082	0.28	27875	87.2
874	4/17/97	42.0	3HmB(45)	3090005	3	5	External	Core Half Mixer	Baseline	45	C2/Pt 21	1157	0.28	32818	91.2
875	4/17/97	42.0	3HmB(45)	3090005	3	5	External	Core Half Mixer	Baseline	45	C2/Pt 20	1197	0.28	35294	93.3
876	4/17/97	42.0	3HmB(45)	3090005	3	5	External	Core Half Mixer	Baseline	45	C2/Pt 21	1156	0.2	36008	94.3
877	4/17/97	42.0	3HmB(45)	3090005	3	5	External	Core Half Mixer	Baseline	45	C2/Pt 21	1156	0.0	44301	98.2
878	4/17/97	44.8	3DxB	3060000	3	5	External	20 Ext. VG Doublets	Baseline	0	C2/Pt 24	916	0.28	18111	78.8
879	4/17/97	44.8	3DxB	3060000	3	5	External	20 Ext. VG Doublets	Baseline	0	C2/Pt 23	983	0.28	21845	81.7
880	4/17/97	44.8	3DxB	3060000	3	5	External	20 Ext. VG Doublets	Baseline	0	C2/Pt 22	1076	0.28	27546	86.8
881	4/17/97	44.8	3DxB	3060000	3	5	External	20 Ext. VG Doublets	Baseline	0	C2/Pt 21	1155	0.28	32482	91.3
882	4/17/97	44.8	3DxB	3060000	3	5	External	20 Ext. VG Doublets	Baseline	0	C2/Pt 20	1200	0.28	35449	94.2
883	4/17/97	44.8	3DxB	3060000	3	5	External	20 Ext. VG Doublets	Baseline	0	C2/Pt 21	1158	0.2	36120	95.8

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
884	4/17/97	44.8	3DxB	3060000	3	5	External	20 Ext. VG Doublets	Baseline	0	C2/Pt 21	1153	0.0	43827	99.5
888	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 24	915	0.28	18594	78.0
889	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 23	984	0.28	22105	80.2
890	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 22	1084	0.28	28472	84.7
891	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 21	1156	0.28	33044	88.6
892	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 20	1194	0.28	35580	90.8
893	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 21	1161	0.2	36532	92.5
894	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 24	915	0.2	20729	81.1
895	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 25	837	0.2	16705	77.8
896	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 26	704	0.2	10807	73.5
897	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 26	700	0.0	15383	76.6
898	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 24	917	0.0	27429	87.1
900	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 23	984	0.0	31878	92.8
901	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 22	1077	0.0	38410	93.6
902	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 21	1155	0.0	44547	97.1
903	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 20	1197	0.0	47908	98.7
904	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 21	1151	0.28	32746	88.2
905	4/18/97	43.9	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C2/Pt 24	910	0.28	18062	77.6
906	4/18/97	42.0	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C6/PT 64	905	0.28	17862	77.6
907	4/18/97	42.0	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C6/Pt 63	973	0.28	21695	80.1
909	4/18/97	42.0	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C6/Pt 62	3075	0.28	28028	84.2
910	4/18/97	42.0	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C6/Pt 61	1134	0.28	32040	86.8
911	4/18/97	42.0	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C6/Pt 60	1172	0.28	34841	88.5
912	4/18/97	42.0	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C6/Pt 63	976	0.0	31512	88.4
913	4/18/97	42.0	3IC	3030100	3	5	External	12 Inward Chevrons	24 Chevrons	0	C6/Pt 61	1133	0.0	43620	95.7
915	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	986	0.28	21984	81.0
916	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1079	0.28	27302	86.3
917	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1154	0.28	32190	91.3
918	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1200	0.28	35093	93.8
919	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1157	0.2	35763	95.4
920	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1154	0.0	43839	102.4
921	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 10	1100	0.28	28497	88.6
923	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 11	1020	0.28	23688	83.7
924	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 12	929	0.28	18550	78.9
925	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	913	0.28	17862	77.9

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
926	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 13	823	0.28	13448	74.9
927	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C6/Pt 64	905	0.28	17534	77.4
928	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C6/Pt 63	974	0.28	21421	80.1
929	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C6/Pt 62	1074	0.28	27676	85.2
930	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C6/Pt 61	1133	0.28	31409	88.8
931	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C6/Pt 60	1172	0.28	34167	90.9
932	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C6/Pt 61	1135	0.0	43282	97.4
933	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C6/Pt 63	975	0.0	31370	89.5
934	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 11	1021	0.0	34109	96.3
936	4/18/97	45.9	3BB	3000000	3	5	External	Baseline	Baseline	0	C1/Pt 13	819	0.0	21592	83.0
940	4/21/97	59.9	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 24	909	0.28	17554	77.1
941	4/21/97	59.9	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 23	983	0.28	21508	80.7
942	4/21/97	59.9	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 22	1082	0.28	27555	86.3
943	4/21/97	59.9	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 21	1159	0.28	32297	91.0
945	4/21/97	59.9	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 20	1202	0.28	35228	93.8
946	4/21/97	59.9	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 21	1156	0.2	35394	94.8
947	4/21/97	59.9	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 21	1158	0.0	43569	99.1
948	4/21/97	60.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 11	1018	0.0	33196	92.6
949	4/21/97	60.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 13	822	0.0	21082	82.4
950	4/21/97	60.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 13	822	0.28	13247	73.6
951	4/21/97	60.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 12	928	0.28	18368	78.2
952	4/21/97	60.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 11	1016	0.28	23262	82.6
953	4/21/97	60.0	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C1/Pt 10	1099	0.28	28334	90.3
954	4/21/97	57.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 24	909	0.28	17664	77.4
955	4/21/97	57.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 23	978	0.28	21517	80.2
956	4/21/97	57.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 22	1076	0.28	27485	85.3
957	4/21/97	57.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 21	1151	0.28	32348	90.2
958	4/21/97	57.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 20	1196	0.28	35449	92.8
959	4/21/97	57.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 21	1156	0.2	35903	94.0
960	4/21/97	57.0	2BC	2000100	2	5	Internal	Baseline	24 Chevrons	0	C2/Pt 21	1152	0.0	44064	98.6
961	4/21/97	54.5	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 24	915	0.28	17986	77.6
962	4/21/97	54.5	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 23	981	0.28	21690	80.2
963	4/21/97	54.5	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 22	1080	0.28	27838	84.9
964	4/21/97	54.5	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 21	1156	0.28	32815	89.5
965	4/21/97	54.5	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 20	1199	0.28	35948	91.9
966	4/21/97	54.5	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 21	1156	0.2	35975	93.4

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
967	4/21/97	54.5	2C12C	2010100	2	5	Internal	12 Chevrons	24 Chevrons	0	C2/Pt 21	1155	0.0	44431	97.9
971	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 45	686	0.28	8407	71.1
972	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 44	777	0.28	12213	73.8
973	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 43	878	0.28	16973	77.3
974	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 42	949	0.28	20847	80.7
975	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 41	992	0.28	23170	83.5
976	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 40	1031	0.28	25482	85.9
977	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C3/Pt 33	674	0.28	21264	79.8
978	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C3/Pt 32	781	0.28	17059	76.8
979	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C3/Pt 31	877	0.28	12375	73.7
980	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C3/Pt 30	674	0.28	8037	70.6
981	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C3/Pt 32	778	0.2	14591	76.4
982	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 44	780	0.2	14560	76.5
983	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 44	776	0.0	19896	80.4
984	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 42	952	0.0	31066	90.7
985	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 40	1036	0.0	36824	95.3
986	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C3/Pt 32	782	0.0	20406	80.7
988	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C3/Pt 30	949	0.0	31321	89.1
989	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 41	991	0.0	33566	93.1
990	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C3/Pt 31	871	0.0	26001	85.3
991	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C4/Pt 43	879	0.0	26175	86.5
992	4/21/97	53.7	4BB	4000000	4	8	Internal	Baseline	Baseline	0	C3/Pt 33	679	0.0	15283	76.3
996	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 45	680	0.28	8576	71.2
997	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 44	783	0.28	12760	74.2
998	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 43	885	0.28	17683	78.4
999	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 42	956	0.28	21546	81.7
1000	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 41	998	0.28	23823	84.2
1001	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 40	1041	0.28	26342	87.4
1002	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C3/Pt 30	951	0.28	21564	80.3
1003	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C3/Pt 31	879	0.28	17521	77.4
1004	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C3/Pt 32	779	0.28	12631	74.0
1005	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C3/Pt 33	677	0.28	8442	71.7
1006	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 44	779	0.2	14939	76.9
1007	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C3/Pt 32	779	0.2	14992	77.0
1008	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C3/Pt 33	674	0.0	15220	77.0
1009	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C3/Pt 32	776	0.0	20601	81.1
1010	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C3/Pt 31	875	0.0	26660	85.9

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
1011	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C3/Pt 30	954	0.0	32016	90.3
1012	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 44	784	0.0	20796	81.8
1014	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 43	885	0.0	26839	87.5
1015	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 42	958	0.0	31608	91.7
1016	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 41	999	0.0	34405	94.1
1017	4/22/97	43.9	5BB	5000000	5	8	External	Baseline	Baseline	0	C4/Pt 40	1045	0.0	37520	96.4
1018	4/22/97	44.2	5C12B	5010000	5	8	External	12 Chevrons	Baseline	0	C4/Pt 45	680	0.28	8567	71.5
1019	4/22/97	44.2	5C12B	5010000	5	8	External	12 Chevrons	Baseline	0	C4/Pt 44	785	0.28	12802	74.5
1021	4/22/97	44.2	5C12B	5010000	5	8	External	12 Chevrons	Baseline	0	C4/Pt 43	885	0.28	17668	77.9
1022	4/22/97	44.2	5C12B	5010000	5	8	External	12 Chevrons	Baseline	0	C4/Pt 42	960	0.28	21811	81.3
1023	4/22/97	44.2	5C12B	5010000	5	8	External	12 Chevrons	Baseline	0	C4/Pt 41	1003	0.28	24237	84.2
1024	4/22/97	44.2	5C12B	5010000	5	8	External	12 Chevrons	Baseline	0	C4/Pt 40	1044	0.28	26469	86.7
1025	4/22/97	44.2	5C12B	5010000	5	8	External	12 Chevrons	Baseline	0	C4/Pt 44	784	0.2	15146	77.2
1026	4/22/97	44.2	5C12B	5010000	5	8	External	12 Chevrons	Baseline	0	C4/Pt 44	780	0.0	20559	82.0
1027	4/22/97	49.0	5C12C	5010100	5	8	External	12 Chevrons	24 Chevrons	0	C4/Pt 45	680	0.28	8599	71.7
1028	4/22/97	49.0	5C12C	5010100	5	8	External	12 Chevrons	24 Chevrons	0	C4/Pt 44	781	0.28	12915	73.9
1029	4/22/97	49.0	5C12C	5010100	5	8	External	12 Chevrons	24 Chevrons	0	C4/Pt 43	880	0.28	17709	77.9
1030	4/22/97	49.0	5C12C	5010100	5	8	External	12 Chevrons	24 Chevrons	0	C4/Pt 42	953	0.28	21774	81.1
1031	4/22/97	49.0	5C12C	5010100	5	8	External	12 Chevrons	24 Chevrons	0	C4/Pt 41	998	0.28	24389	83.4
1032	4/22/97	49.0	5C12C	5010100	5	8	External	12 Chevrons	24 Chevrons	0	C4/Pt 40	1037	0.28	26612	86.2
1033	4/22/97	49.0	5C12C	5010100	5	8	External	12 Chevrons	24 Chevrons	0	C4/Pt 44	787	0.2	15302	76.6
1034	4/22/97	49.0	5C12C	5010100	5	8	External	12 Chevrons	24 Chevrons	0	C4/Pt 44	780	0.0	21041	80.9
1035	4/22/97	42.9	5BC	5000100	5	8	External	Baseline	24 Chevrons	0	C4/Pt 45	682	0.28	8835	77.1
1036	4/22/97	42.9	5BC	5000100	5	8	External	Baseline	24 Chevrons	0	C4/Pt 44	783	0.28	12864	74.4
1037	4/22/97	42.9	5BC	5000100	5	8	External	Baseline	24 Chevrons	0	C4/Pt 43	884	0.28	17814	77.9
1038	4/22/97	42.9	5BC	5000100	5	8	External	Baseline	24 Chevrons	0	C4/Pt 42	954	0.28	21806	81.0
1039	4/22/97	42.9	5BC	5000100	5	8	External	Baseline	24 Chevrons	0	C4/Pt 41	1001	0.28	24444	83.6
1040	4/22/97	42.9	5BC	5000100	5	8	External	Baseline	24 Chevrons	0	C4/Pt 40	1040	0.28	26967	86.2
1041	4/22/97	42.9	5BC	5000100	5	8	External	Baseline	24 Chevrons	0	C4/Pt 44	778	0.2	15021	76.7
1042	4/22/97	42.9	5BC	5000100	5	8	External	Baseline	24 Chevrons	0	C4/Pt 44	780	0.0	20819	81.1
1044	4/23/97	47.7	3T24T24	3070300	3	5	External	24 Flipper Tabs	24 Flipper Tabs	0	C2/Pt 24	916	0.28	17010	80.6
1046	4/23/97	47.7	3T24T24	3070300	3	5	External	24 Flipper Tabs	24 Flipper Tabs	0	C2/Pt 23	990	0.28	20674	83.2
1047	4/23/97	47.7	3T24T24	3070300	3	5	External	24 Flipper Tabs	24 Flipper Tabs	0	C2/Pt 22	1083	0.28	25992	87.2
1049	4/23/97	47.7	3T24T24	3070300	3	5	External	24 Flipper Tabs	24 Flipper Tabs	0	C2/Pt 21	1157	0.28	30439	90.4
1050	4/23/97	47.7	3T24T24	3070300	3	5	External	24 Flipper Tabs	24 Flipper Tabs	0	C2/Pt 21	1160	0.2	33707	93.3
1051	4/23/97	47.7	3T24T24	3070300	3	5	External	24 Flipper Tabs	24 Flipper Tabs	0	C2/Pt 21	1160	0.0	41634	97.0

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
1053	4/23/97	48.8	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 24	917	0.28	18132	77.6
1054	4/23/97	48.8	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 23	983	0.28	21725	80.9
1055	4/23/97	48.8	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 22	1076	0.28	27322	85.3
1056	4/23/97	48.8	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 21	1153	0.28	31909	88.7
1057	4/23/97	48.8	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 20	1196	0.28	34855	91.0
1058	4/23/97	48.8	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 21	1149	0.2	34773	92.1
1059	4/23/97	48.8	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 21	1151	0.0	42988	96.3
1061	4/23/97	46.1	3T48B	3080000	3	5	External	48 Flipper Tabs	Baseline	0	C2/Pt 24	916	0.28	17908	77.2
1062	4/23/97	46.1	3T48B	3080000	3	5	External	48 Flipper Tabs	Baseline	0	C2/Pt 23	977	0.28	21279	79.9
1064	4/23/97	46.1	3T48B	3080000	3	5	External	48 Flipper Tabs	Baseline	0	C2/Pt 22	1084	0.28	27537	84.7
1065	4/23/97	46.1	3T48B	3080000	3	5	External	48 Flipper Tabs	Baseline	0	C2/Pt 21	1150	0.28	31727	89.2
1066	4/23/97	46.1	3T48B	3080000	3	5	External	48 Flipper Tabs	Baseline	0	C2/Pt 20	1198	0.28	34883	91.3
1067	4/23/97	46.1	3T48B	3080000	3	5	External	48 Flipper Tabs	Baseline	0	C2/Pt 21	1153	0.2	35012	92.6
1068	4/23/97	46.1	3T48B	3080000	3	5	External	48 Flipper Tabs	Baseline	0	C2/Pt 21	1151	0.0	43108	97.1
1069	4/23/97	50.4	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	916	0.28	17954	77.7
1070	4/23/97	50.4	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	983	0.28	21528	80.6
1071	4/23/97	50.4	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1079	0.28	27093	85.8
1072	4/23/97	50.4	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.28	32245	91.2
1073	4/23/97	50.4	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1200	0.28	35021	93.5
1074	4/23/97	50.4	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1161	0.2	35813	95.0
1075	4/23/97	50.4	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.0	43644	99.0
1076	4/23/97	49.7	3T48C	3080100	3	5	External	48 Flipper Tabs	24 Chevrons	0	C2/Pt 24	911	0.28	18116	76.6
1077	4/23/97	49.7	3T48C	3080100	3	5	External	48 Flipper Tabs	24 Chevrons	0	C2/Pt 23	979	0.28	21700	80.0
1078	4/23/97	49.7	3T48C	3080100	3	5	External	48 Flipper Tabs	24 Chevrons	0	C2/Pt 22	1076	0.28	27482	84.5
1079	4/23/97	49.7	3T48C	3080100	3	5	External	48 Flipper Tabs	24 Chevrons	0	C2/Pt 21	1156	0.28	32725	88.5
1080	4/23/97	49.7	3T48C	3080100	3	5	External	48 Flipper Tabs	24 Chevrons	0	C2/Pt 20	1194	0.28	35211	90.8
1081	4/23/97	47.2	3T48T48	3080400	3	5	External	48 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 24	909	0.28	16930	78.8
1082	4/23/97	47.2	3T48T48	3080400	3	5	External	48 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 23	981	0.28	20272	80.6
1083	4/23/97	47.2	3T48T48	3080400	3	5	External	48 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 22	1081	0.28	26000	84.4
1084	4/23/97	47.2	3T48T48	3080400	3	5	External	48 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 21	1162	0.28	31569	88.9
1085	4/23/97	47.2	3T48T48	3080400	3	5	External	48 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 20	1200	0.28	33904	91.0
1086	4/23/97	47.2	3T48T48	3080400	3	5	External	48 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 21	1160	0.2	34159	92.2
1087	4/23/97	47.2	3T48T48	3080400	3	5	External	48 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 21	1160	0.0	42241	96.7
1233	5/12/97	56.1	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 24	914	0.28	17897	77.6
1234	5/12/97	56.1	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 23	980	0.28	21283	80.4
1235	5/12/97	56.1	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 22	1079	0.28	27224	86.1

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
1236	5/12/97	56.1	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 21	1153	0.28	31807	90.5
1237	5/12/97	56.1	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 20	1200	0.28	35087	93.2
1238	5/12/97	56.1	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 21	1152	0.2	34923	94.6
1239	5/12/97	56.1	2BB	2000000	2	5	Internal	Baseline	Baseline	0	C2/Pt 21	1156	0.0	43608	99.3
1240	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 24	906	0.28	17525	78.2
1241	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 23	983	0.28	21598	81.5
1242	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 22	1082	0.28	27708	86.9
1243	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 21	1164	0.28	33027	91.3
1245	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 20	1208	0.28	35968	93.9
1246	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 21	1167	0.2	36589	94.5
1247	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 21	1166	0.0	44771	97.4
1248	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 24	904	0.28	17358	78.1
1249	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 23	979	0.28	21468	81.4
1250	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 22	1080	0.28	27464	86.6
1251	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 21	1161	0.28	32735	91.0
1252	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 20	1208	0.28	35950	93.7
1253	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 21	1167	0.2	36504	94.3
1254	5/12/97	57.3	6TmB	6100000	6	< 5	Long Int	Tongue Mixer	Baseline	0	C2/Pt 21	1164	0.0	44690	97.3
1255	5/12/97	57.3	6TmC	6100100	6	< 5	Long Int	Tongue Mixer	24 Chevrons	0	C2/Pt 24	914	0.28	18248	78.7
1256	5/12/97	57.3	6TmC	6100100	6	< 5	Long Int	Tongue Mixer	24 Chevrons	0	C2/Pt 23	984	0.28	22157	81.8
1257	5/12/97	57.3	6TmC	6100100	6	< 5	Long Int	Tongue Mixer	24 Chevrons	0	C2/Pt 22	1083	0.28	28166	86.5
1258	5/12/97	57.3	6TmC	6100100	6	< 5	Long Int	Tongue Mixer	24 Chevrons	0	C2/Pt 21	1164	0.28	33461	90.7
1259	5/12/97	57.3	6TmC	6100100	6	< 5	Long Int	Tongue Mixer	24 Chevrons	0	C2/Pt 20	1208	0.28	36380	93.3
1260	5/12/97	57.3	6TmC	6100100	6	< 5	Long Int	Tongue Mixer	24 Chevrons	0	C2/Pt 21	1163	0.2	37055	93.4
1261	5/12/97	57.3	6TmC	6100100	6	< 5	Long Int	Tongue Mixer	24 Chevrons	0	C2/Pt 21	1159	0.0	45082	96.6
1272	5/13/97	59.8	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	917	0.28	18092	77.5
1273	5/13/97	59.8	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	984	0.28	21759	80.6
1274	5/13/97	59.8	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1079	0.28	27360	86.1
1275	5/13/97	59.8	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1157	0.28	32238	90.7
1276	5/13/97	59.8	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1200	0.28	35148	93.2
1278	5/13/97	59.8	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1158	0.2	35631	94.8
1279	5/13/97	59.8	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1159	0.0	43883	99.6
1280	5/13/97	58.3	3FmB	3110000	3	5	External	Core Full Mixer	Baseline	0	C2/Pt 24	918	0.28	18078	78.9
1281	5/13/97	58.3	3FmB	3110000	3	5	External	Core Full Mixer	Baseline	0	C2/Pt 23	985	0.28	21783	82.2
1282	5/13/97	58.3	3FmB	3110000	3	5	External	Core Full Mixer	Baseline	0	C2/Pt 22	1081	0.28	27436	86.6
1283	5/13/97	58.3	3FmB	3110000	3	5	External	Core Full Mixer	Baseline	0	C2/Pt 21	1156	0.28	32202	90.8
1284	5/13/97	58.3	3FmB	3110000	3	5	External	Core Full Mixer	Baseline	0	C2/Pt 20	1198	0.28	34947	92.9
1285	5/13/97	58.3	3FmB	3110000	3	5	External	Core Full Mixer	Baseline	0	C2/Pt 21	1153	0.0	43263	97.7

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
1287	5/13/97	57.5	3HmB	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 24	914	0.28	18157	78.4
1288	5/13/97	57.5	3HmB	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 23	983	0.28	21886	81.6
1289	5/13/97	57.5	3HmB	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 22	1076	0.28	27460	86.4
1290	5/13/97	57.5	3HmB	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 21	1149	0.28	31872	90.1
1291	5/13/97	57.5	3HmB	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 20	1197	0.28	35210	92.3
1292	5/13/97	57.5	3HmB	3090000	3	5	External	Core Half Mixer	Baseline	0	C2/Pt 21	1196	0.0	46711	98.8
1293	5/13/97	57.1	3FmC	3110100	3	5	External	Core Full Mixer	24 Chevrons	0	C2/Pt 24	909	0.28	17956	78.9
1294	5/13/97	57.1	3FmC	3110100	3	5	External	Core Full Mixer	24 Chevrons	0	C2/Pt 23	984	0.28	22000	81.8
1295	5/13/97	57.1	3FmC	3110100	3	5	External	Core Full Mixer	24 Chevrons	0	C2/Pt 22	1076	0.28	27556	86.3
1296	5/13/97	57.1	3FmC	3110100	3	5	External	Core Full Mixer	24 Chevrons	0	C2/Pt 21	1156	0.28	32469	90.4
1297	5/13/97	57.1	3FmC	3110100	3	5	External	Core Full Mixer	24 Chevrons	0	C2/Pt 20	1195	0.28	35139	92.2
1298	5/13/97	57.1	3FmC	3110100	3	5	External	Core Full Mixer	24 Chevrons	0	C2/Pt 21	1154	0.0	43651	97.0
1299	5/13/97	56.5	3T24T48	3070400	3	5	External	24 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 24	914	0.28	17018	78.8
1300	5/13/97	56.5	3T24T48	3070400	3	5	External	24 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 23	986	0.28	20769	81.5
1301	5/13/97	56.5	3T24T48	3070400	3	5	External	24 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 22	1083	0.28	26417	85.3
1302	5/13/97	56.5	3T24T48	3070400	3	5	External	24 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 21	1155	0.28	30871	88.4
1303	5/13/97	56.5	3T24T48	3070400	3	5	External	24 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 20	1198	0.28	33757	90.6
1304	5/13/97	56.5	3T24T48	3070400	3	5	External	24 Flipper Tabs	48 Flipper Tabs	0	C2/Pt 21	1155	0.0	41914	95.4
1594	6/17/97	64.6	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1155	0.0	44456	98.9
1595	6/17/97	64.6	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.2	35782	93.9
1596	6/17/97	64.6	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.28	32266	89.6
1597	6/17/97	64.6	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1199	0.28	35270	92.1
1598	6/17/97	64.6	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1081	0.28	27459	85.1
1599	6/17/97	64.6	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	981	0.28	21520	79.9
1600	6/17/97	64.6	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	911	0.28	17712	77.2
1604	6/17/97	62.5	3T24C	3070100	3	5	External	24 Flipper Tabs	24 Chevrons	0	C2/Pt 24	910	0.28	17870	77.2
1605	6/17/97	62.5	3T24C	3070100	3	5	External	24 Flipper Tabs	24 Chevrons	0	C2/Pt 23	978	0.28	21669	79.8
1606	6/17/97	62.5	3T24C	3070100	3	5	External	24 Flipper Tabs	24 Chevrons	0	C2/Pt 22	1075	0.28	27391	83.8
1607	6/17/97	62.5	3T24C	3070100	3	5	External	24 Flipper Tabs	24 Chevrons	0	C2/Pt 21	1153	0.28	32391	87.5
1608	6/17/97	62.5	3T24C	3070100	3	5	External	24 Flipper Tabs	24 Chevrons	0	C2/Pt 20	1188	0.28	34806	89.0
1609	6/17/97	62.5	3T24C	3070100	3	5	External	24 Flipper Tabs	24 Chevrons	0	C2/Pt 21	1151	0.2	44331	90.6
1610	6/17/97	62.5	3T24C	3070100	3	5	External	24 Flipper Tabs	24 Chevrons	0	C2/Pt 21	1149	0.0	44079	95.4
1612	6/17/97	62.5	3T24C	3070100	3	5	External	24 Flipper Tabs	24 Chevrons	0	C2/Pt 21	1151	0.2	35778	90.7
1613	6/17/97	62.5	3T24C	3070100	3	5	External	24 Flipper Tabs	24 Chevrons	0	C2/Pt 21	1149	0.28	32078	87.0
1656	6/18/97	66.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 24	912	0.28	18240	77.0
1657	6/18/97	66.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 23	980	0.28	21639	79.9
1658	6/18/97	66.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 22	1078	0.28	27859	85.2

Table 4. EPNL Summary for SFNT97 Test

Escort No.	Test Date	Tamb (deg F)	Test Config.	Config. Code	Model No.	Nominal BPR	Plug Config.	Core Mixer Enhancer	Fan Mixer Enhancer	Clock Position	Cycle / Point No.	Ideal Vmix (fps)	Freejet Mach No.	Ideal Fn (lb)	1500-Ft EPNL
1660	6/18/97	66.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 21	1156	0.28	32586	89.8
1661	6/18/97	66.0	3BB	3000000	3	5	External	Baseline	Baseline	0	C2/Pt 20	1200	0.28	35501	92.2
1662	6/18/97	66.0	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 24	910	0.28	18050	77.3
1663	6/18/97	66.0	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 23	973	0.28	21387	79.8
1664	6/18/97	66.0	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 22	1080	0.28	27897	84.2
1665	6/18/97	66.0	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 21	1155	0.28	32358	87.7
1666	6/18/97	66.0	3T24B	3070000	3	5	External	24 Flipper Tabs	Baseline	0	C2/Pt 20	1195	0.28	35080	89.7

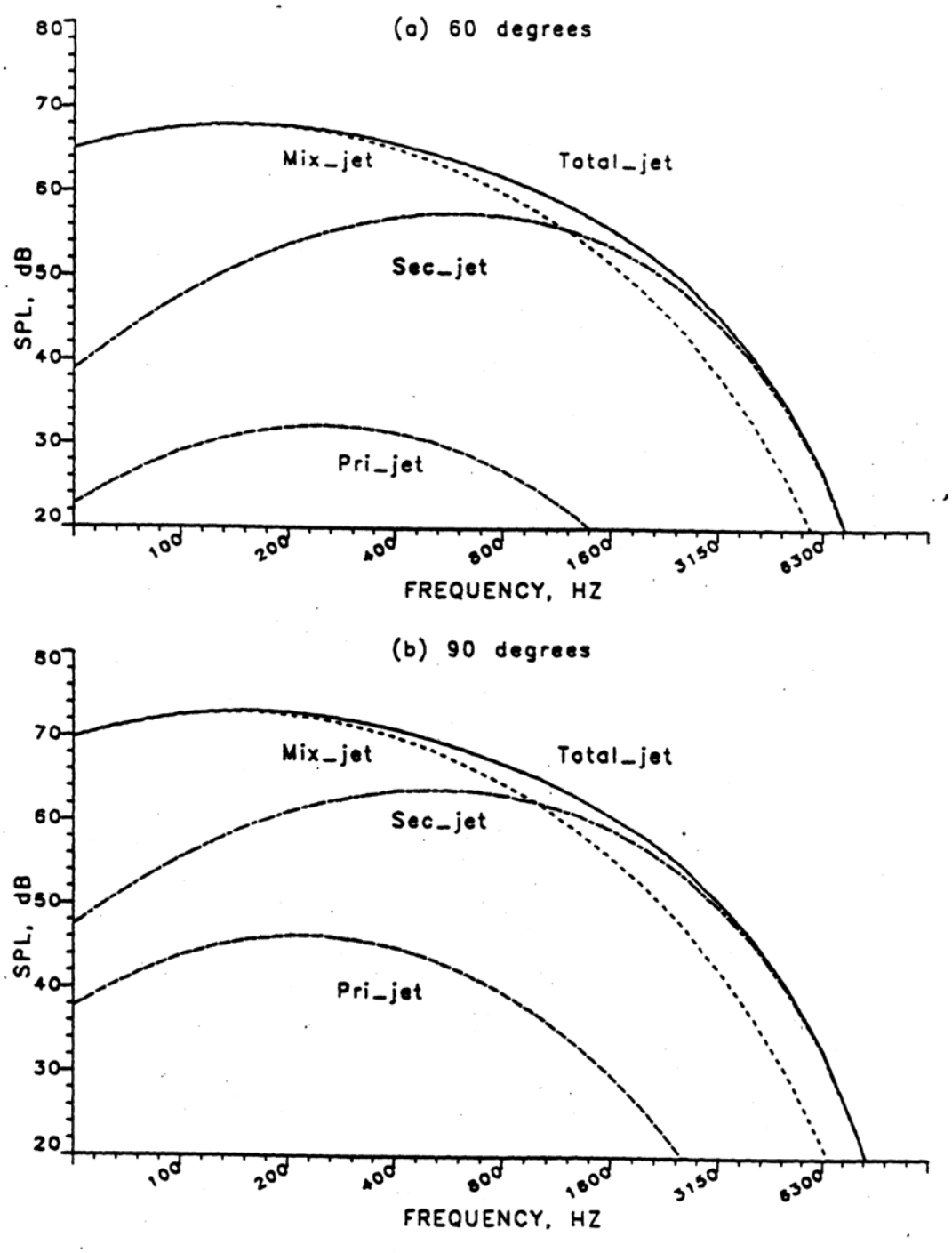


Figure 1a. Source Noise Spectra (1500 ft Sideline) For Separate Flow High-Bypass Ratio Jet (Vmix=1155 fps) Predicted Using Boeing's JEN6 Coaxial Jet Prediction Method for Far-field Angles; (a) 60 deg. And (b) 90 deg.

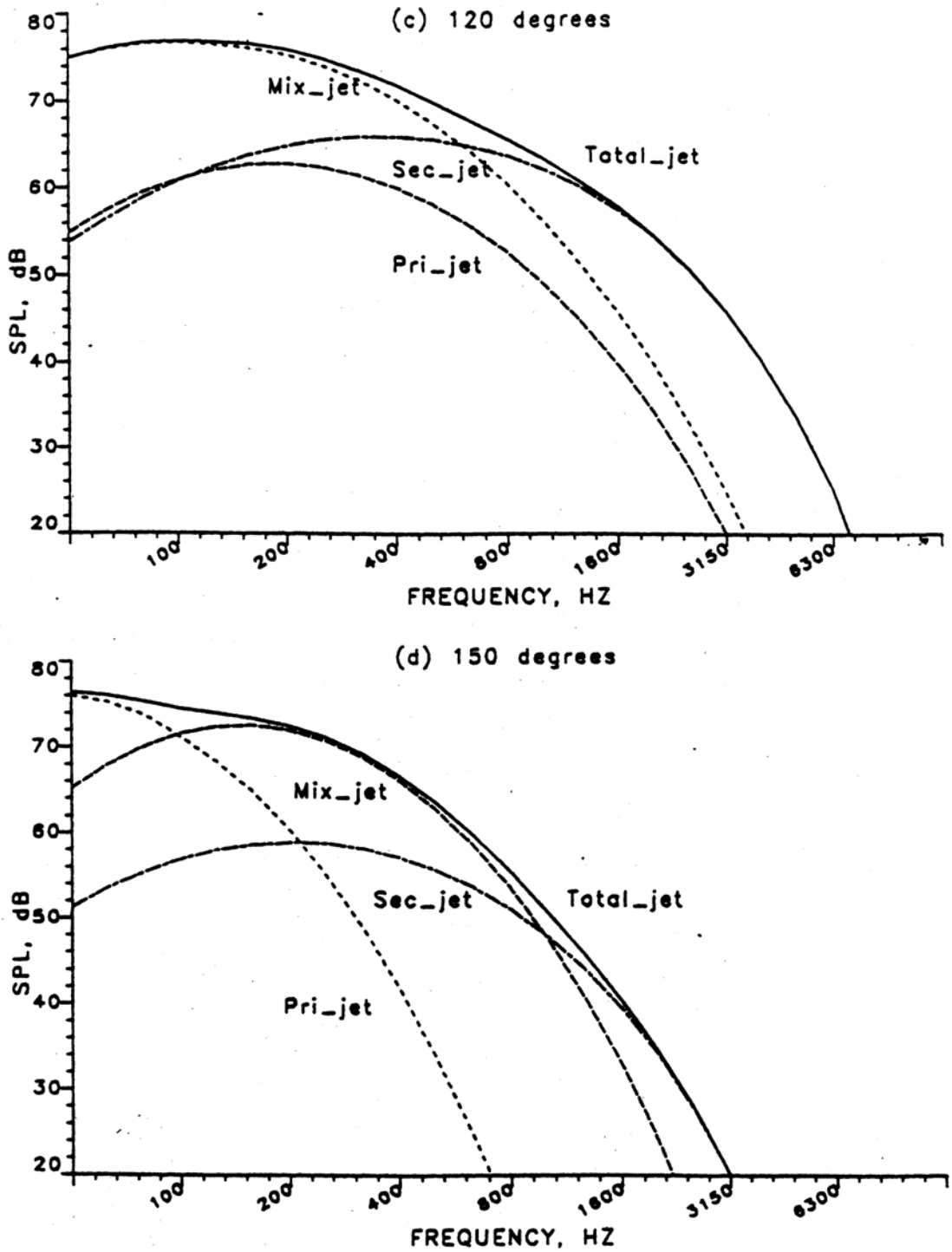


Figure 1b. Source Noise Spectra (1500 ft Sideline) For Separate Flow High-Bypass Ratio Jet (Vmix=1155 fps) Predicted Using Boeing's JEN6 Coaxial Jet Prediction Method for Far-field Angles; (a) 120 deg. And (b) 150 deg.

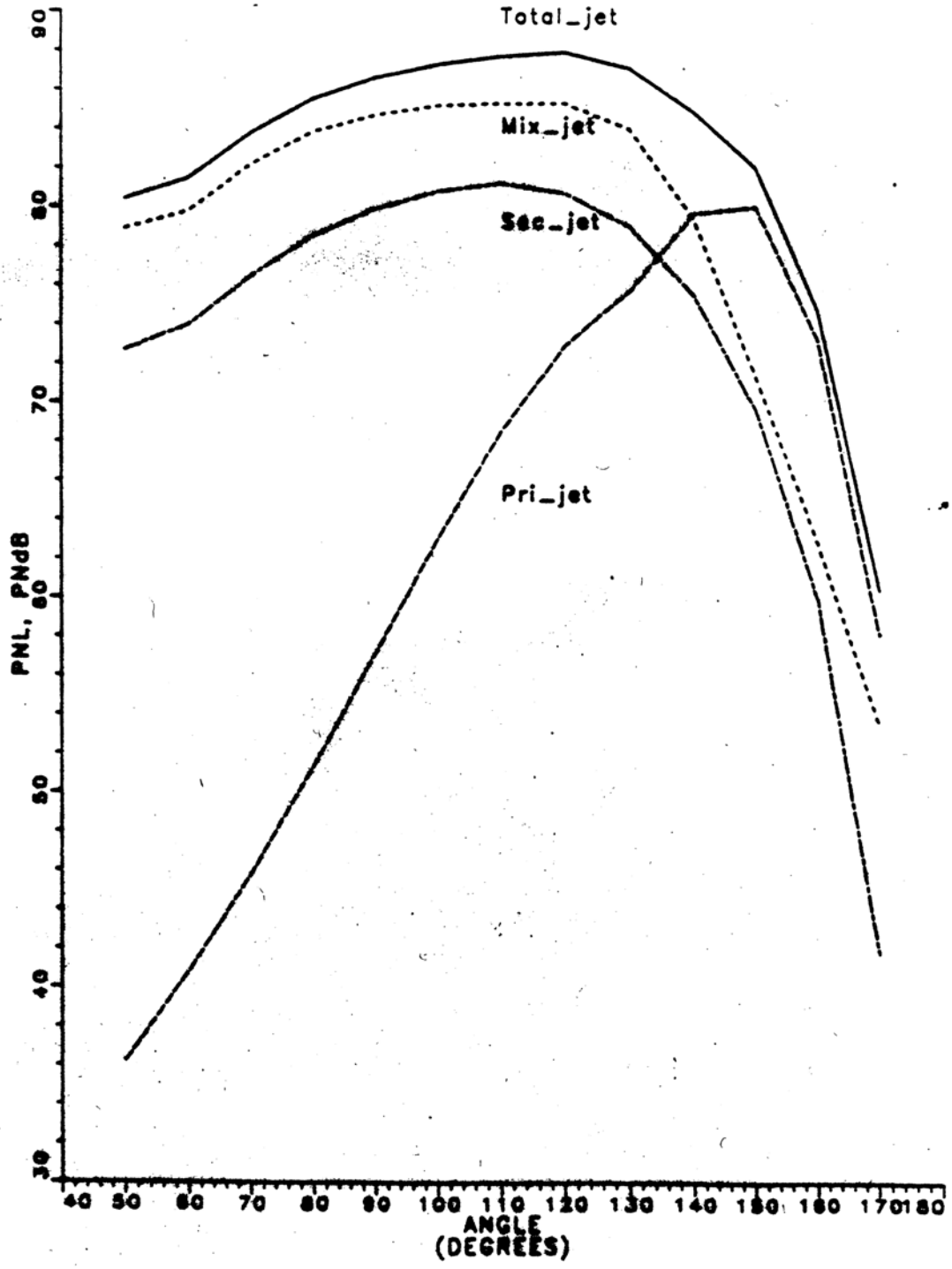


Figure 2. Source Noise PNL Directivities (1500 ft Sideline) For Separate Flow High-Bypass Ratio Jet (Vmix=1155 fps) Predicted Using Boeing's JEN6.

Figure 3 Picture of Model #1 Baseline Nozzle (1BB), BPR=5, Internal Plug Coplanar Nozzle.

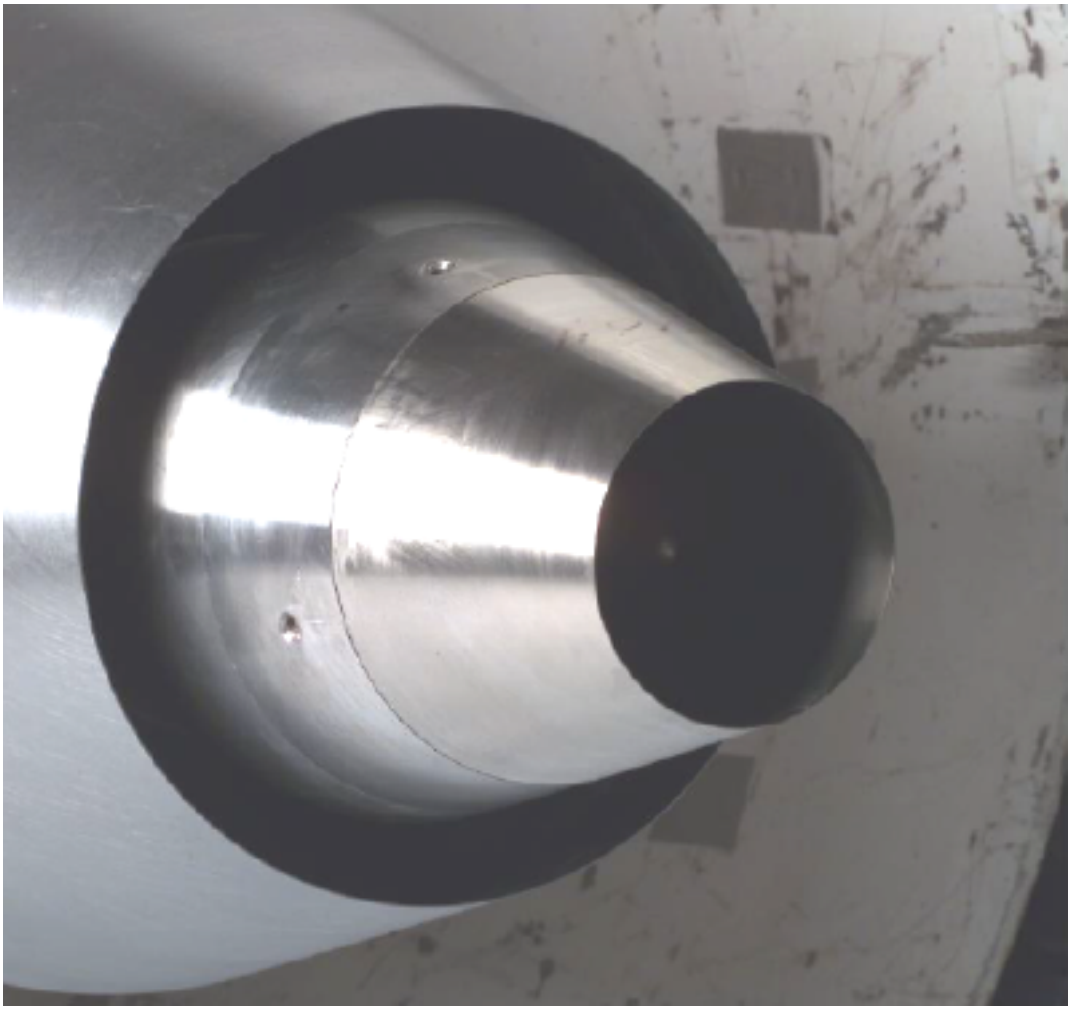


Figure 4 Picture of Model #2 Baseline Nozzle (2BB), BPR=5, Internal Plug Separate-Flow Nozzle.

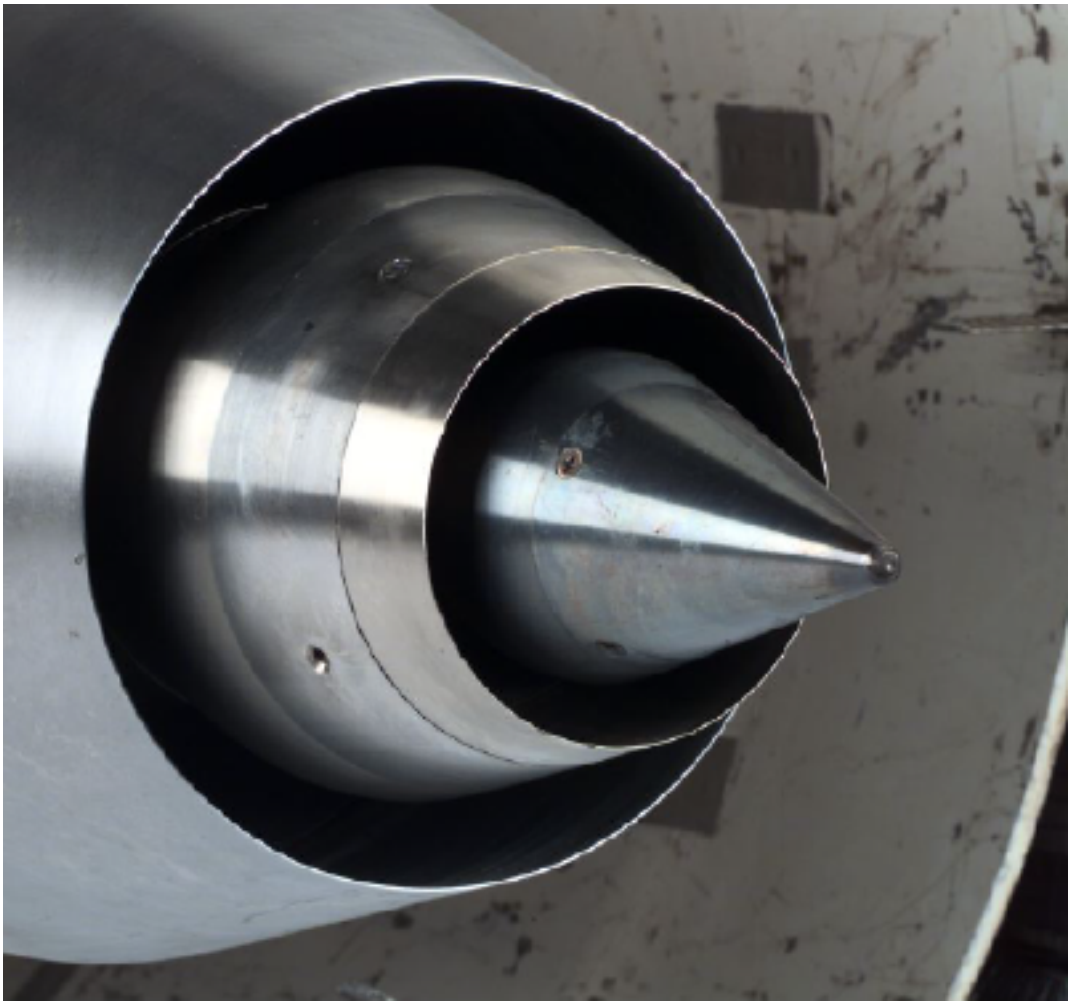


Figure 5 Picture of Model #3 Baseline Nozzle (3BB), BPR=5, External Plug Separate-Flow Nozzle.

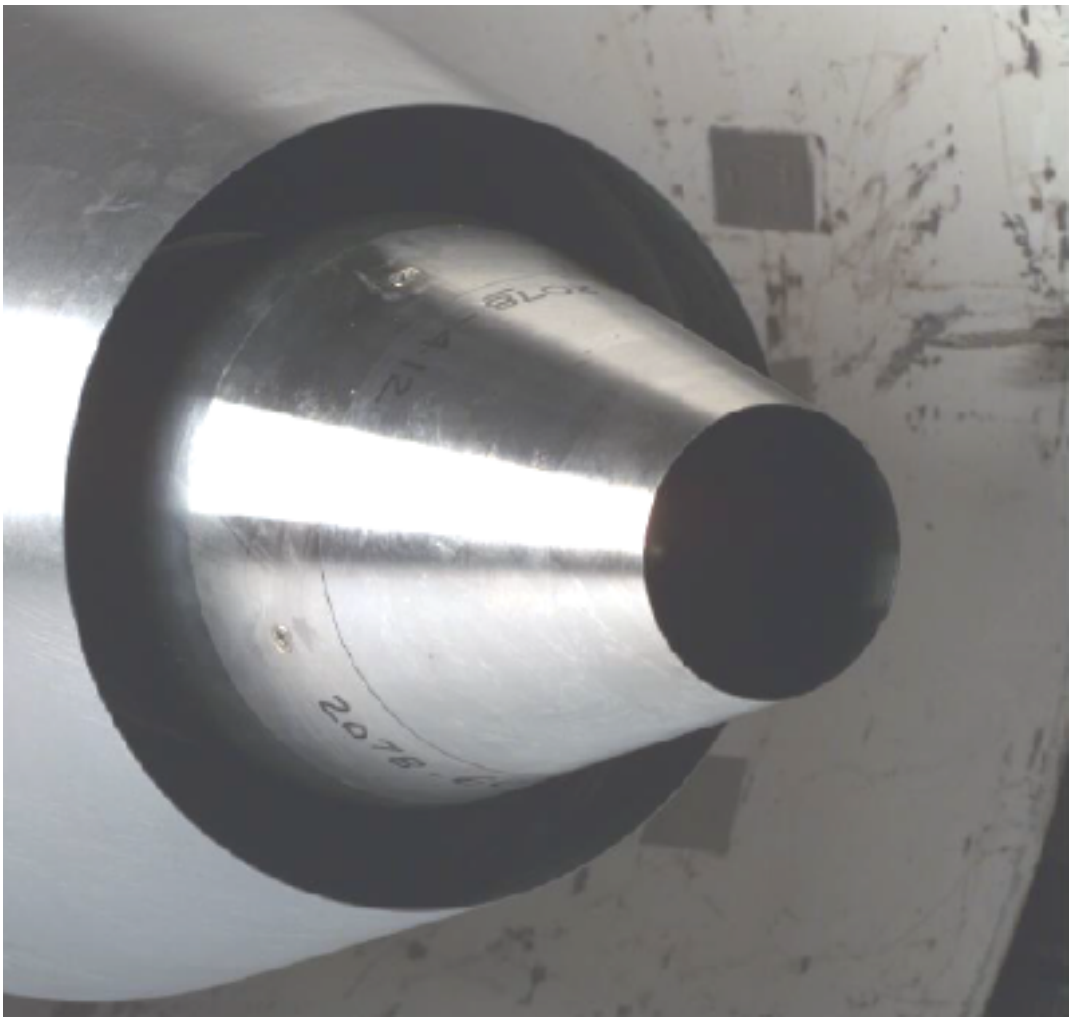


Figure 6 Picture of Model #4 Baseline Nozzle (4BB), BPR=8, Internal Plug Separate-Flow Nozzle.

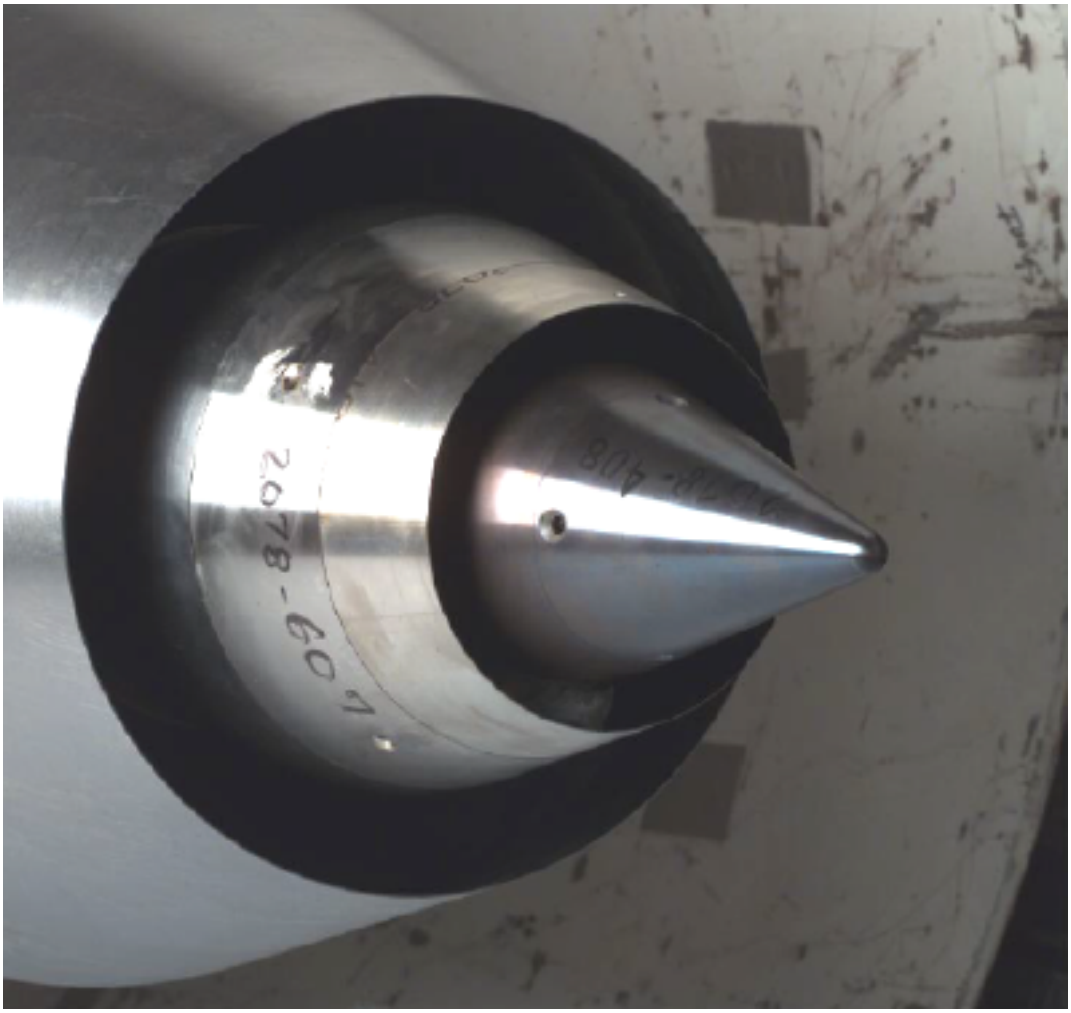


Figure 7 Picture of Model #5 Baseline Nozzle (5BB), BPR=8, External Plug Separate-Flow Nozzle.

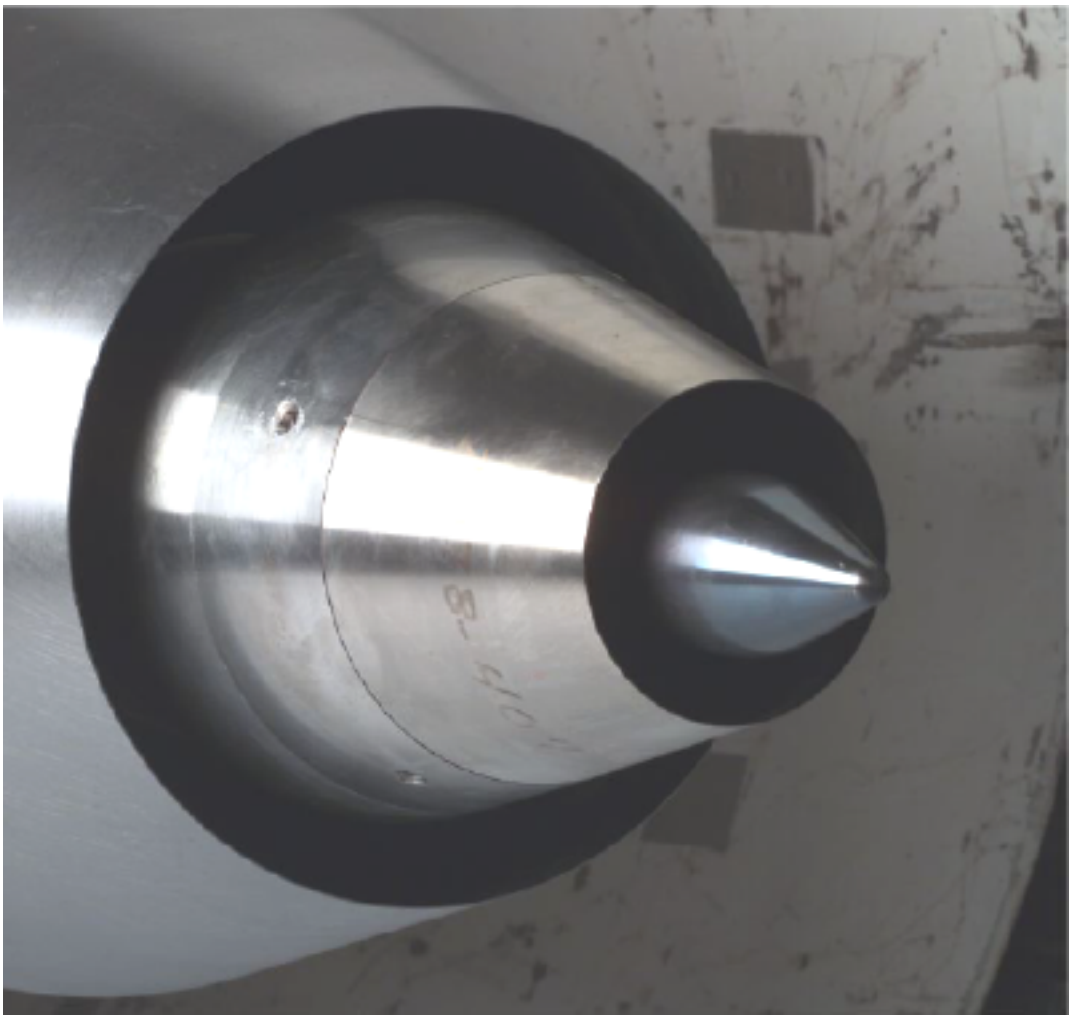


Figure 8 Picture of Model #6 Baseline (6BB) with Modified, Plug for AEC's Tongue Mixer Nozzle.

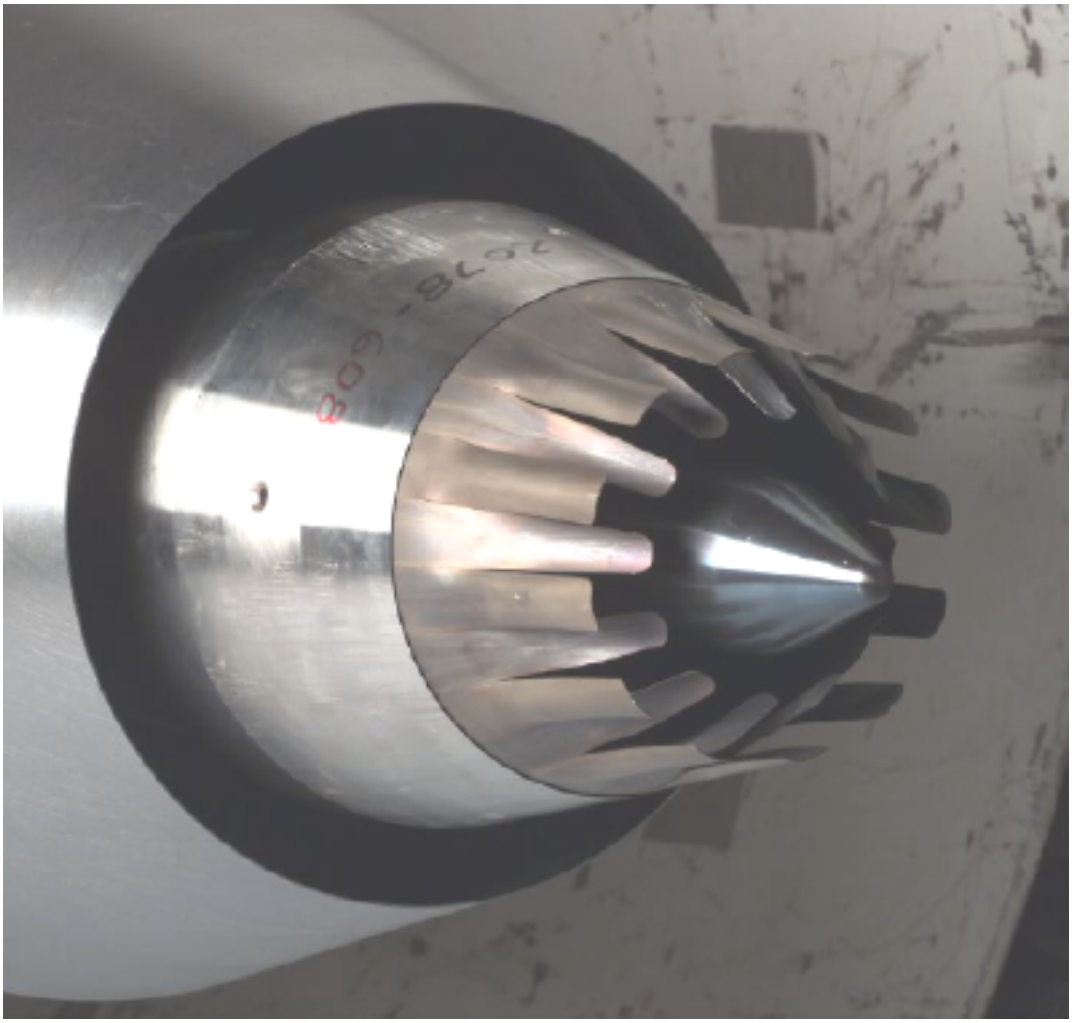


Figure 9 Picture of AEC's Tongue Mixer Nozzle with Modified Plug Installed in Model #6 Configuration.

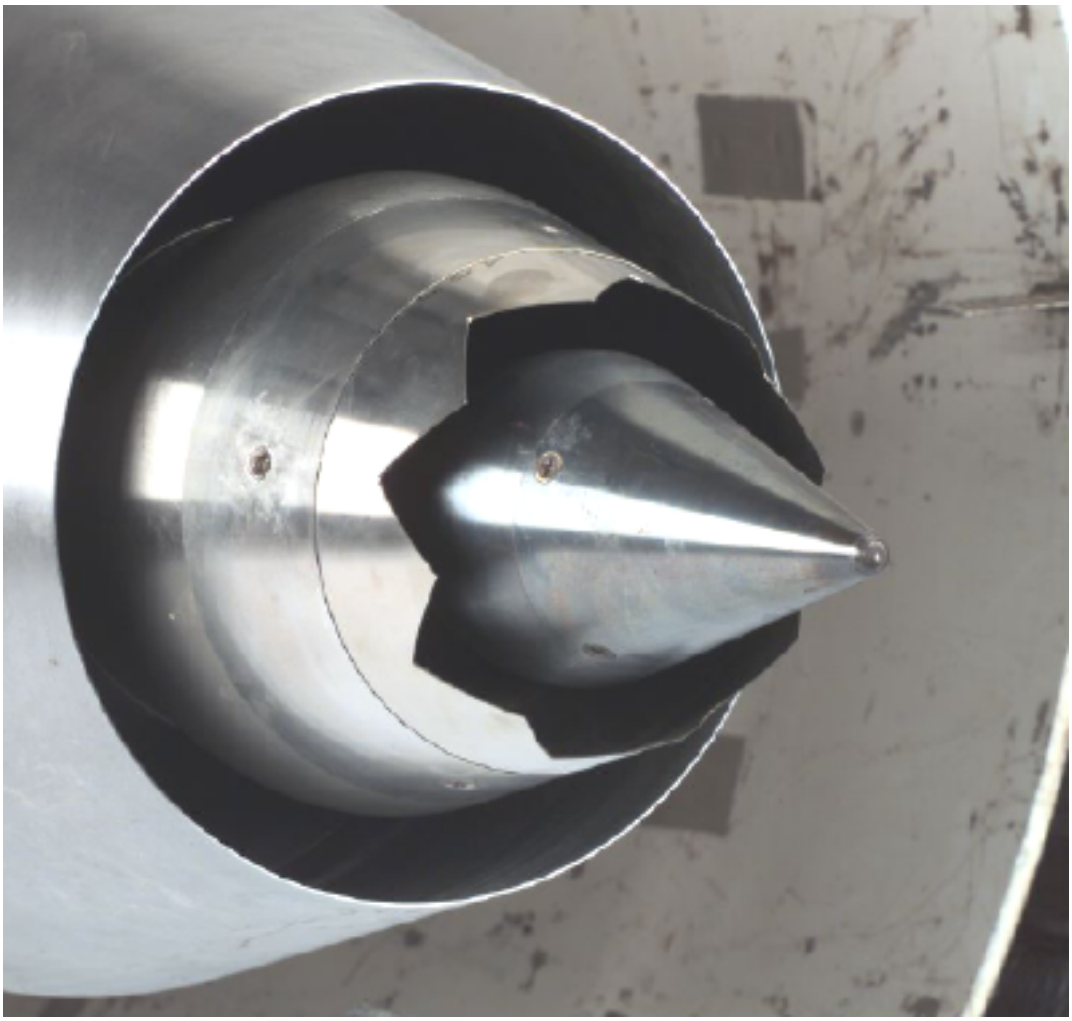


Figure 10 Picture of an Eight (8) Neutral-Chevrons Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3C8B).

Figure 11 Picture of a Twelve (12) Neutral-Chevrons Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3C12B).

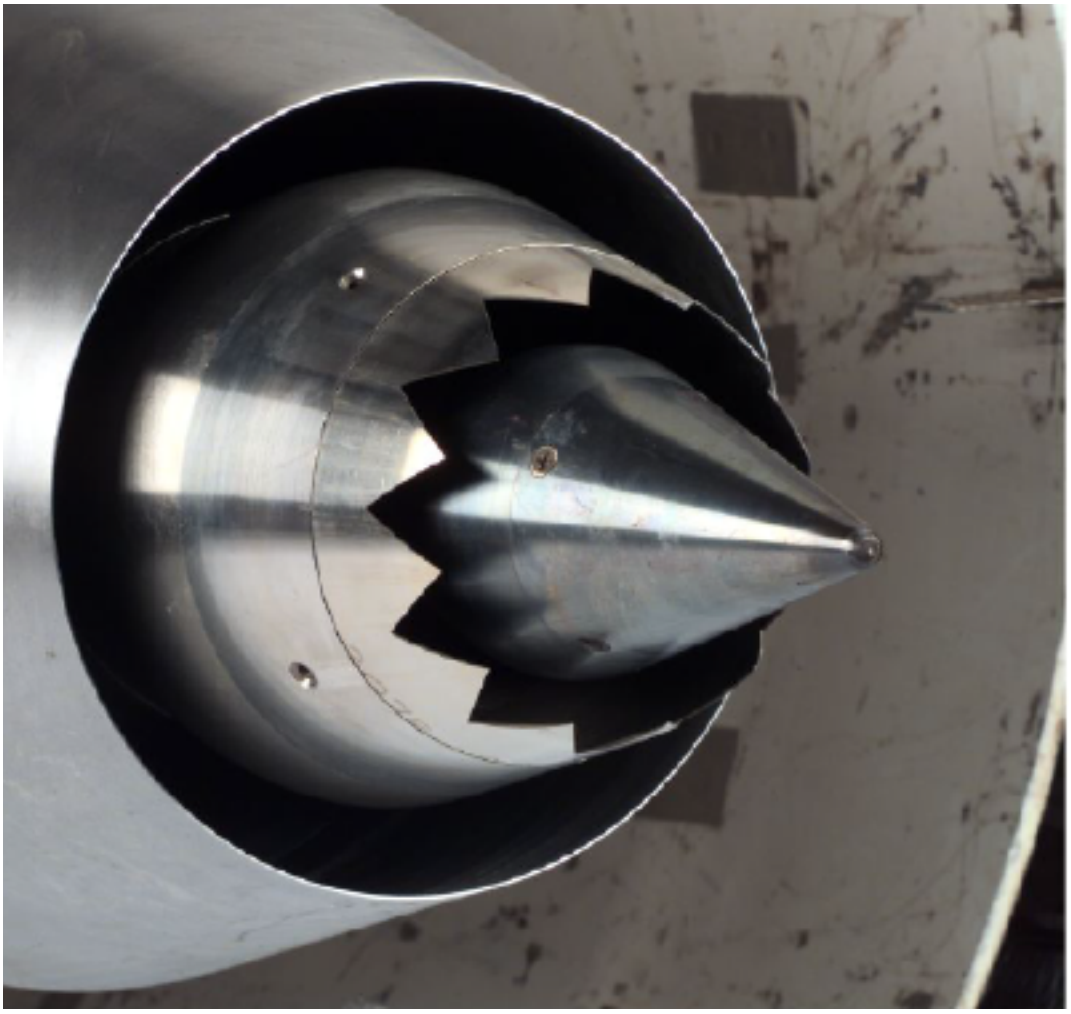


Figure 12 Picture of a Twelve (12) Inward-Facing-Chevrons Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3IB).

Figure 13 Picture of a Twelve (12) Alternating Inward-Outward Chevrons Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3AB).

Figure 14 Picture of a Twenty Four (24) Neutral-Chevrons Fan Nozzle Combined with Model 3 Baseline Core Nozzle (3BC).

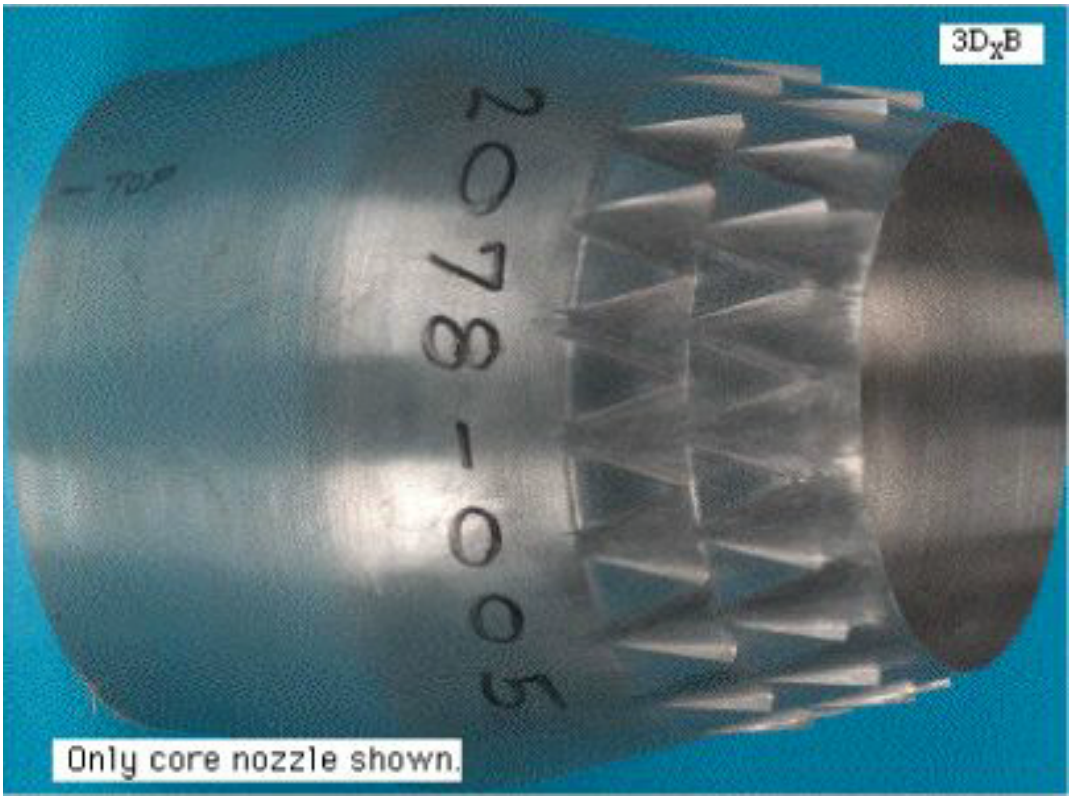


Figure 15 Picture of the Arrangement of Twenty (20) Vortex Generators (VG) Doublets on the Outer Surface of a Core Nozzle (3DxB).

Figure 16 Picture of the Arrangement of 64 VG Doublets on the Inner Surface of a Core Nozzle (3DiB).

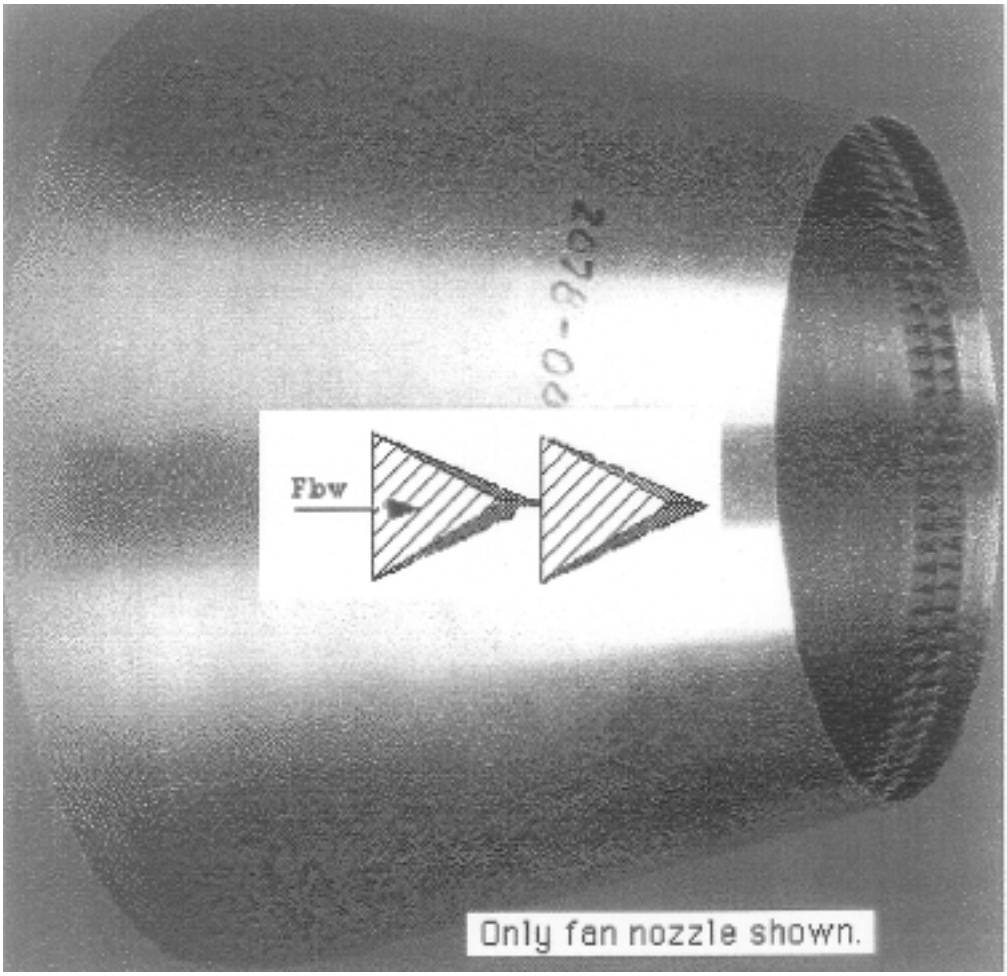


Figure 17 Picture of the Arrangement of 96 VG Doublets on the Inner Surface of a Fan Nozzle (3BDi).

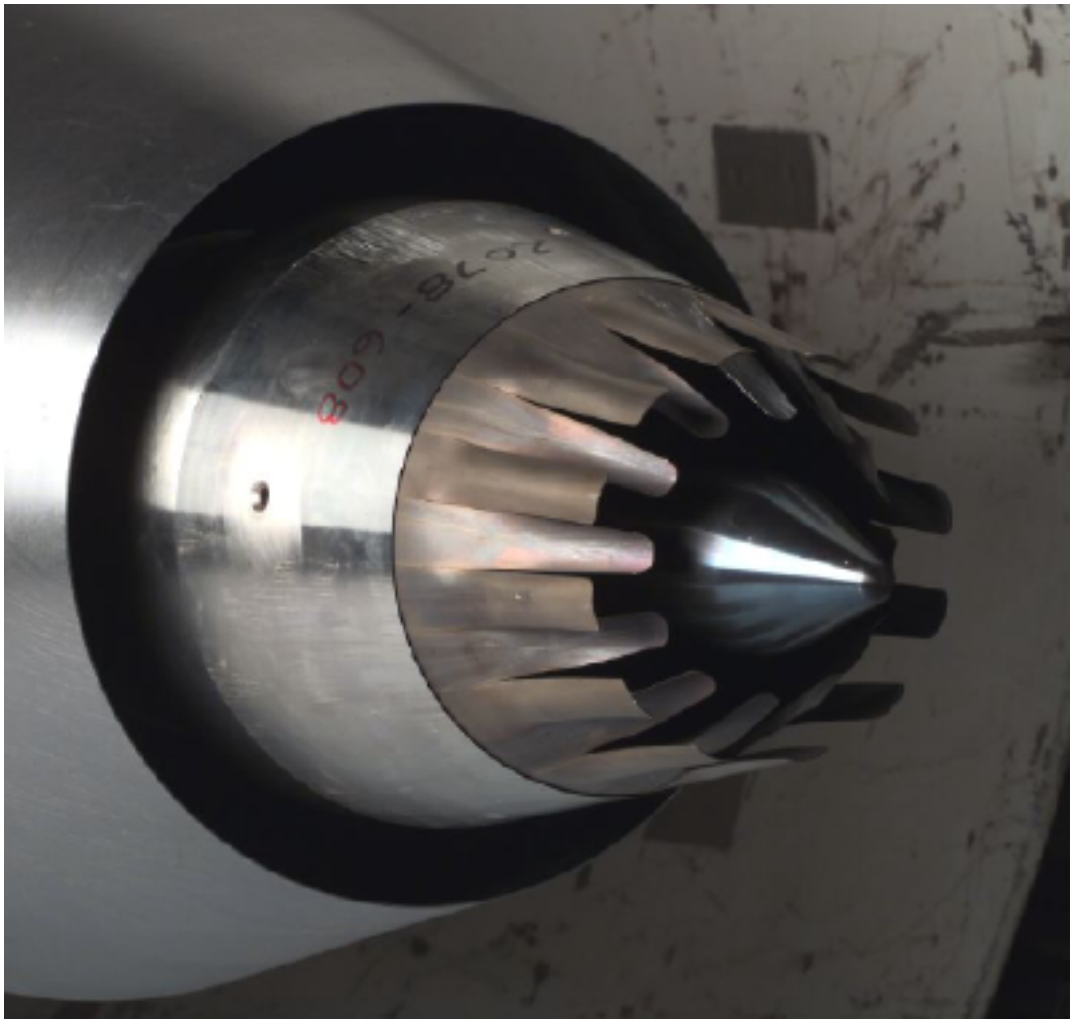


Figure 18. Picture of AEC's Tongue Mixer Core Nozzle With Model 2 Baseline Fan Nozzle.

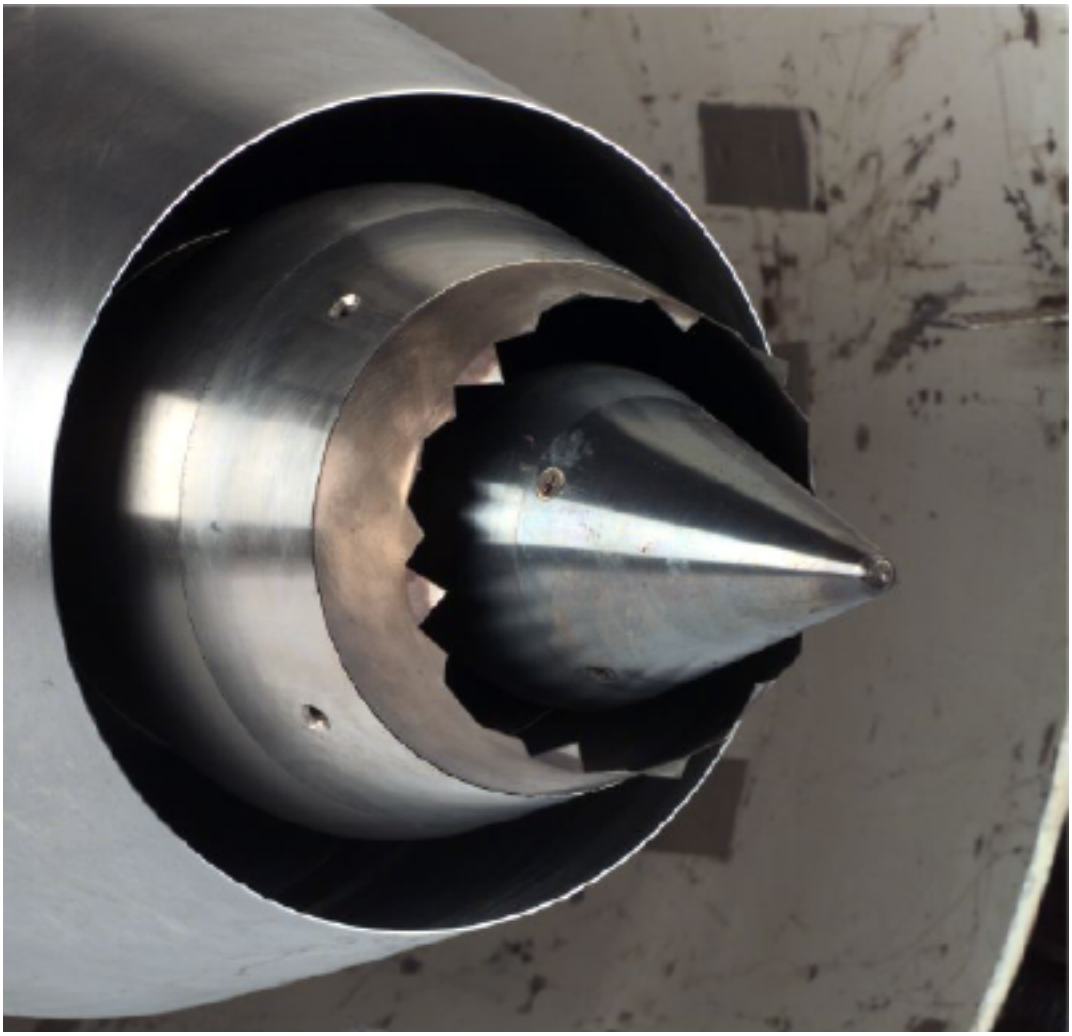


Figure 19 Picture of a Twenty Four (24) Flipper-Tabbed Core Nozzle with Model 3 Baseline Fan Nozzle (3T24B).

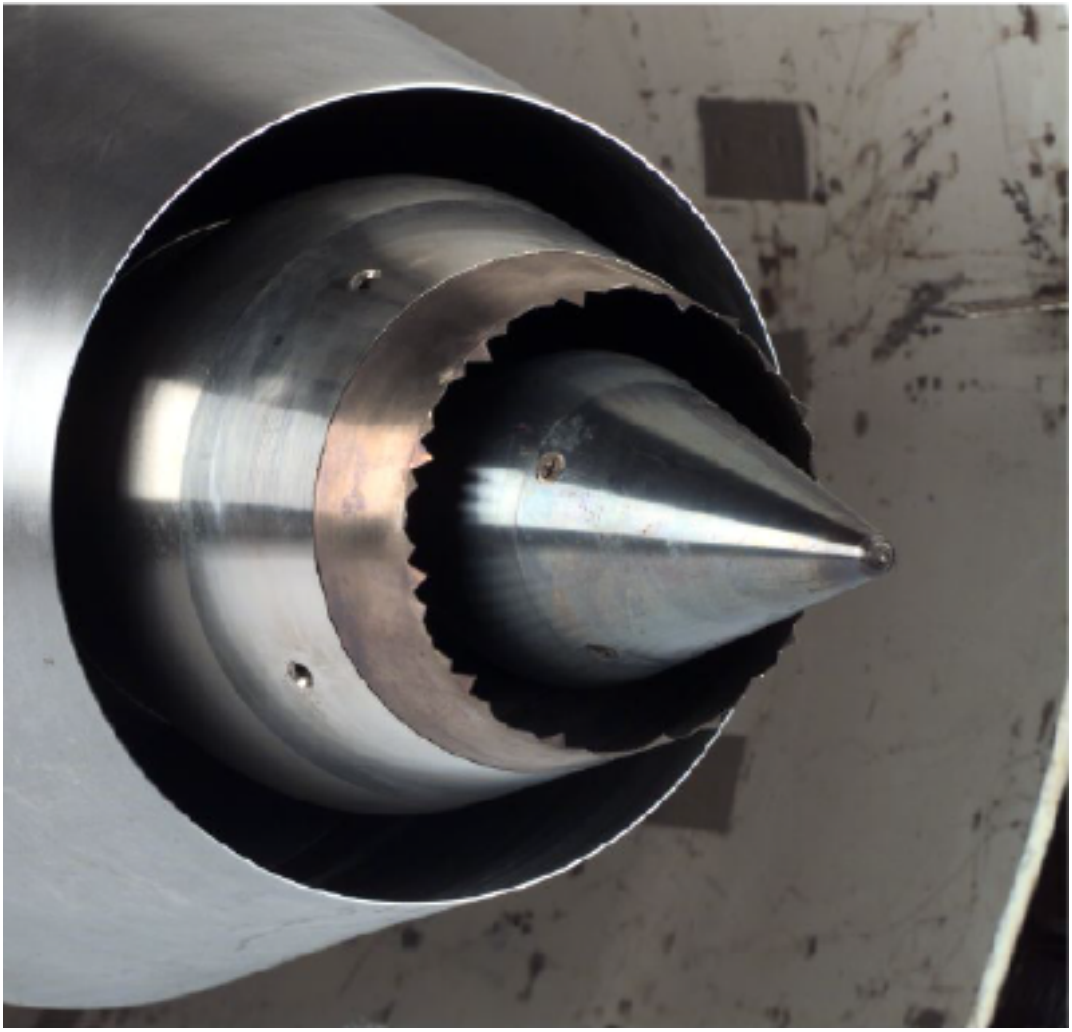


Figure 20 Picture of a Forty Eight (48) Flipper-Tabbed Core Nozzle with Model 3 Baseline Fan Nozzle (3T48B).

Figure 21 Picture of a Twenty Four (24) Flipper-Tabbed Fan Nozzle with Model 3 Baseline Core Nozzle (3BT24).

Figure 22 Picture of a Forty Eight (48) Flipper-Tabbed Fan Nozzle with Model 3 Baseline Core Nozzle (3BT48).

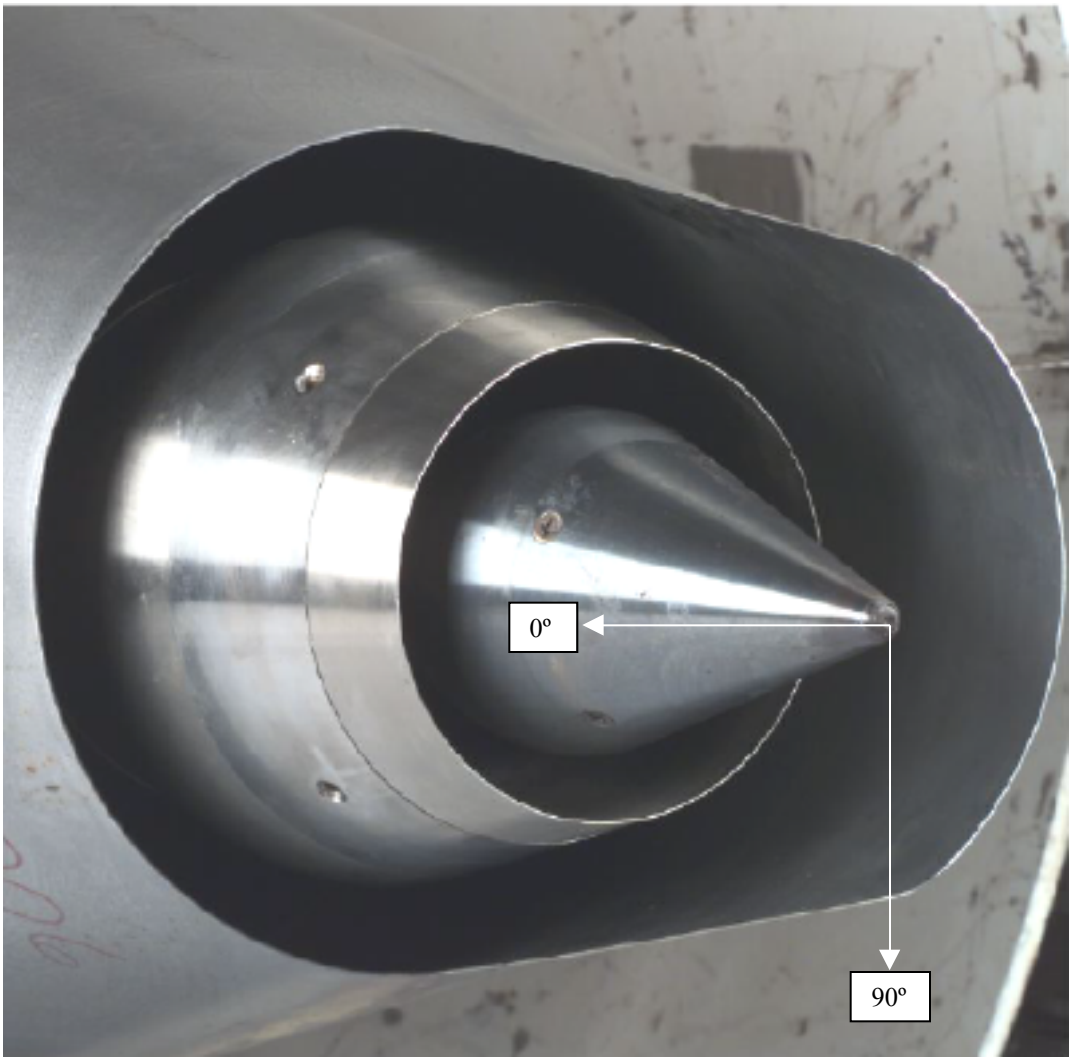


Figure 23 Picture of a Scarfed Fan Nozzle with Model 3 Baseline Core Nozzle (3BS).

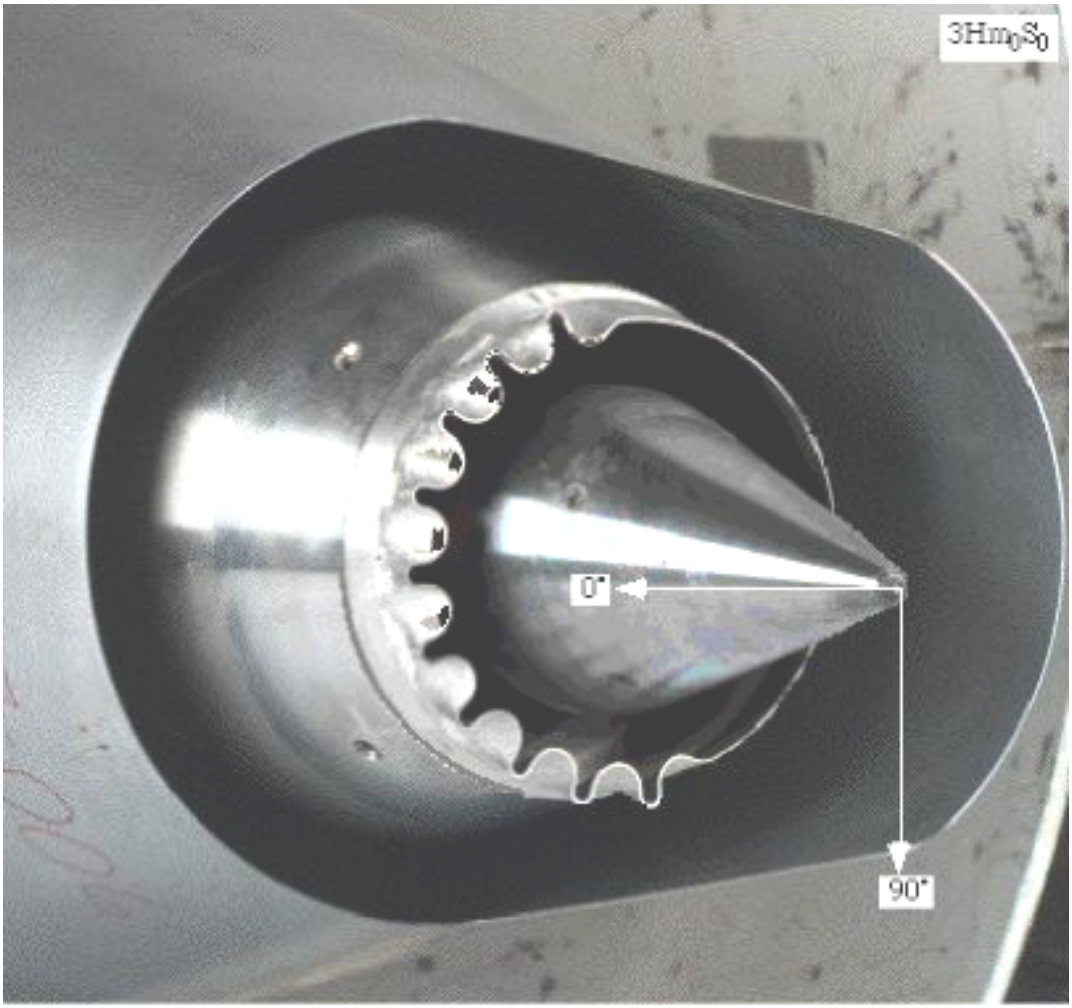


Figure 24 Picture of a Scarfed Fan Nozzle Combined with the Core Half-Mixer Nozzle (3HmS).

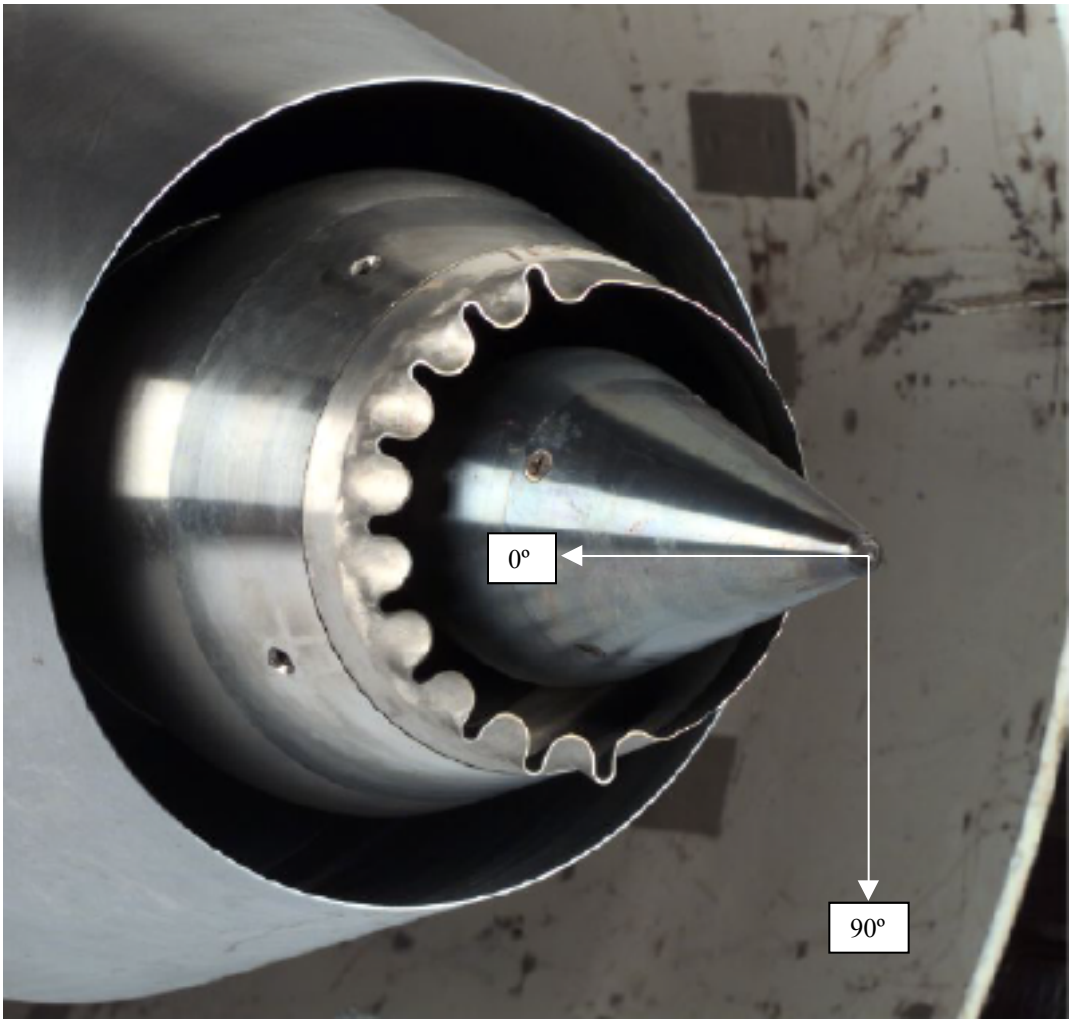


Figure 25 Picture of a Half-Mixer Core Nozzle with Model 3 Baseline Fan Nozzle (3HmB).

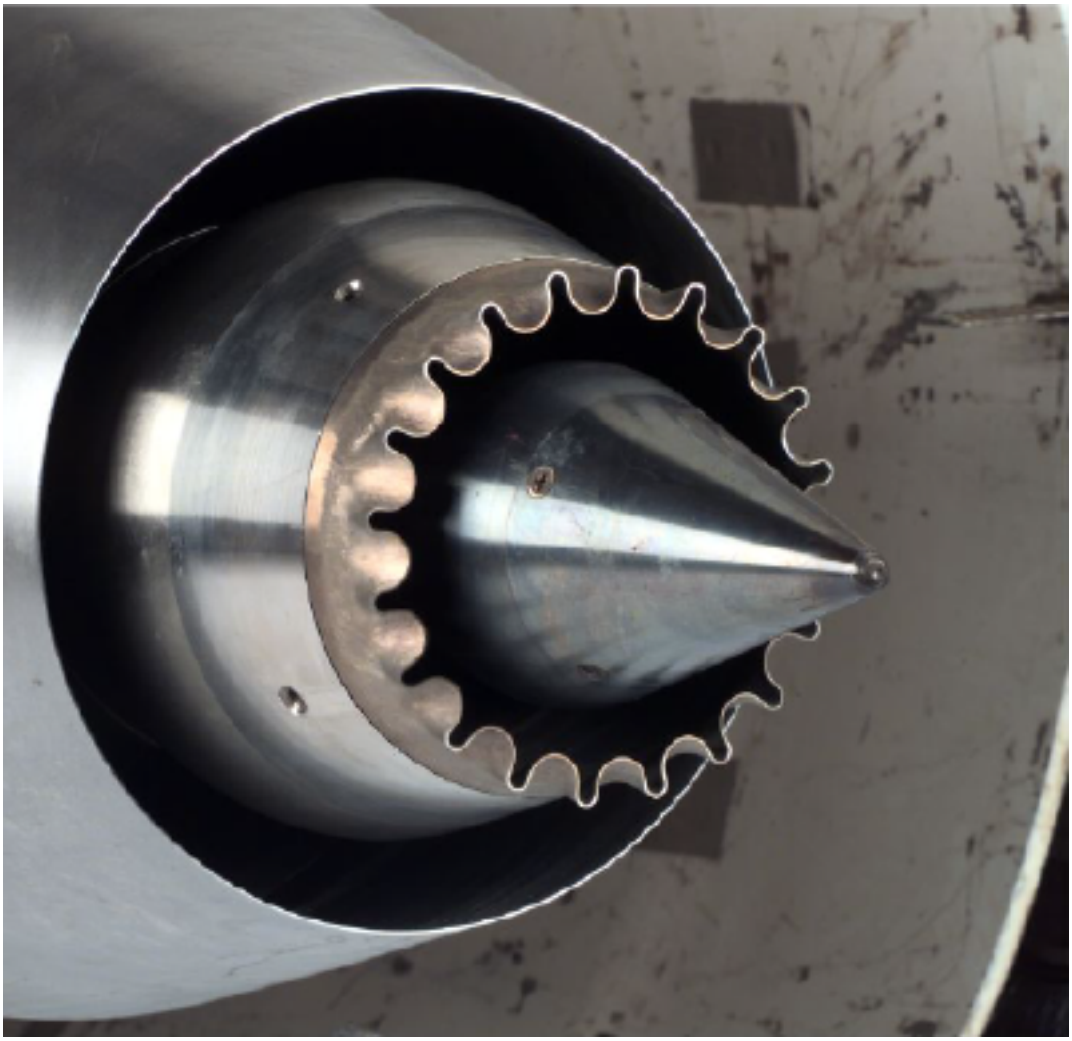


Figure 26 Picture of a Full-Mixer Core Nozzle with Model 3 Baseline Fan Nozzle (3FmB).

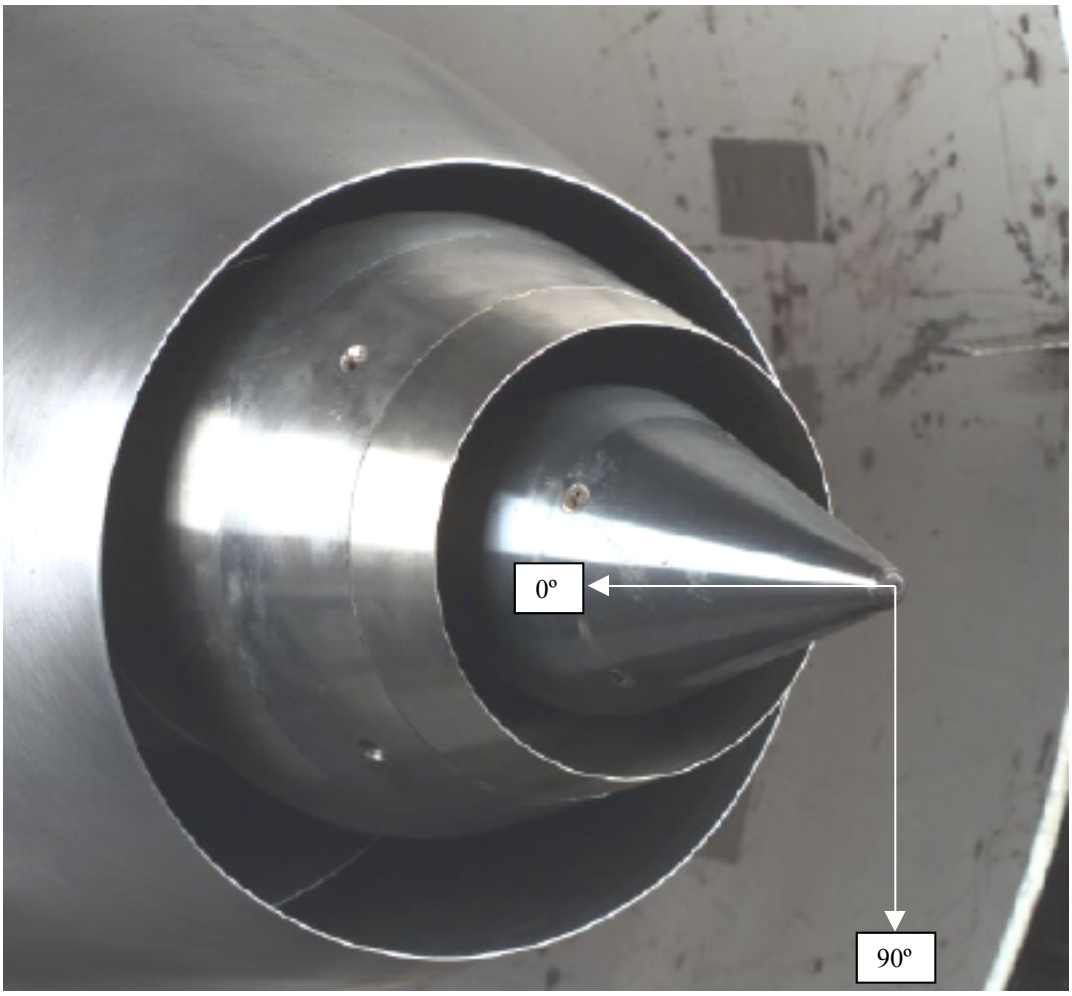


Figure 27 Picture of Offset Centerline Fan Nozzle with Model 3 Baseline Core Nozzle (3BOmax).

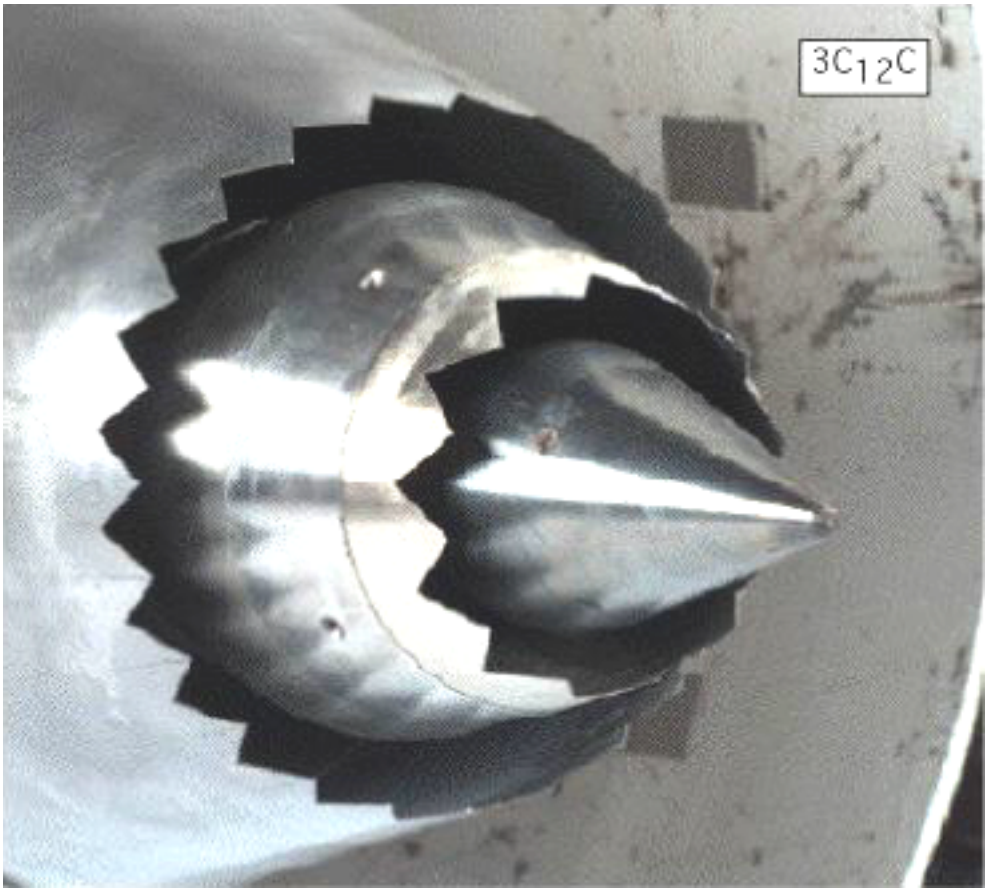


Figure 28. Picture of the Combination Nozzle Configuration (3C12C), 12-Neutral-Chevrons Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

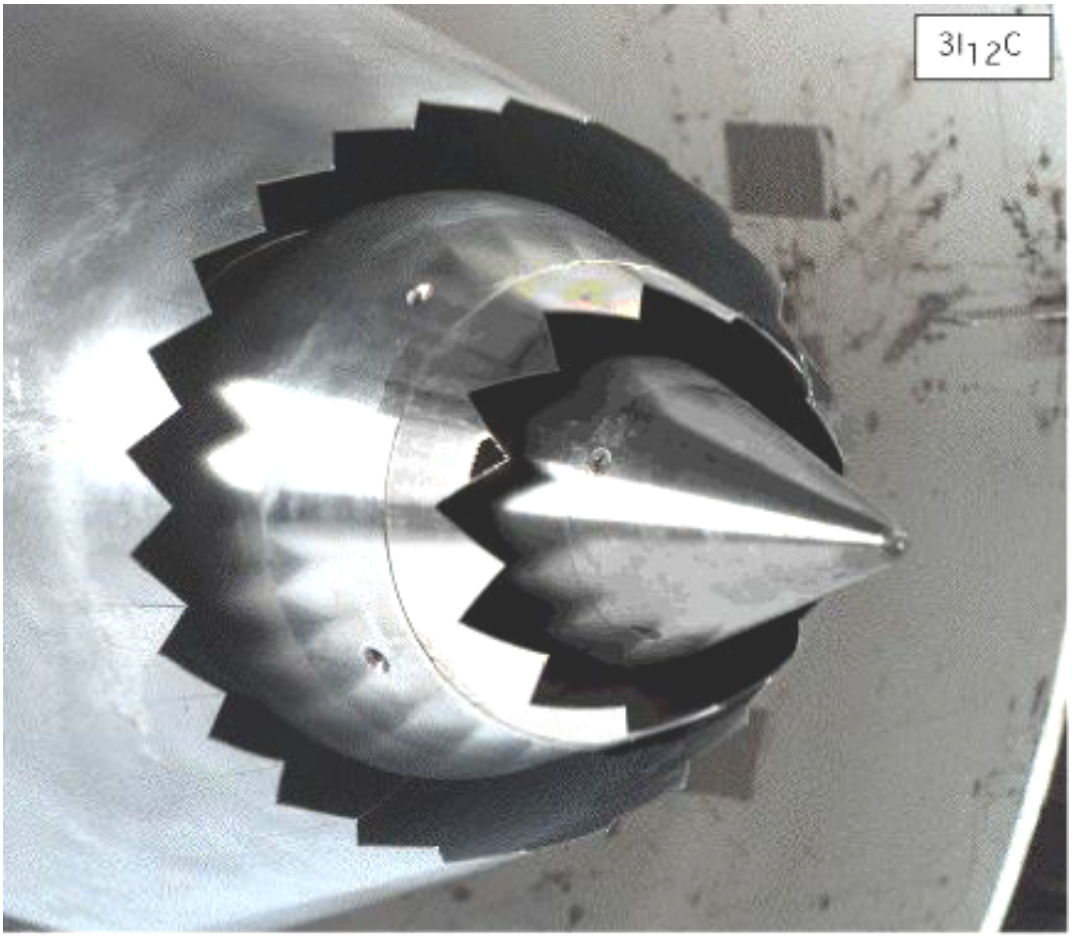


Figure 29. Picture of the Combination Nozzle Configuration (3IC), 12-Inward-Facing-Chevrons Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

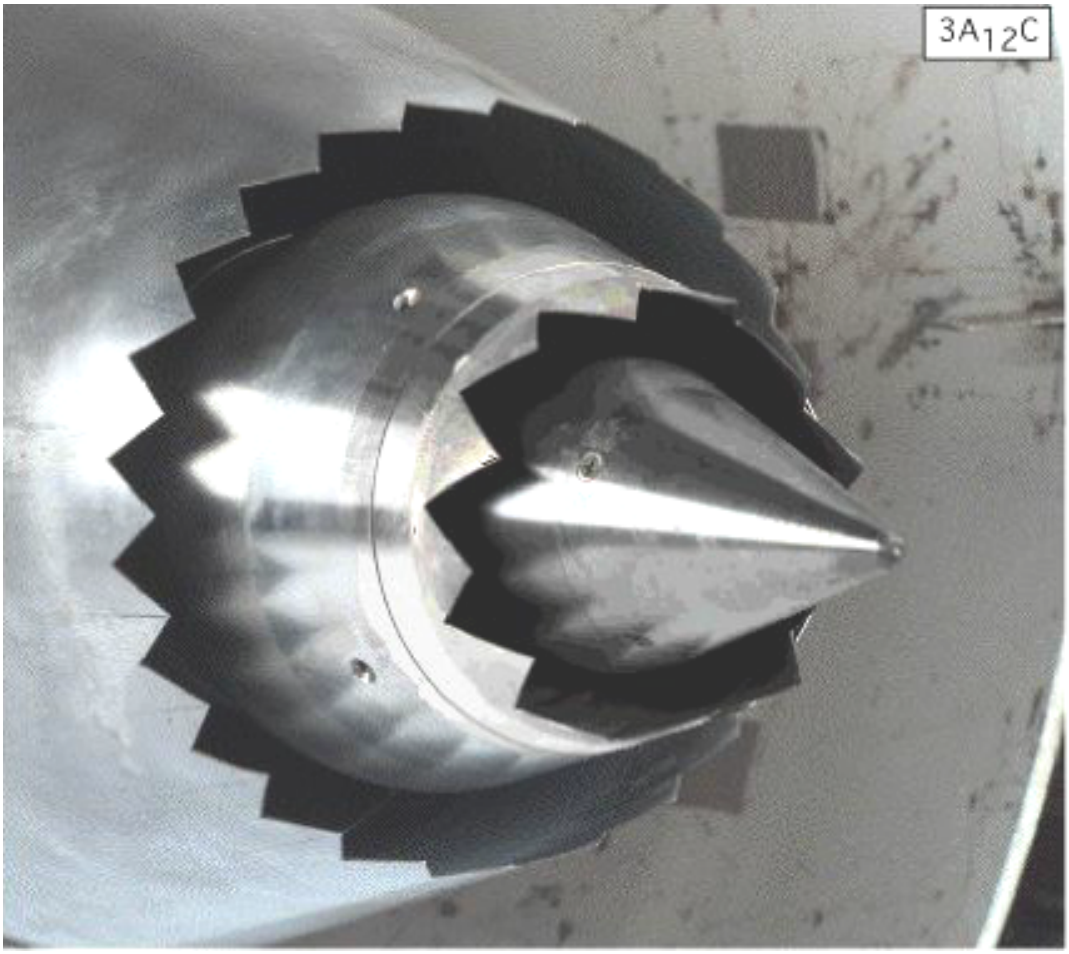


Figure 30. Picture of the Combination Nozzle Configuration (3AC), 12-Alternating Inward-Outward-Facing-Chevrons Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

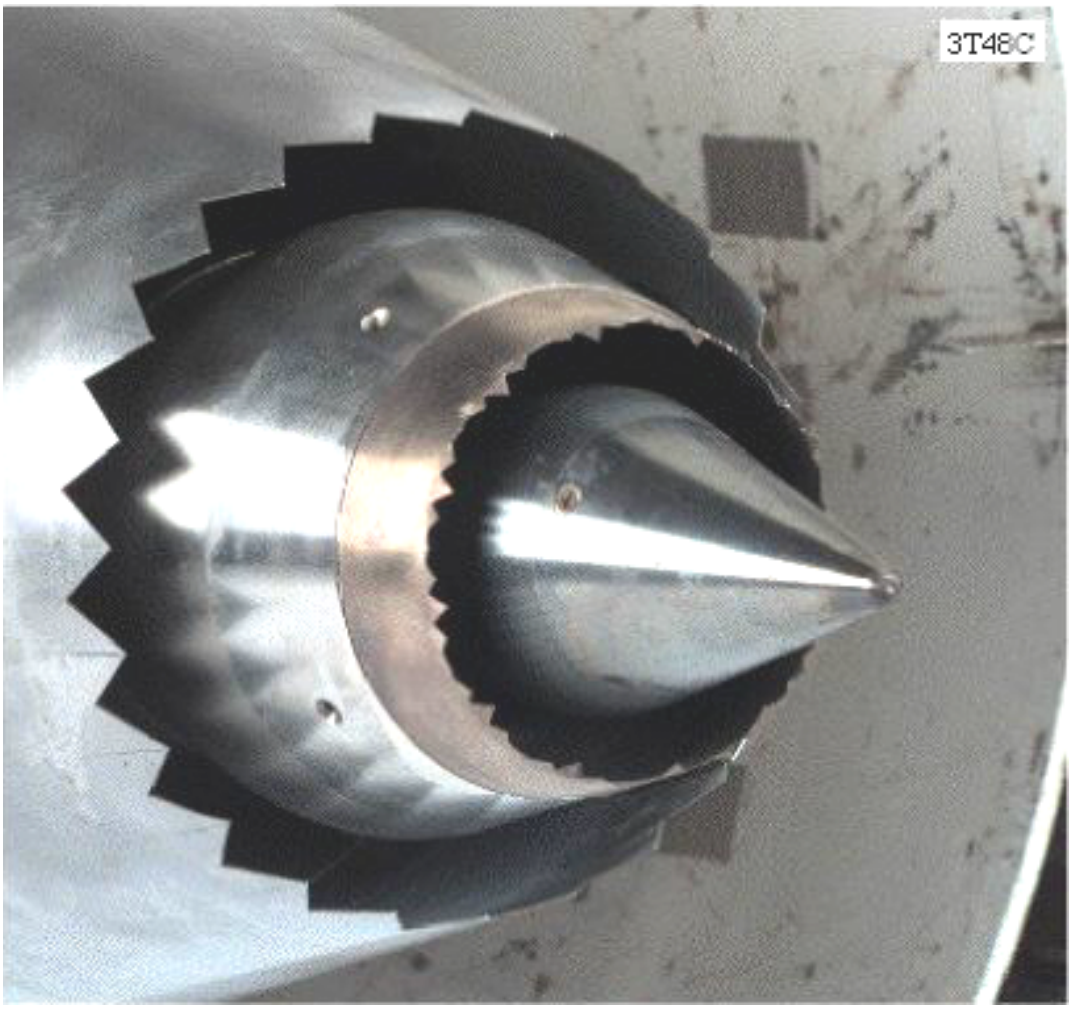


Figure 31. Picture of the Combination Nozzle Configuration (3T48C), 48-Flipper-Tabbed Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

Figure 32. Picture of the Combination Nozzle Configuration (3T24C), 24-Flipper-Tabbed Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

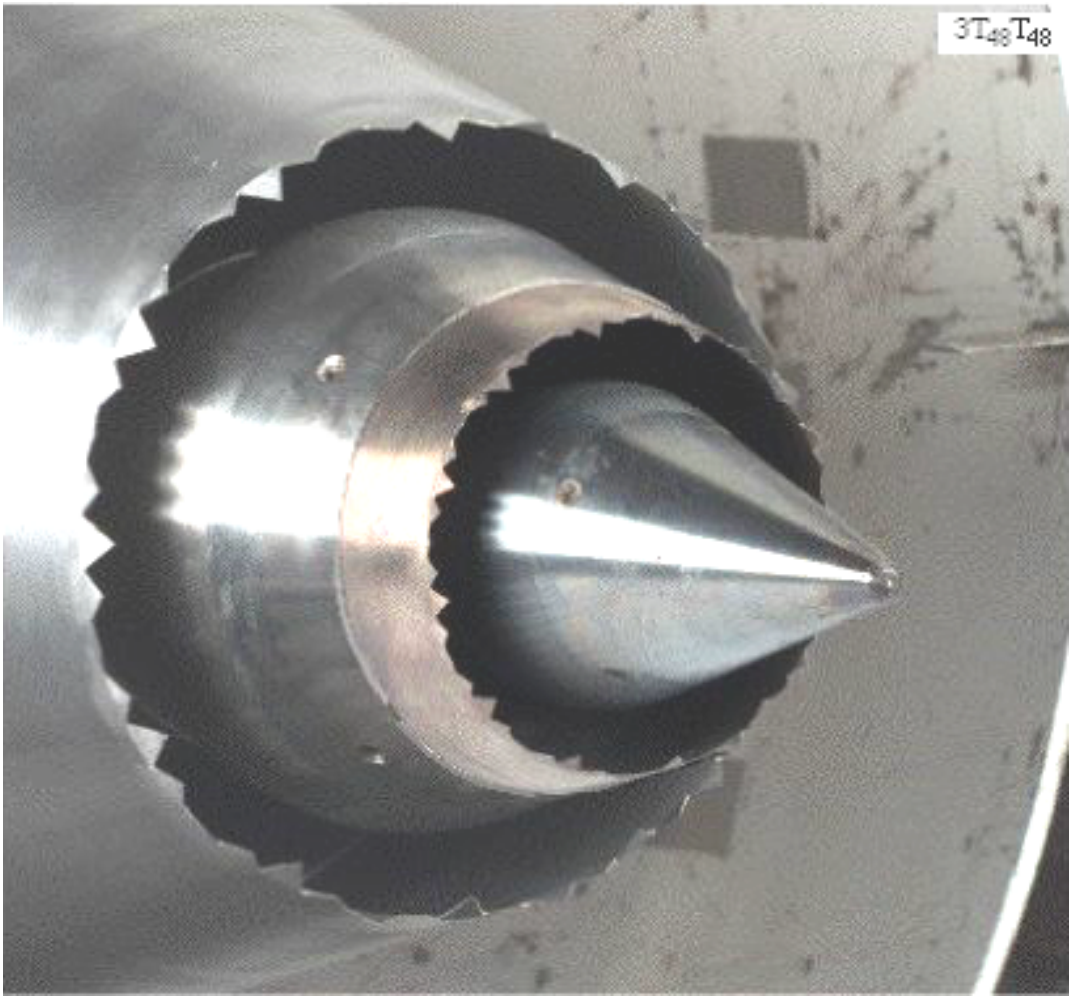


Figure 33. Picture of the Combination Nozzle Configuration (3T48T48), 48-Flipper-Tabbed Core Nozzle with 48-Flipper-Tabbed Fan Nozzle.

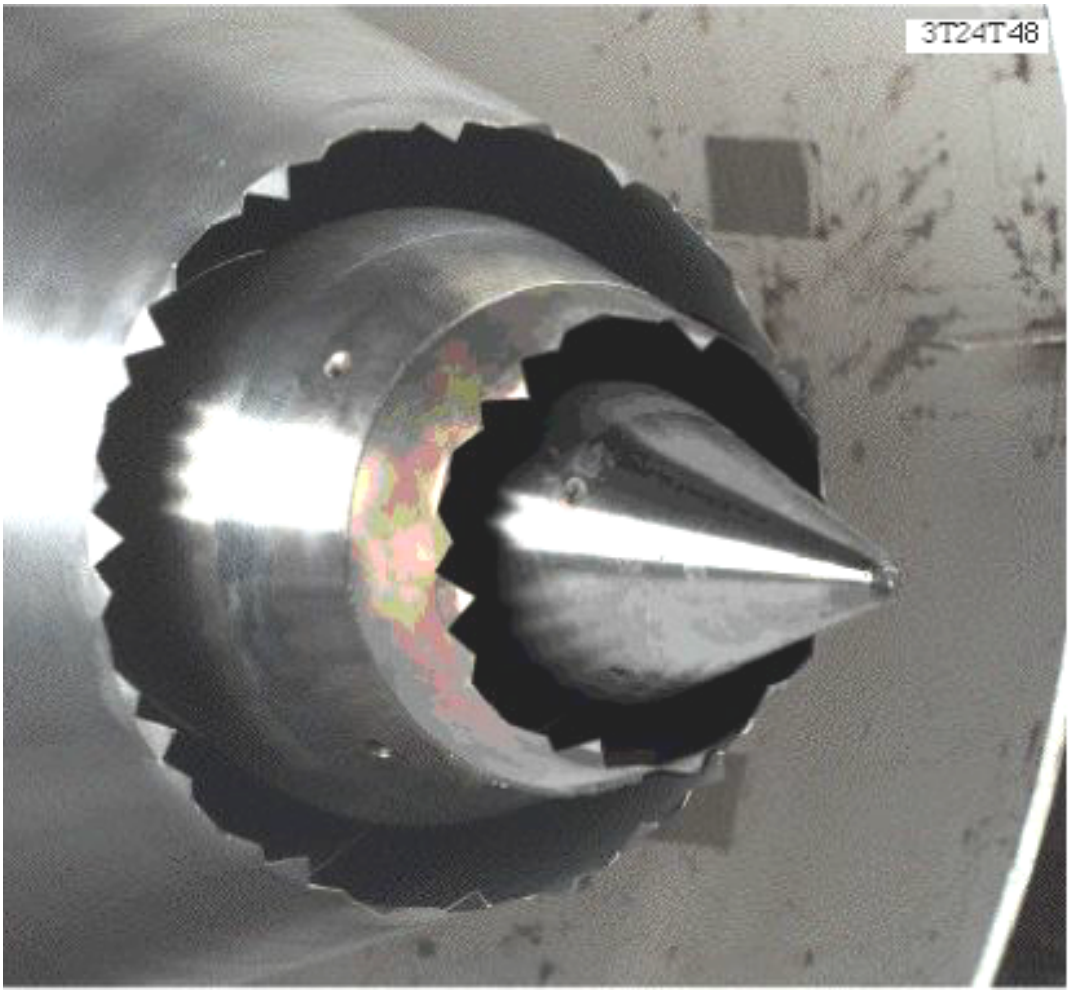


Figure 34. Picture of the Combination Nozzle Configuration (3T24T48), 24-Flipper-Tabbed Core Nozzle with 48-Flipper-Tabbed Fan Nozzle.

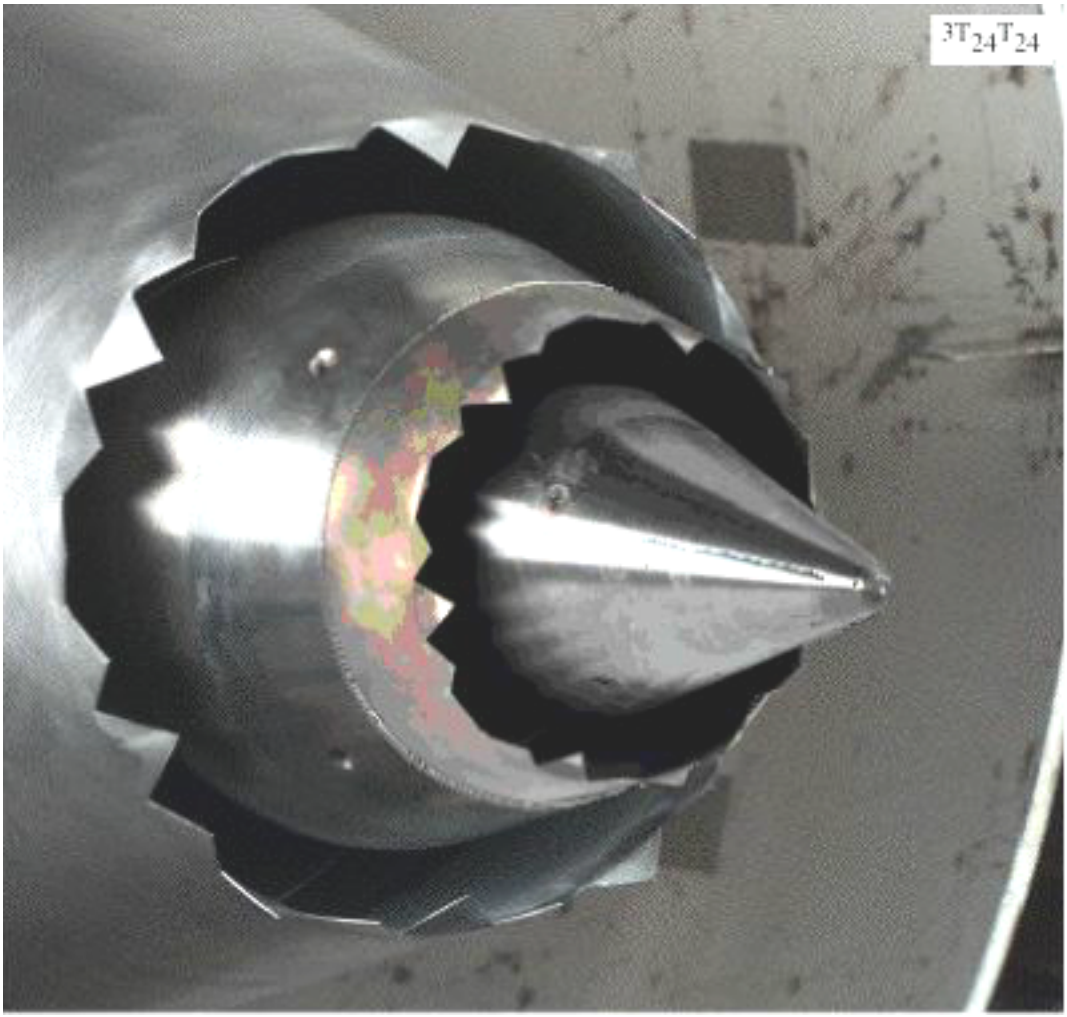


Figure 35. Picture of the Combination Nozzle Configuration (3T24T24), 24-Flipper-Tabbed Core Nozzle with 24-Flipper-Tabbed Fan Nozzle.

Figure 36. Picture of the Combination Nozzle Configuration (6TmC), Tongue-Mixer Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

Figure 37. Picture of the Combination Nozzle Configuration (3HmC), Half-Mixer Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

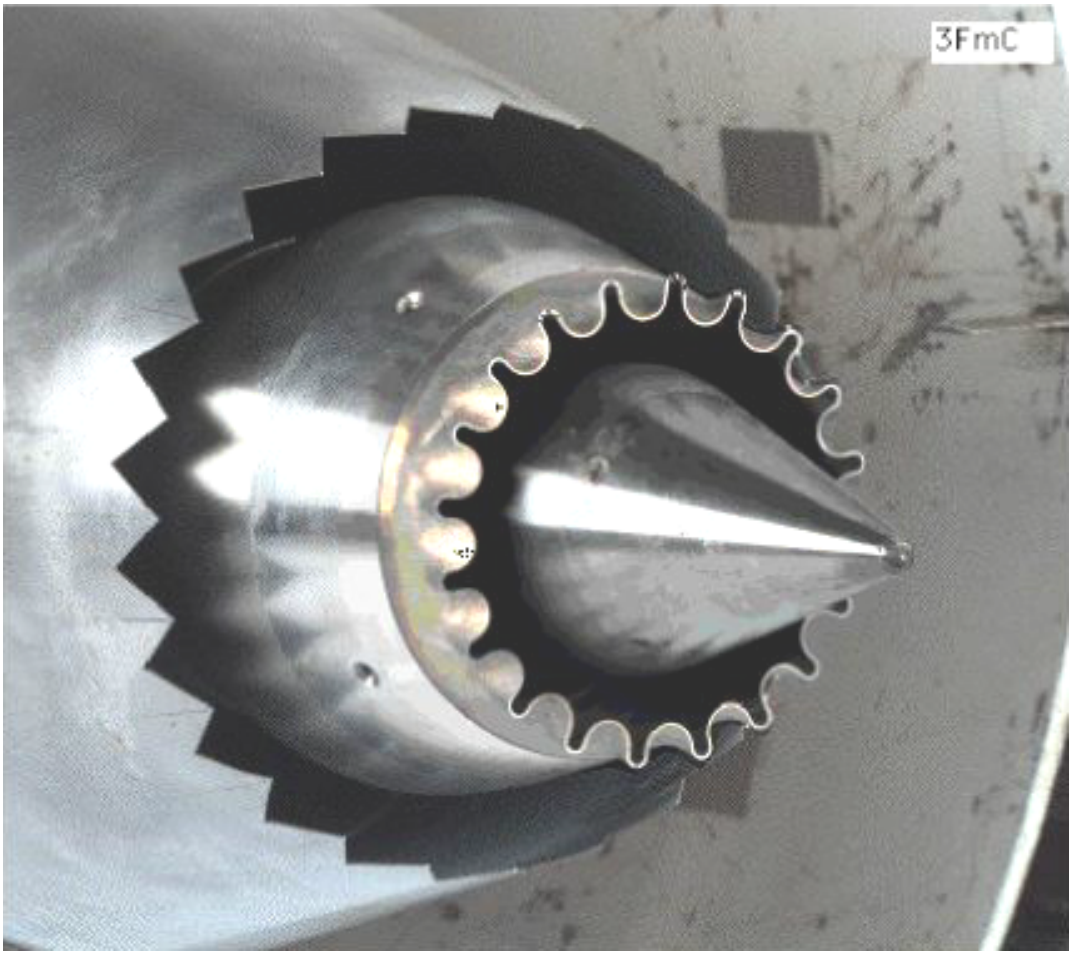


Figure 38. Picture of the Combination Nozzle Configuration (3FmC), Full-Mixer Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

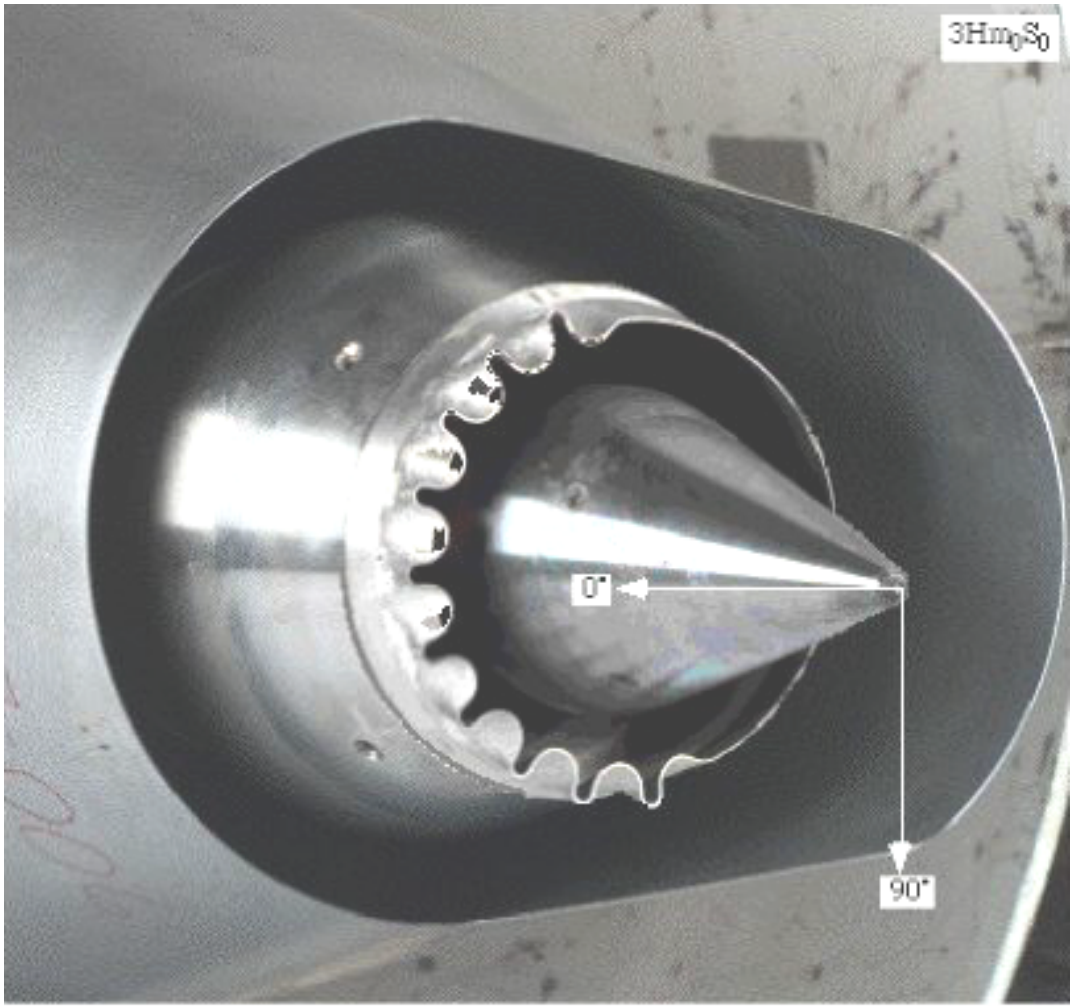


Figure 39. Picture of the Combination Nozzle Configuration (3HmS), Half-Mixer Core Nozzle with Scarfed Fan Nozzle.

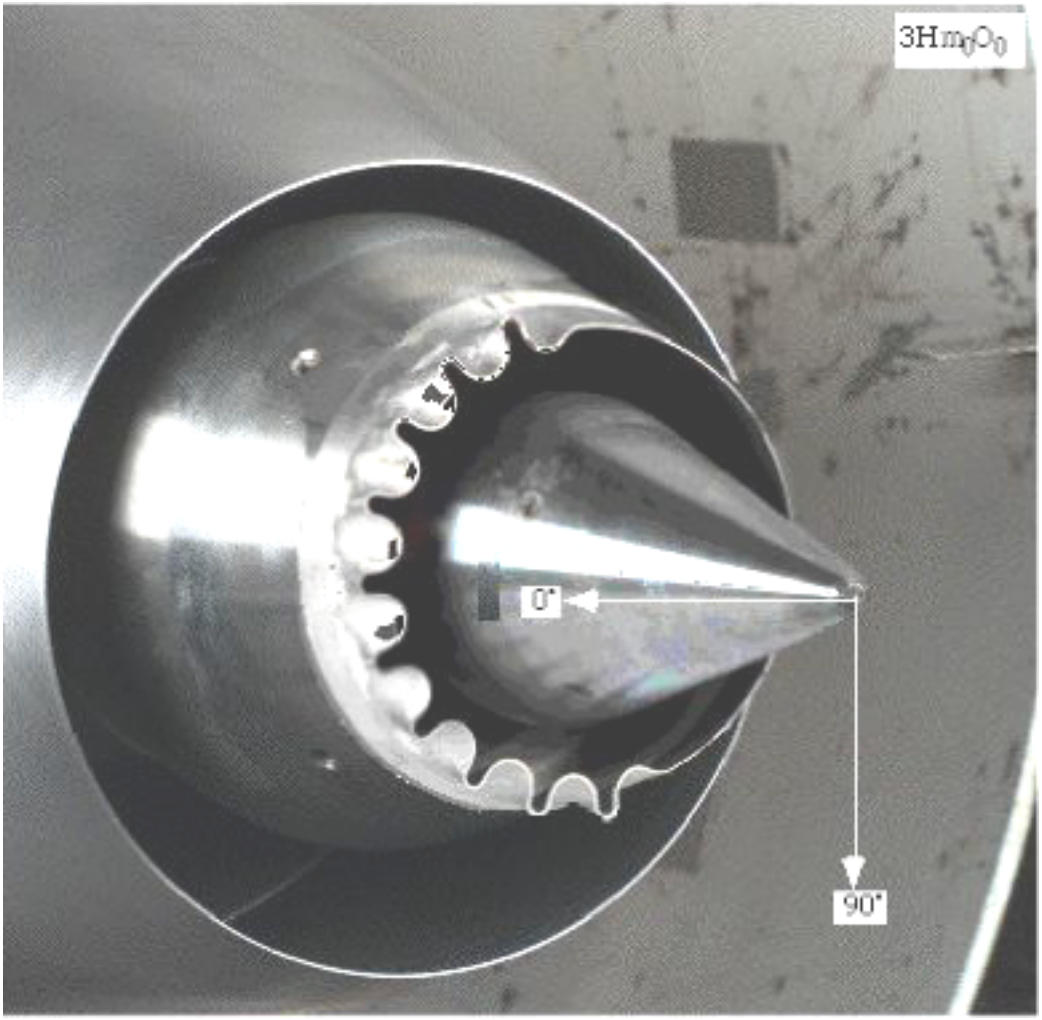


Figure 40. Picture of the Combination Nozzle Configuration (3HmOmax), Half-Mixer Core Nozzle with Offset Centerline Fan Nozzle.

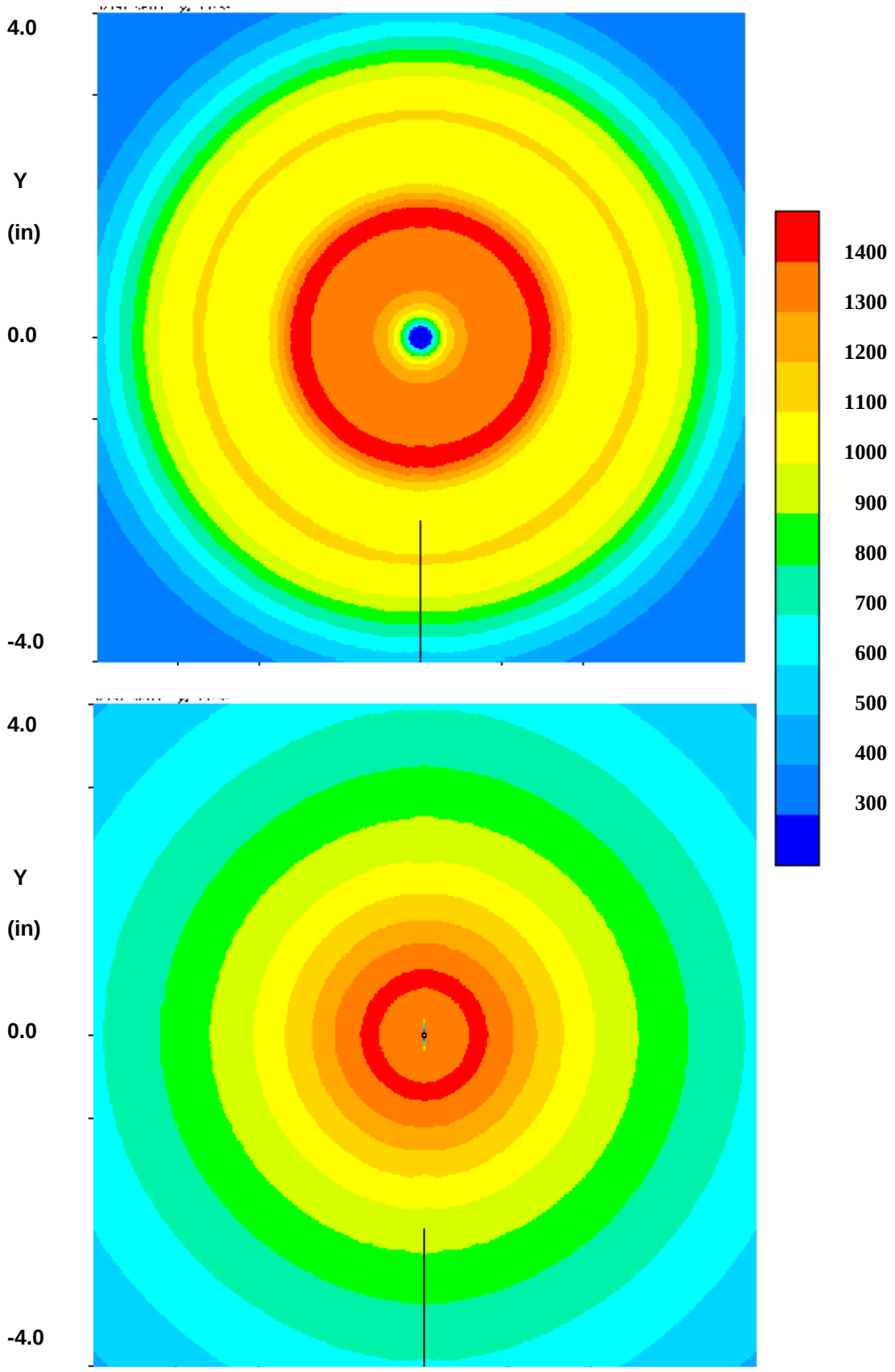


Figure 41: Axial Velocity Contours (ft/sec) for Model #3 Axisymmetric or Baseline Nozzle (3BB) at Cross-Plane Locations of x/D = 0.0 and 6.0.

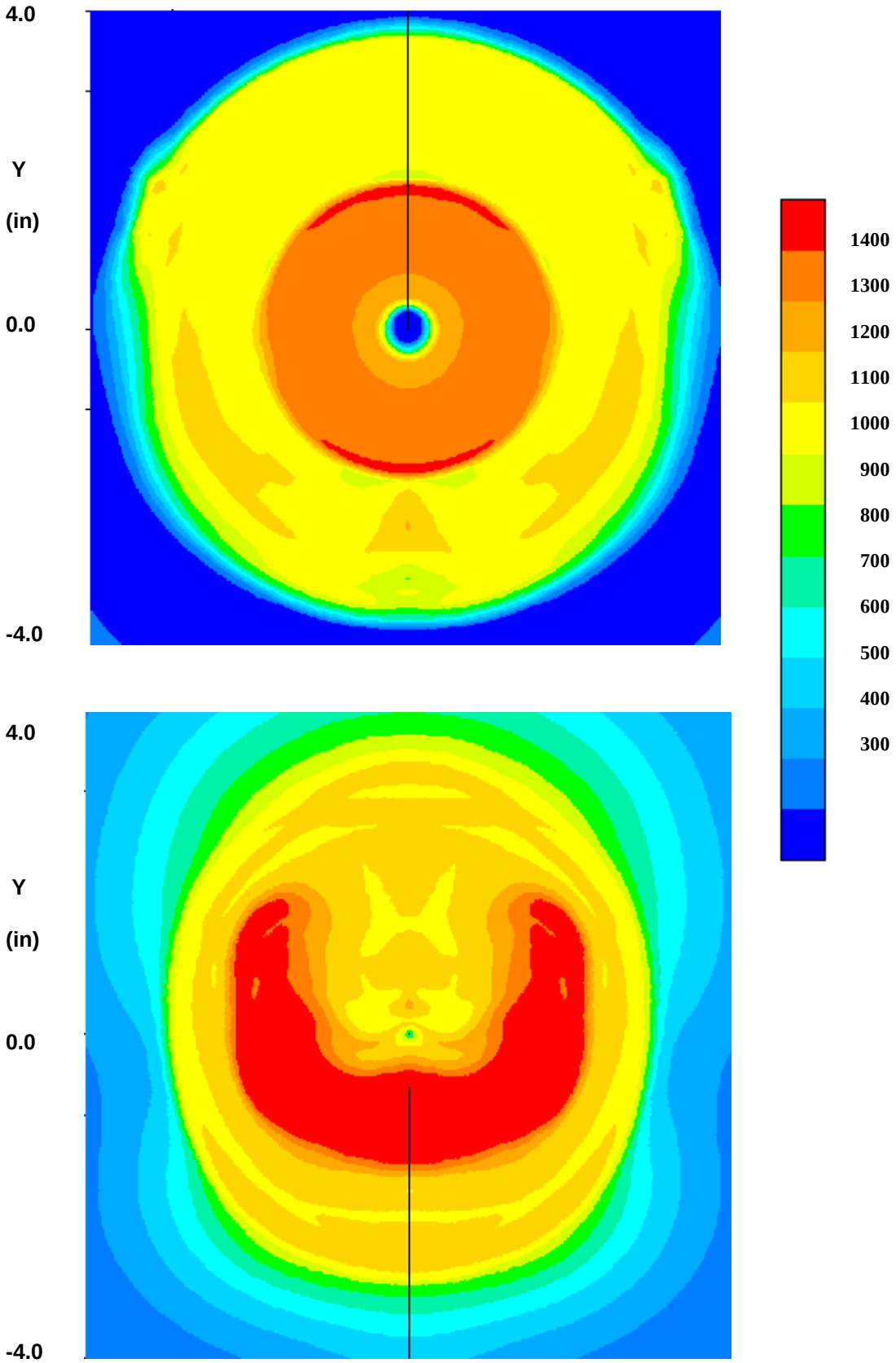


Figure 42: Axial Velocity Contours (ft/sec) for Model #3 Fan Scarfed Nozzle at Cross-Plane Locations of x/D = 0.0 and 6.0.

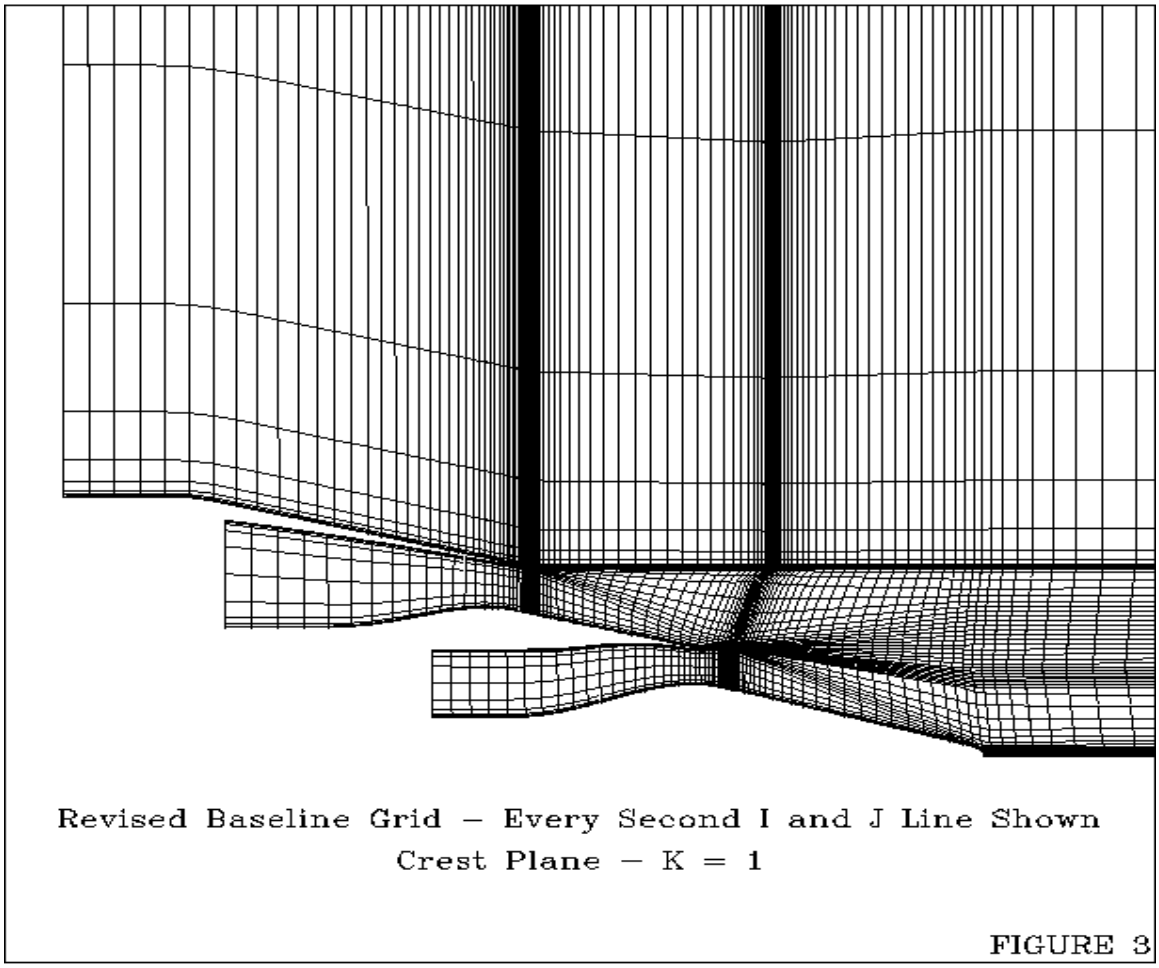
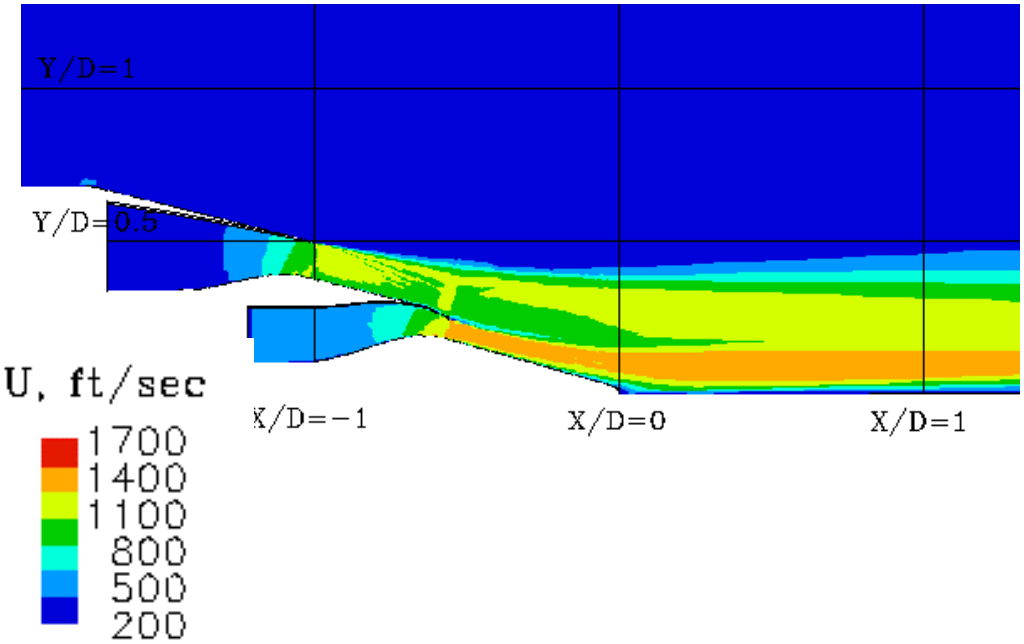


Figure 43: Coarsened View of Axial Grid Slice Through Model #3 Core Full Mixer Configuration.

Trough



Crest

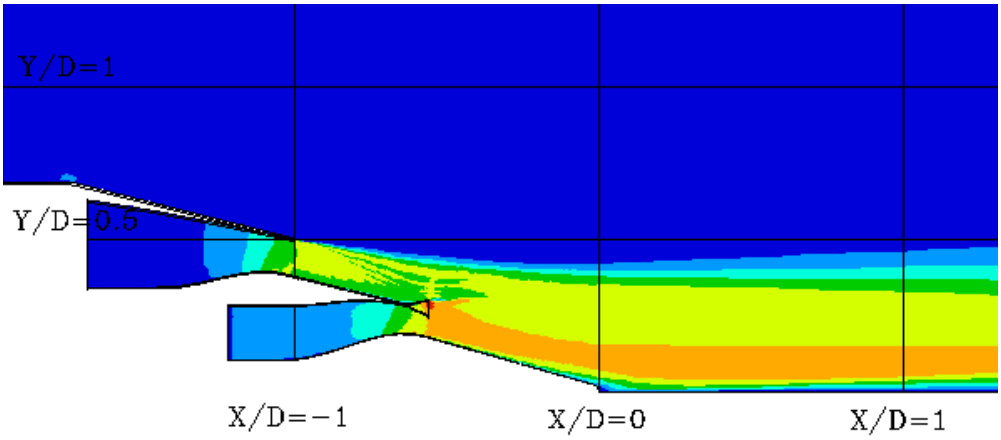


Figure 44 - Trough and Crest Cut Axial Velocity Distributions for Model #3 Core Full Mixer Configuration

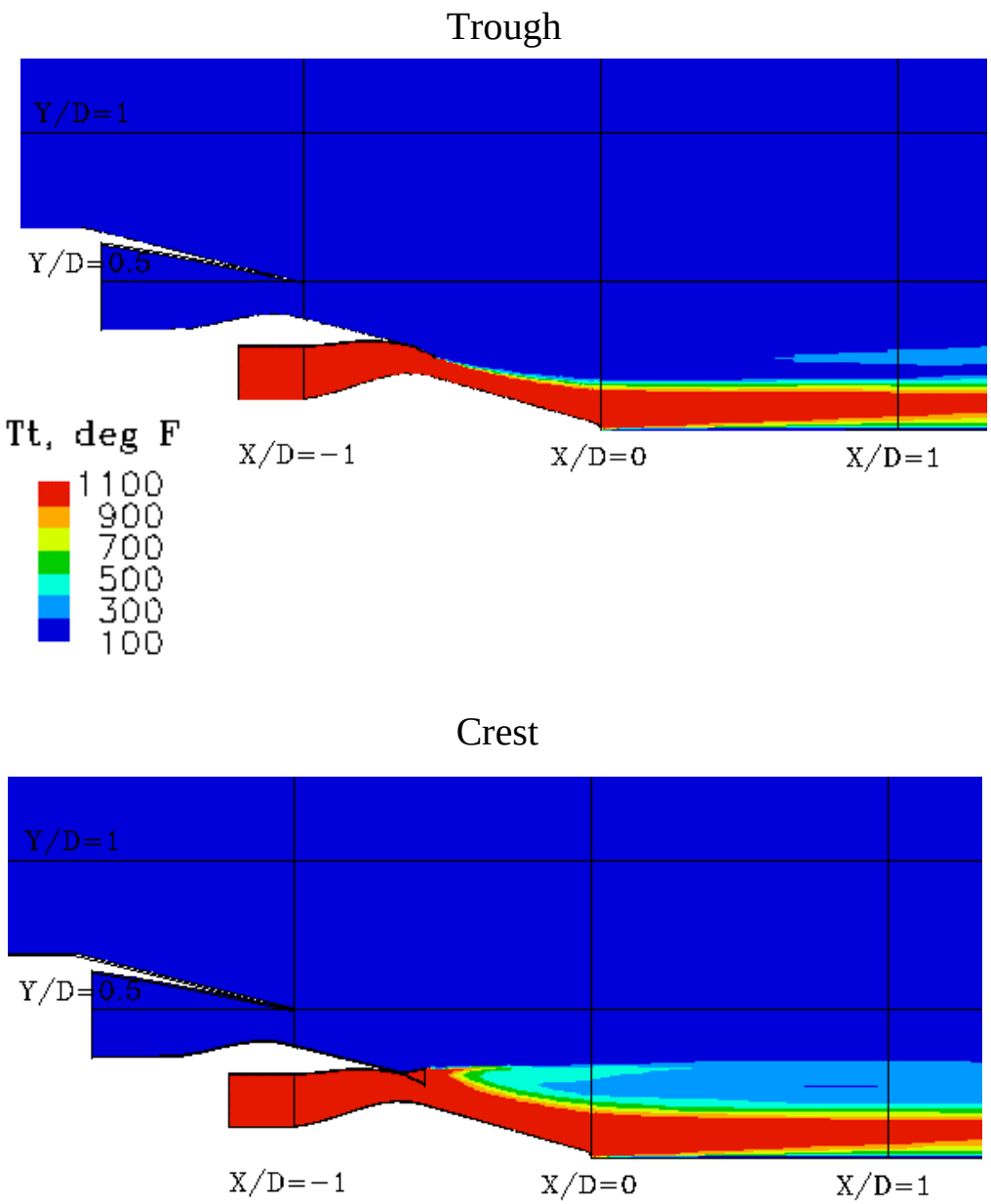


Figure 45 - Trough and Crest Cut Total Temperature Distributions for Model #3 Core Full Mixer Configuration

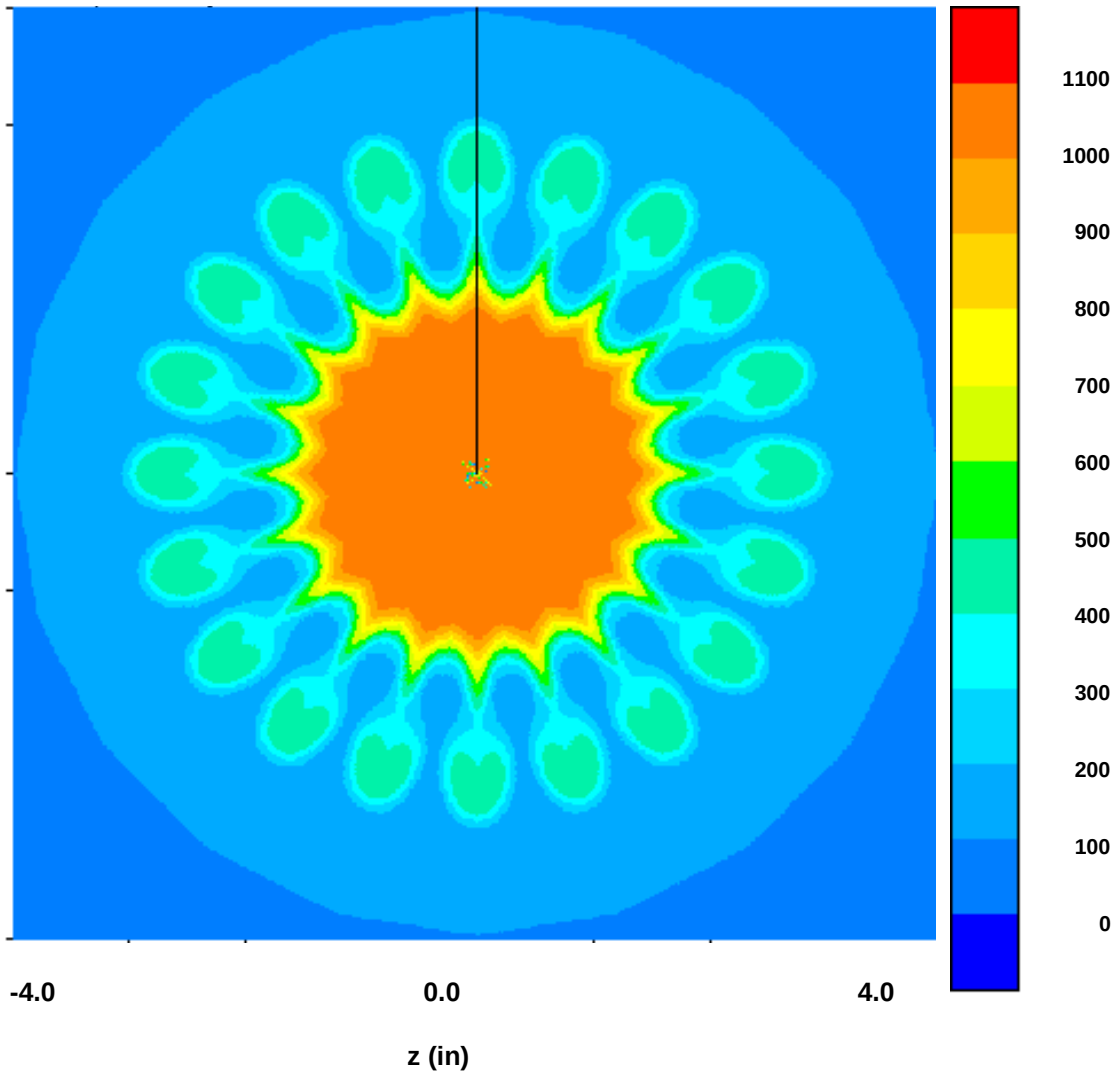


Figure 46: Total Temperature Contours (F) for the Model #3 Core Full Mixer Nozzle (3FmB) at a Cross-plane Location of x/D = 0.0

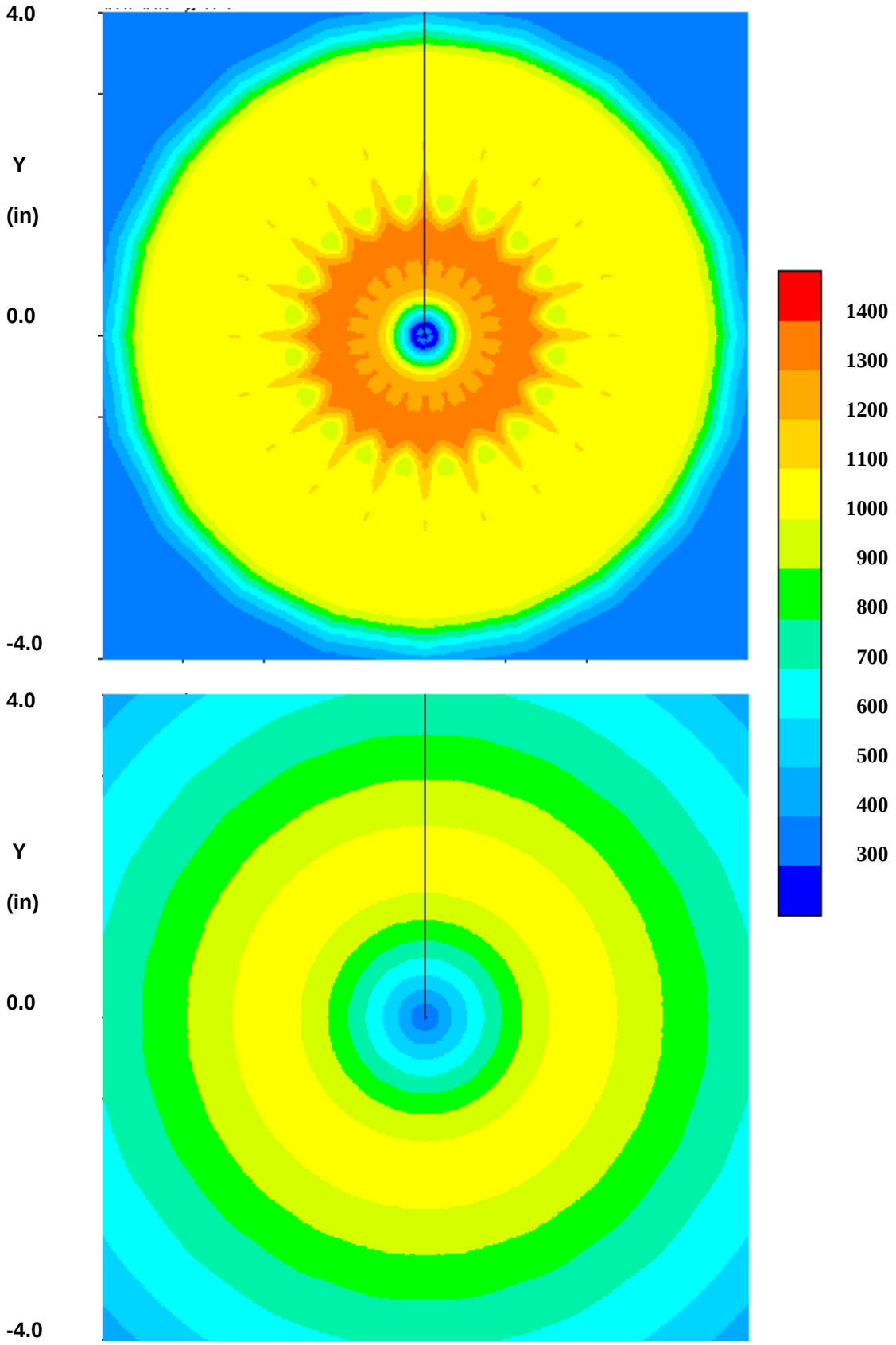


Figure 47: Axial Velocity Contours (ft/sec) for the Model #3 Core Full Mixer Nozzle (3FmB) at Cross- Plane Locations of x/D = 0.0 and 6.0

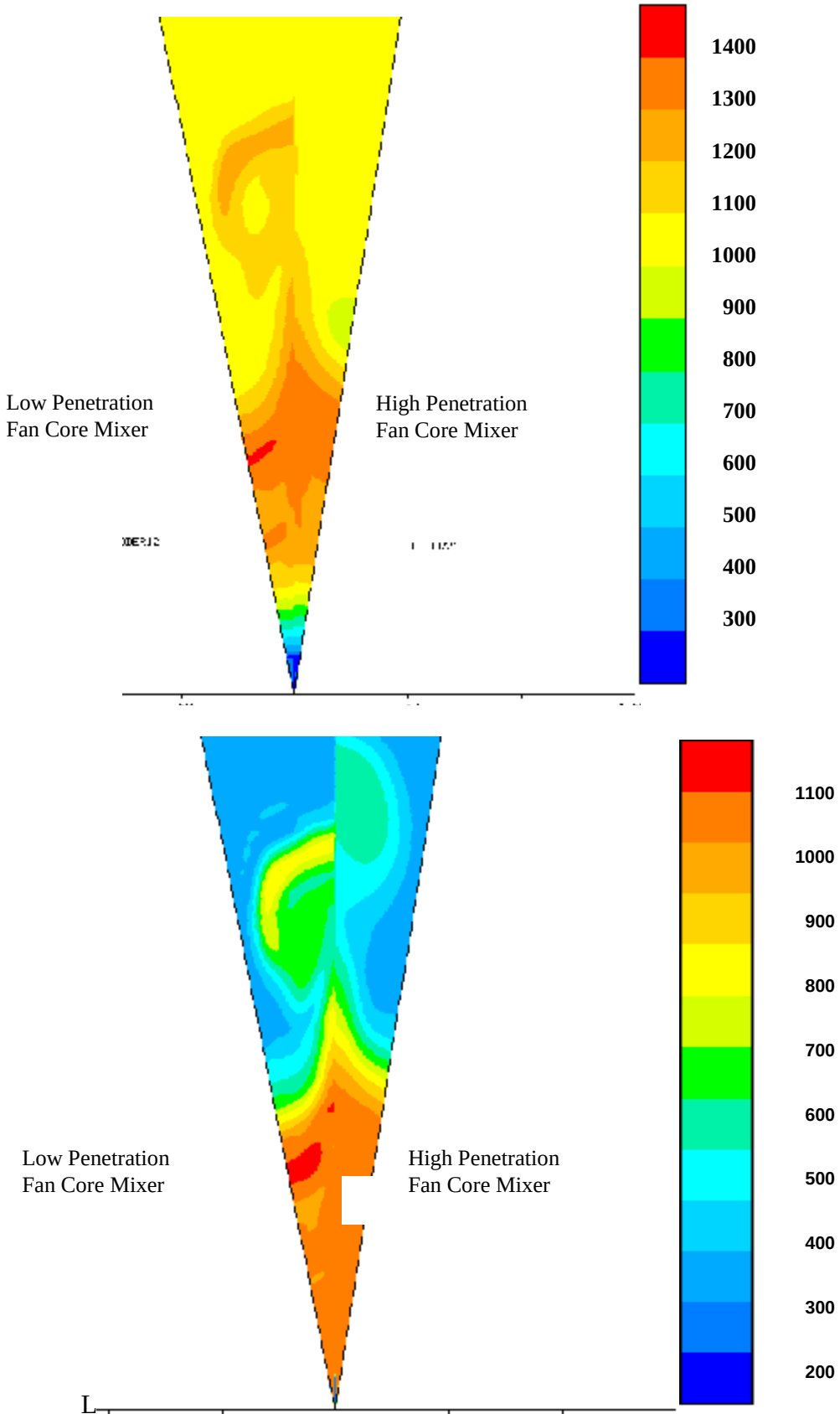


Figure 48: Axial Velocity (ft/sec) and Total Temperature (F) Cross-Plane Contours for Model #3 Core Full Mixer Configuration (3FmB) at End of Centerbody (x/D=0).

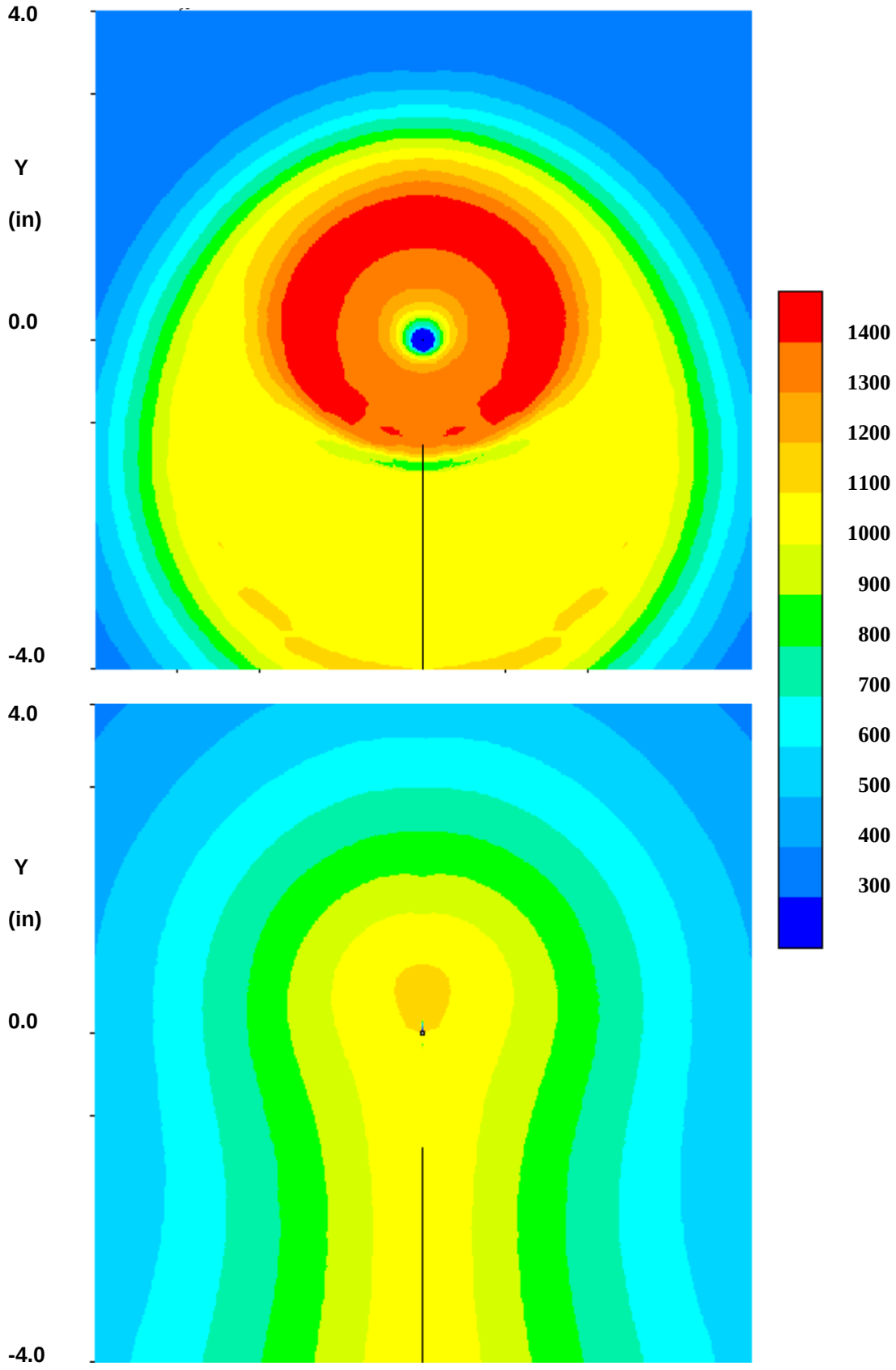


Figure 49: Axial Velocity Contours (ft/sec) for the Model #3 Fan Offset Centerline Nozzle (3Bomax) at Cross-Plane Locations of x/D = 0.0 and 6.0

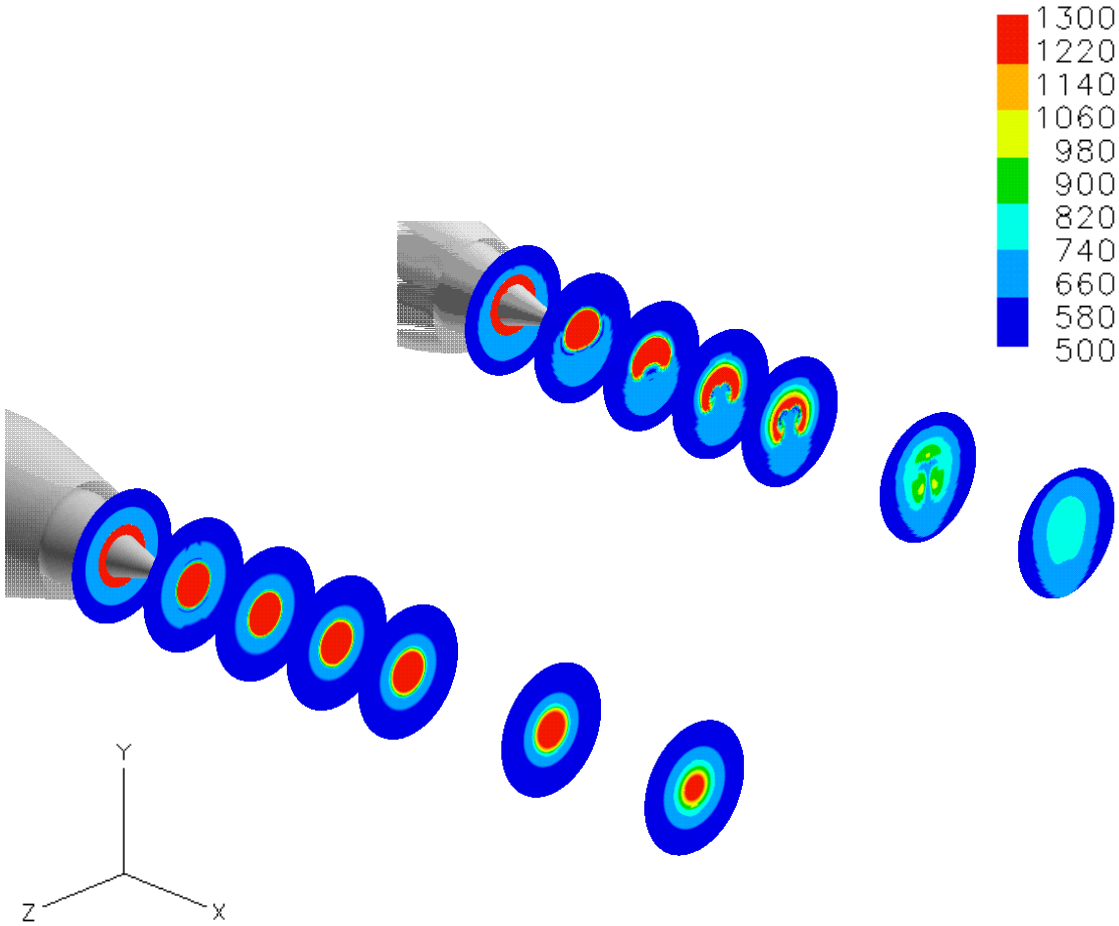


Figure 50: Total Temperature Contours (R) for the Model #3 Fan Offset Centerline (3Bomax) and Baseline Axisymmetric (3BB) Nozzles at Axial Cross-Plane Locations, x/D= -1.0, 0.5, 2.0, 3.5, 5.0, 8.0, 11.0.

Figure 51 Nozzle Acoustic Test Rig Photo

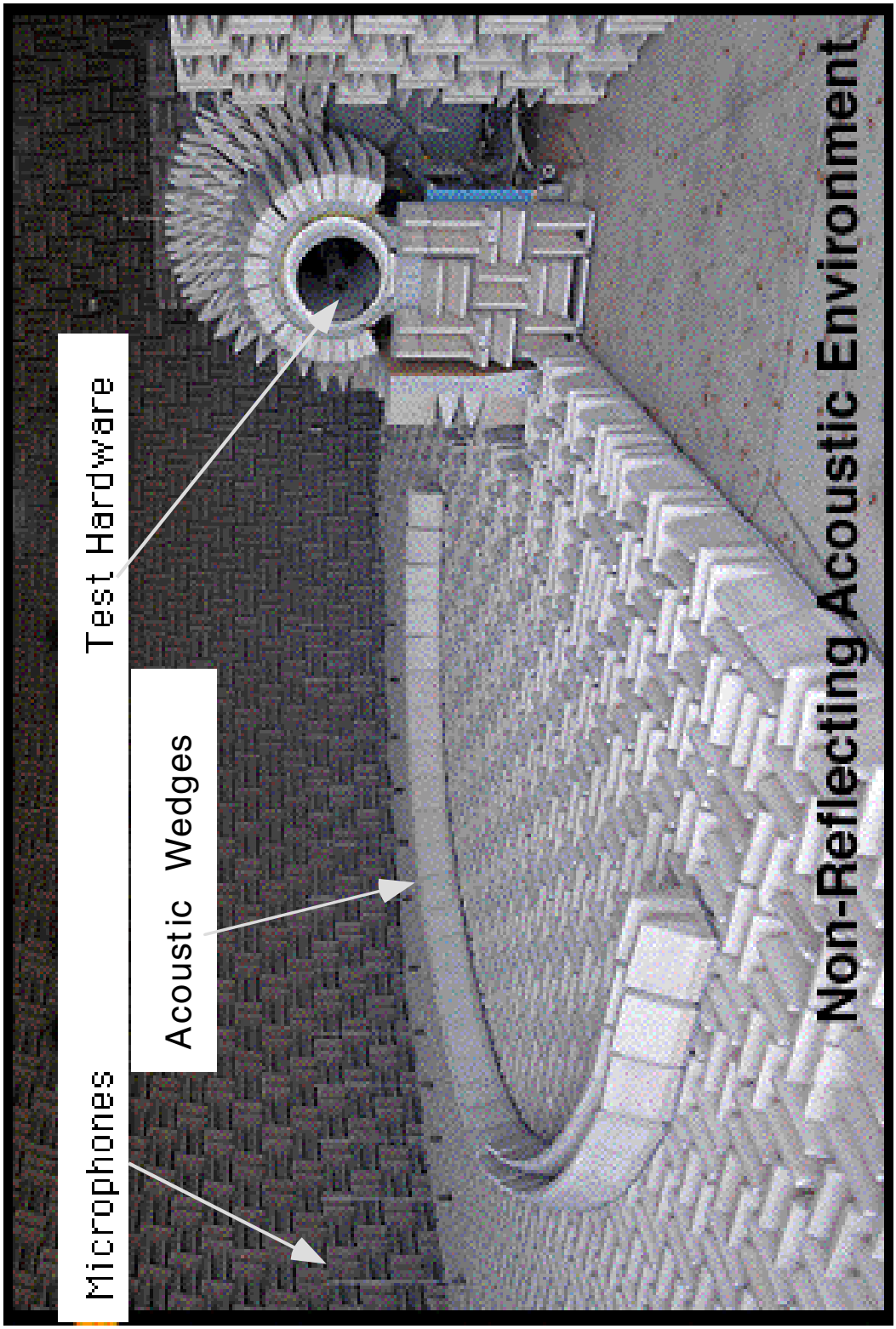


Figure 52 AAPL Microphone Array Photo

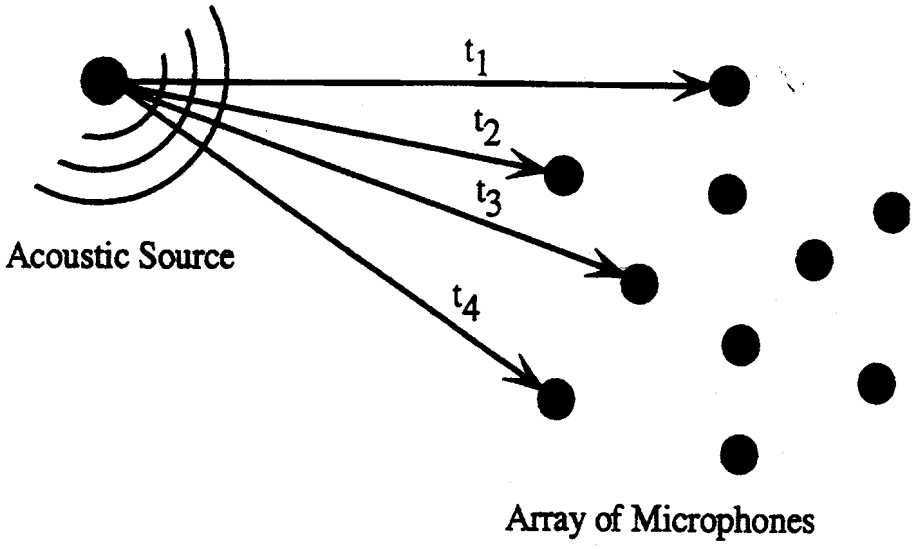


Figure 53. Propagation from Acoustic Source to Microphone Array.

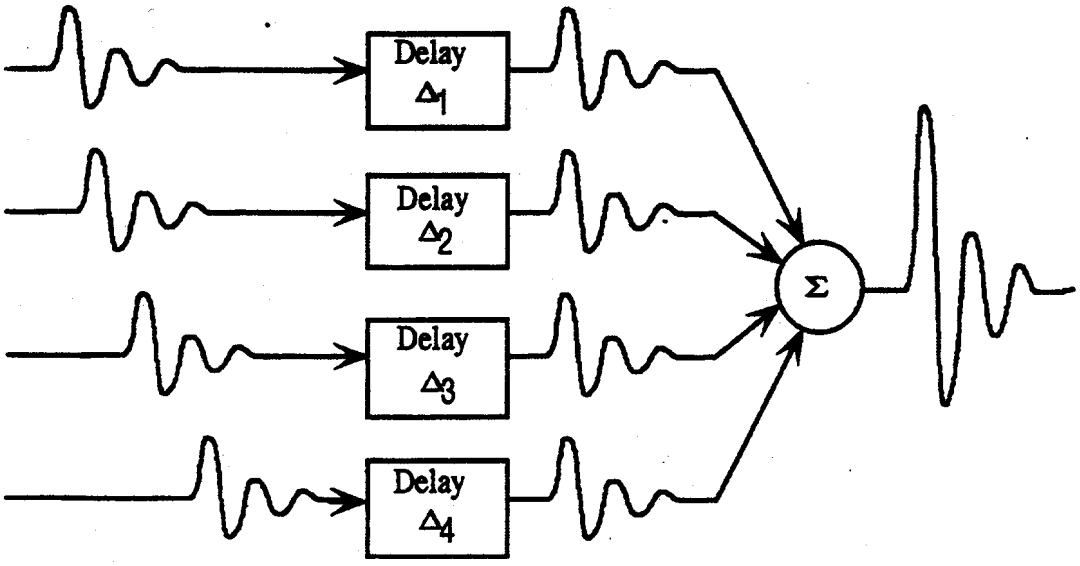


Figure 54. Actual noise source at the target location.

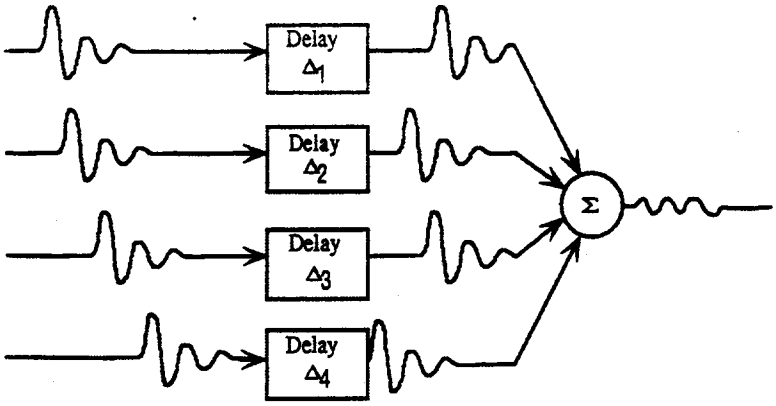


Figure 55. Noise source not at target location.

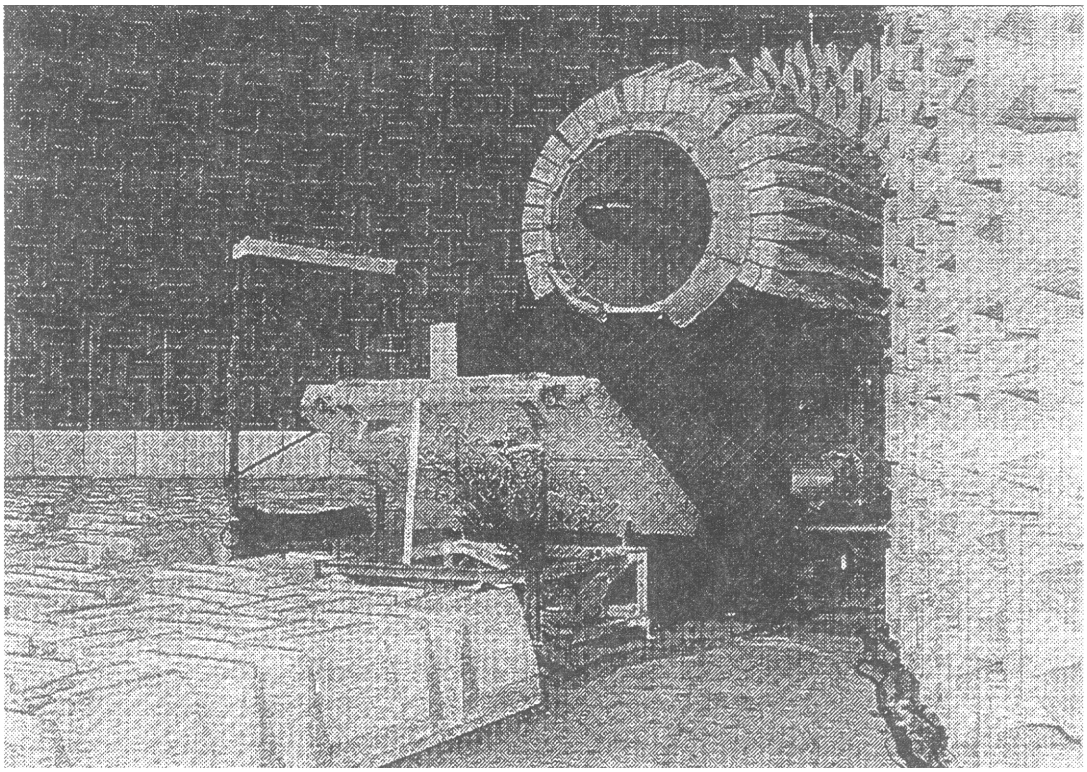


Figure 56. Picture of Test Setup with Downstream Array Position

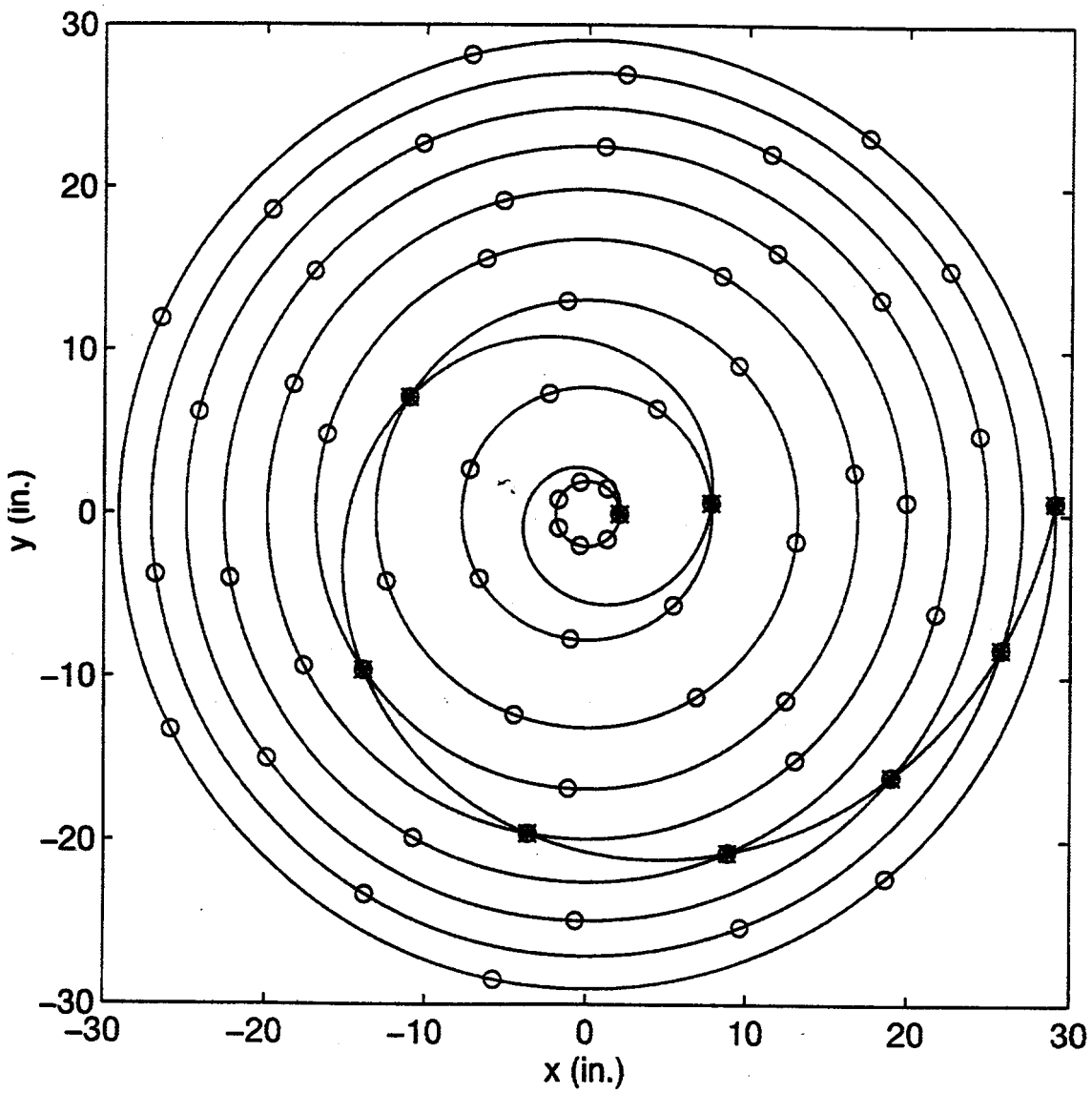


Figure 57. Large 7-Arm Spiral Array Microphone Layout

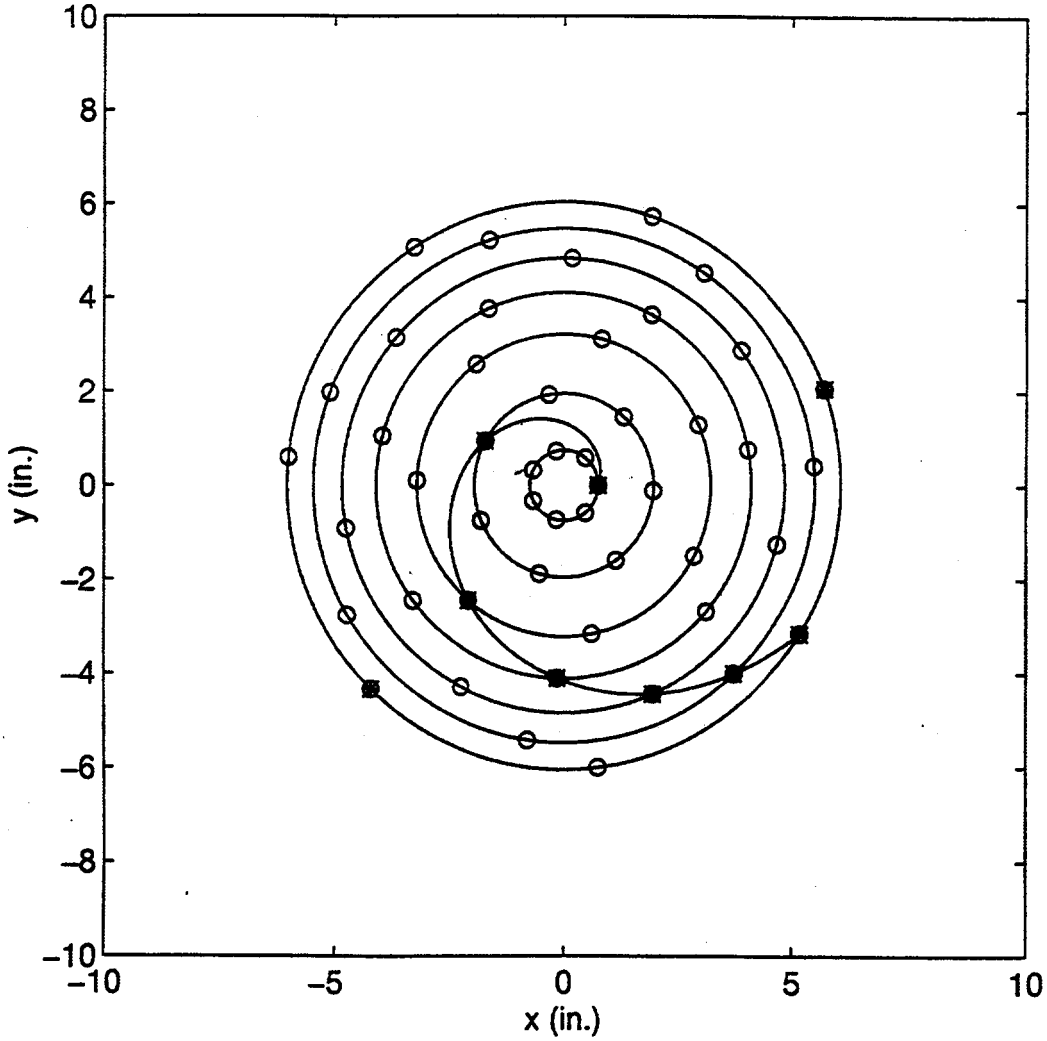


Figure 58. Small 7-Arm Spiral Array Microphone Layout

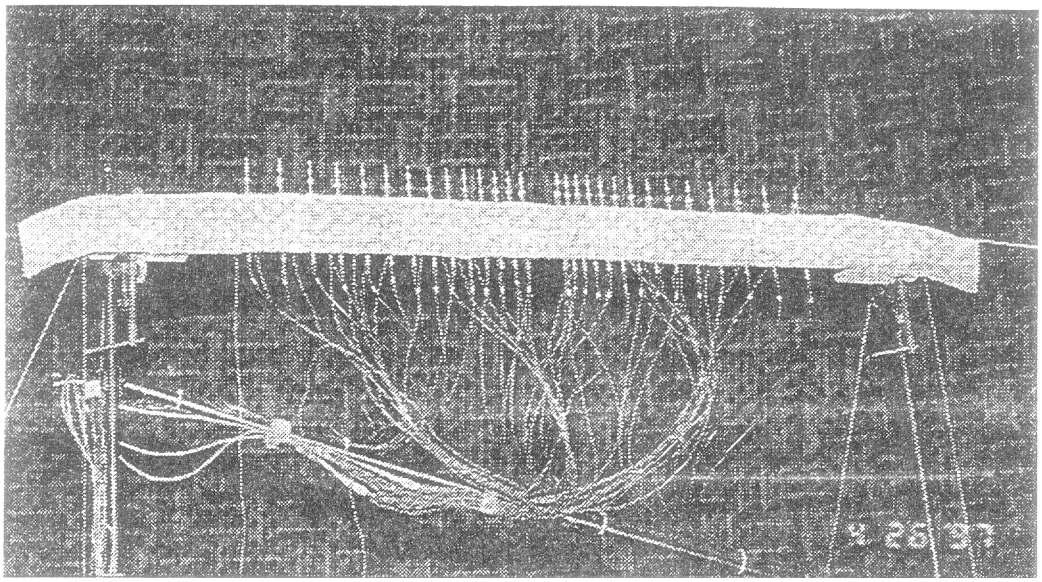


Figure 59. Picture of the Linear Array

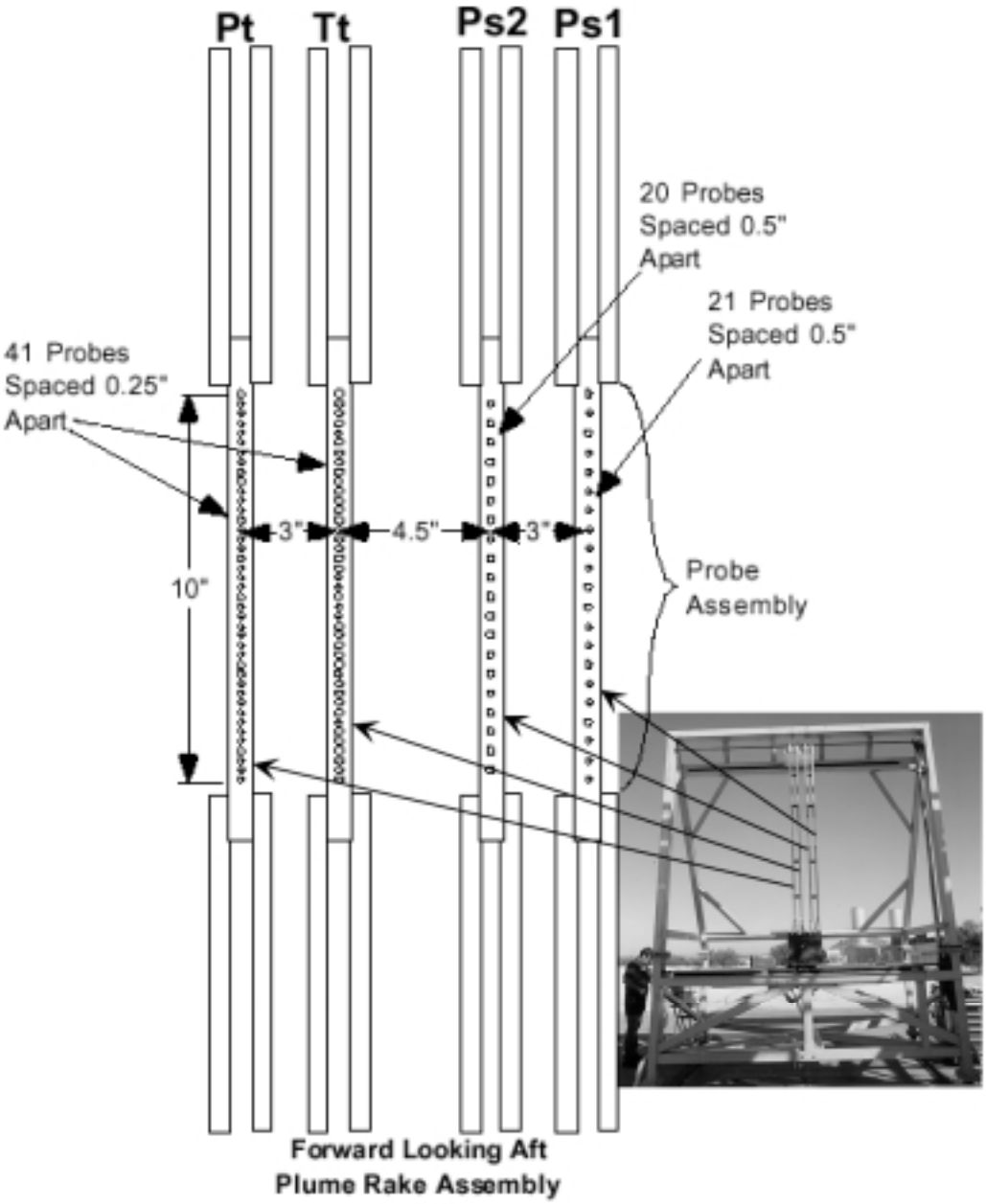
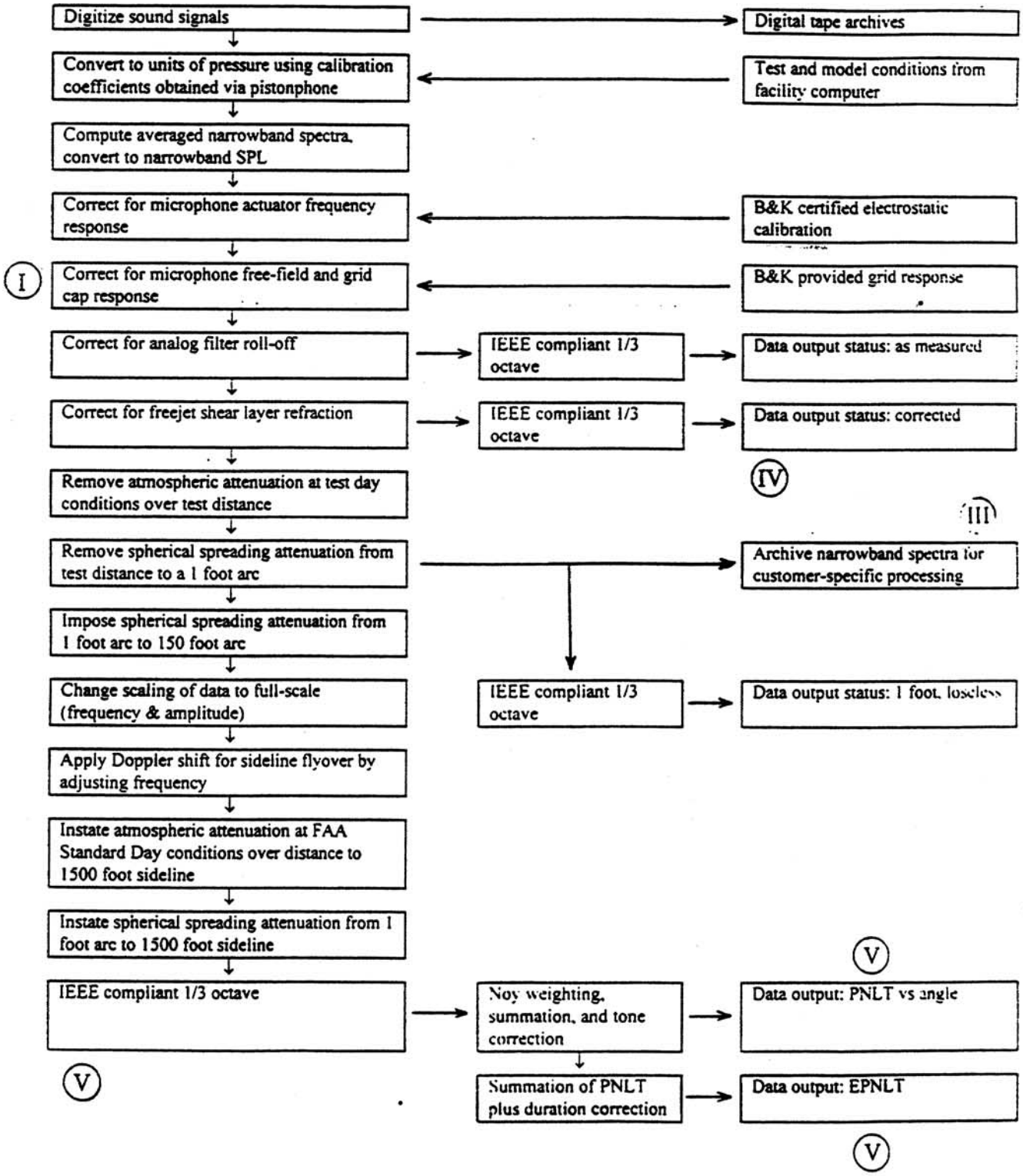


Figure 60 Photo of Plume Survey Traversing Rake Apparatus

Figure 61

NASA LeRC Acoustic Data Processing Scheme



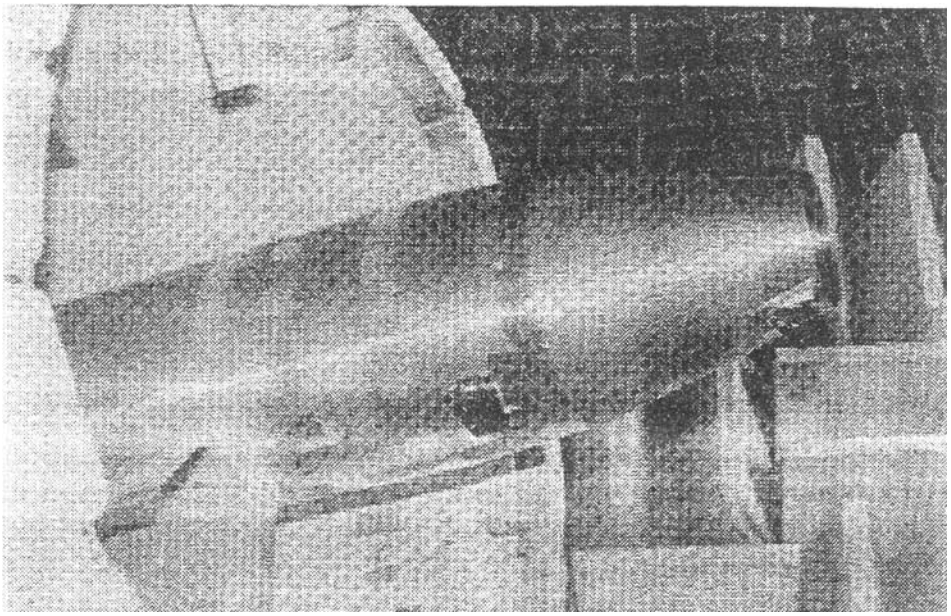


Figure 62. View of Nozzle with Two Deer Whistles Installed

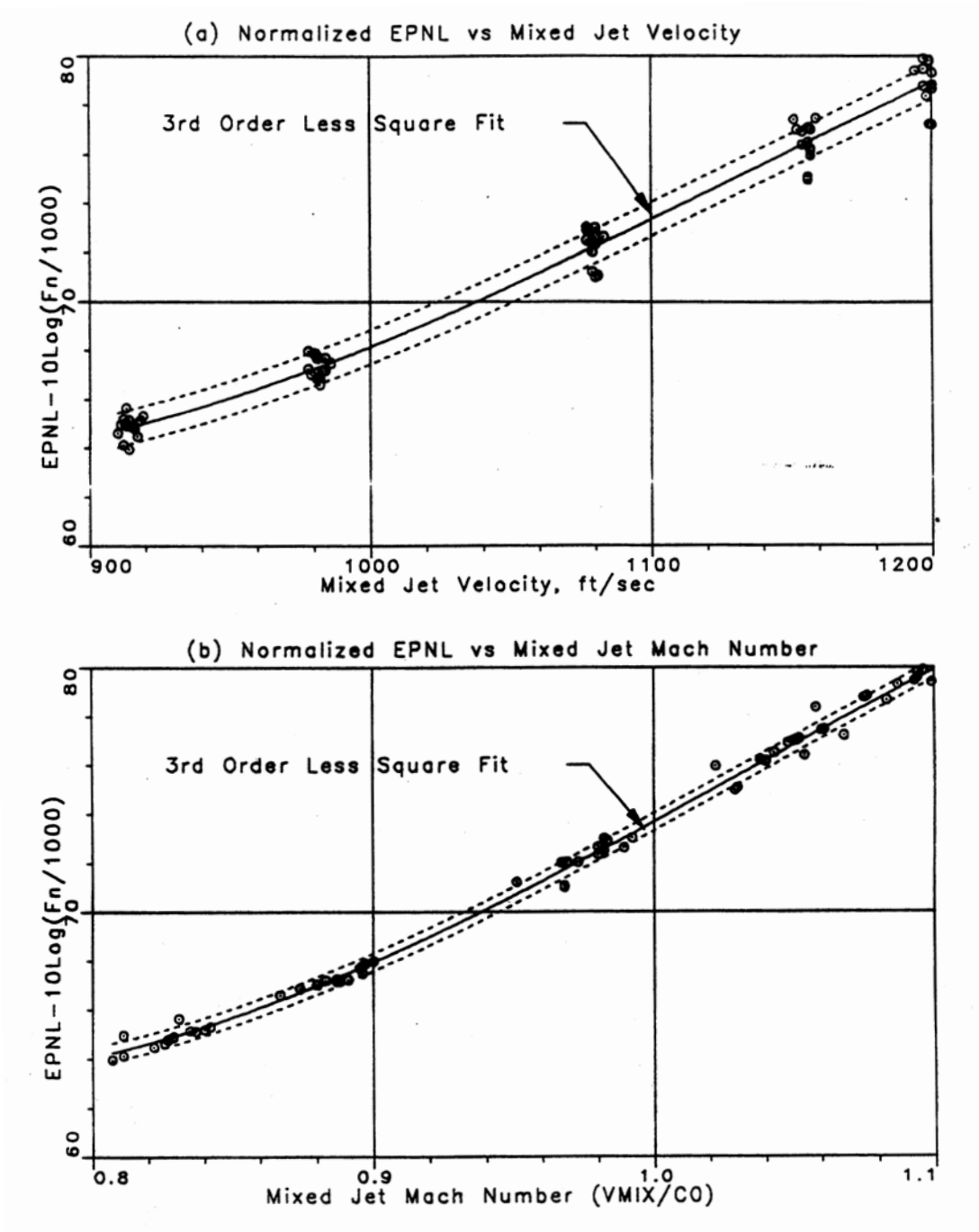


Figure 63. Correlations of Baseline Nozzle Normalized EPNLs with (a) Mixed Jet Velocities, and (b) Mixed jet Mach Numbers.

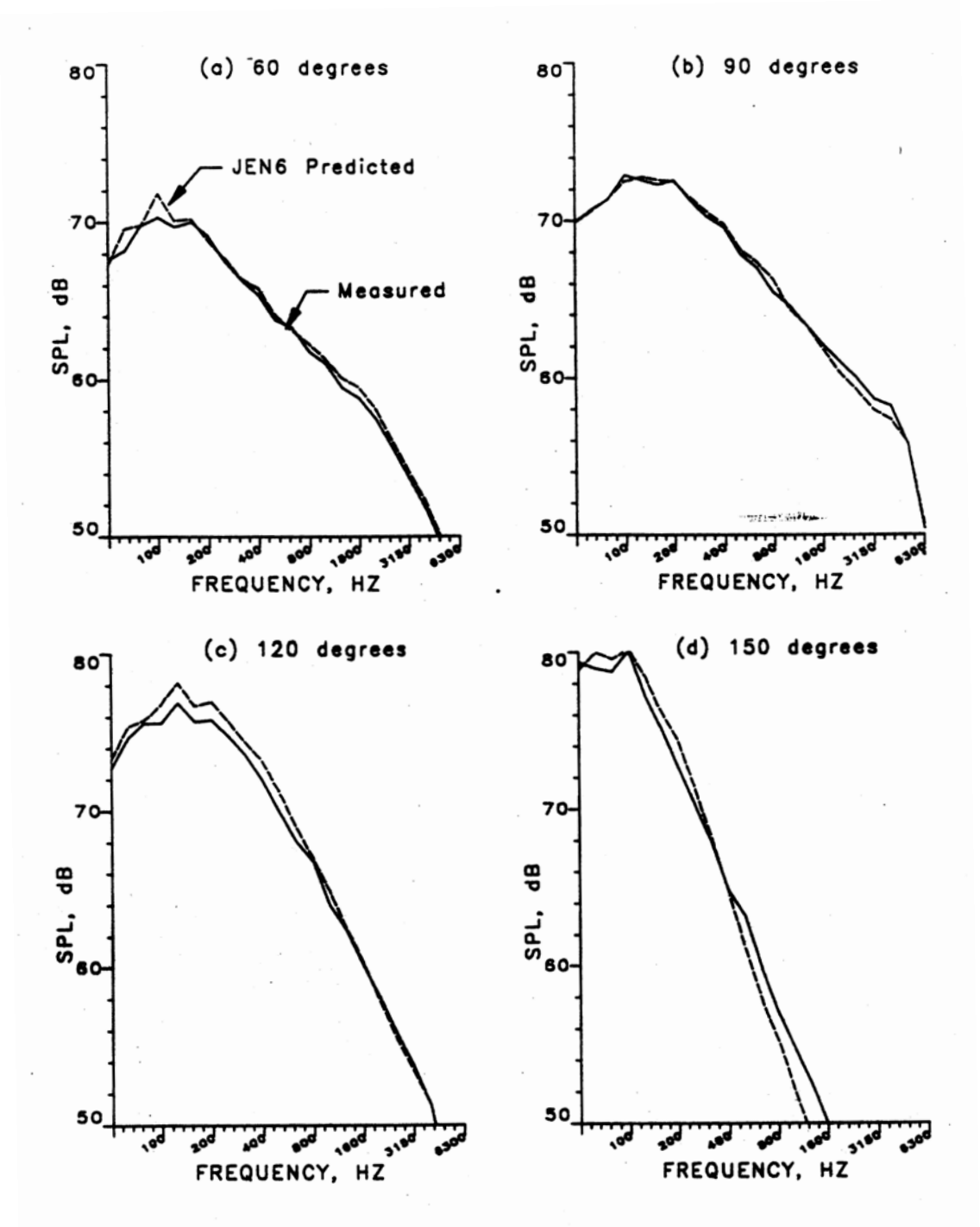


Figure 64. Comparisons of Measured and JEN6 Predicted Jet Noise SPL Spectra For Model 3 Baseline Nozzle (Vmix=1155 ft/sec, 0.28 Freejet Mach No, 1500-ft Sideline Level Flight).

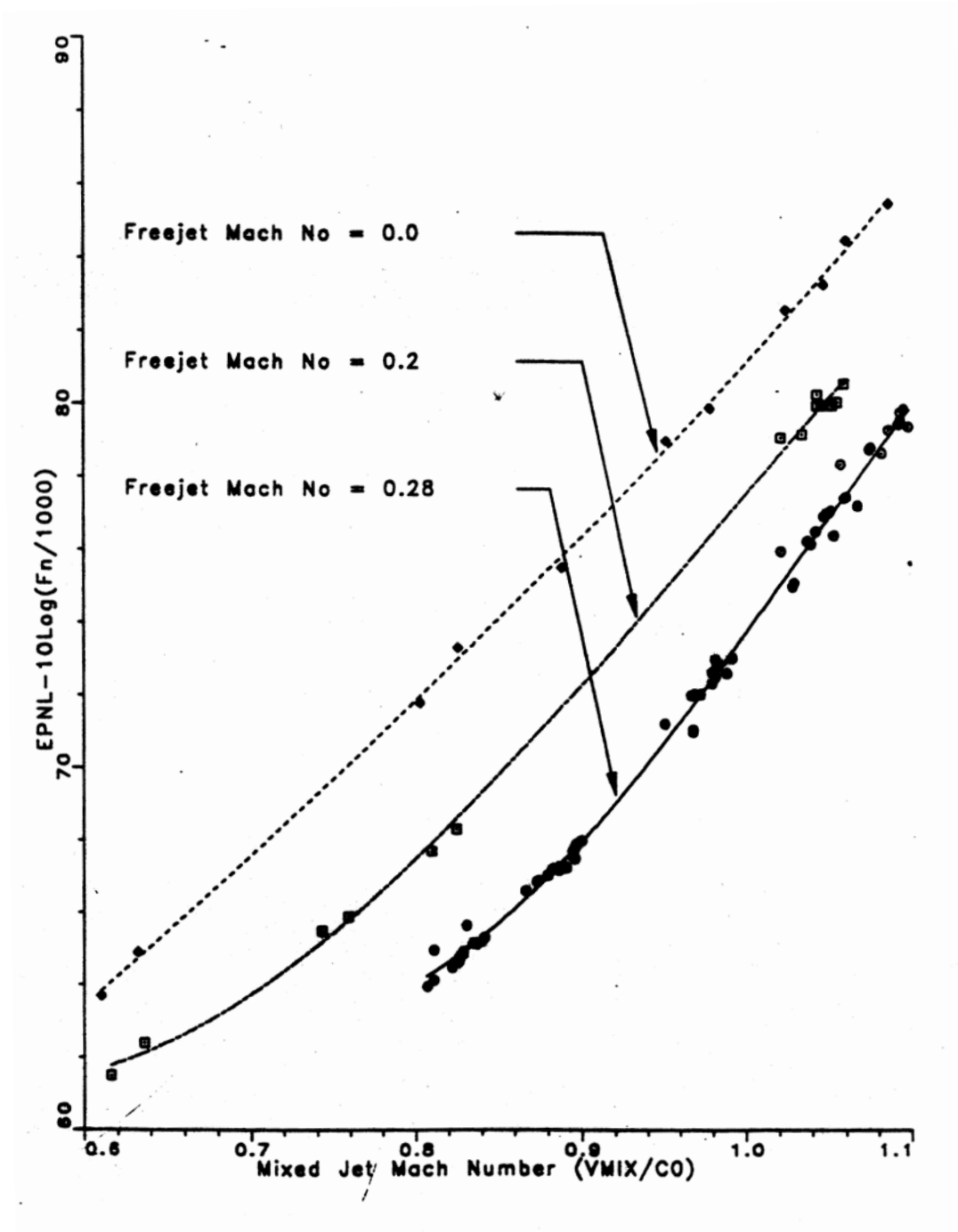


Figure 65. Effect of Frejet Mach Number on Jet Noise EPNL correlations for Model 3 Baseline Nozzle.

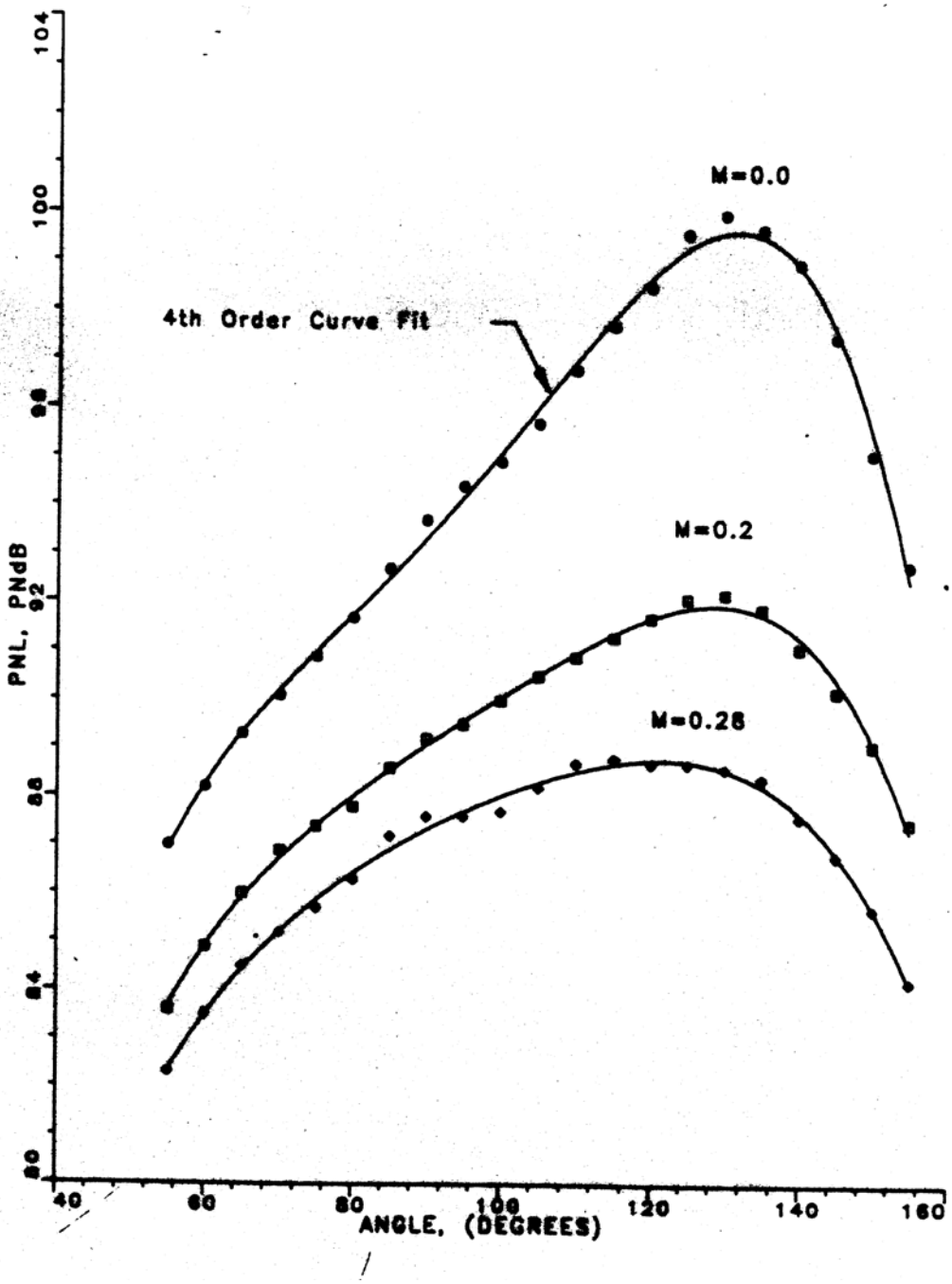


Figure 66. Effect of Frejet Mach Number on Jet Noise PNL Directivities (Vmix=1155 ft/sec) for Model 3 Baseline Nozzle.

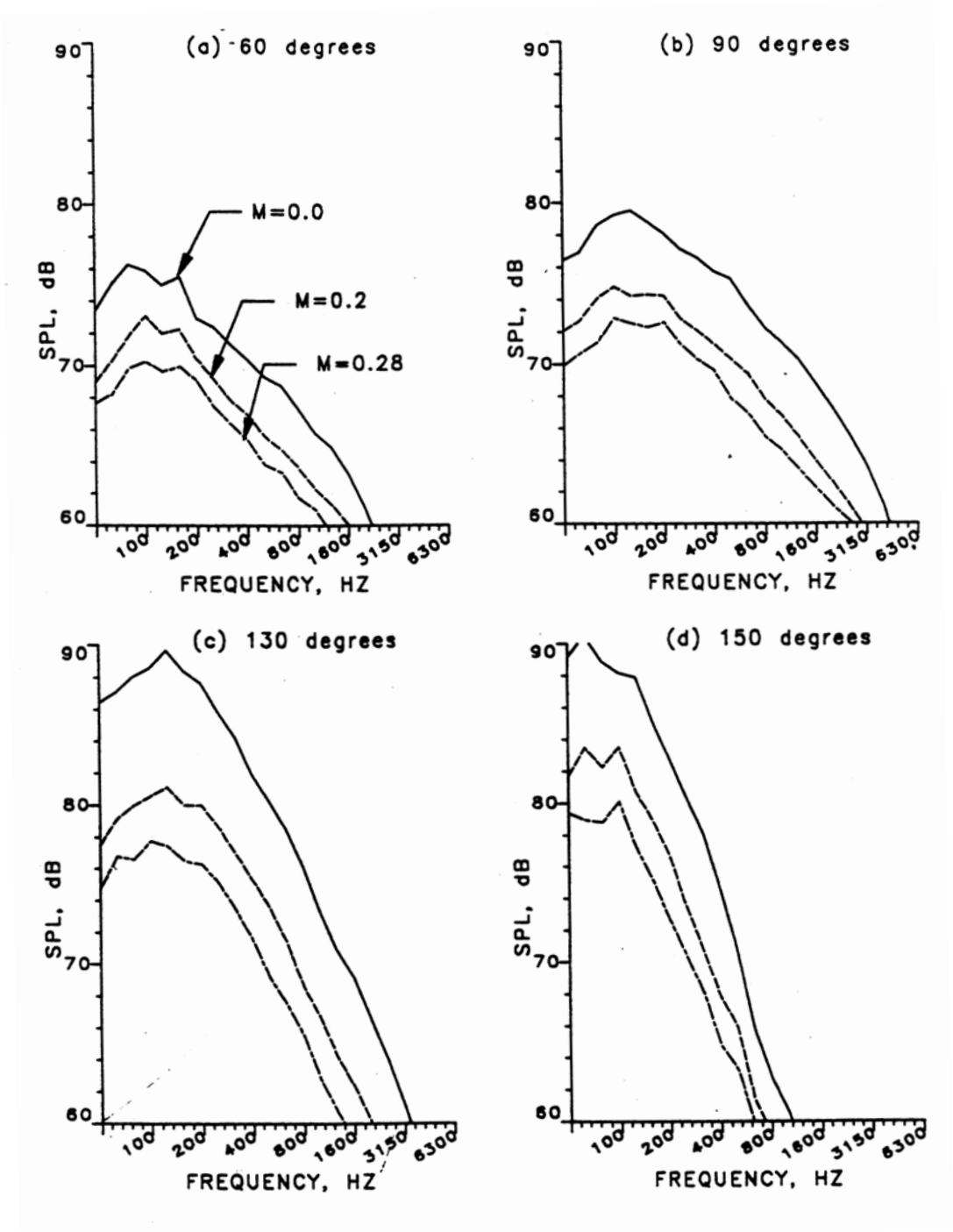


Figure 67. Effect of Frejet Mach Number on Jet Noise SPL Spectra (Vmix=1155 ft/sec) for Model 3 Baseline Nozzle.

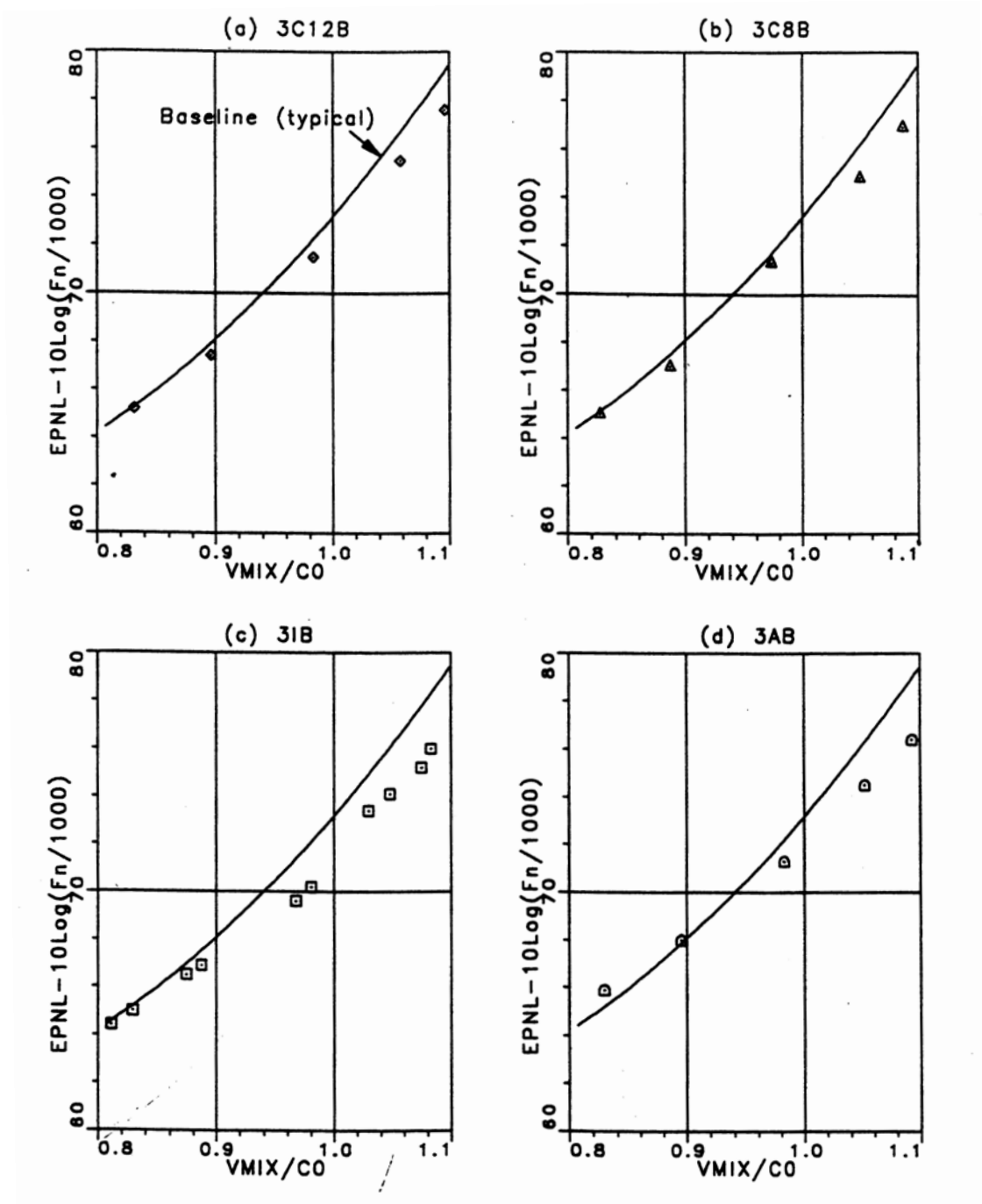


Figure 68. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle Test Configurations, (a) 3C12B, (b) 3C8B, (c) 3IB and (d) 3AB.

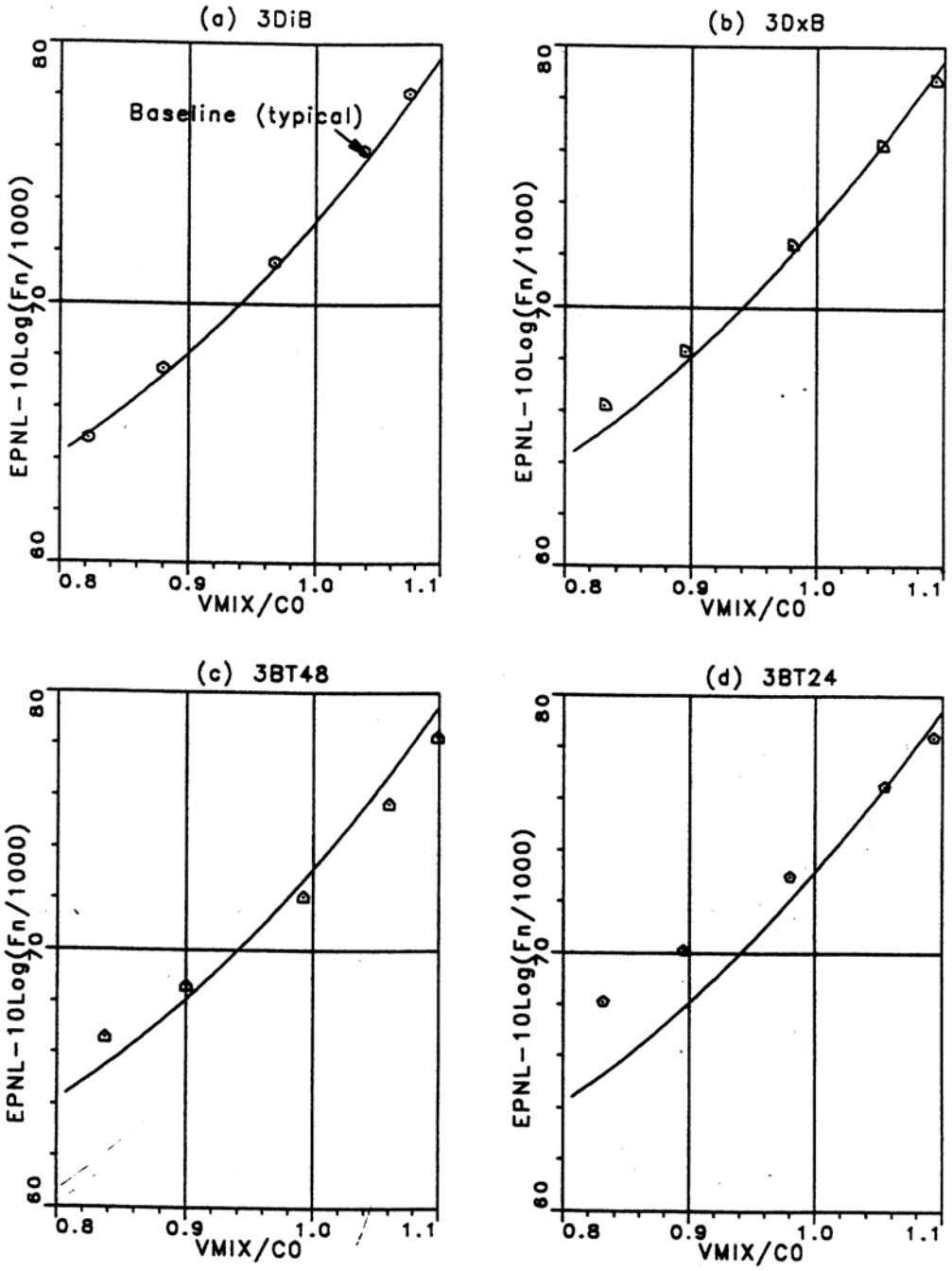


Figure 69. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle Test Configurations, (a) 3DiB, (b) 3DxB, (c) 3BT48 and (d) 3BT24.

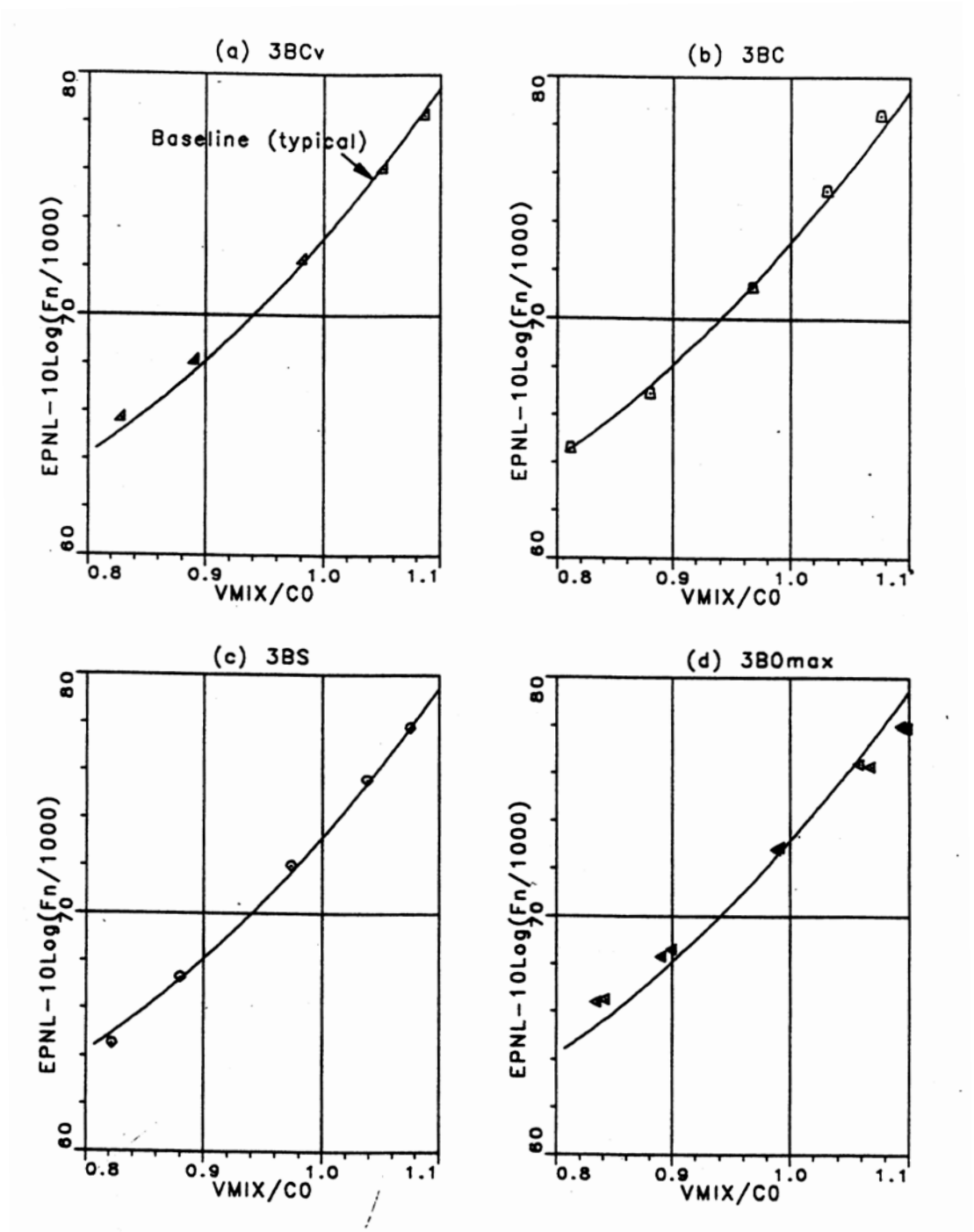


Figure 70. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle Test Configurations, (a) 3BCvg, (b) 3BC, (c) 3BS and (d) 3BOmax.

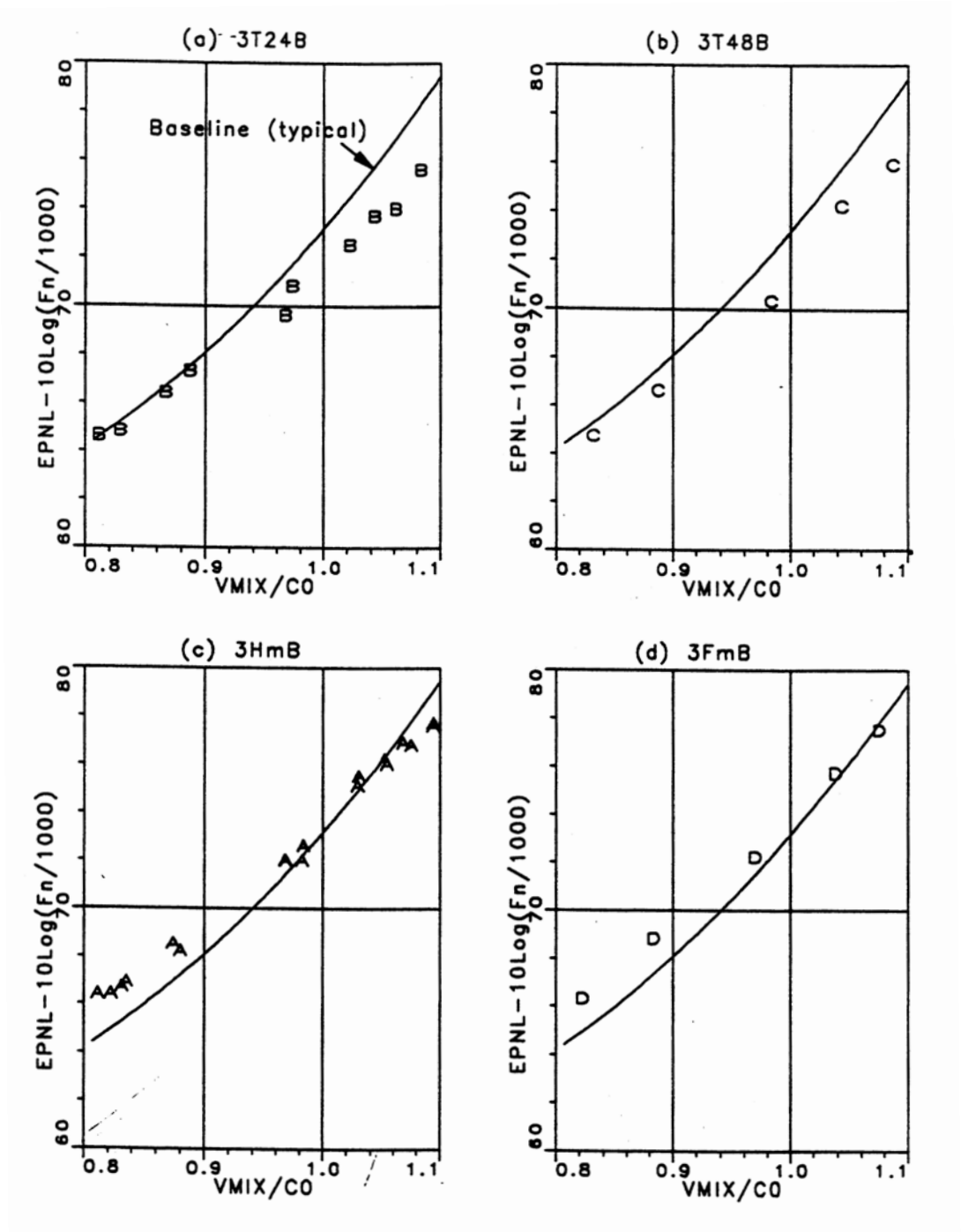


Figure 71. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle Test Configurations, (a) 3T24B, (b) 3T48B, (c) 3HmB and (d) 3FmB.

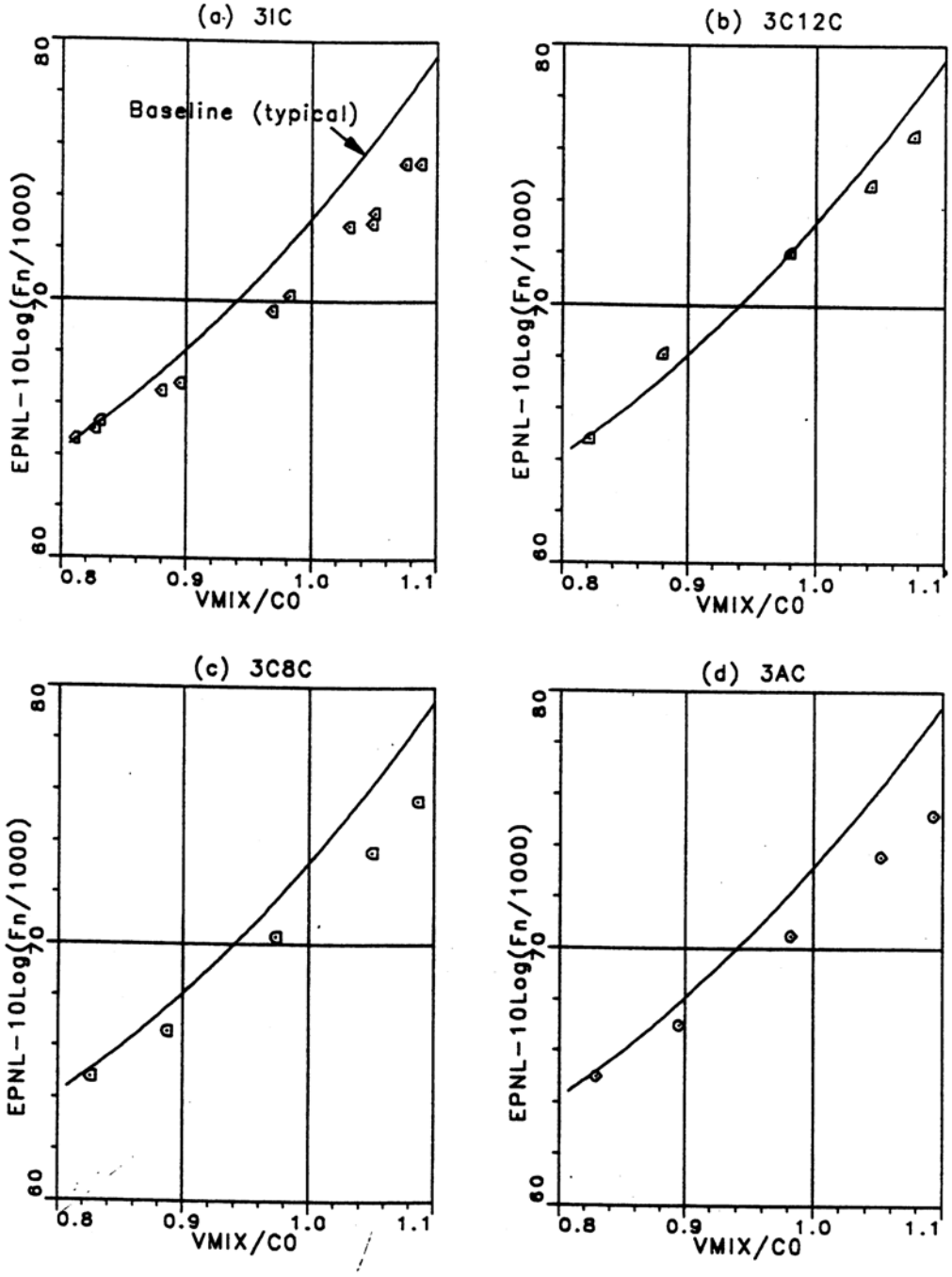


Figure 72. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle Test Configurations, (a) 3IC, (b) 3C12C, (c) 3C8C and (d) 3AC.

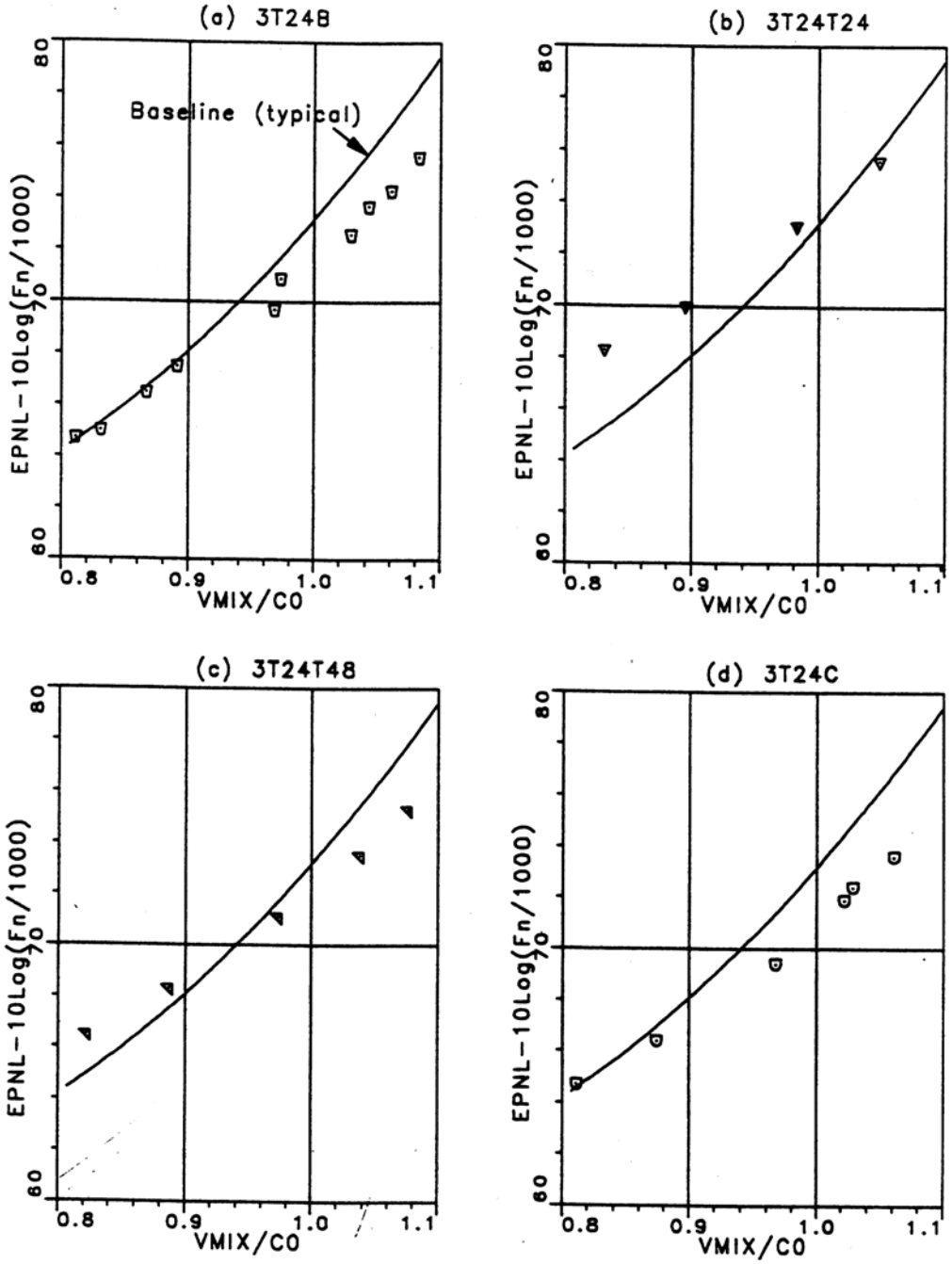


Figure 73. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle Test Configurations, (a) 3T24B, (b) 3T24T24, (c) 3T24T48 and (d) 3T24C.

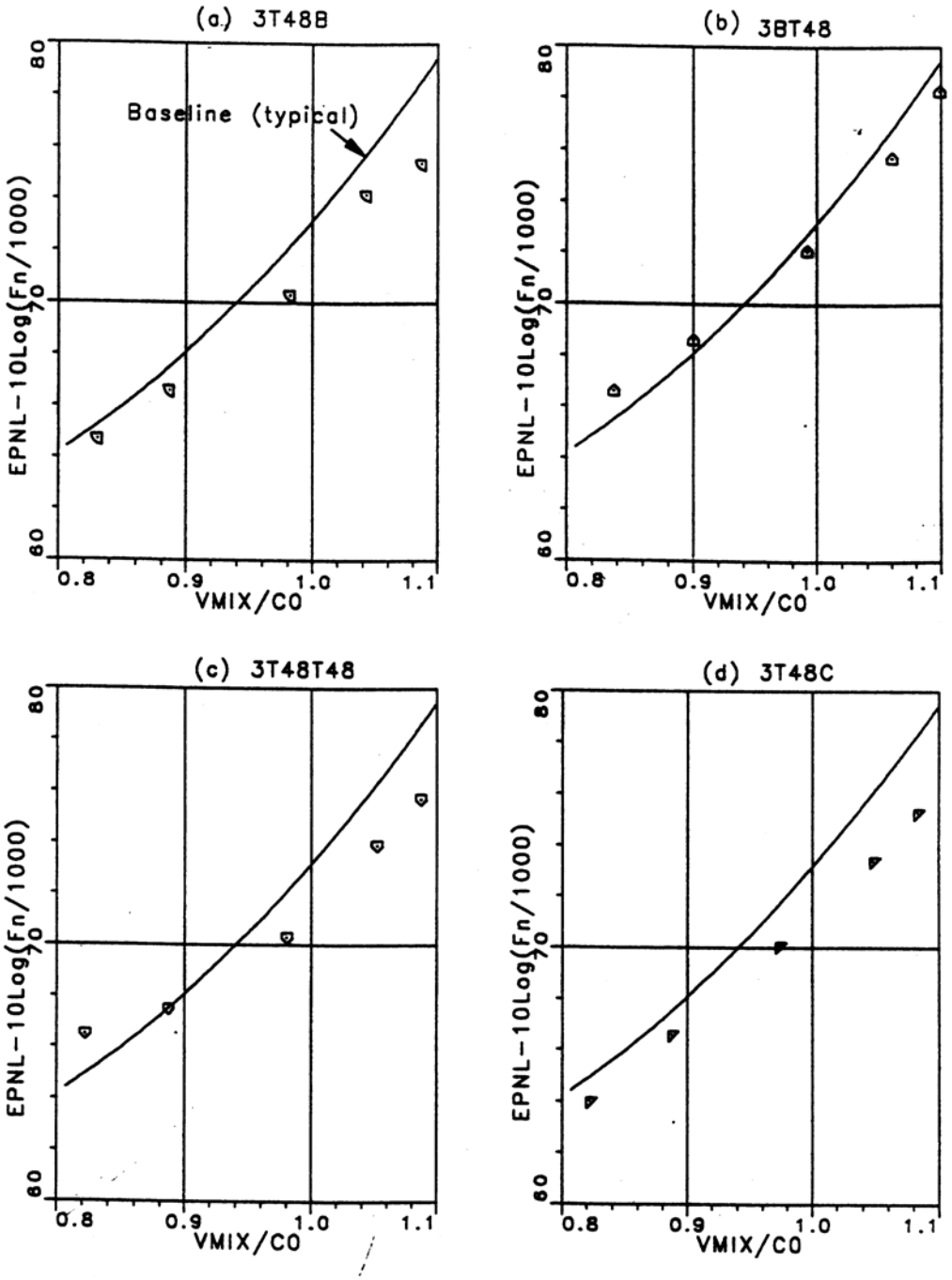


Figure 74. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle Test Configurations, (a) 3T48B, (b) 3BT48, (c) 3T48T48 and (d) 3T48C.

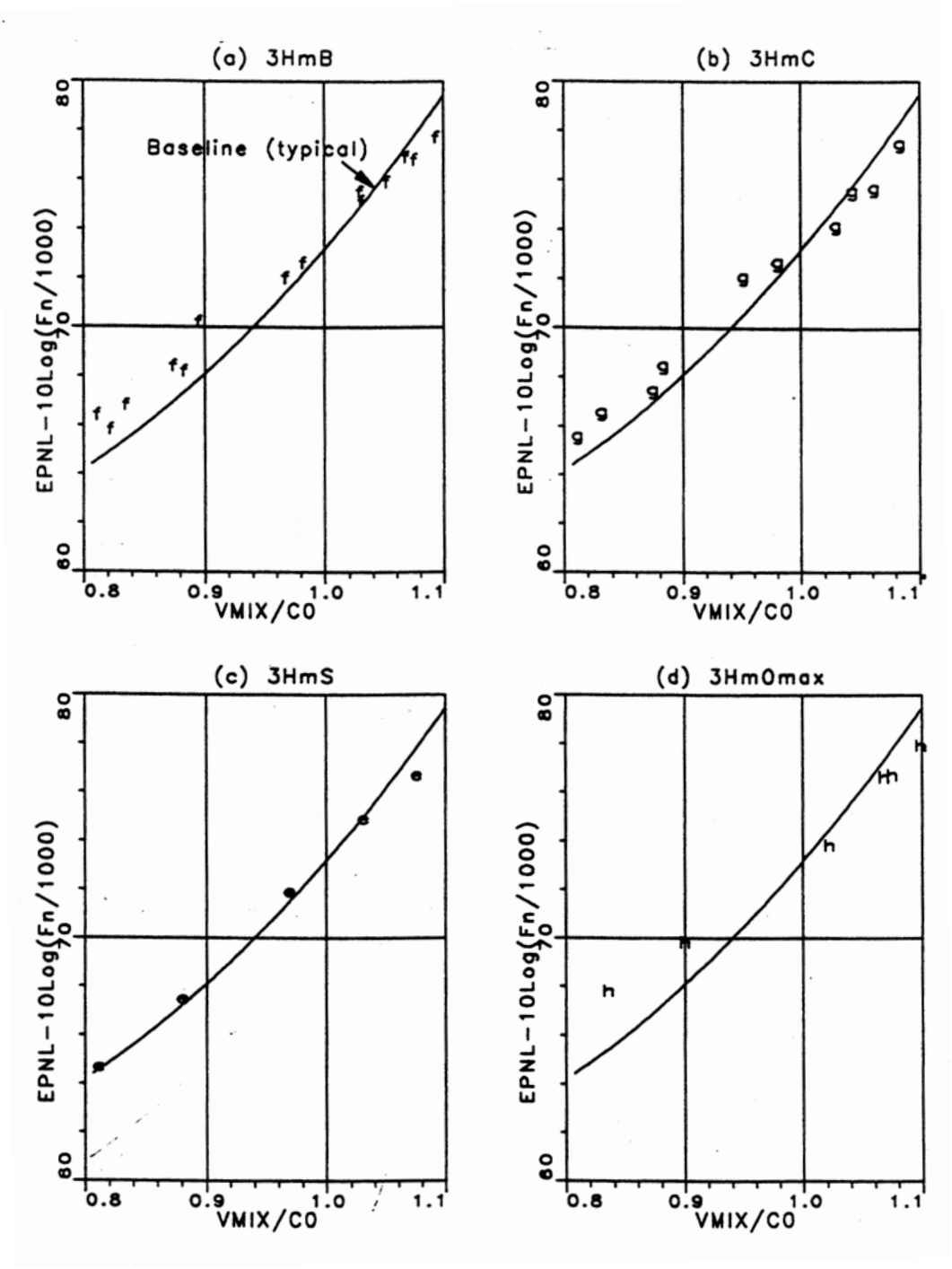


Figure 75. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle Test Configurations, (a) 3HmB, (b) 3HmC, (c) 3HmS and (d) 3HmOmax.

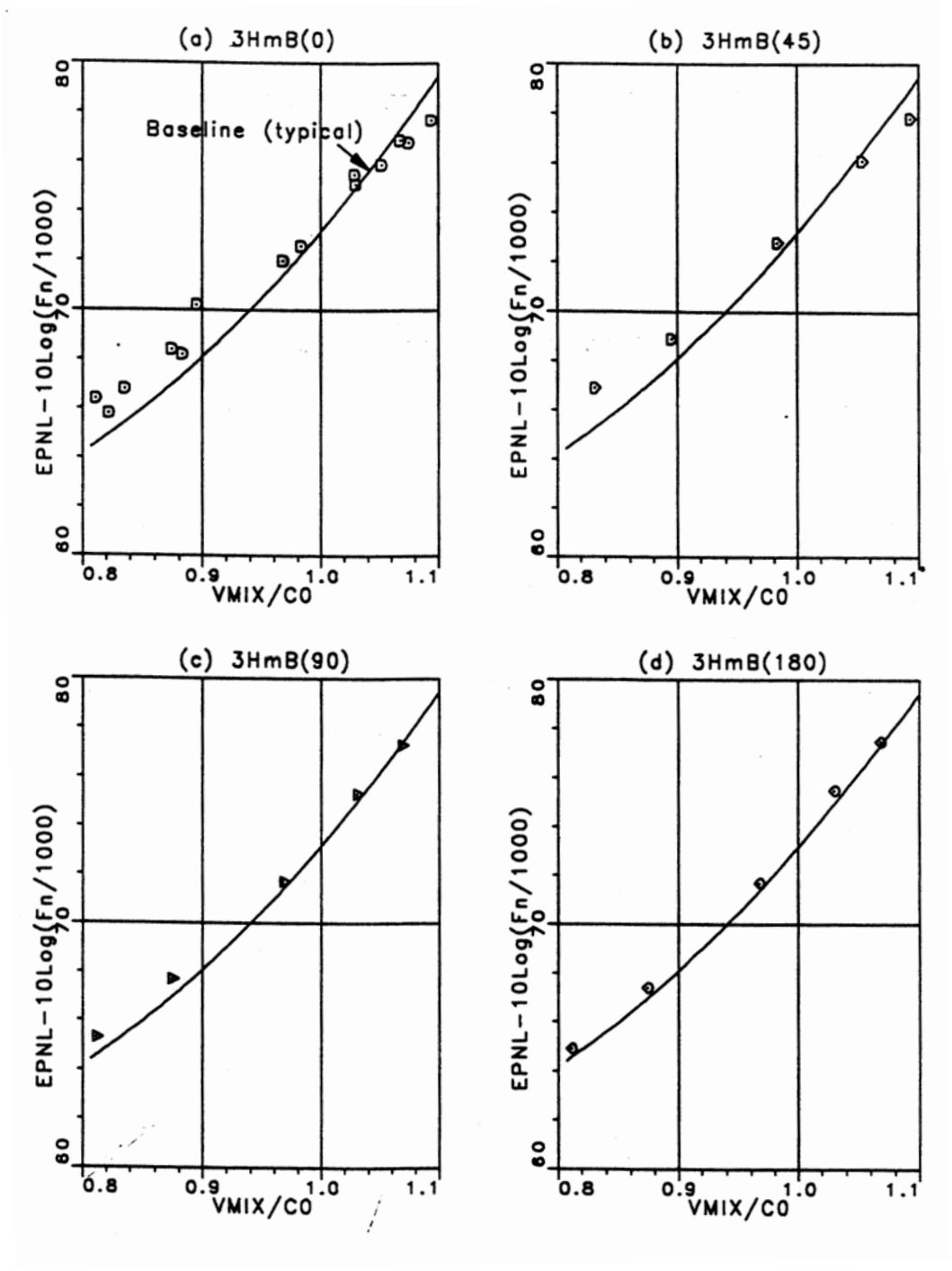


Figure 76. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle 3HmB Jet Noise Measured at Four Different Azimuthal Angles.

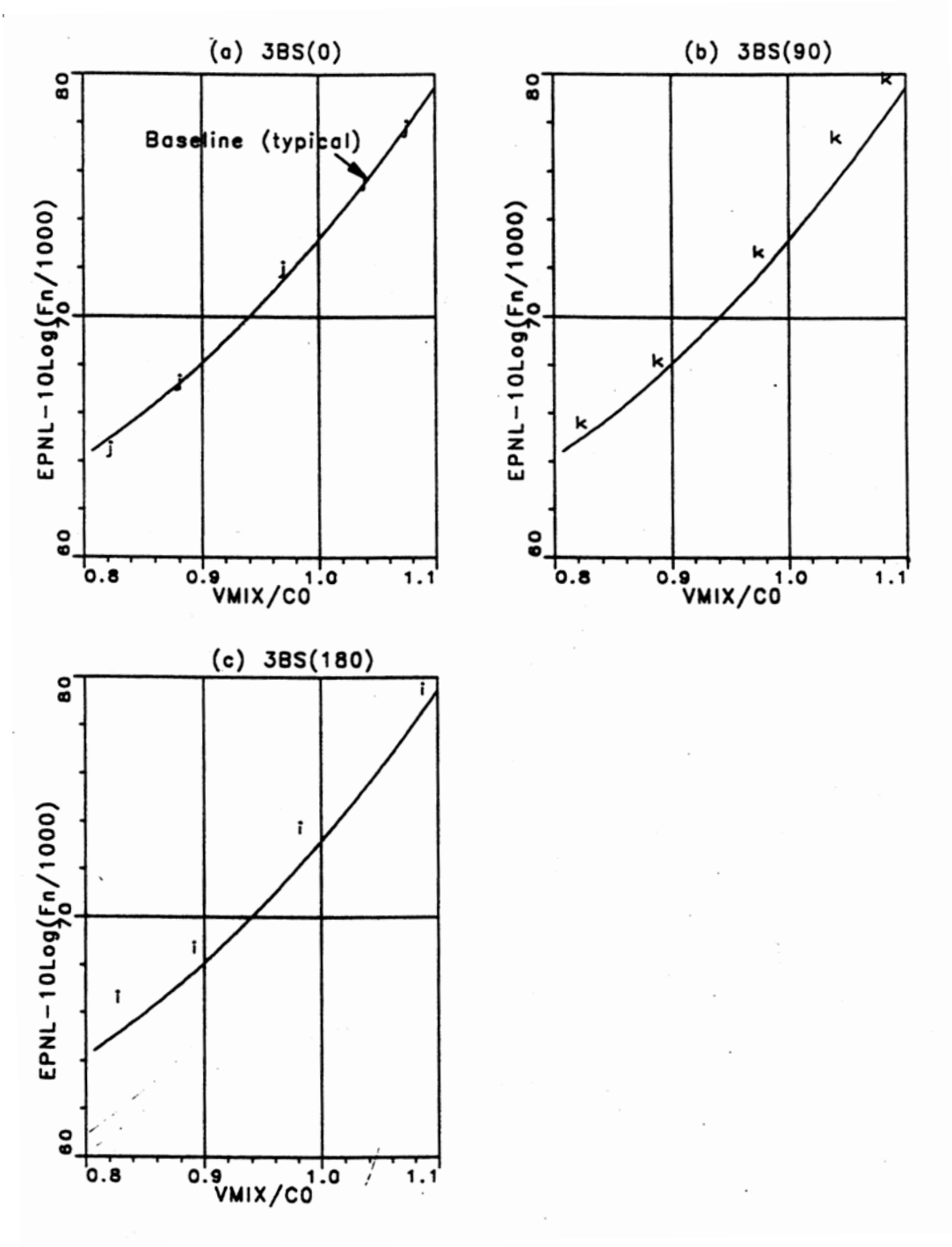


Figure 77. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle 3BS Jet Noise Measured at Three Different Azimuthal Angles.

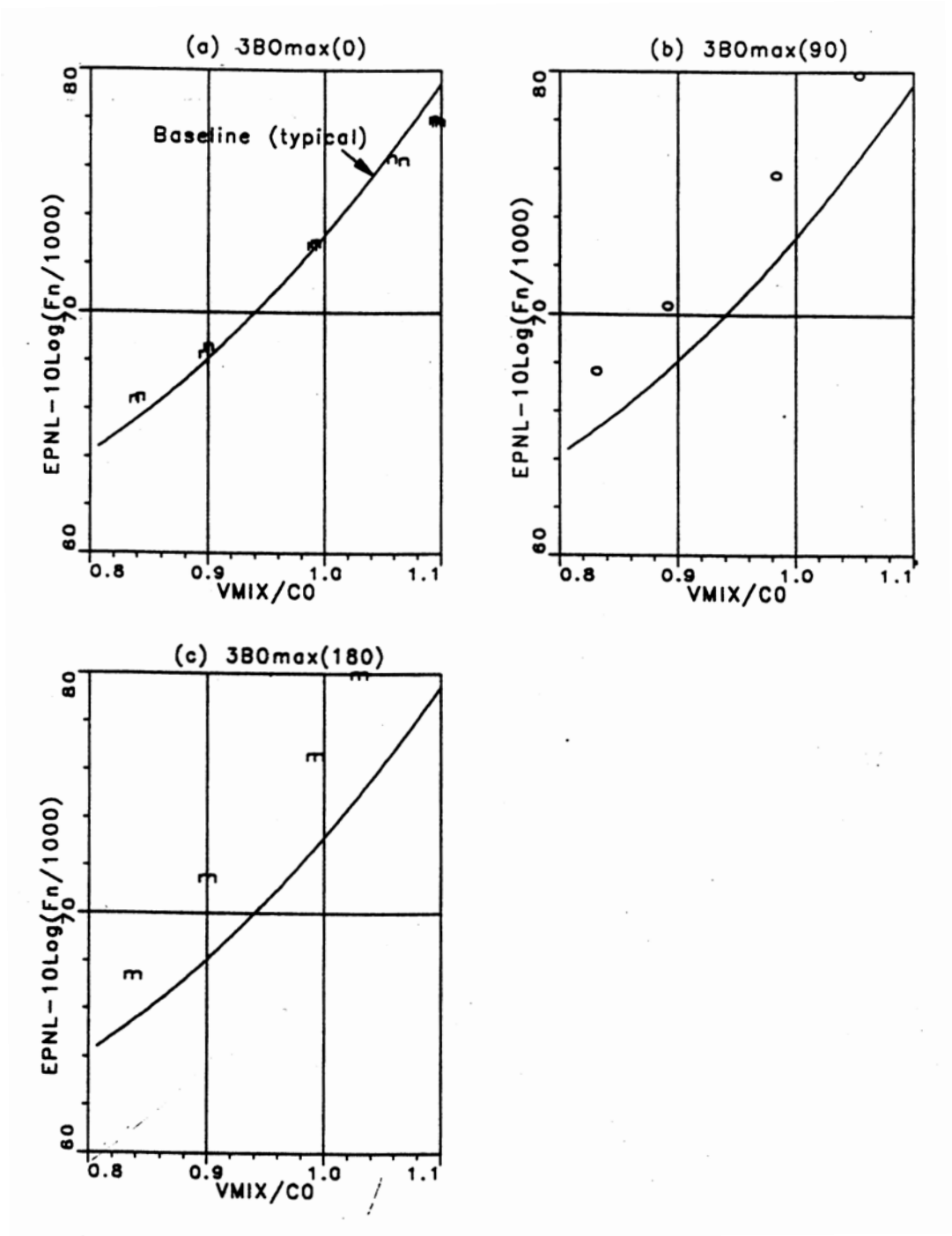


Figure 78. Correlations of EPNLs vs Mixed Jet Mach Numbers for Model 3 Nozzle 3BOmax Jet Noise Measured at Four Different Azimuthal Angles.

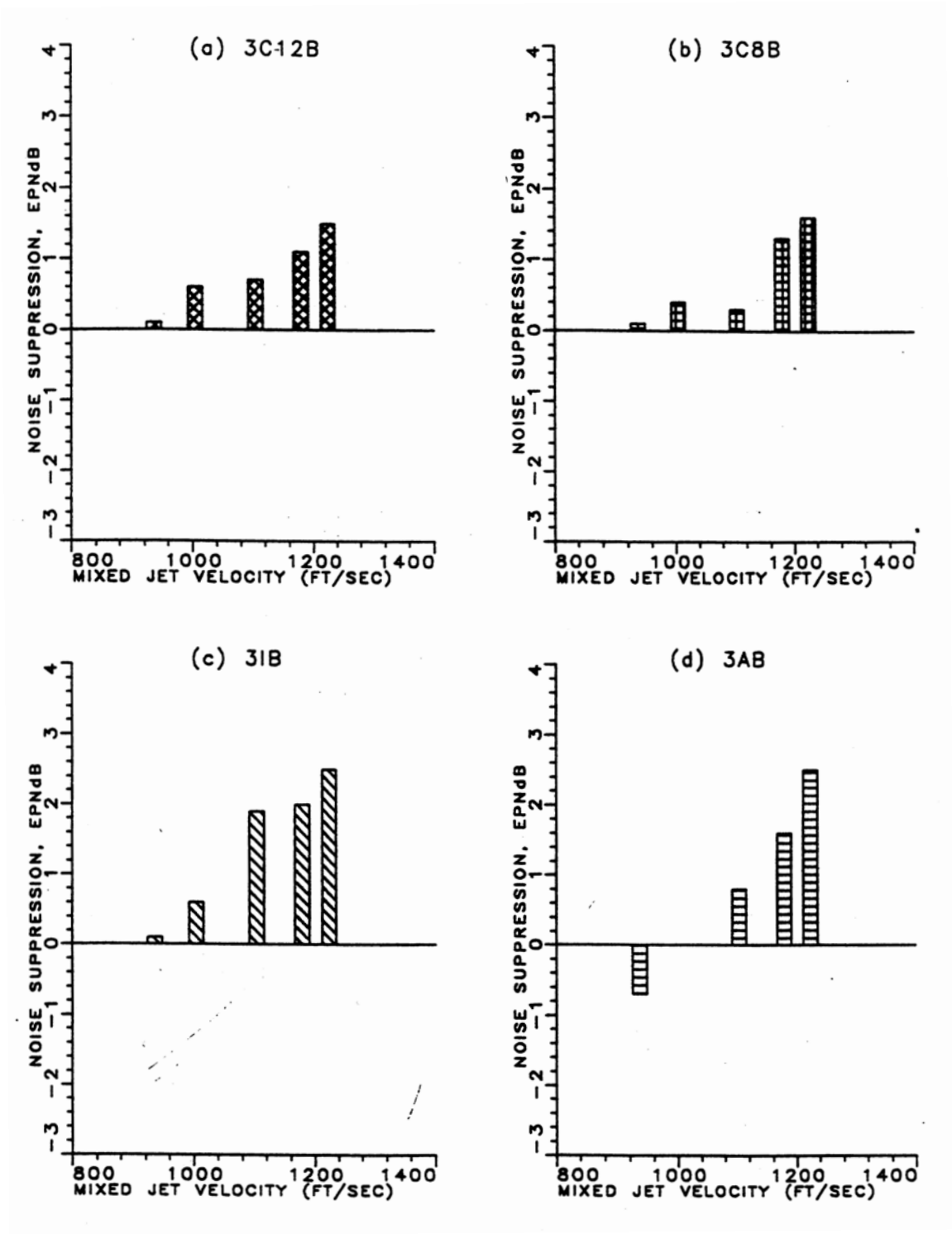


Figure 79. EPNL Reductions (Relative to Baseline Model 3) Achieved by Jet Noise Suppression Devices ; (a) 3C12B, (b) 3C8B, (c) 3IB and (d) 3AB.

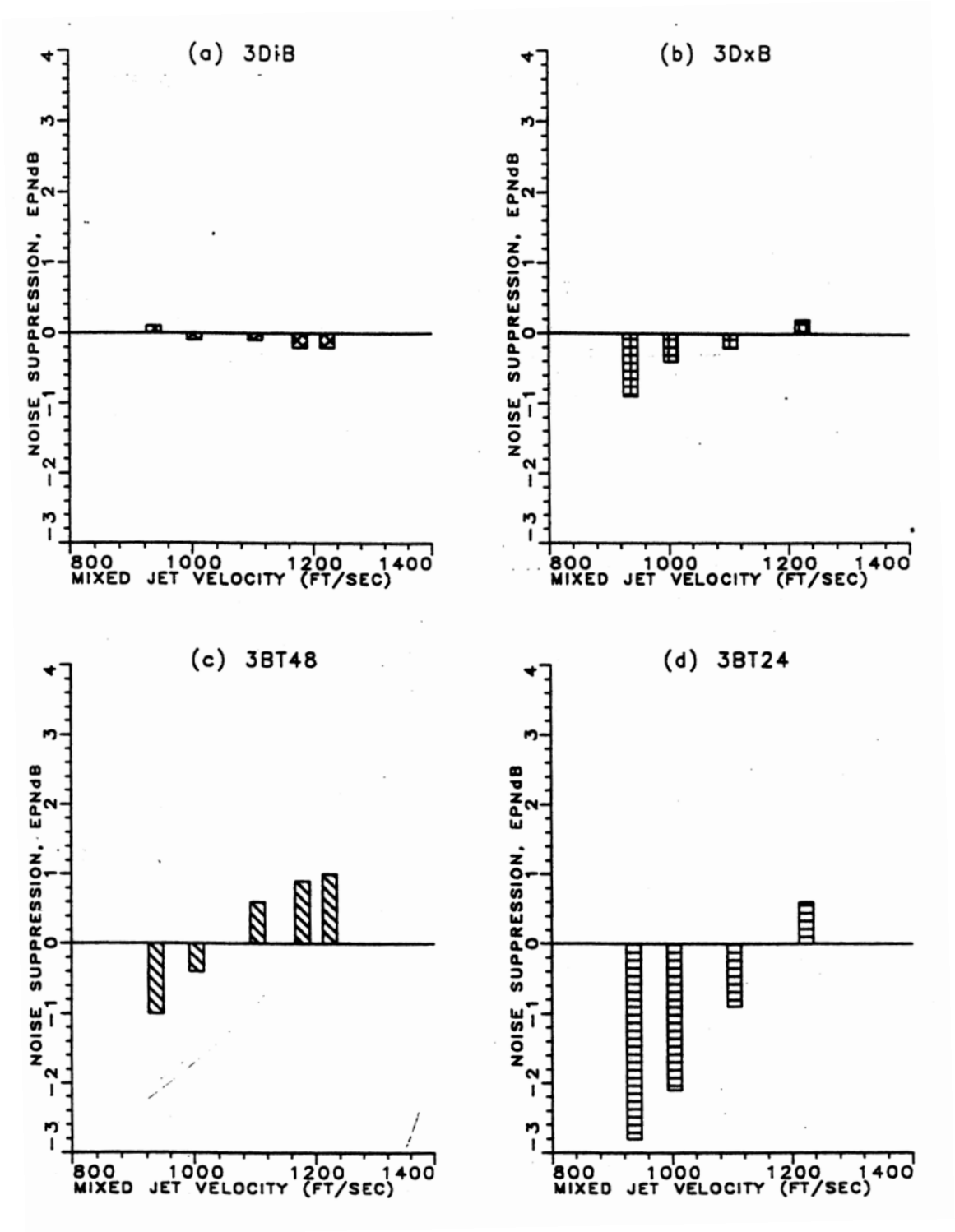


Figure 80. EPNL Reductions (Relative to Baseline Model 3) Achieved by Jet Noise Suppression Devices ; (a) 3DiB, (b) 3DxB, (c) 3BT48 and (d) 3BT24.

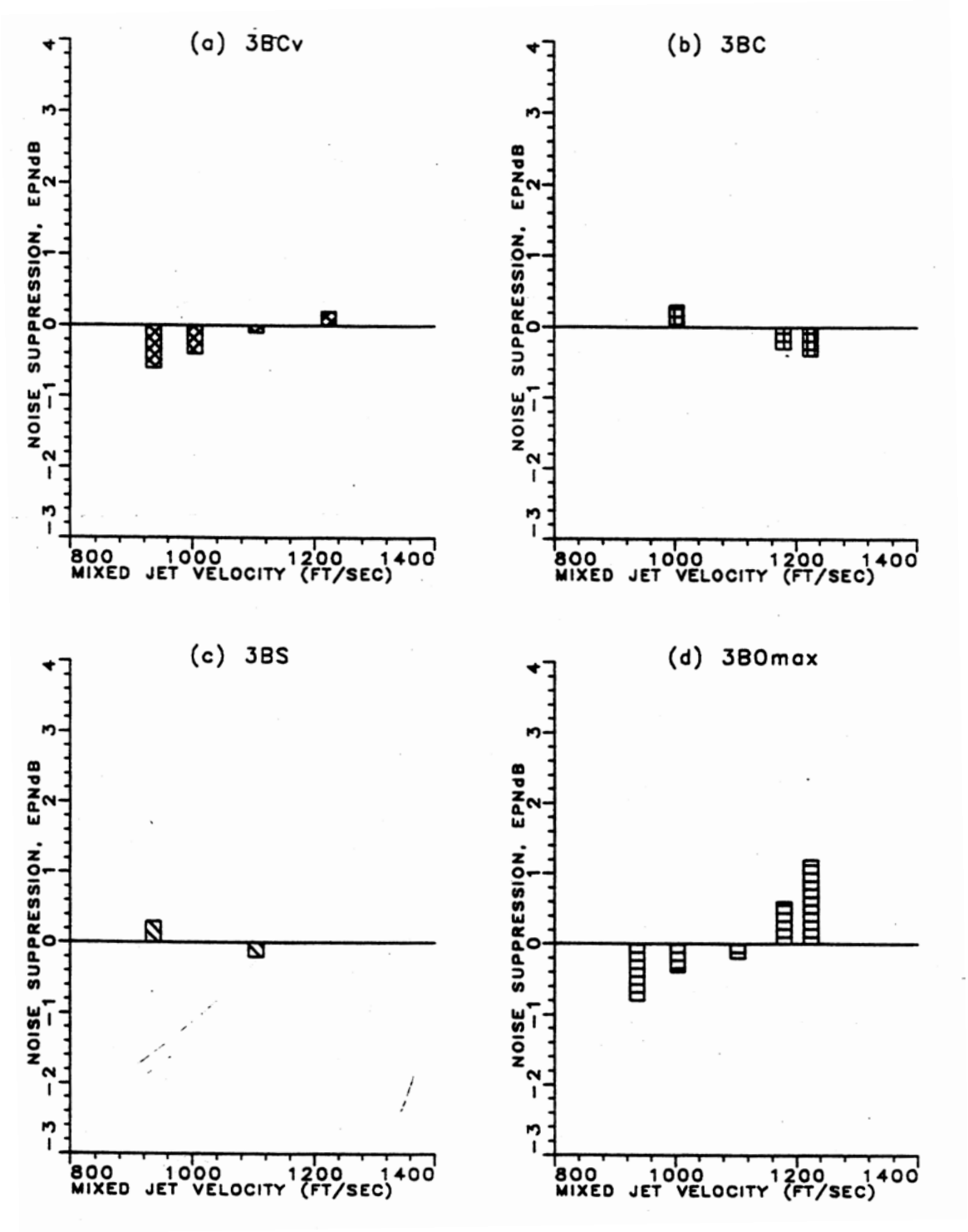


Figure 81. EPNL Reductions (Relative to Baseline Model 3) Achieved by Jet Noise Suppression Devices ; (a) 3BCv, (b) 3BC, (c) 3BS and (d) 3BOmax.

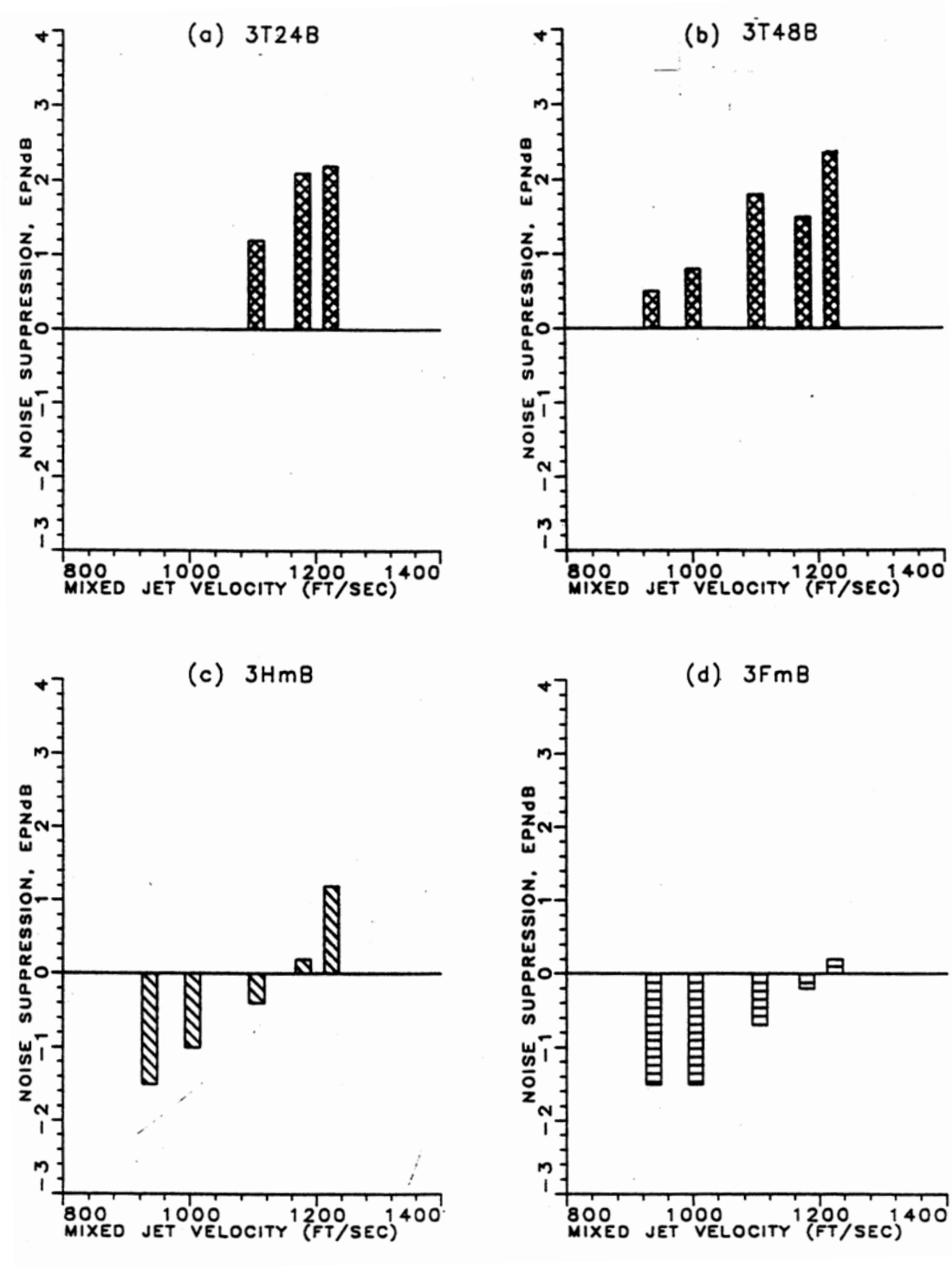


Figure 82. EPNL Reductions (Relative to Baseline Model 3) Achieved by Jet Noise Suppression Devices ; (a) 3T24B, (b) 3T48B, (c) 3HmB and (d) 3FmB.

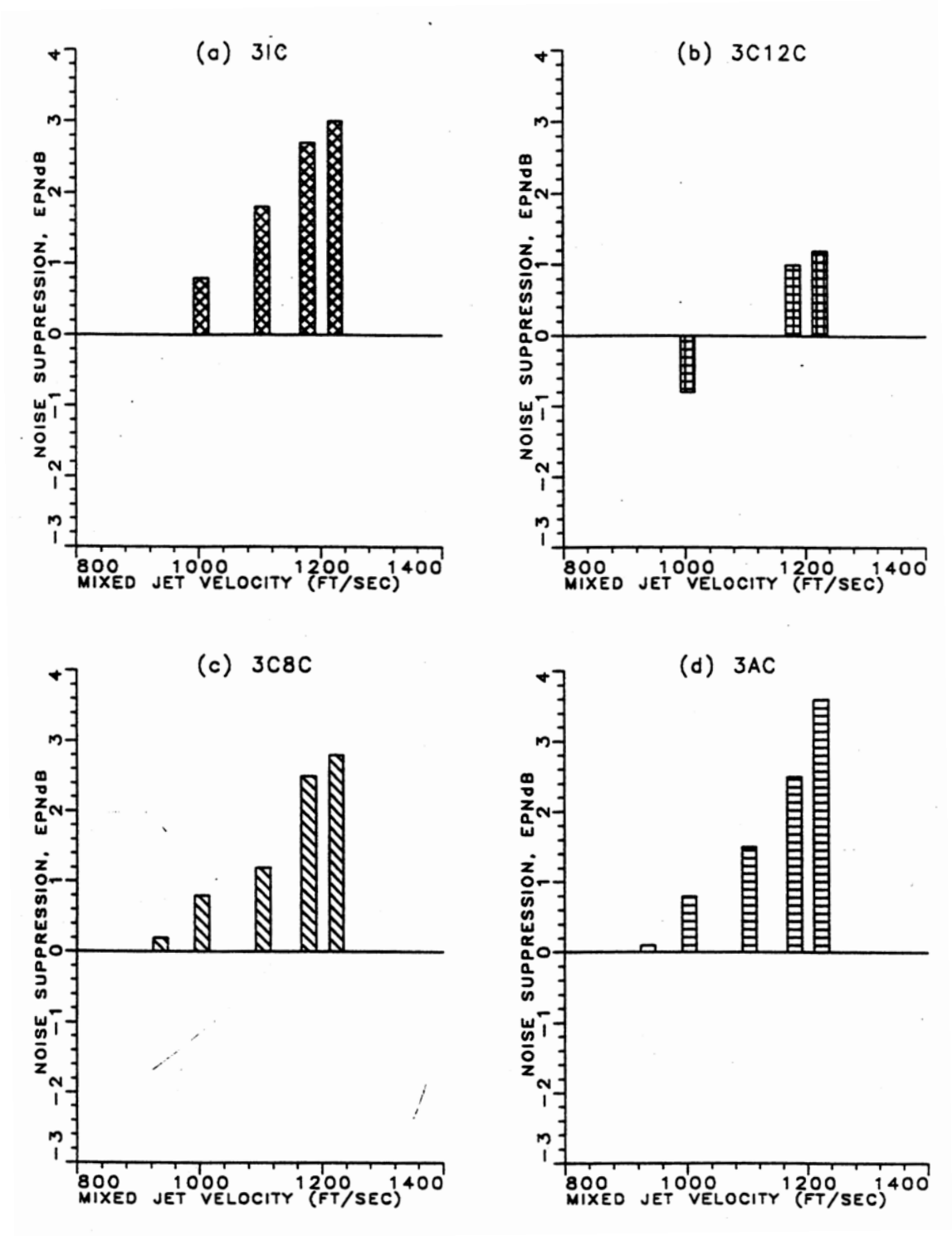


Figure 83. EPNL Reductions (Relative to Baseline Model 3) Achieved by Jet Noise Suppression Devices ; (a) 3IC, (b) 3C12C, (c) 3C8C and (d) 3AC.

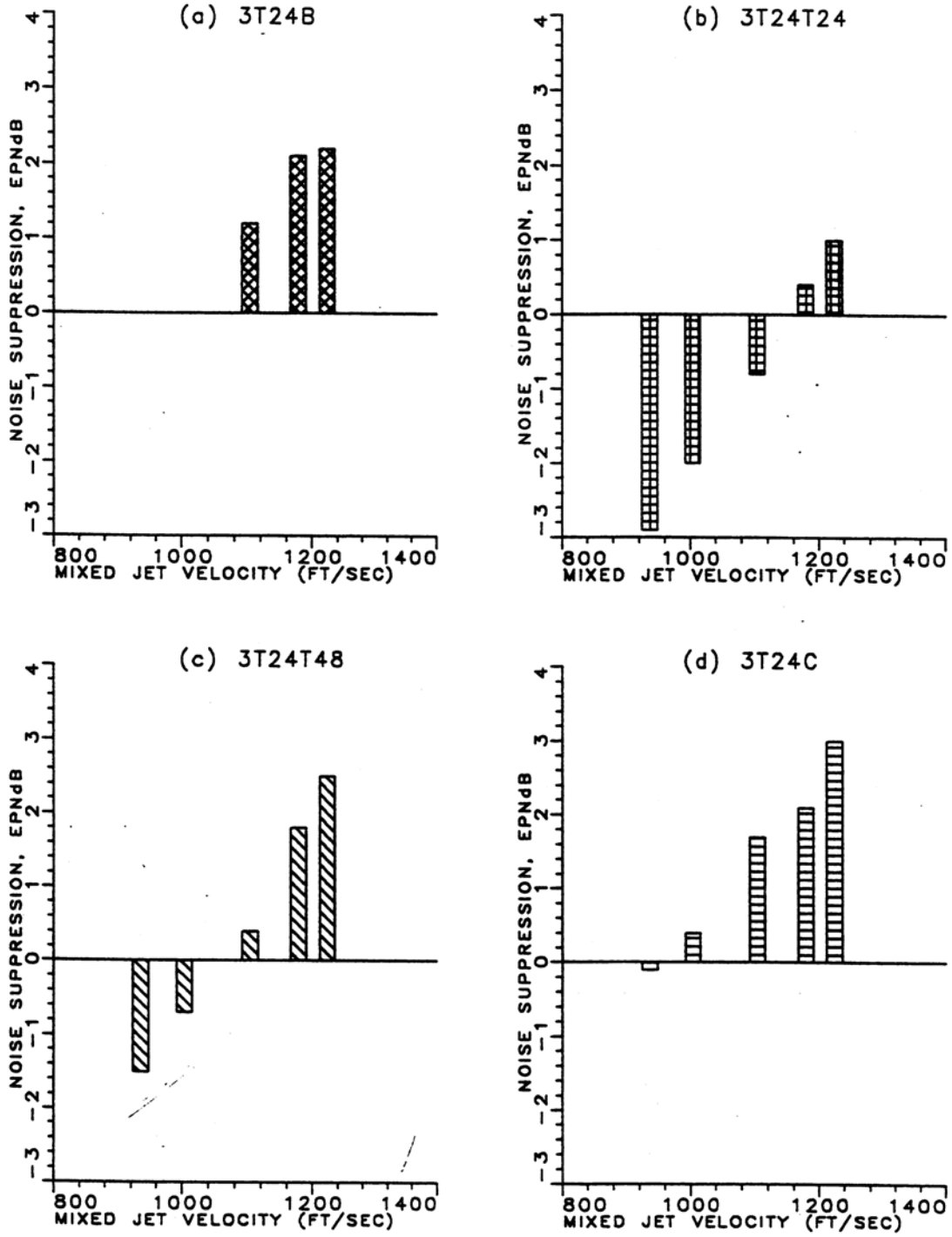


Figure 84. EPNL Reductions (Relative to Baseline Model 3) Achieved by Jet Noise Suppression Devices ; (a) 3T24B, (b) 3T24T24, (c) 3T24T48 and (d) 3T24C.

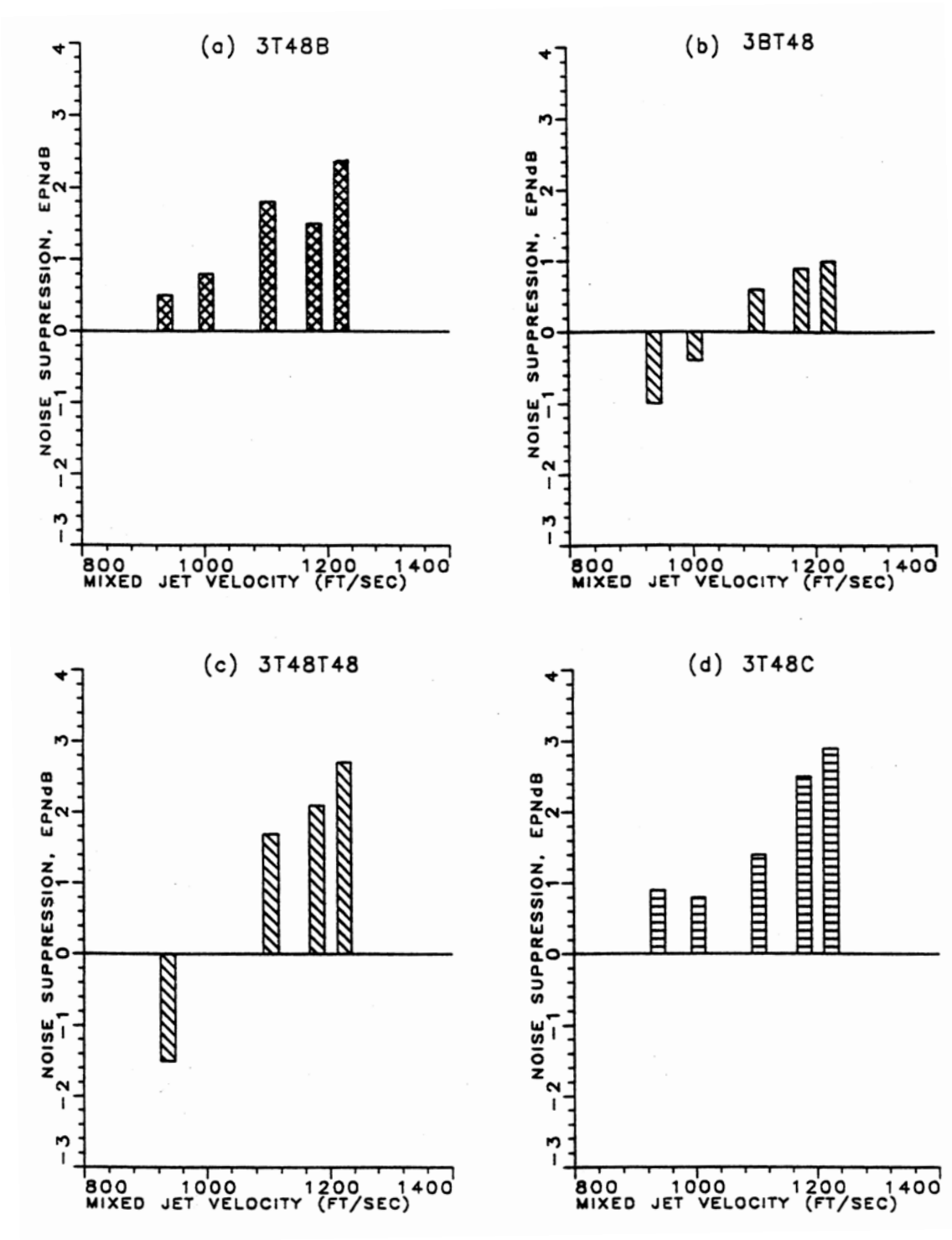


Figure 85. EPNL Reductions (Relative to Baseline Model 3) Achieved by Jet Noise Suppression Devices ; (a) 3T48B, (b) 3BT48, (c) 3T48T48 and (d) 3T48C.

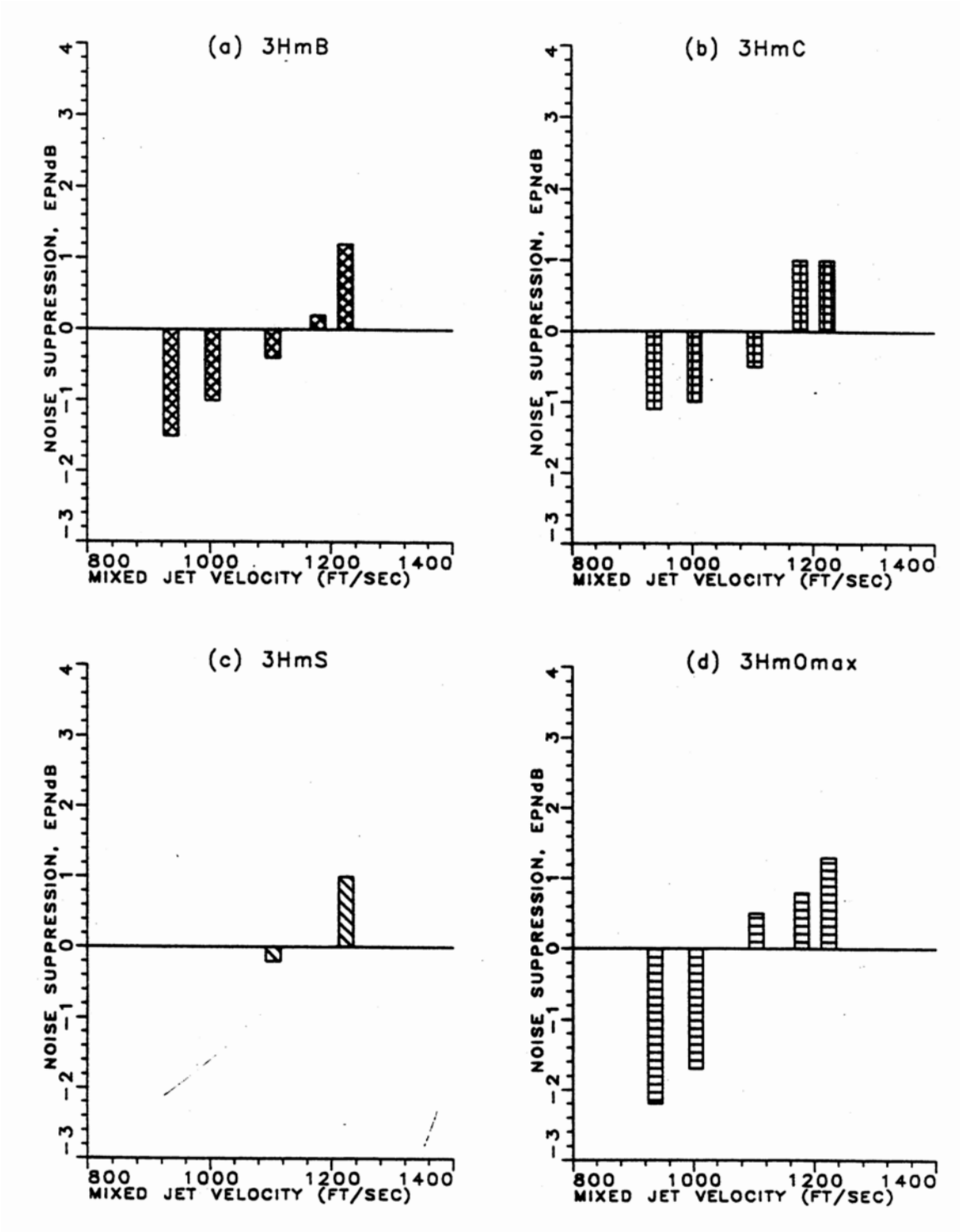


Figure 86. EPNL Reductions (Relative to Baseline Model 3) Achieved by Jet Noise Suppression Devices ; (a) 3HmB, (b) 3HmC, (c) 3HmS and (d) 3HmOmax.

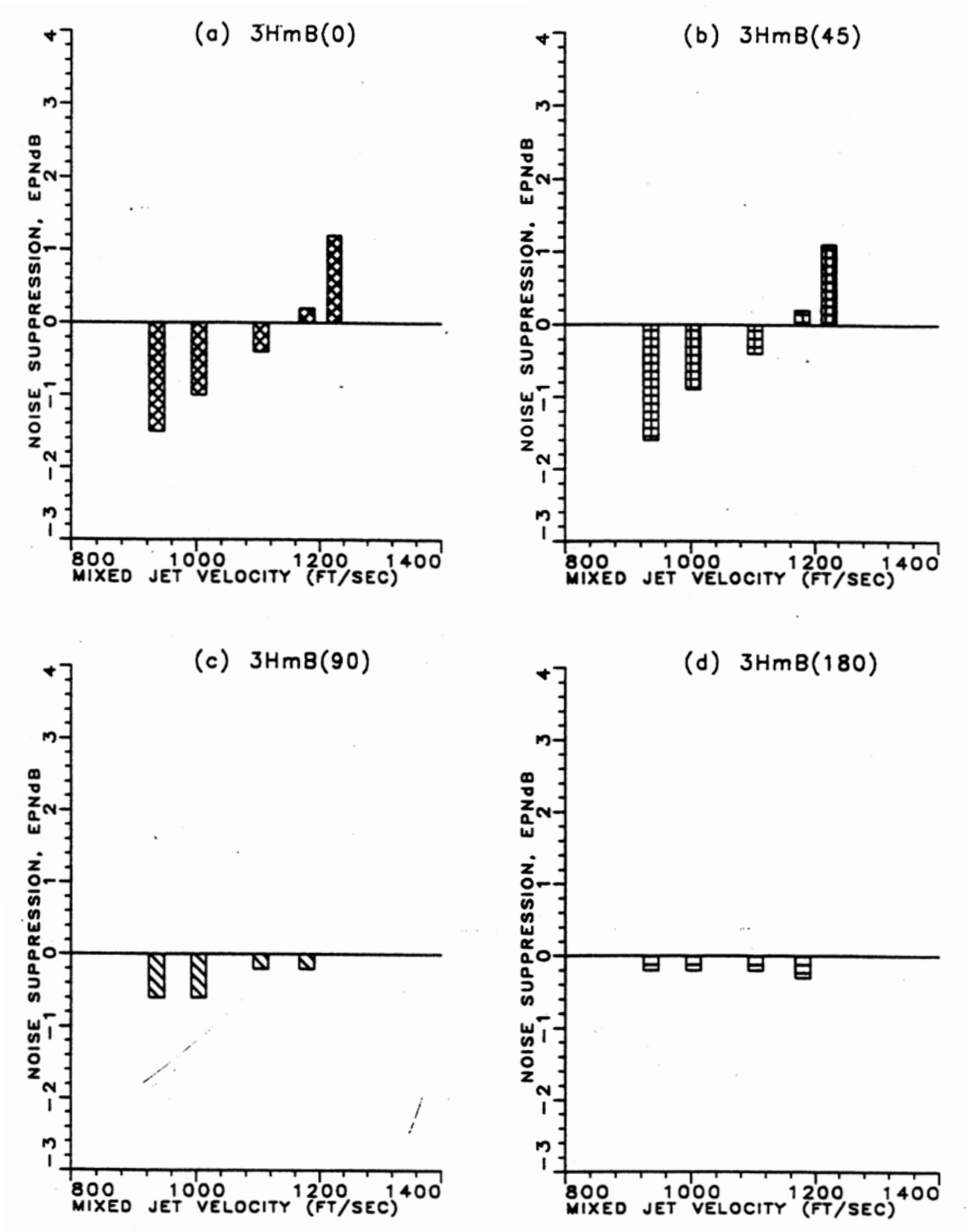


Figure 87. Variations of EPNL Reductions Measured at Four Different Azimuthal Angles for Model 3 Half Core Mixer Jet Noise Suppression Device (3HmB).

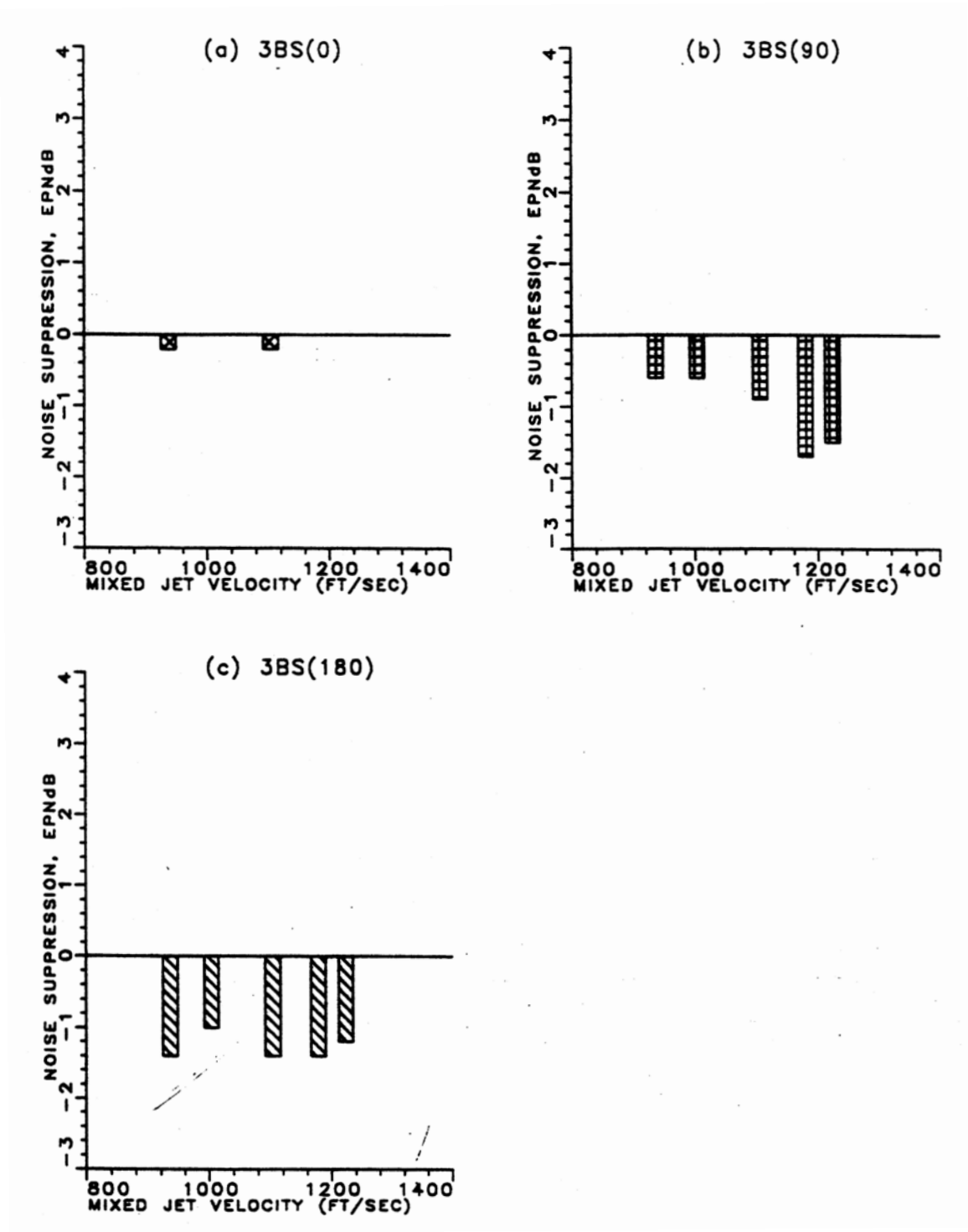


Figure 88. Variations of EPNL Reductions Measured at Three Different Azimuthal Angles for Model 3 Fan Scarfed Nozzle Jet Noise Suppression Device (3BS).

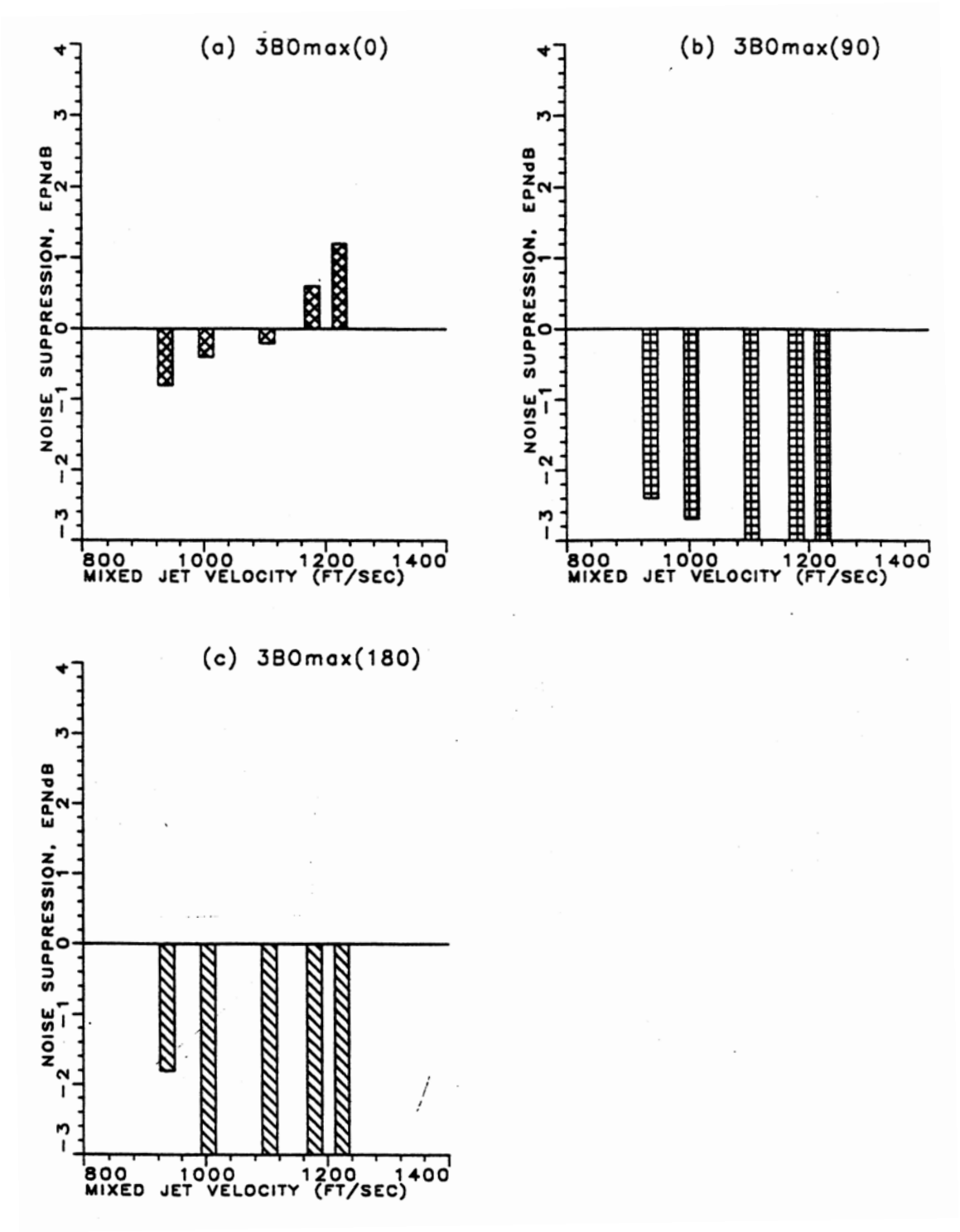


Figure 89. Variations of EPNL Reductions Measured at Three Different Azimuthal Angles for Model 3 Offset Centerline Fan Nozzle Jet Noise Suppression Device (3BOmax).

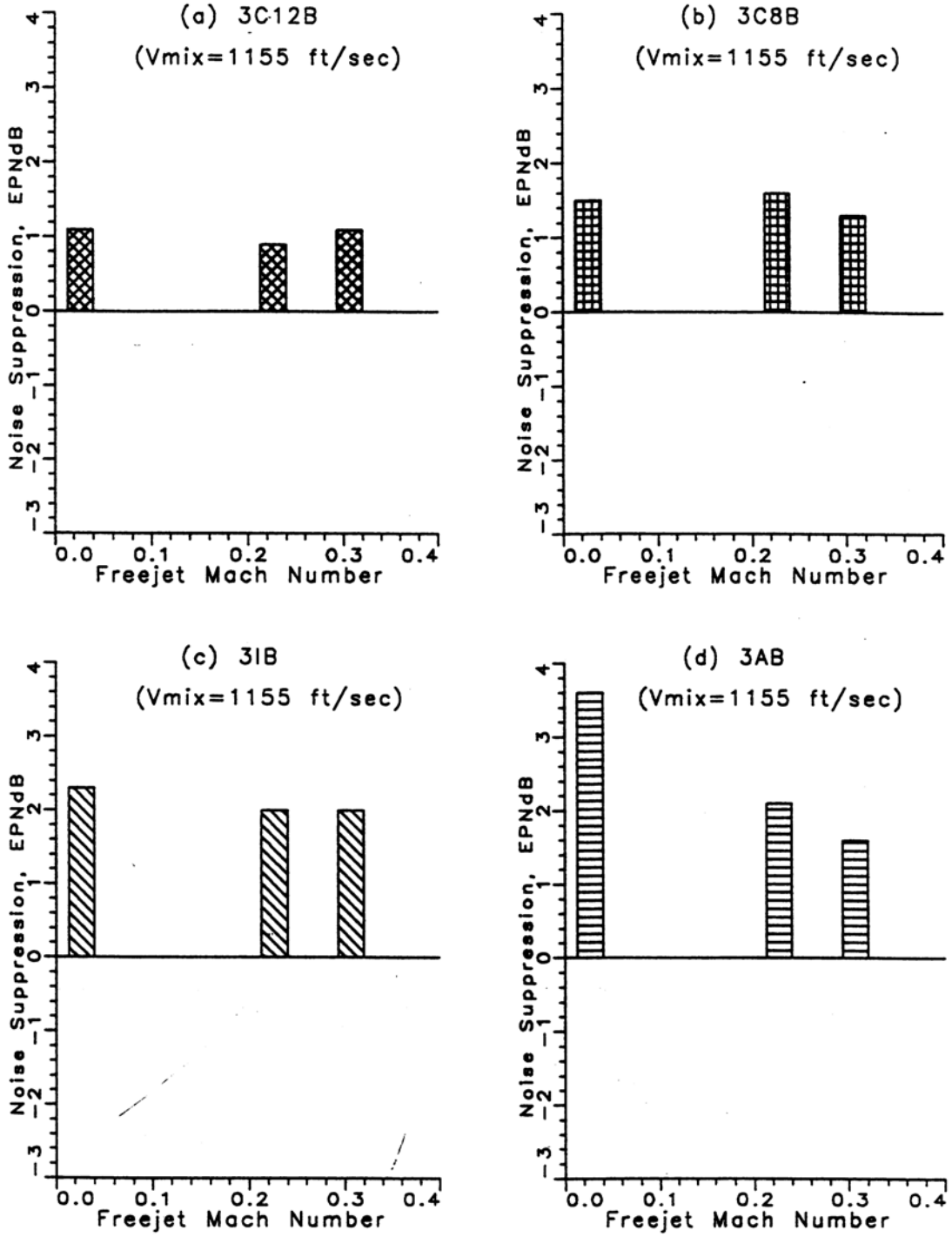


Figure 90. Effect of Freejet Mach Number on EPNL Reductions for Model 3 Jet Noise Suppression Devices ; (a) 3C12B, (b) 3C8B, (c) 3IB and (d) 3AB.

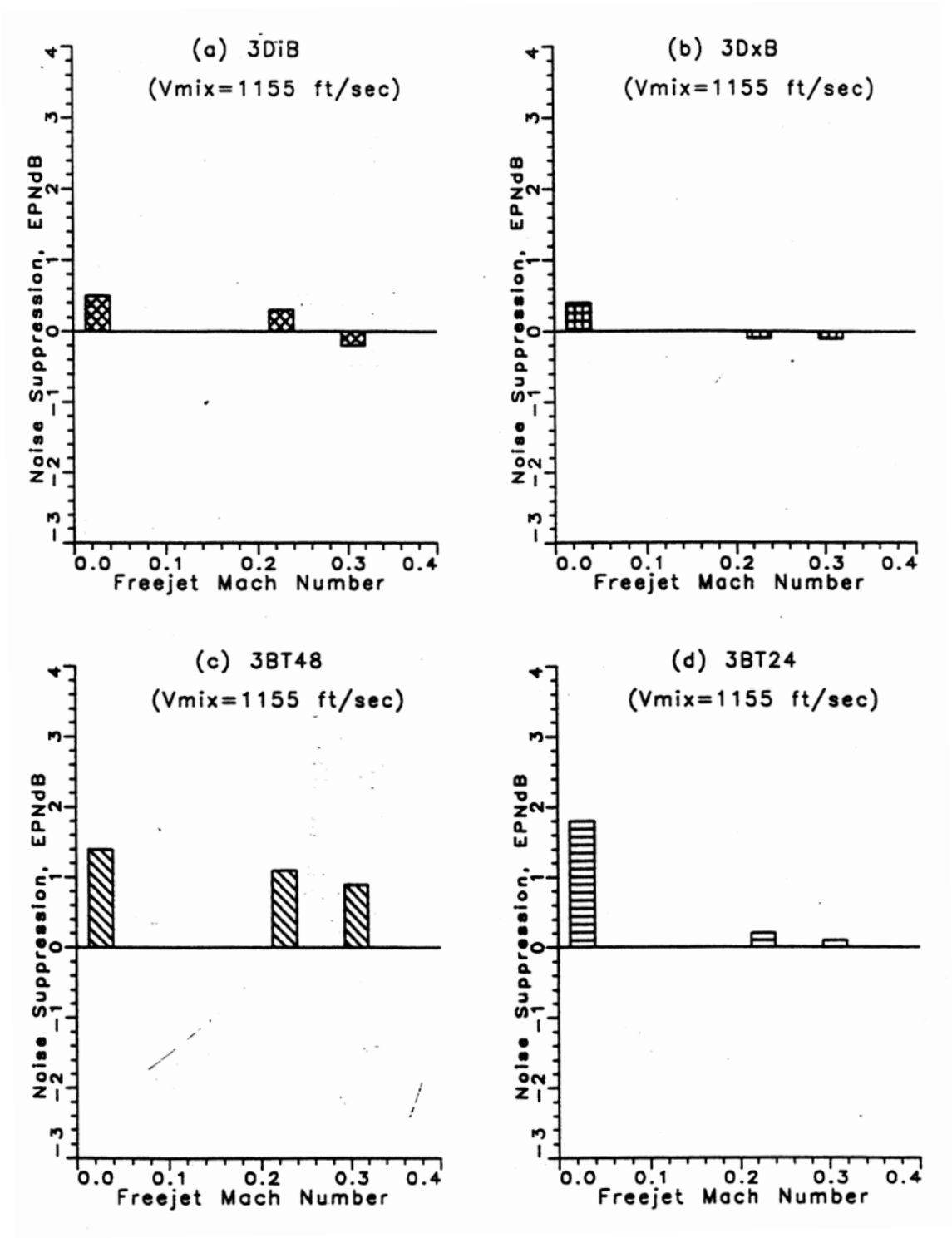


Figure 91. Effect of Freejet Mach Number on EPNL Reductions for Model 3 Jet Noise Suppression Devices ; (a) 3DiB, (b) 3DxB, (c) 3BT48 and (d) 3BT24.

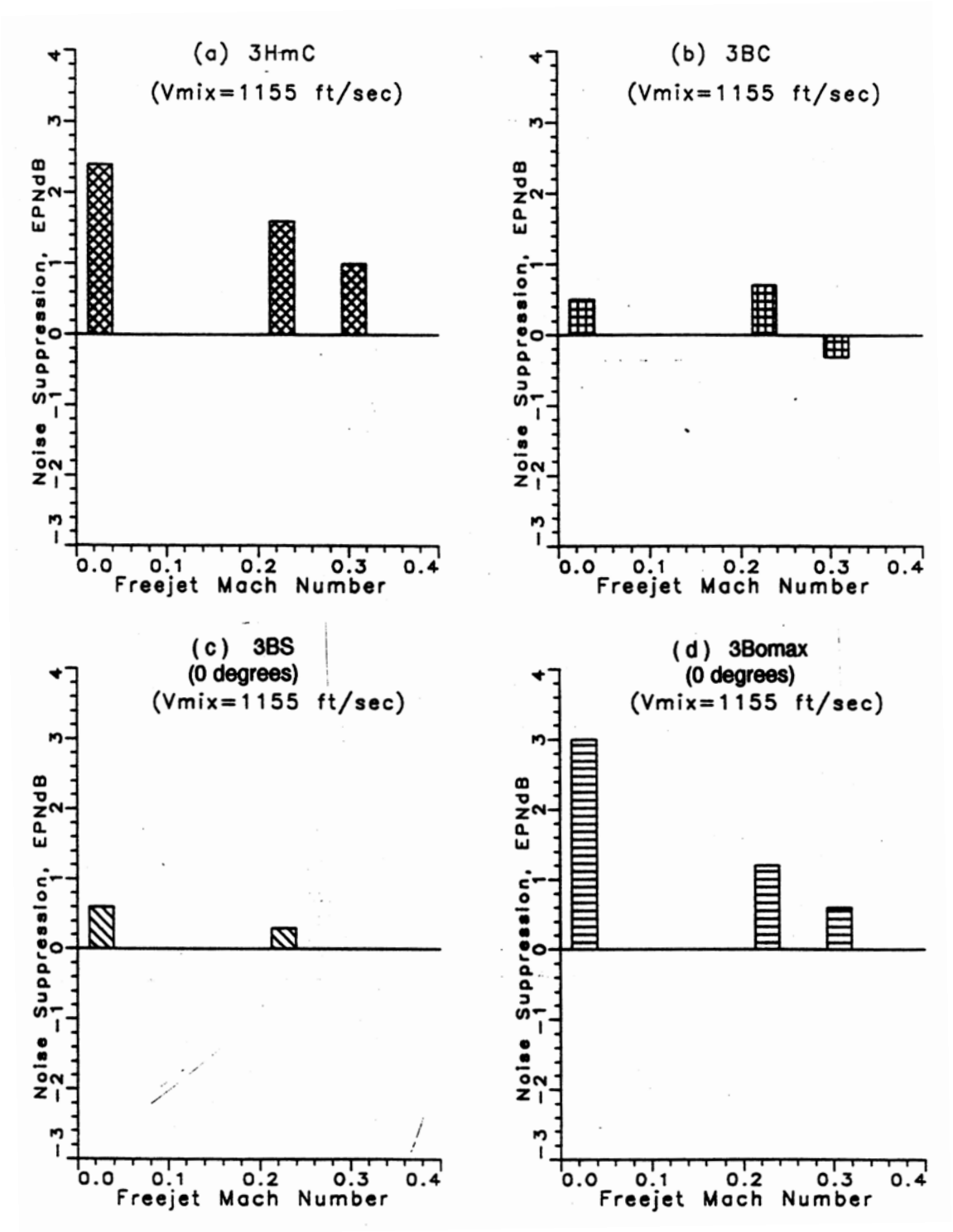


Figure 92. Effect of Freejet Mach Number on EPNL Reductions for Model 3 Jet Noise Suppression Devices ; (a) 3HmC, (b) 3BC, (c) 3BS and (d) 3BOmax.

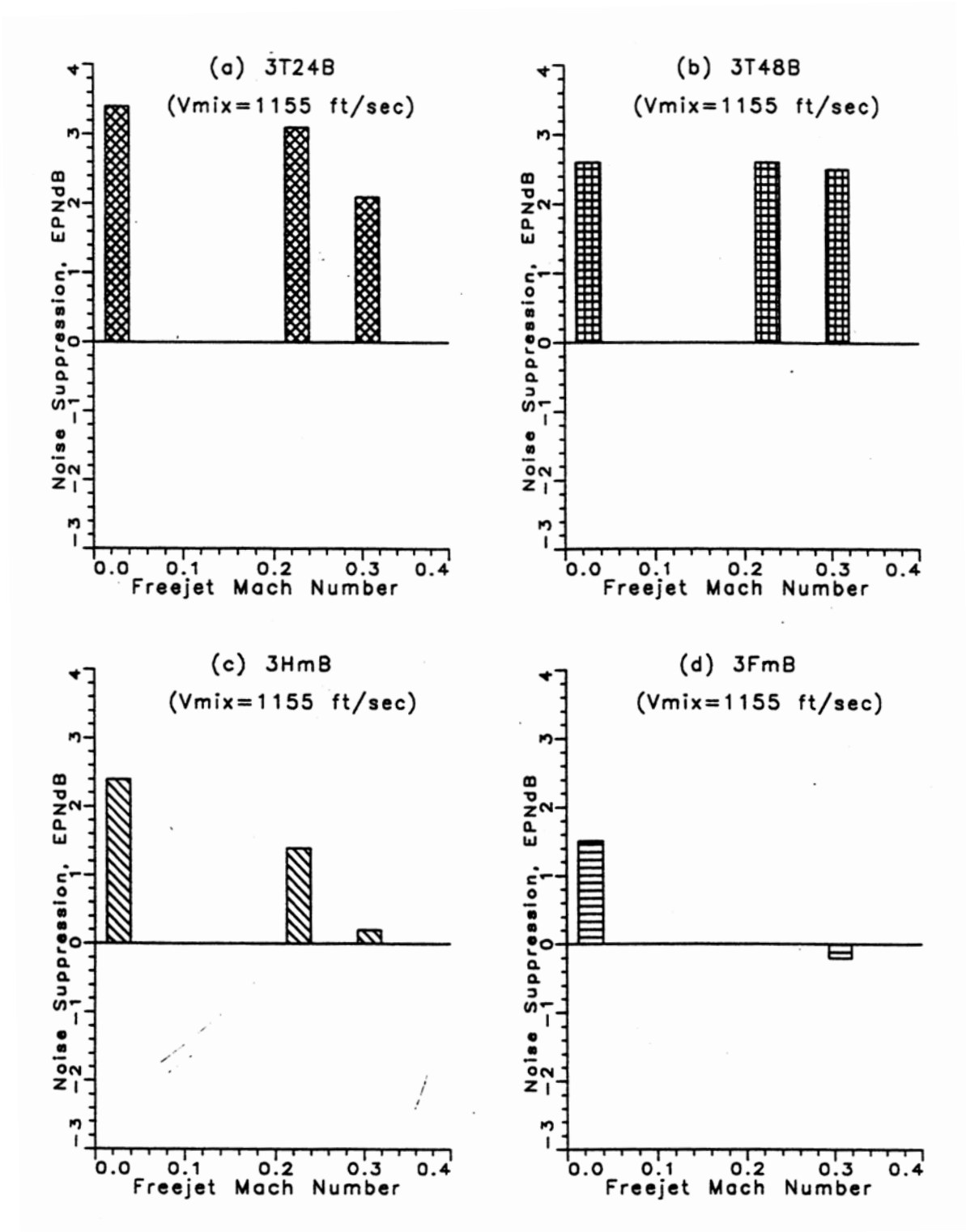


Figure 93. Effect of Freejet Mach Number on EPNL Reductions for Model 3 Jet Noise Suppression Devices ; (a) 3T24B, (b) 3T48B, (c) 3HmB and (d) 3FmB.

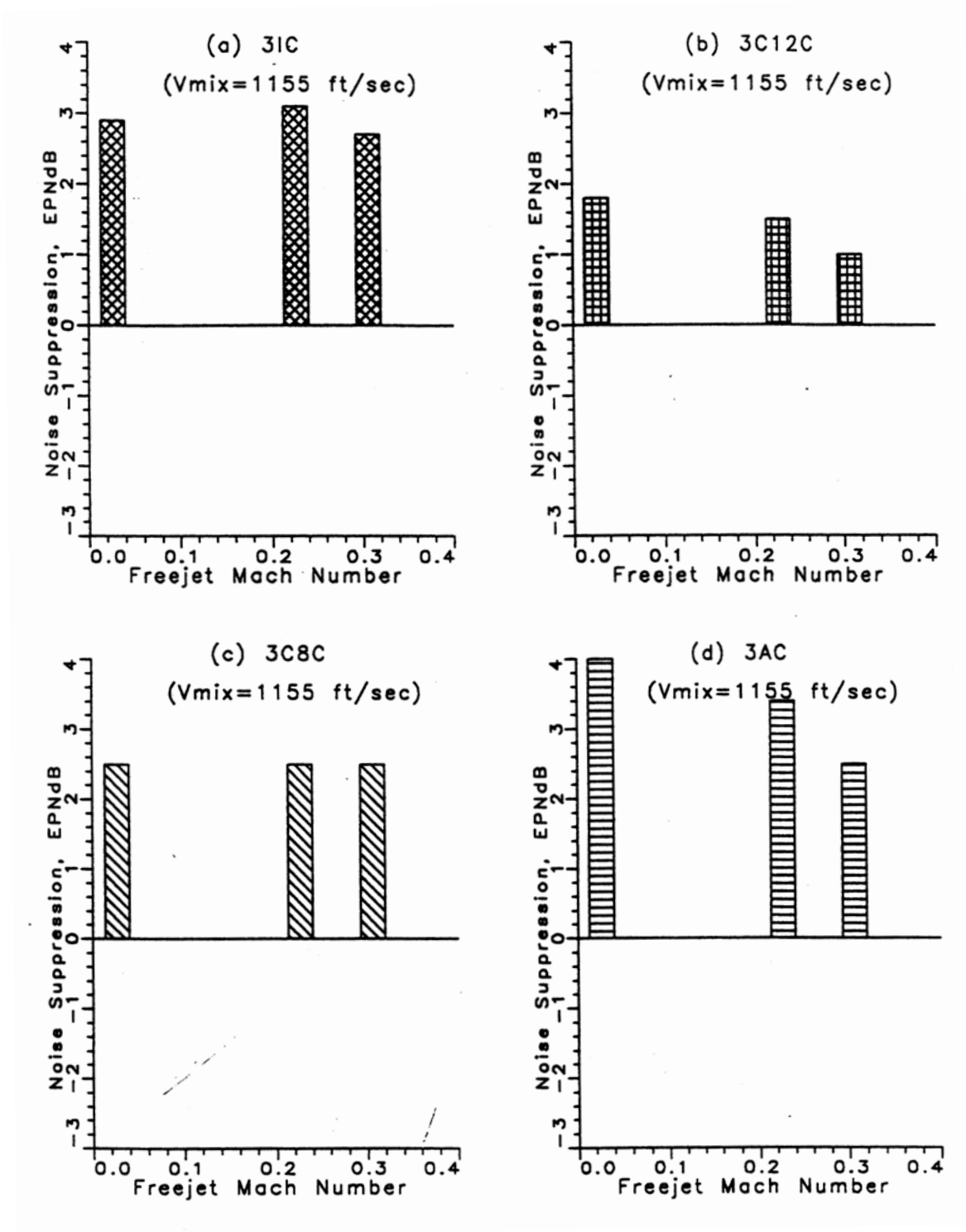


Figure 94. Effect of Freejet Mach Number on EPNL Reductions for Model 3 Jet Noise Suppression Devices ; (a) 3IC, (b) 3C12C, (c) 3C8C and (d) 3AC.

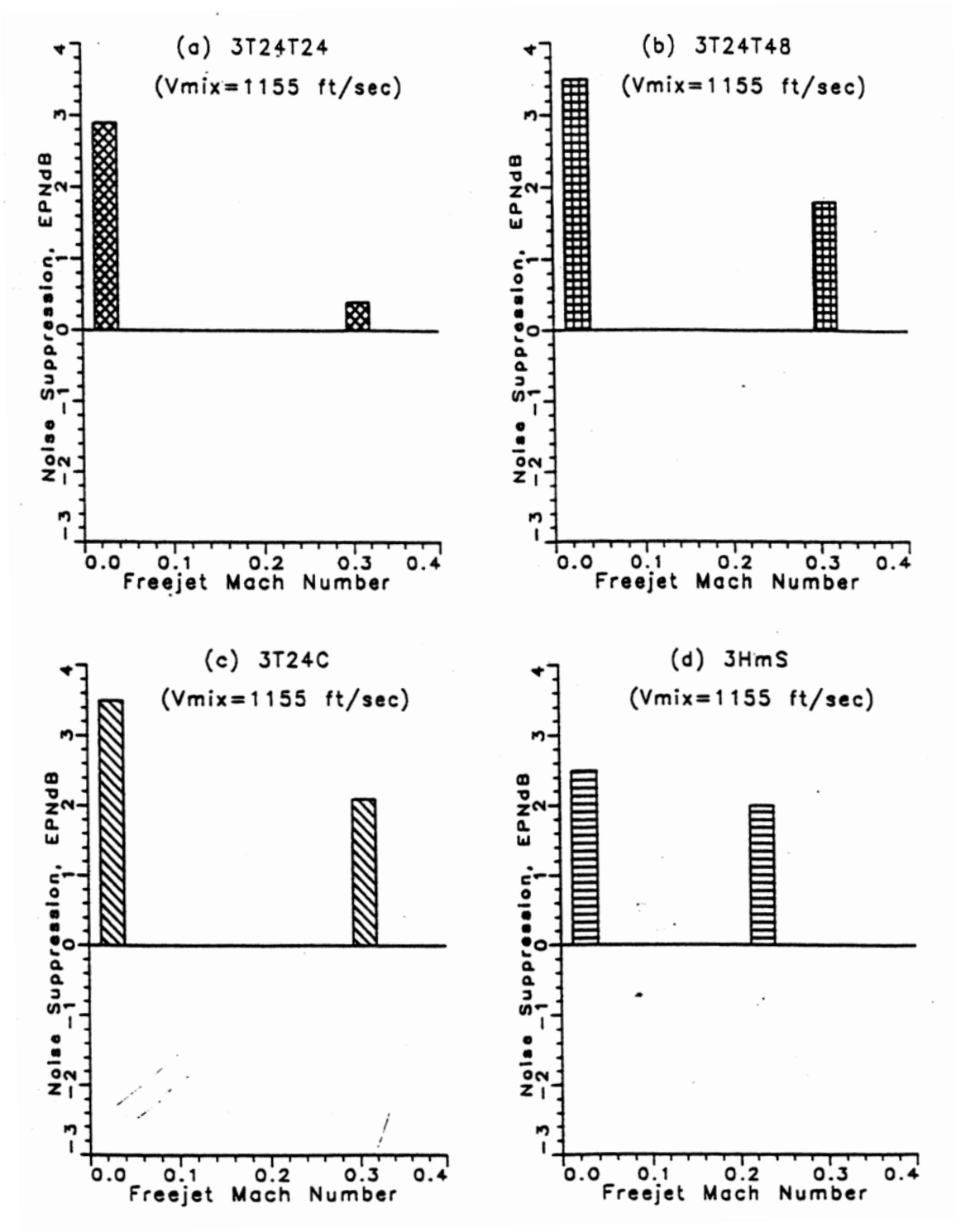


Figure 95. Effect of Freejet Mach Number on EPNL Reductions for Model 3 Jet Noise Suppression Devices ; (a) 3T24T24, (b) 3T24T48, (c) 3T24C and (d) 3HmS.

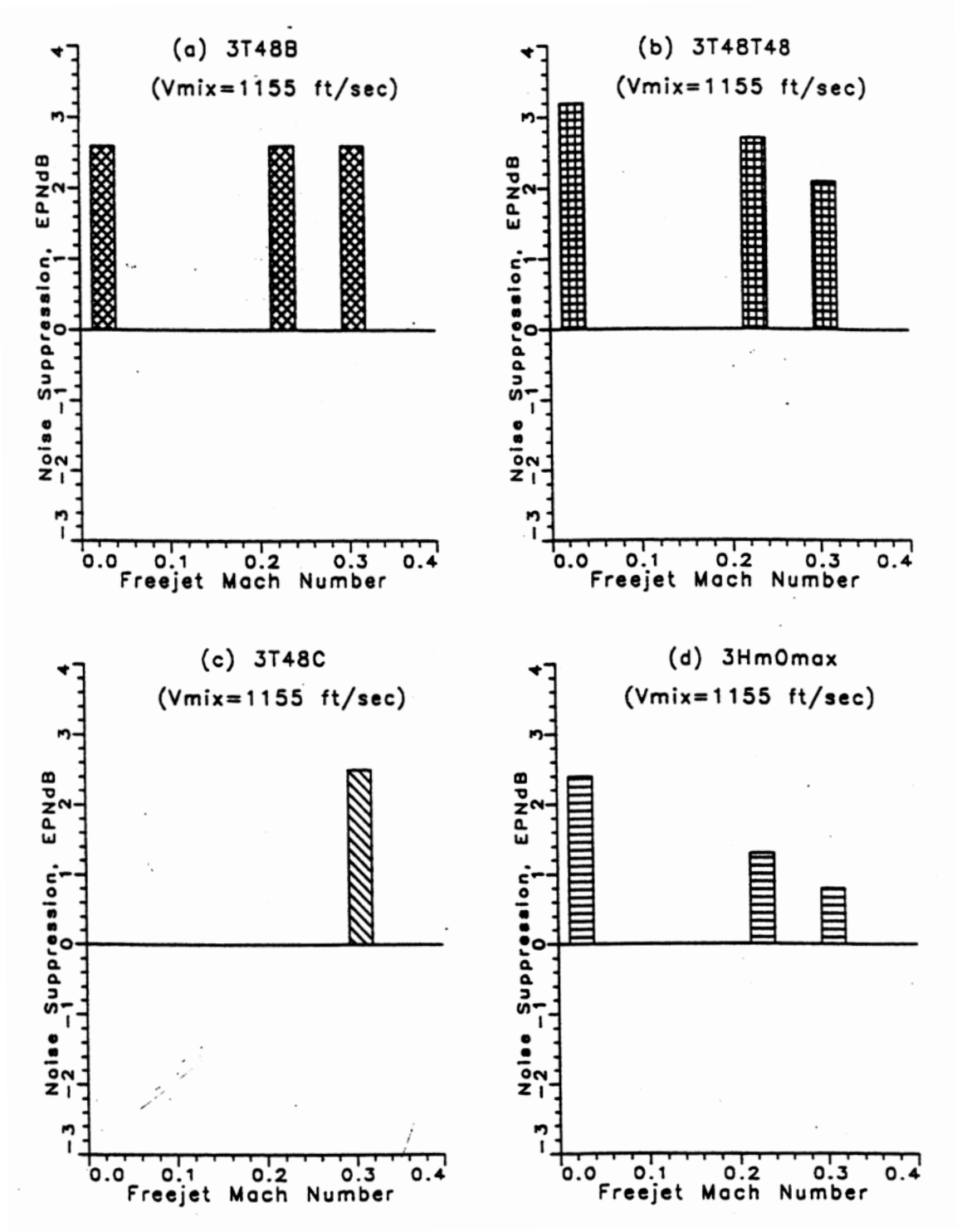


Figure 96. Effect of Freejet Mach Number on EPNL Reductions for Model 3 Jet Noise Suppression Devices ; (a) 3T48B, (b) 3T48T48, (c) 3T48C and (d) 3HmOmax.

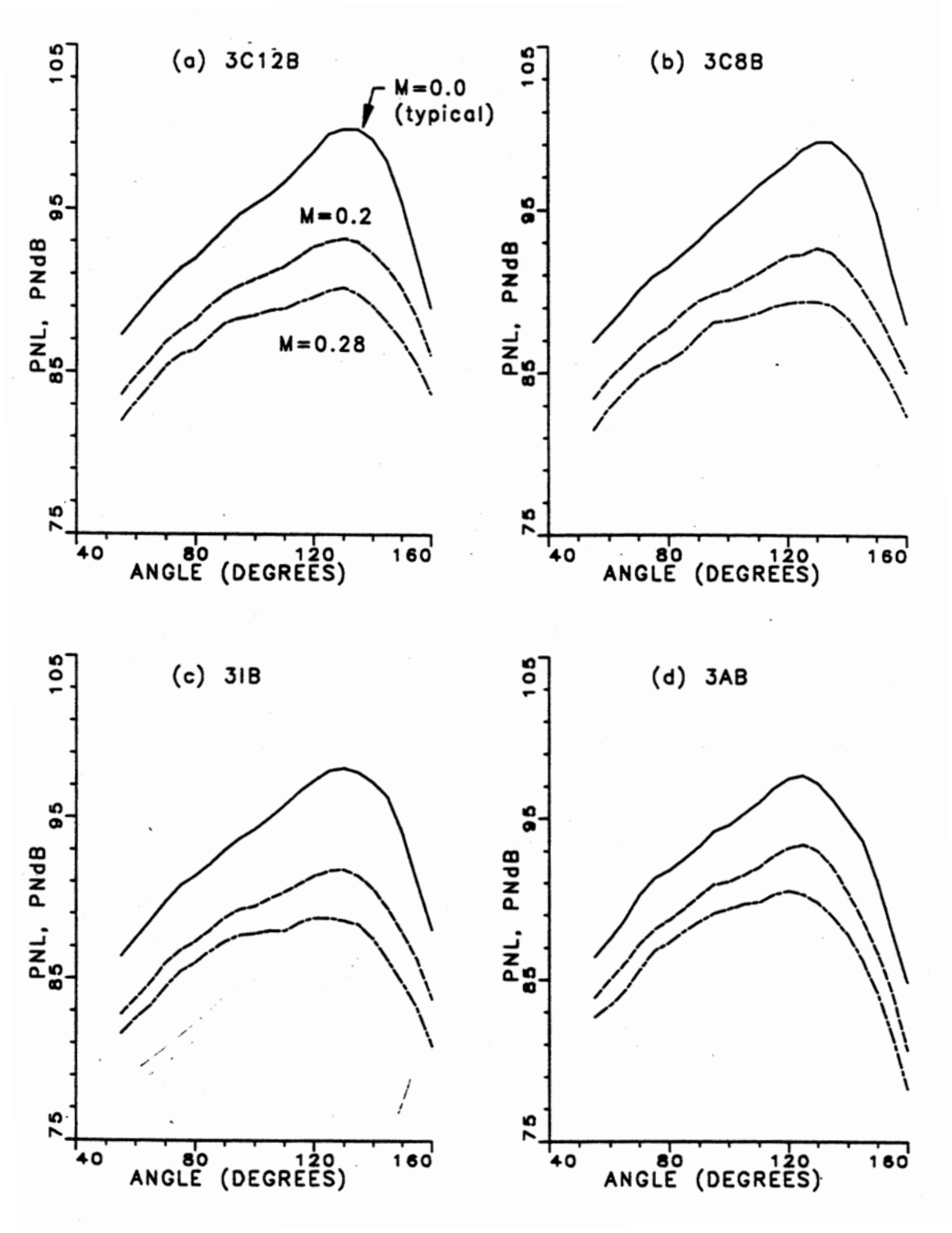


Figure 97. Effect of Freejet Mach Number on PNL Directivities (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3C12B, (b) 3C8B, (c) 3IB and (d) 3AB.

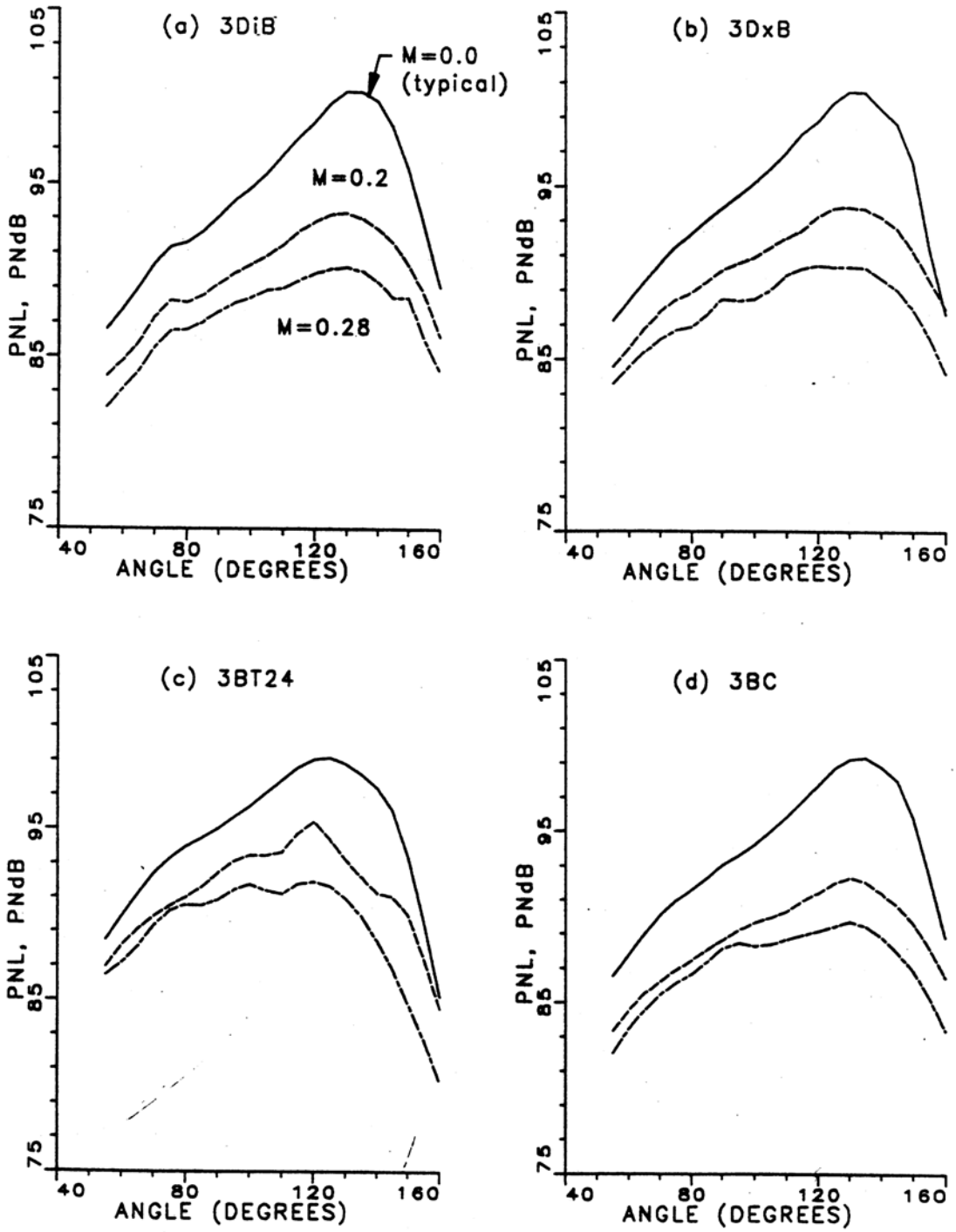


Figure 98. Effect of Freejet Mach Number on PNL Directivities (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3DiB, (b) 3DxB, (c) 3BT24 and (d) 3BC.

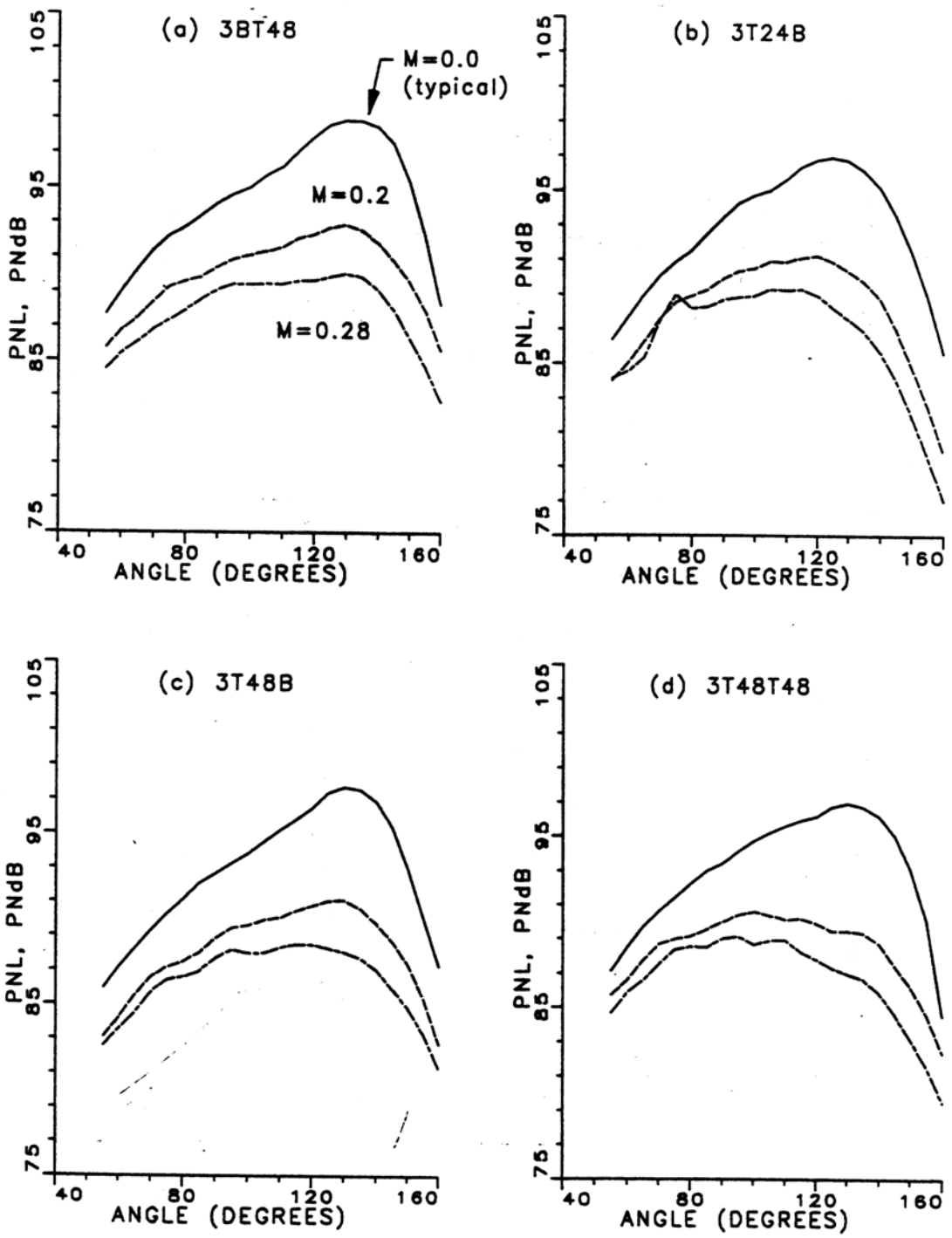


Figure 99. Effect of Freejet Mach Number on PNL Directivities (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3BT48, (b) 3T24B, (c) 3T48B and (d) 3T48T48.

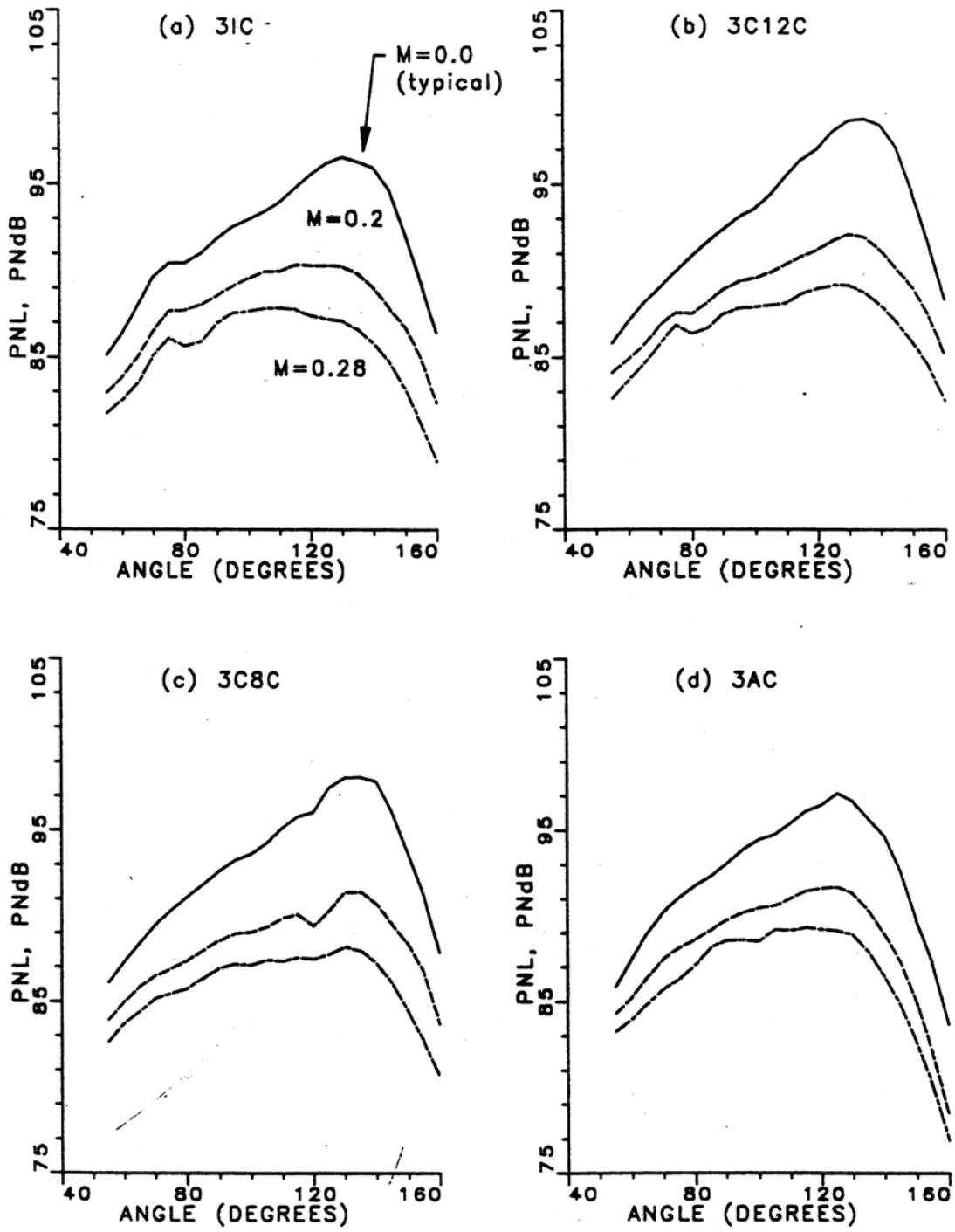


Figure 100. Effect of Freejet Mach Number on PNL Directivities (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3IC, (b) 3C12C, (c) 3C8C and (d) 3AC.

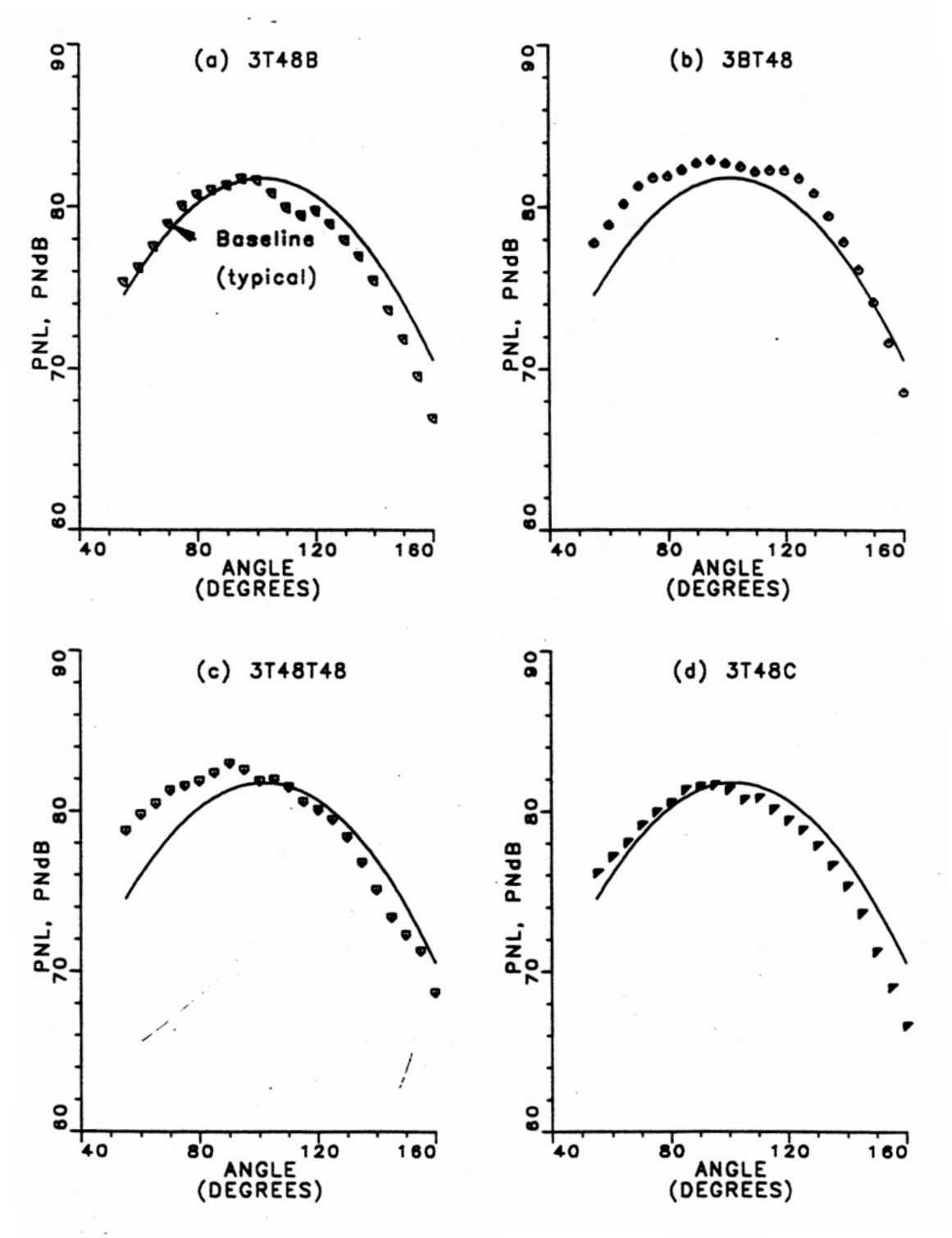


Figure 101. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3T48B, (b) 3BT48, (c) 3T48T48 and (d) 3T48C.

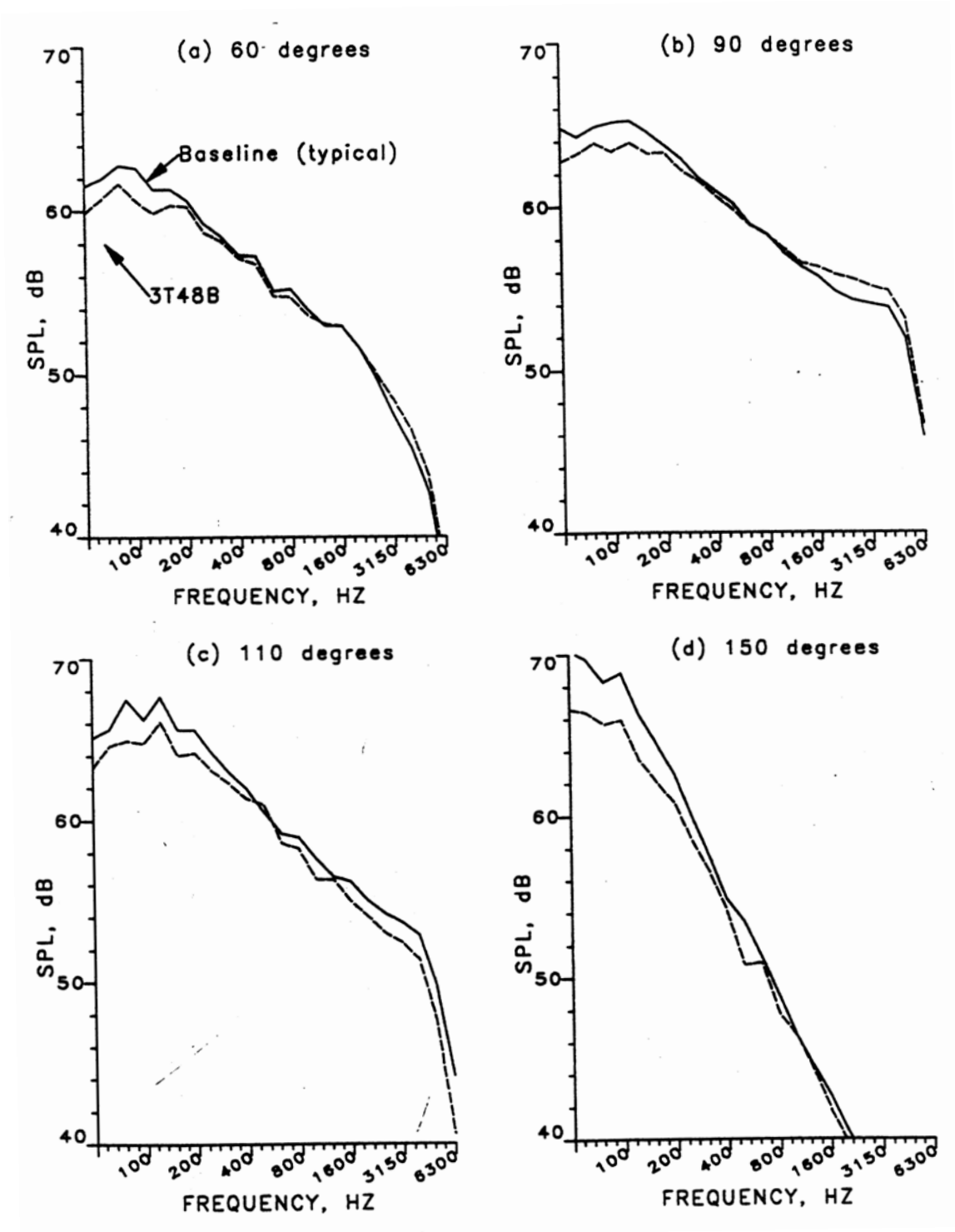


Figure 102. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3T48B) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

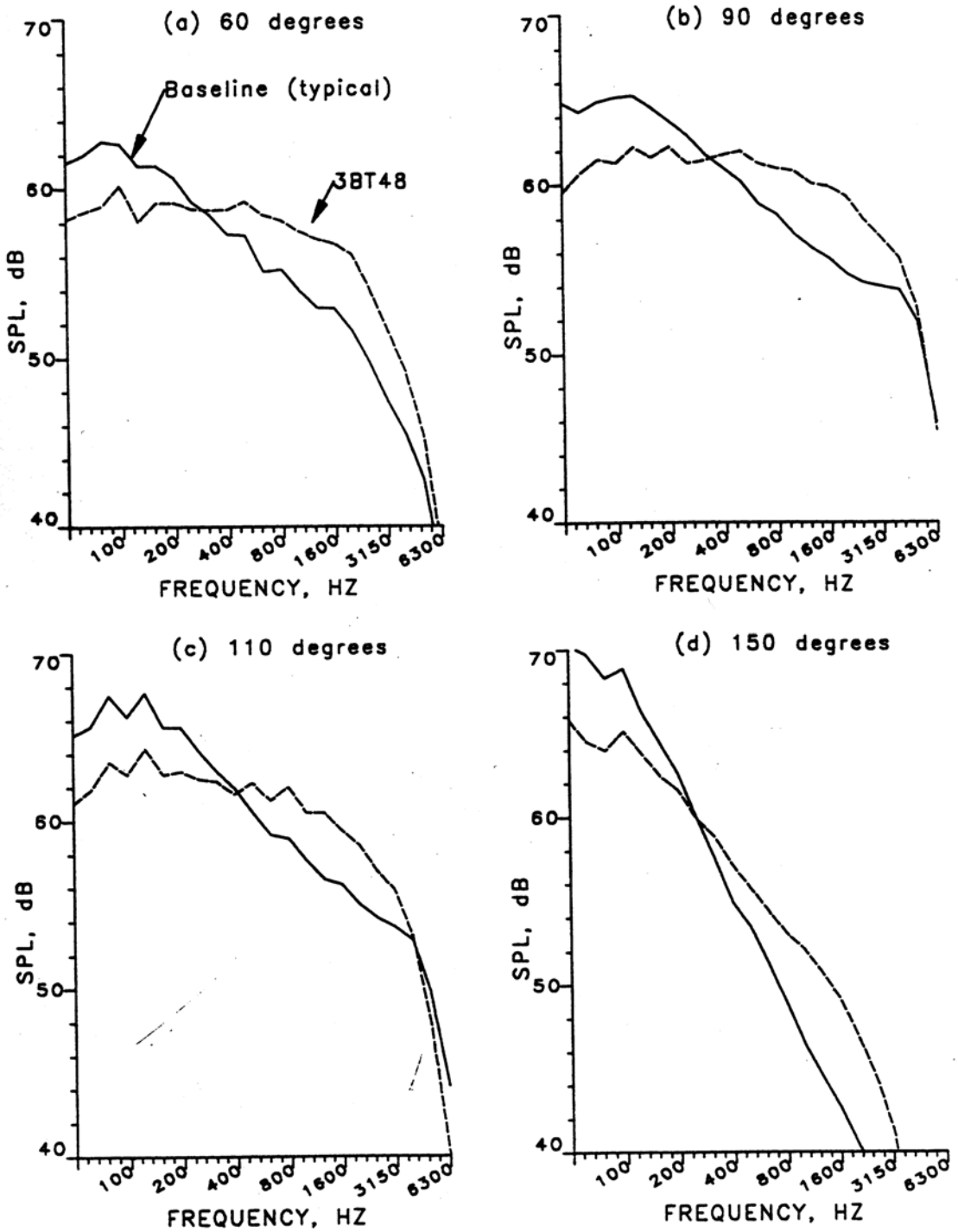


Figure 103. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3BT48) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

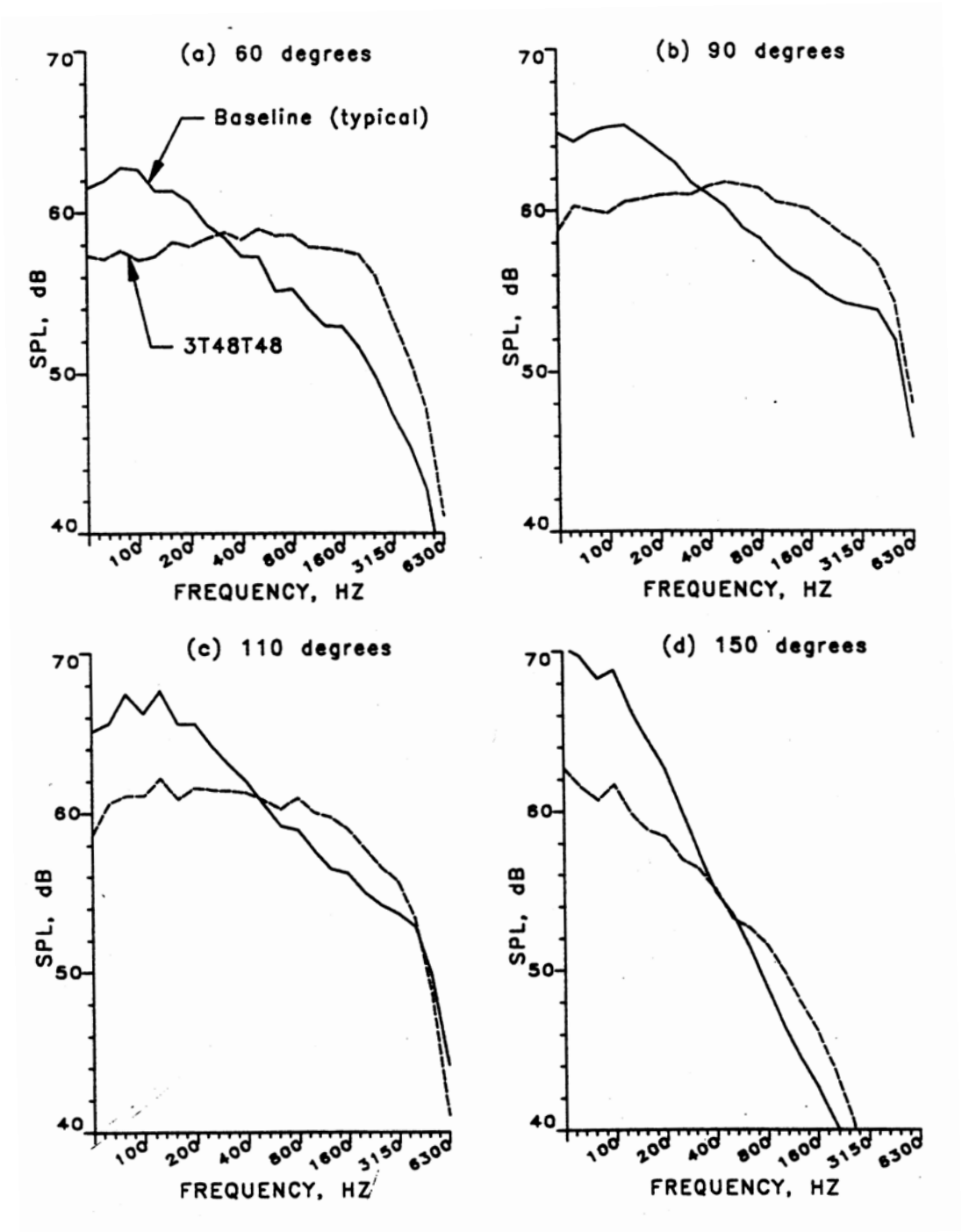


Figure 104. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3T48T48) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

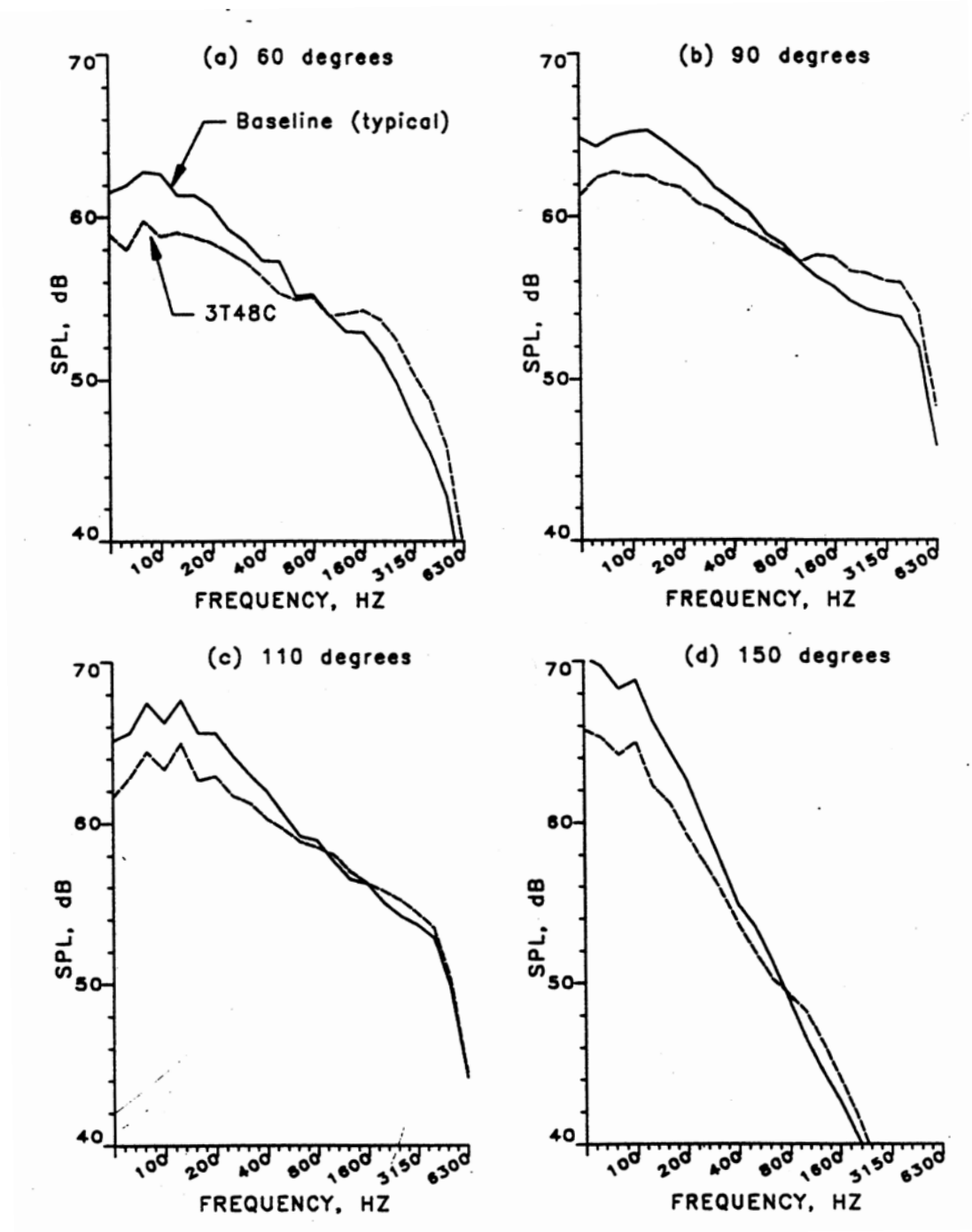


Figure 105. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3T48C) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

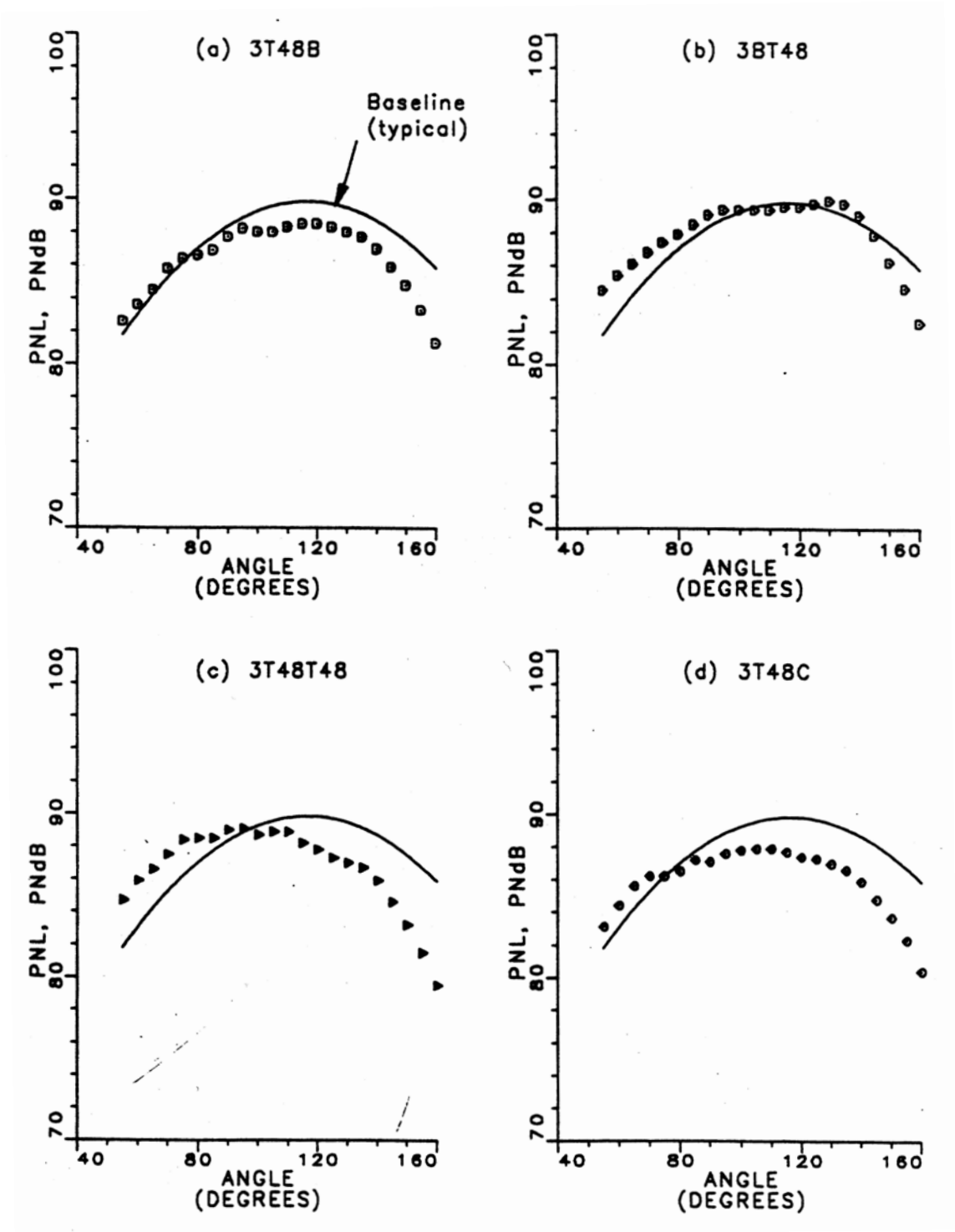


Figure 106. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3T48B, (b) 3BT48, (c) 3T48T48 and (d) 3T48C.

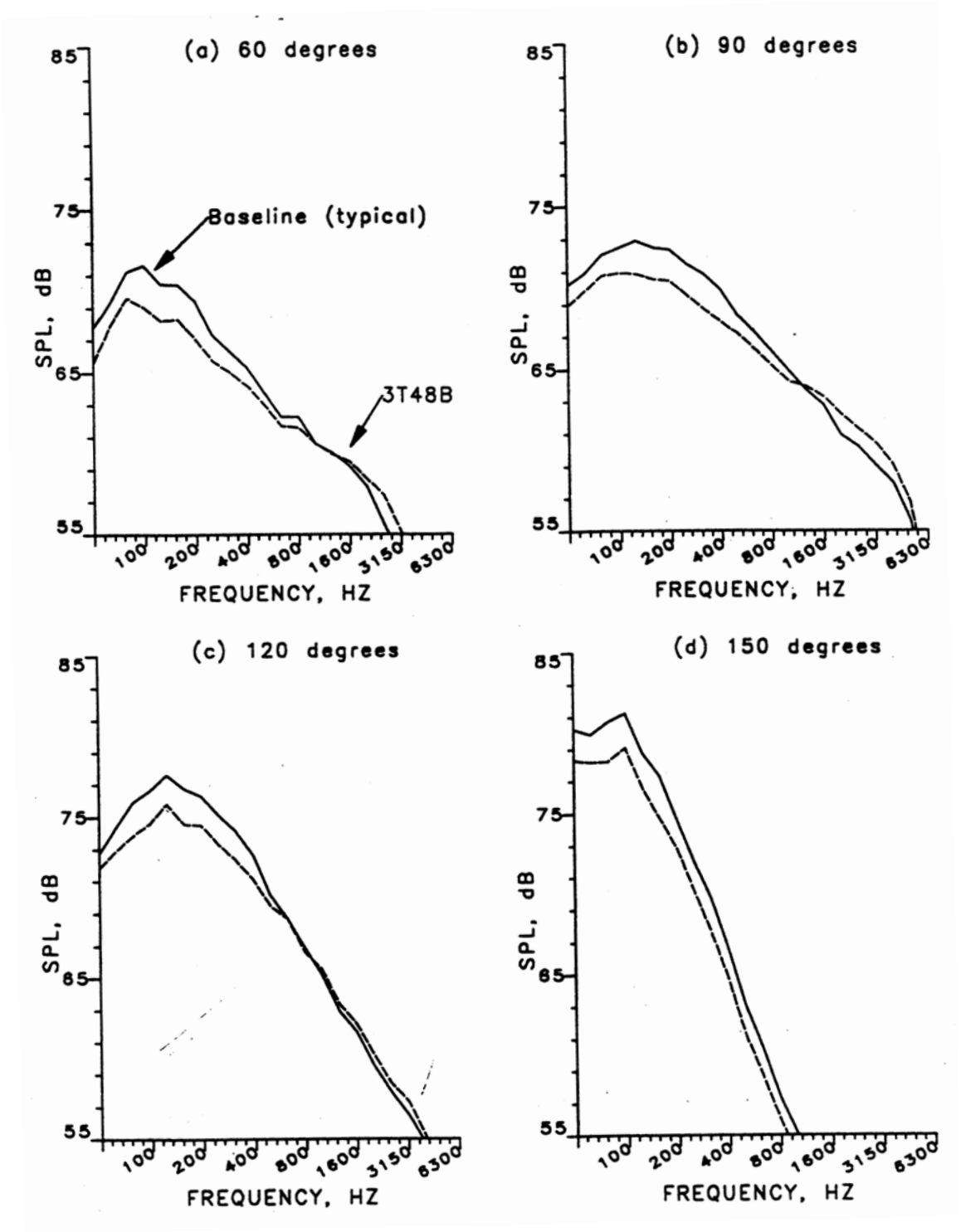


Figure 107. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3T48B) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. (peak PNL angle) and (d) 150 deg.

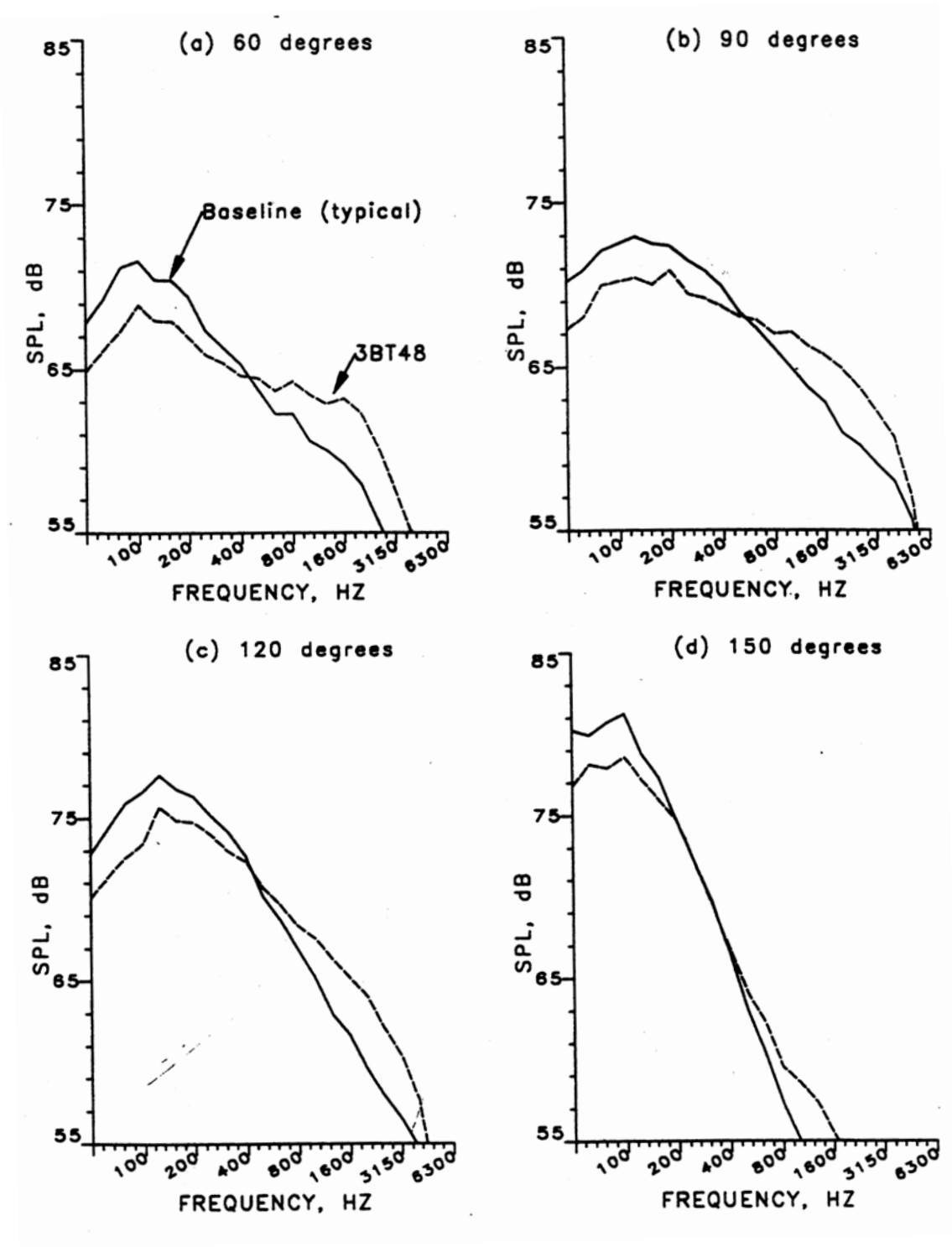


Figure 108. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3BT48) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. (peak PNL angle) and (d) 150 deg.

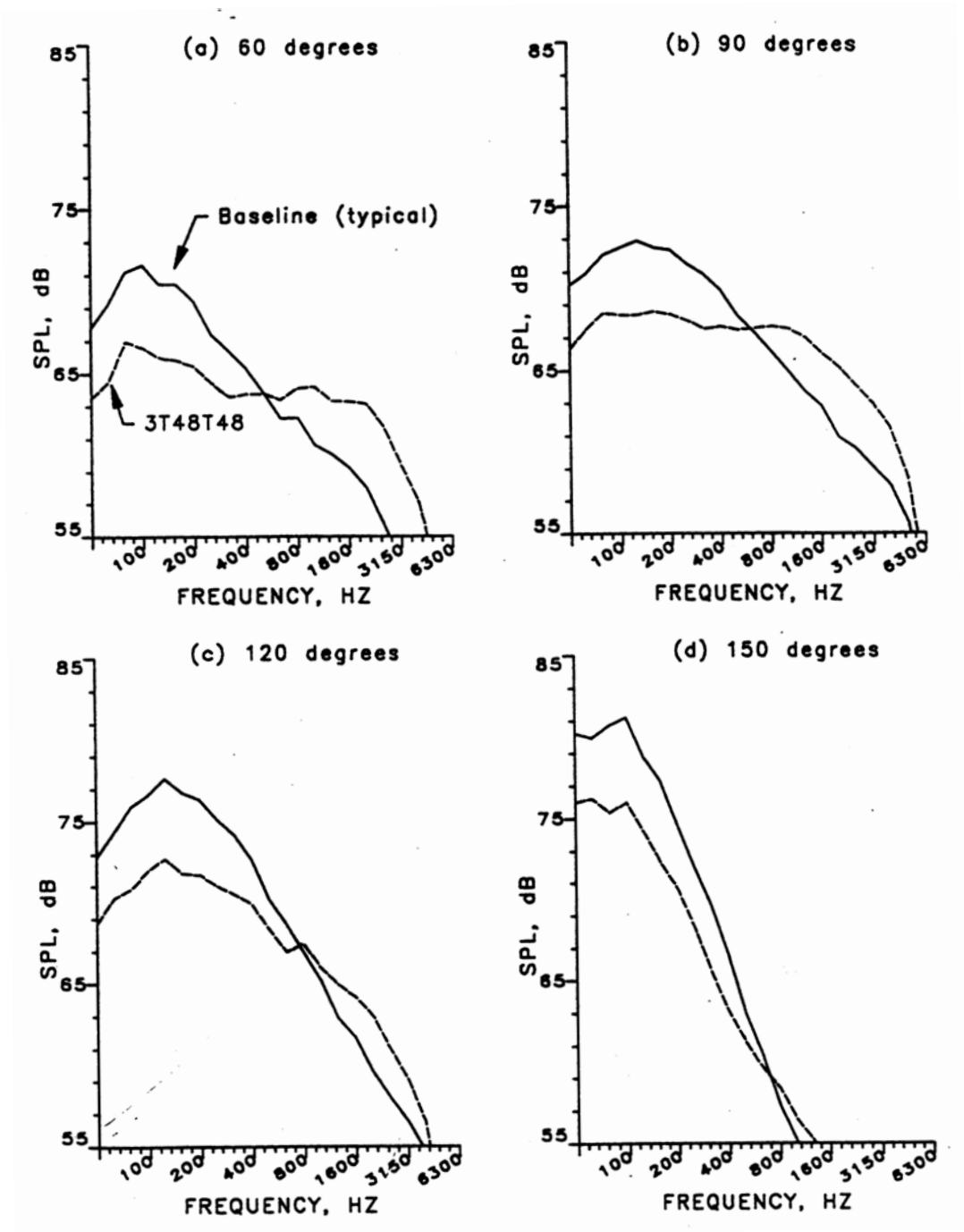


Figure 109. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3T48T48) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. (peak PNL angle) and (d) 150 deg.

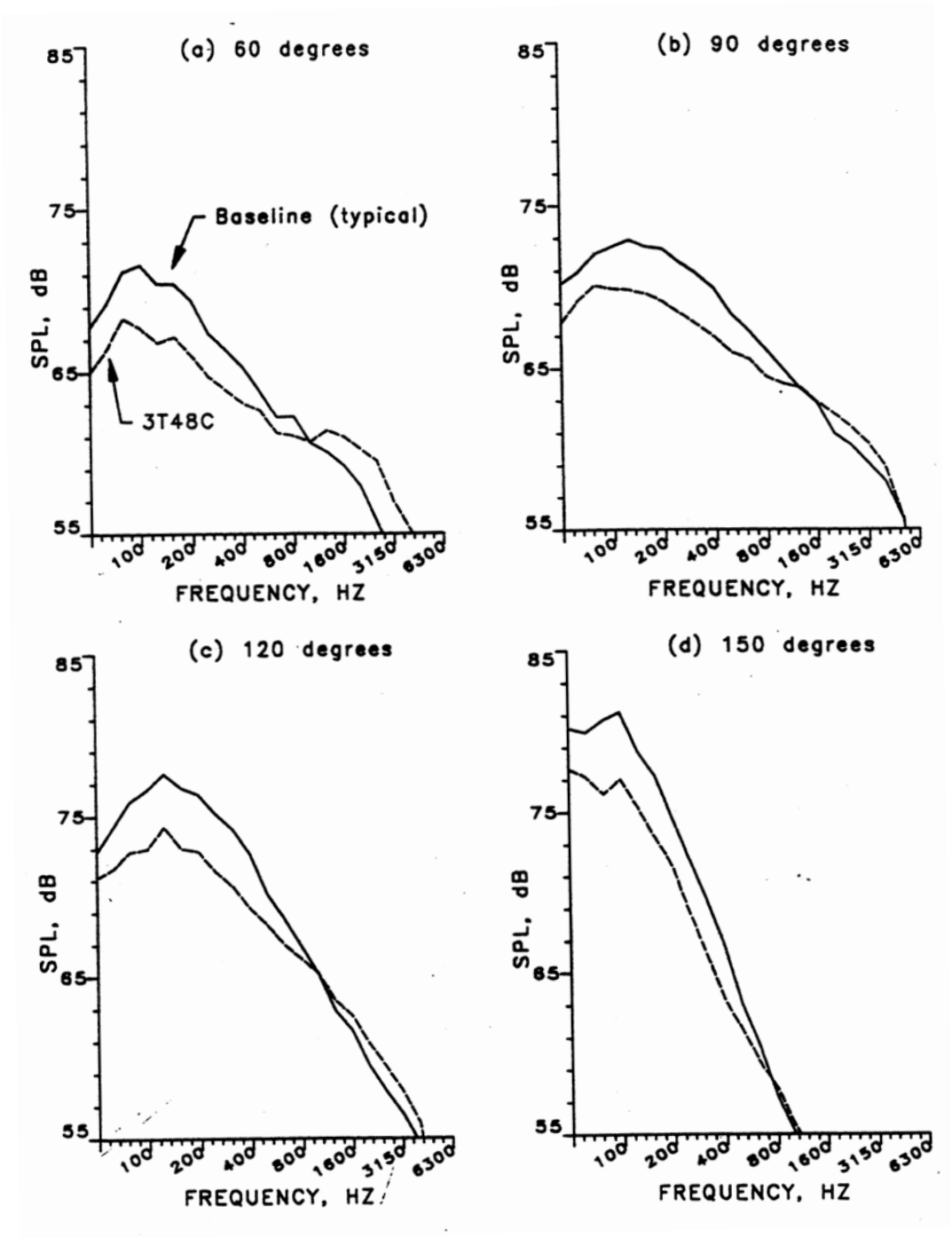


Figure 110. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3T48C) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. and (d) 150 deg.

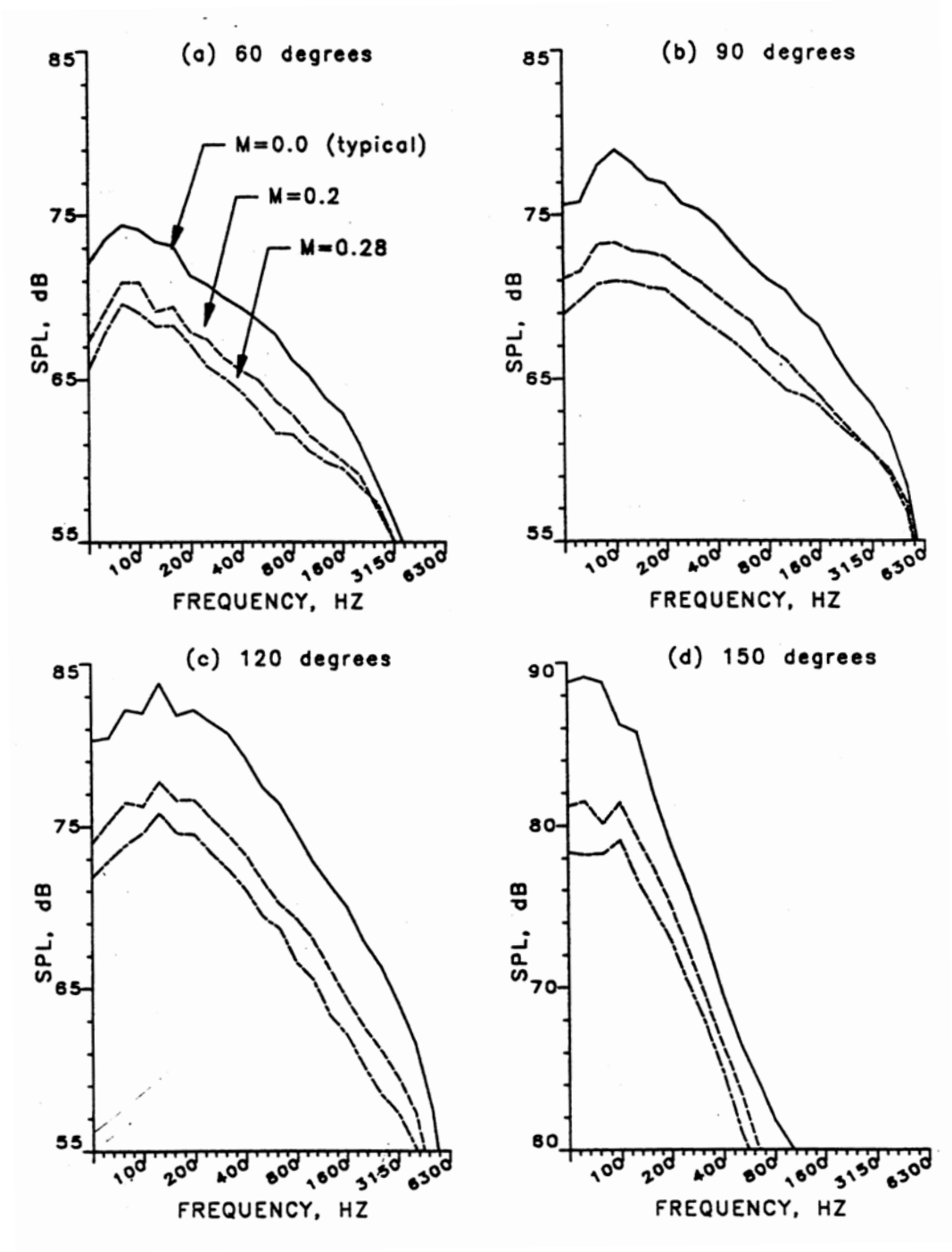


Figure 111. Effect of Freejet Mach Number on SPL Spectra (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3T48B) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. and (d) 150 deg.

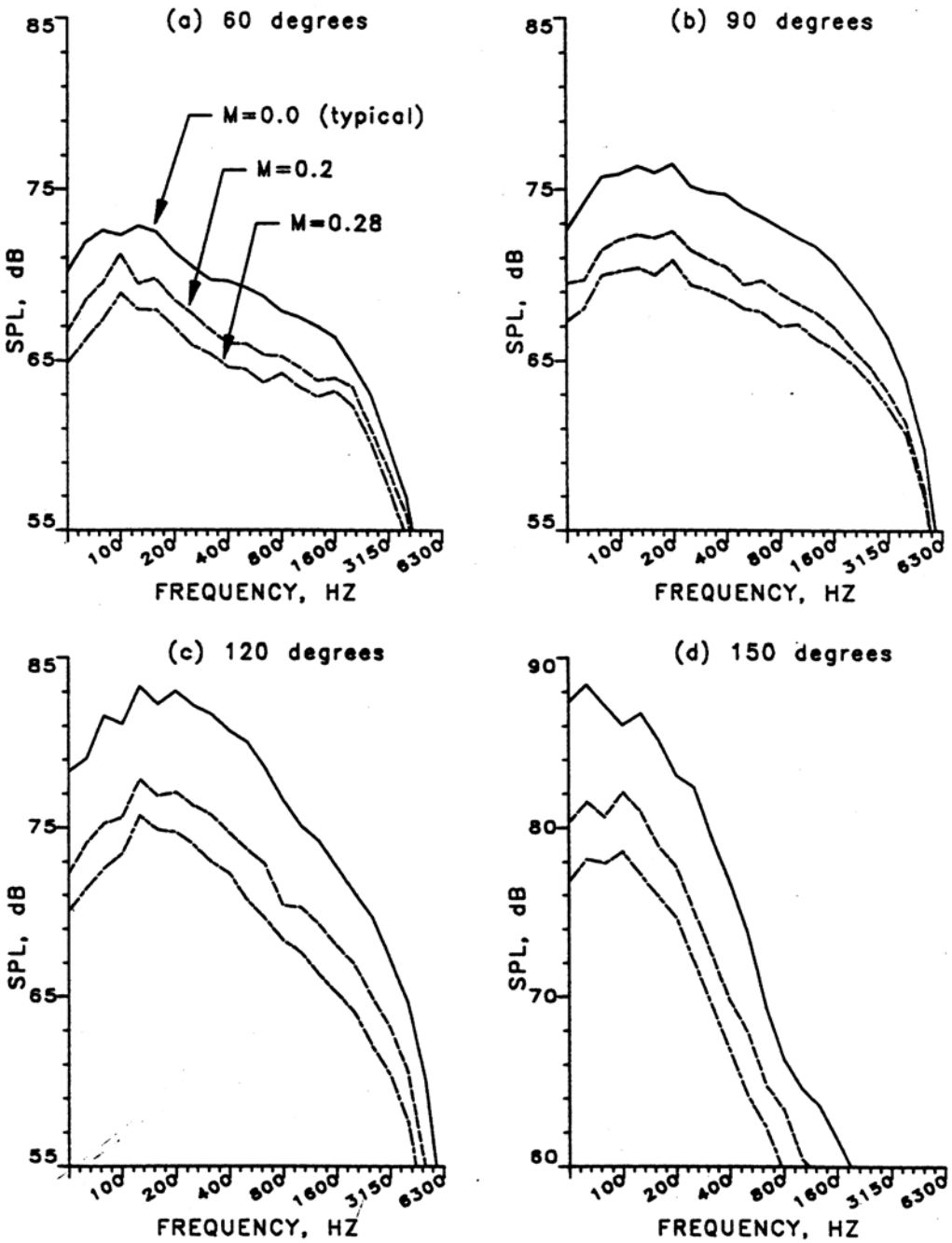


Figure 112. Effect of Freejet Mach Number on SPL Spectra (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3BT48) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. and (d) 150 deg.

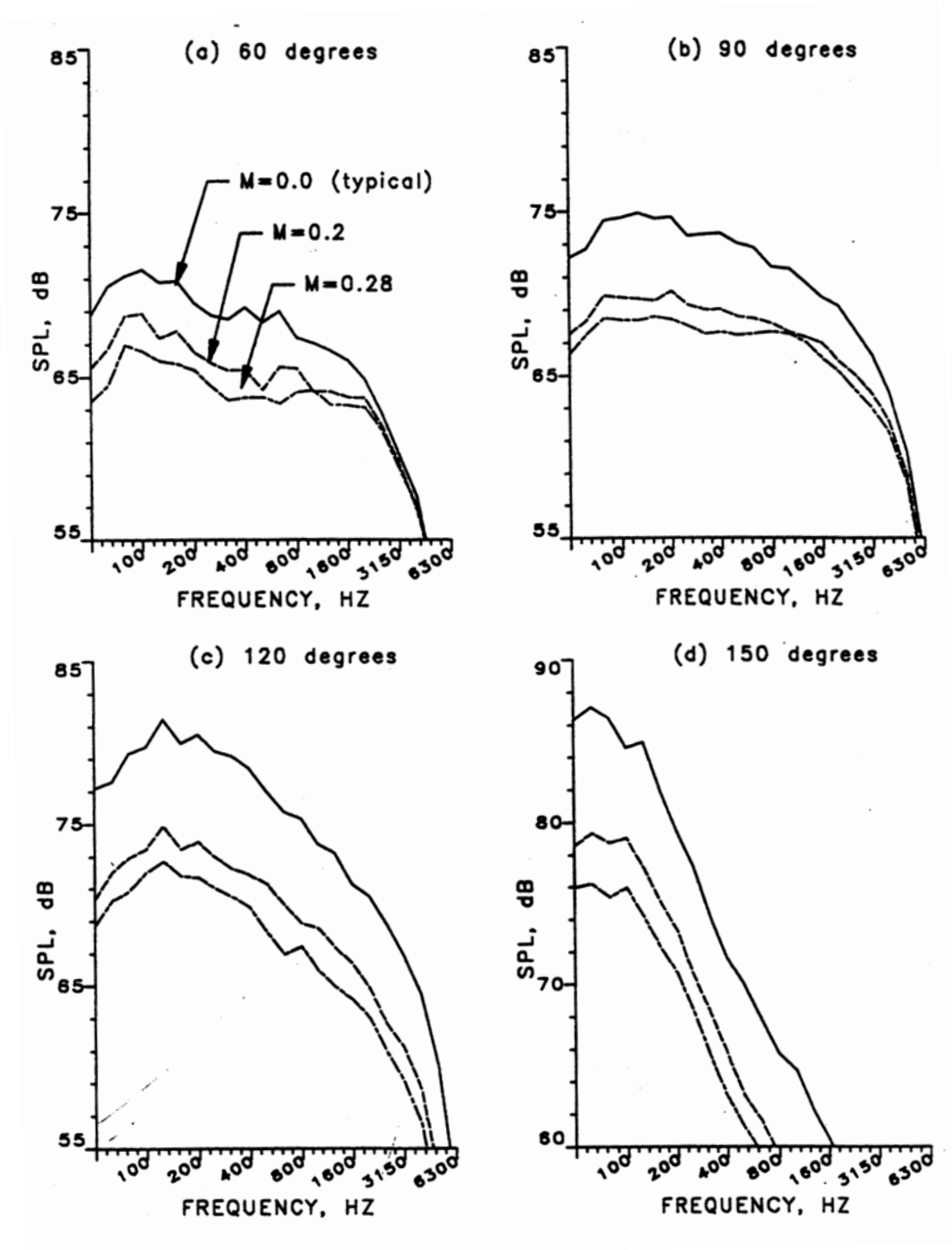


Figure 113. Effect of Freejet Mach Number on SPL Spectra (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3T48T48) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. and (d) 150 deg.

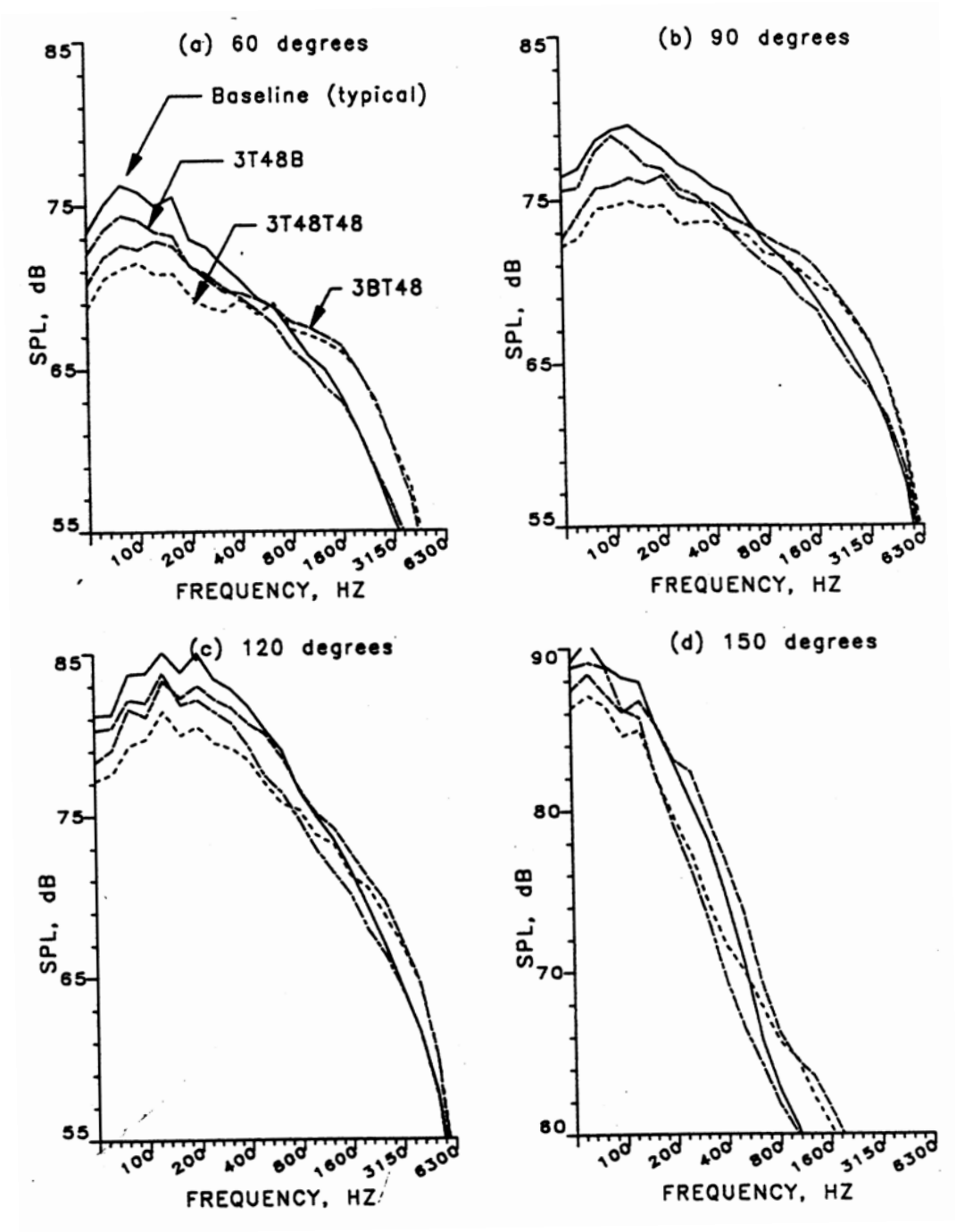


Figure 114. SPL Spectral Comparisons for the 48-Tabbed Jet Noise Suppression Devices (3T48B, 3BT48 and 3T48T48) at Vmix=1155 ft/sec and Freejet Mach Number = 0.0.

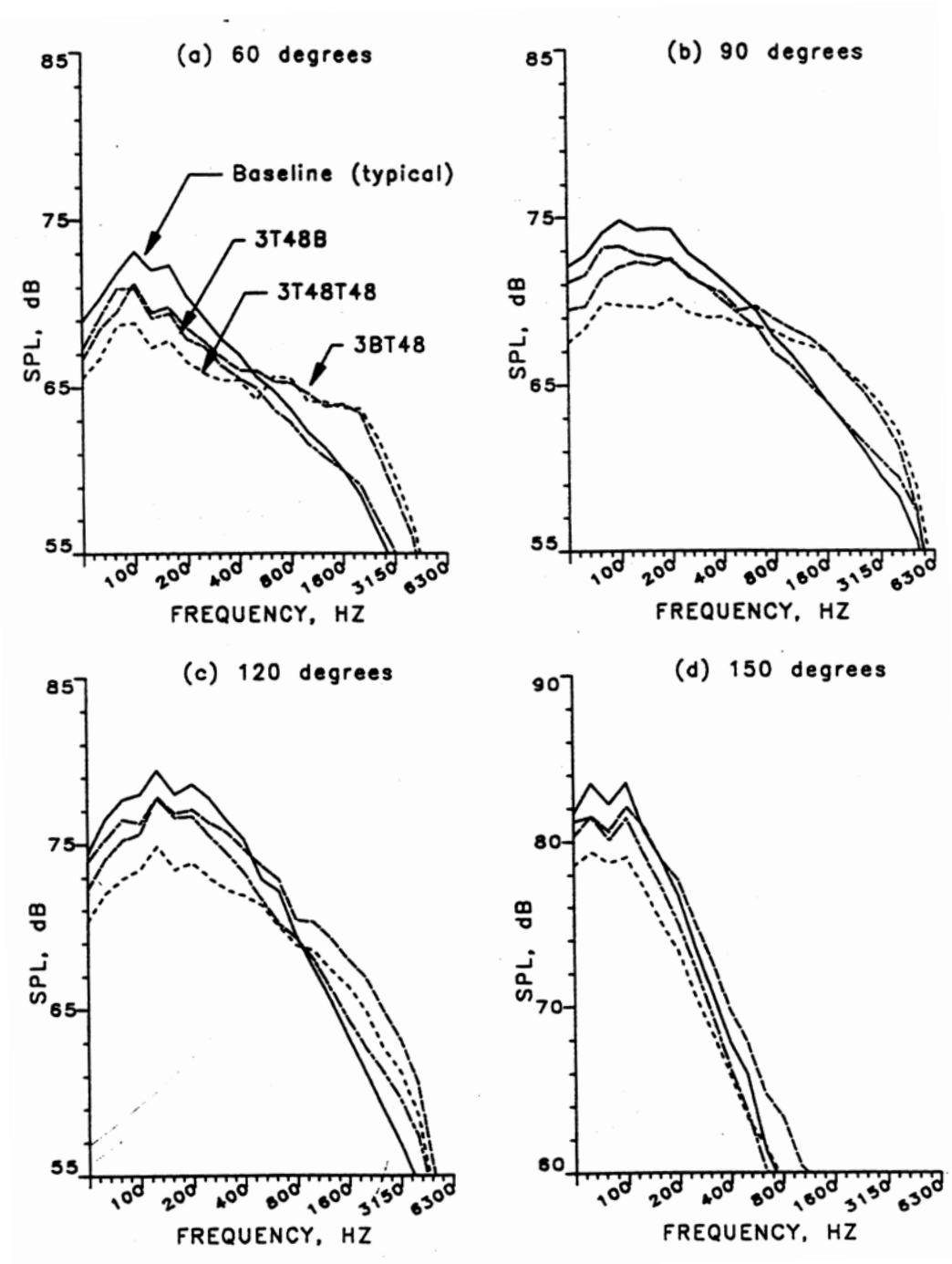


Figure 115. SPL Spectral Comparisons for the 48-Tabbed Jet Noise Suppression Devices (3T48B, 3BT48 and 3T48T48) at Vmix=1155 ft/sec and Freejet Mach Number = 0.20.

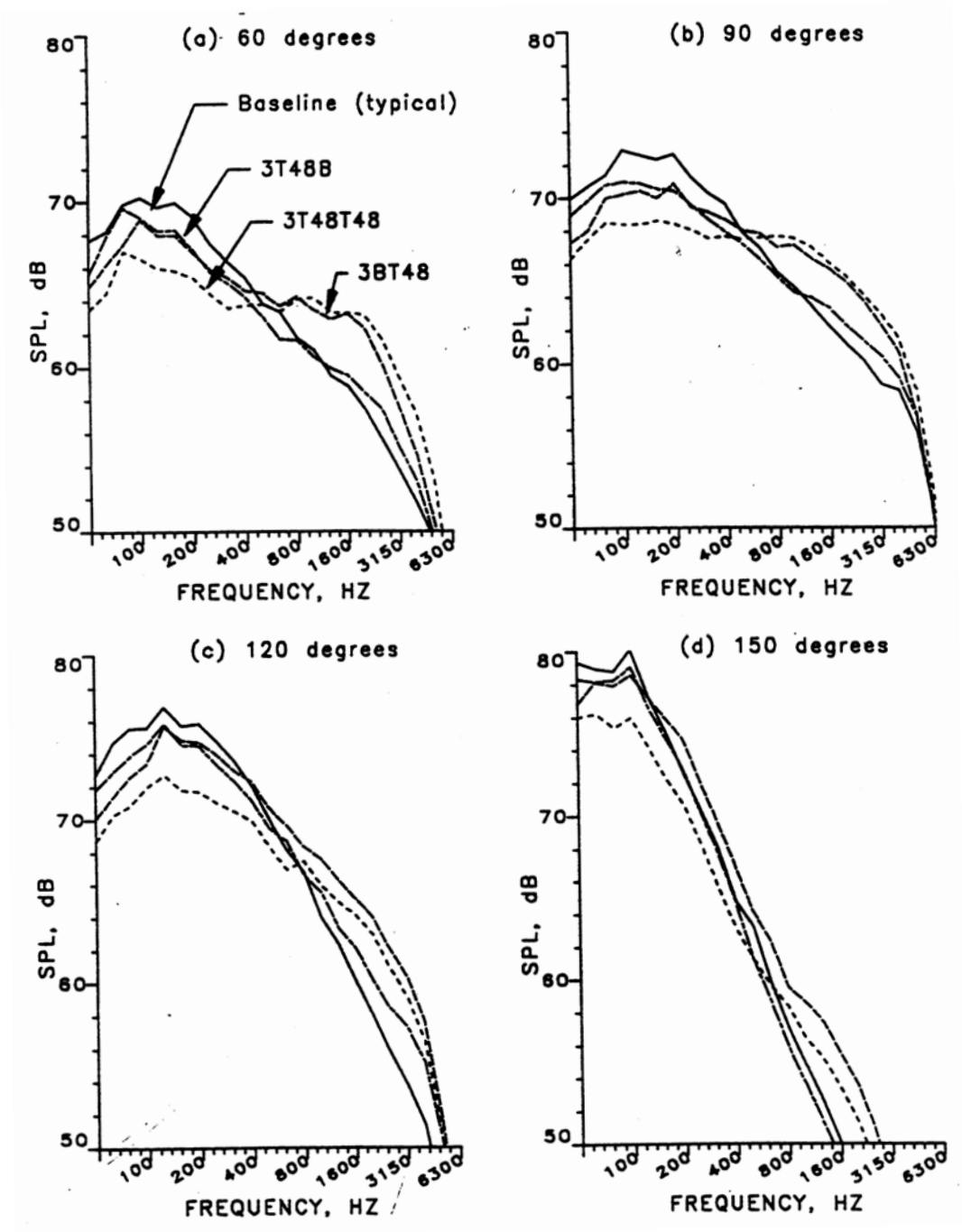


Figure 116. SPL Spectral Comparisons for the 48-Tabbed Jet Noise Suppression Devices (3T48B, 3BT48 and 3T48T48) at Vmix=1155 ft/sec and Freejet Mach Number = 0.28.

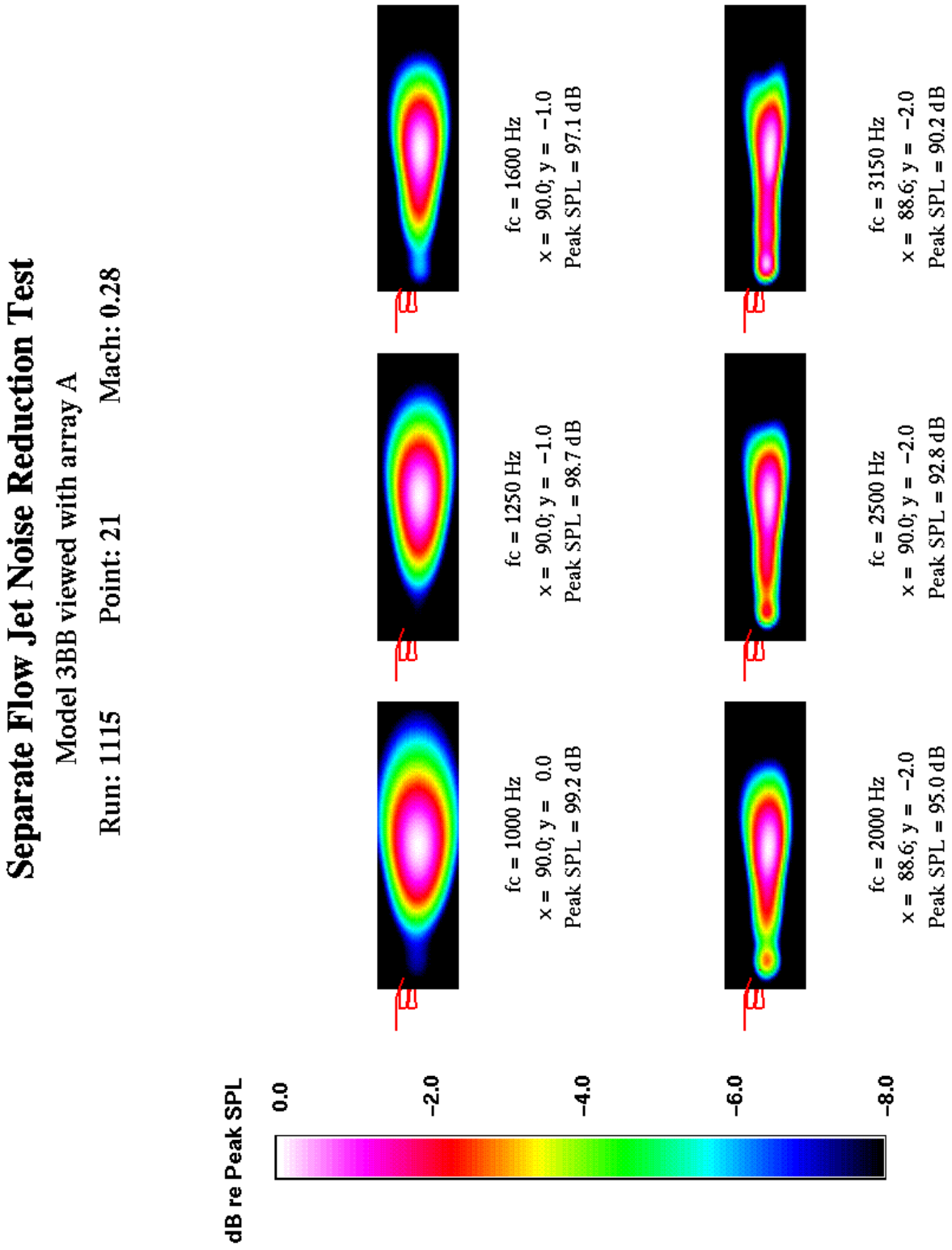


Figure 117. Baseline External Plug Nozzle (3BB) Viewed with Array A

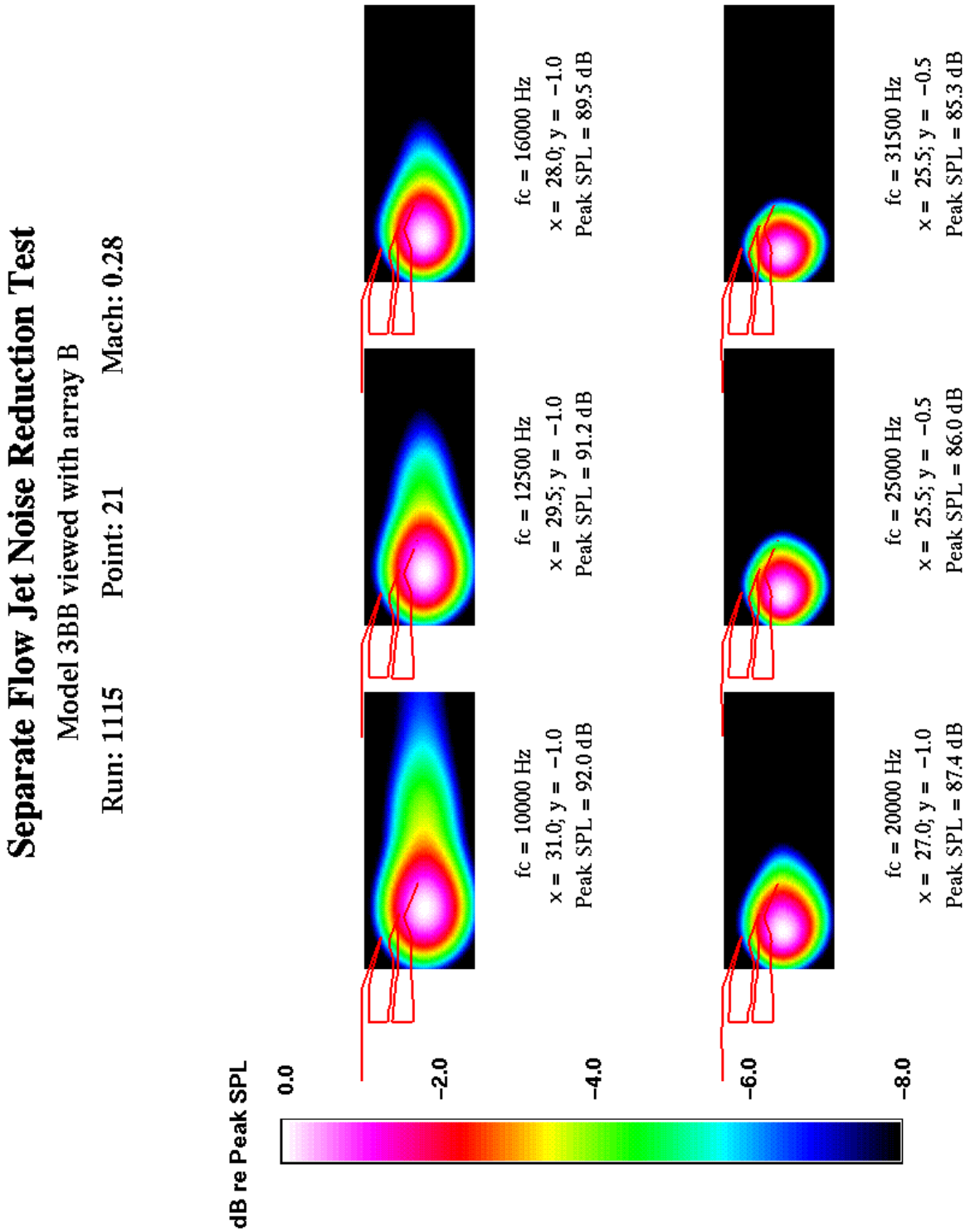


Figure 118. Baseline Extended Plug Nozzle (3BB) Viewed with Array B

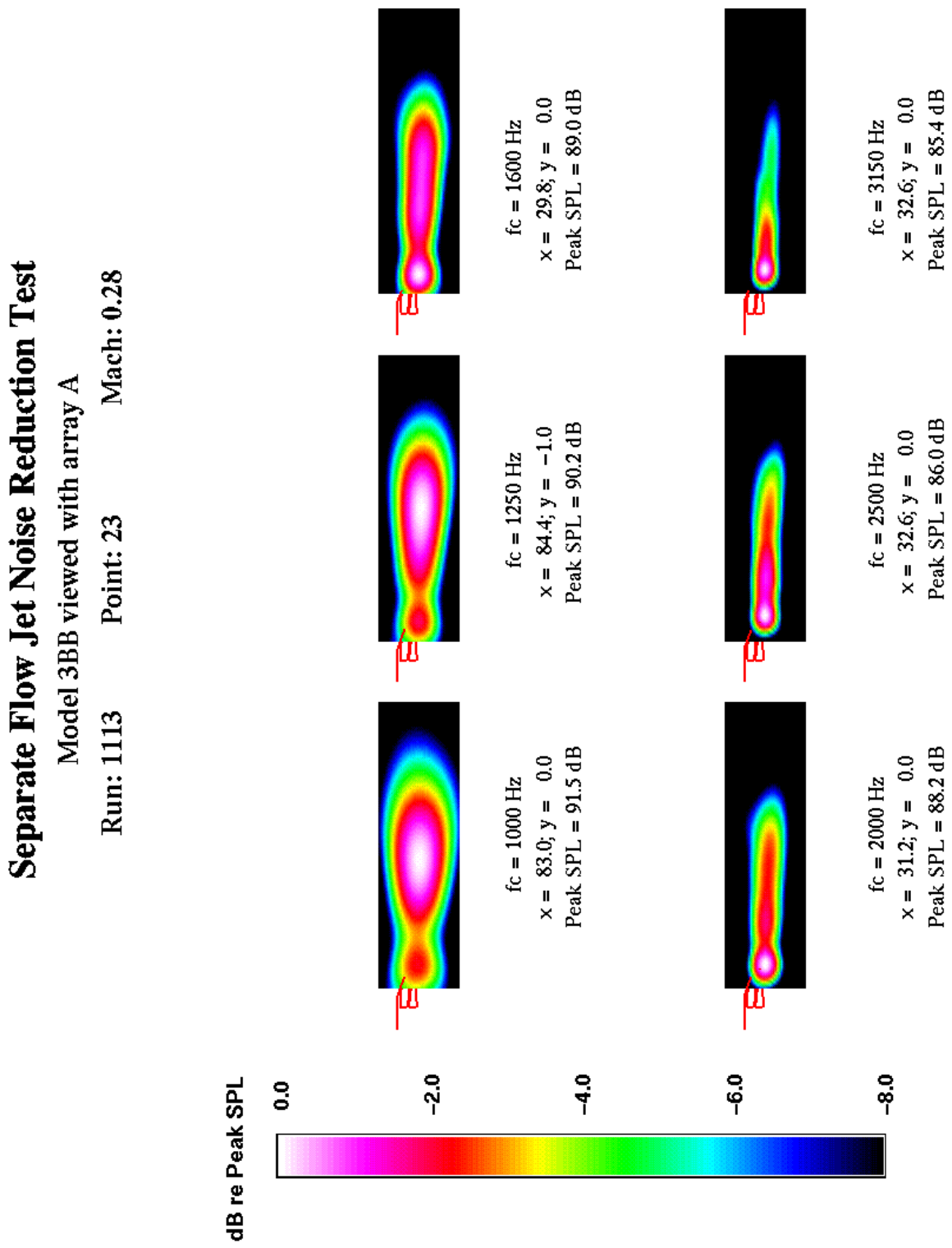


Figure 119. Baseline (3BB) Viewed with Array A at Cutback Power

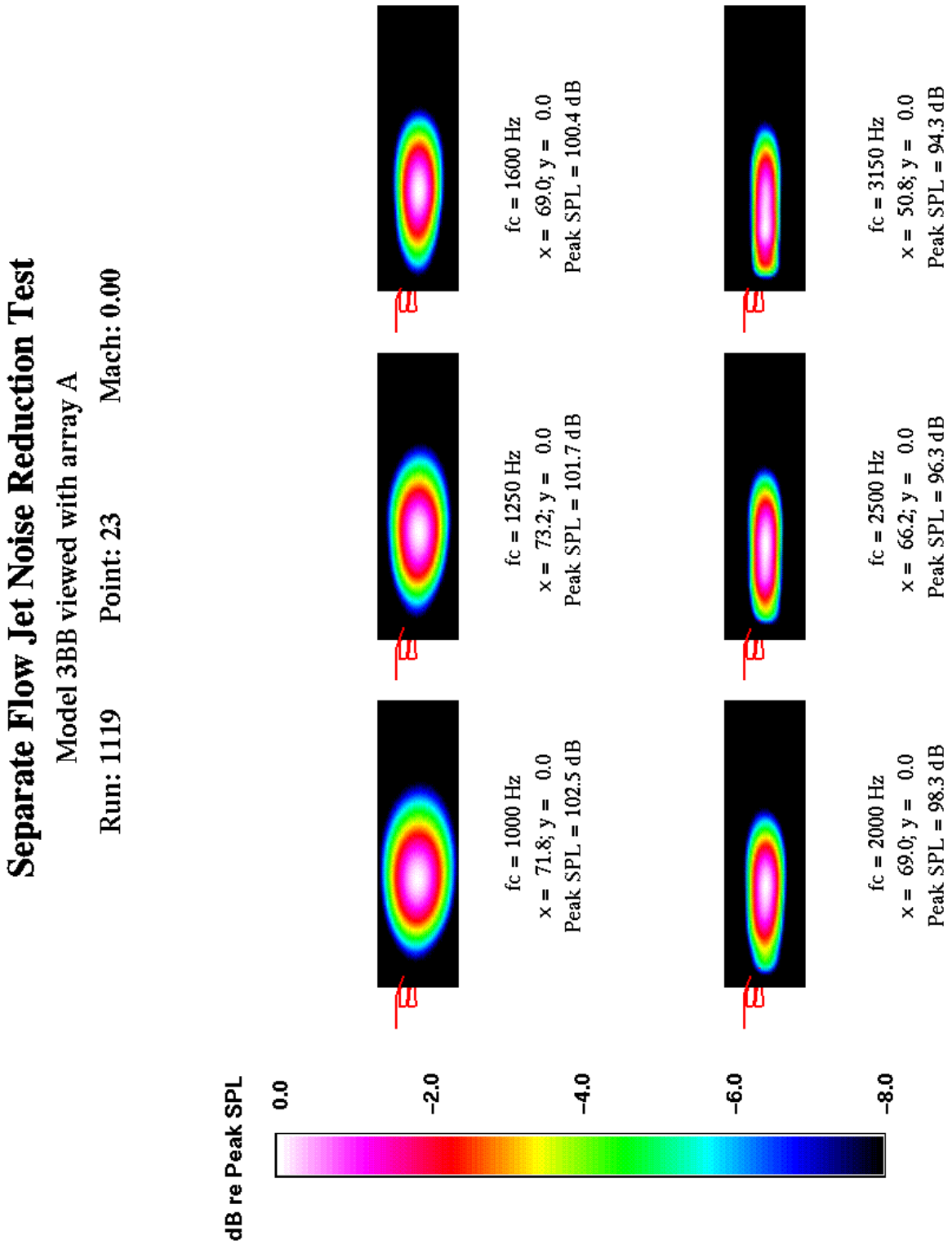


Figure 120. Baseline (3BB) Viewed with Array A at Tunnel Mach No. of 0.0

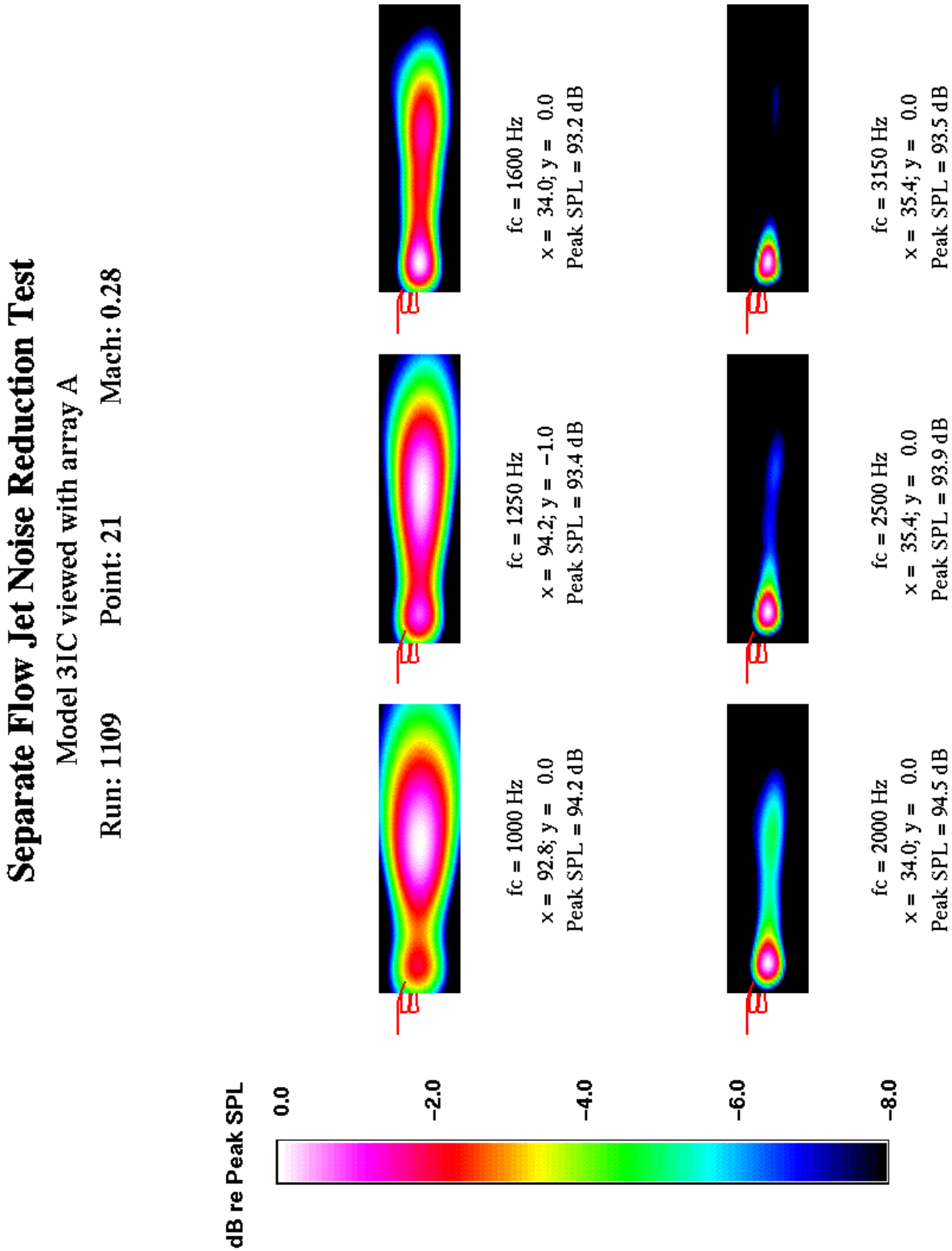


Figure 121. Chevron Nozzle (3IC) Viewed with Array A.

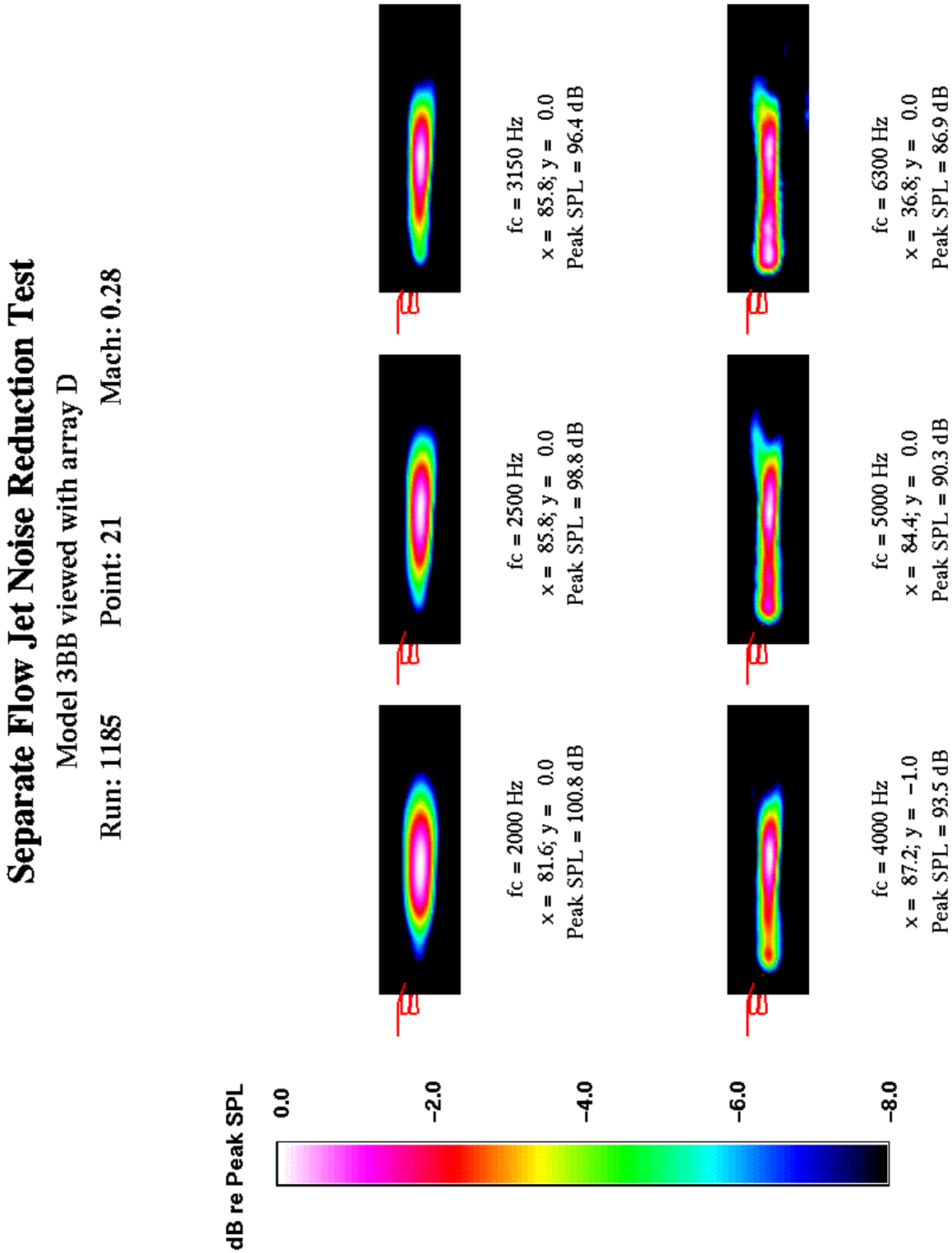


Figure 122. Baseline (3BB) Viewed with Array D
(Downstream Array, 120 deg. View Angle)

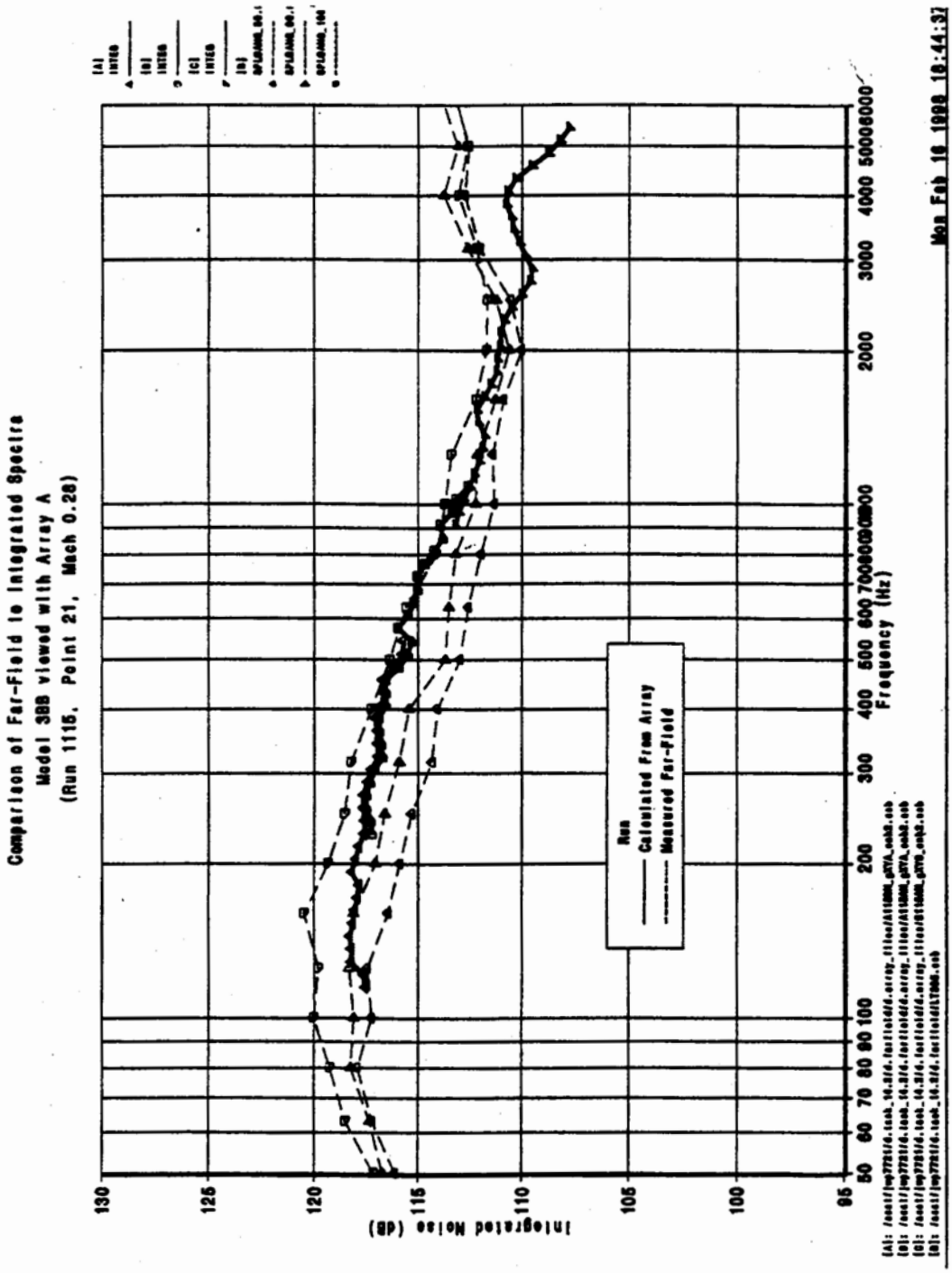


Figure 123. Baseline (3BB) Integrated Spectra Compared to Sideline Data (normalized to 1-ft distance).

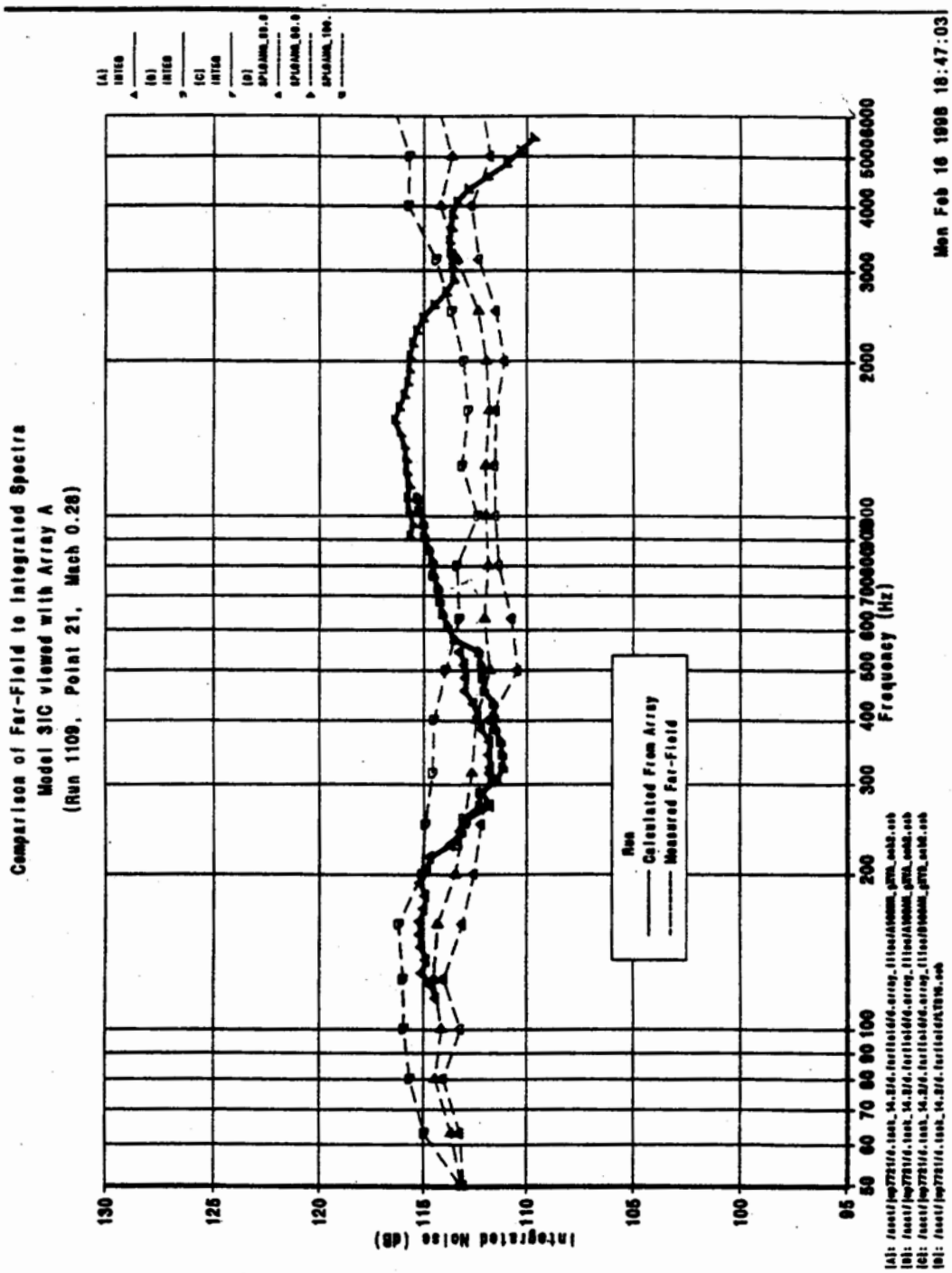


Figure 124. Chevron (3IC) Integrated Spectra Compared to Sideline Data (normalized to 1-ft distance).

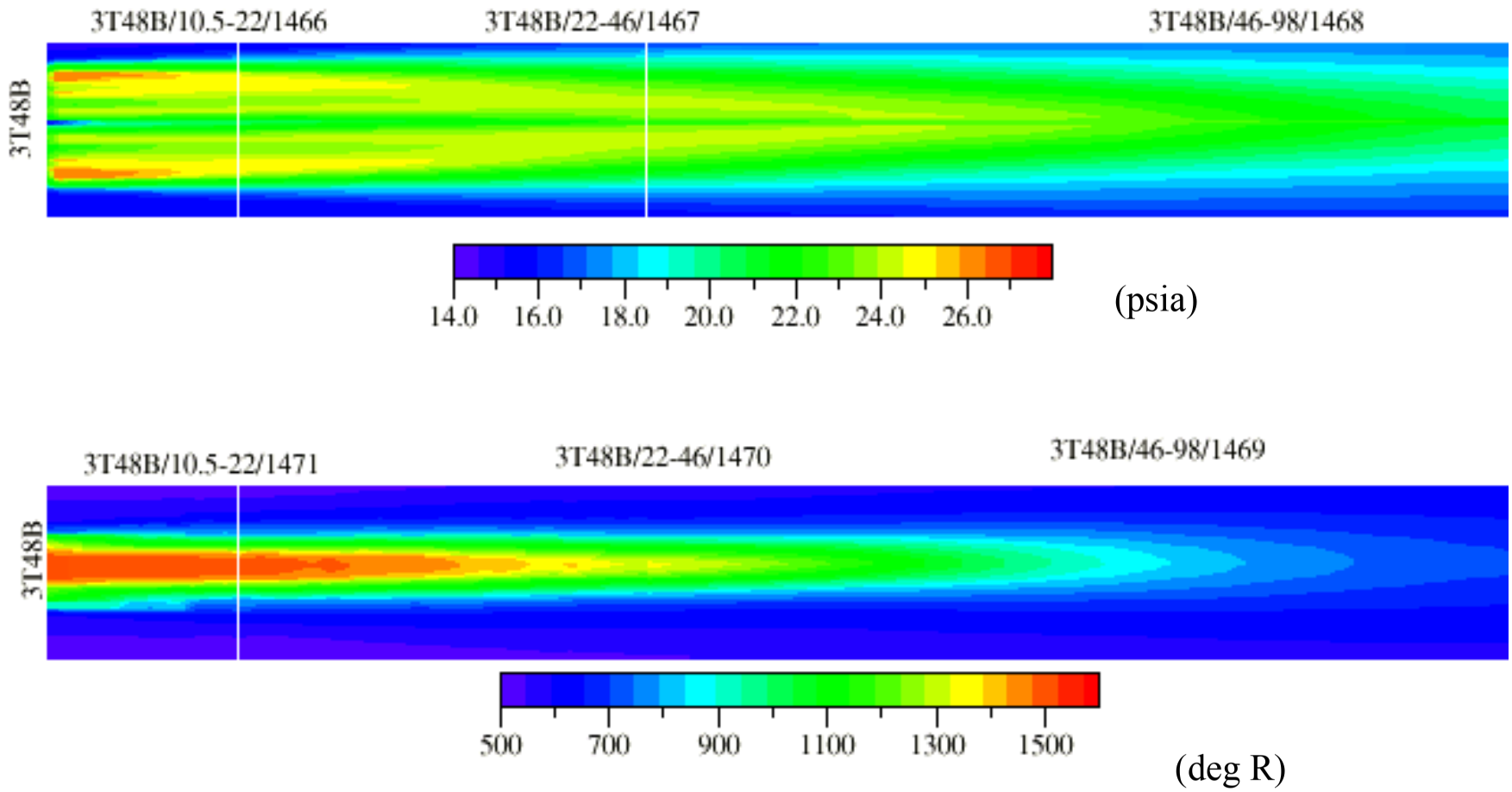


Figure 125a. Traverse Profiles for Nozzle Configuration 3T48B: Axial View of Total Pressure (psia) and Total Temperature (deg. R) (Axial Distance x=10.5 to 98.0 inches)

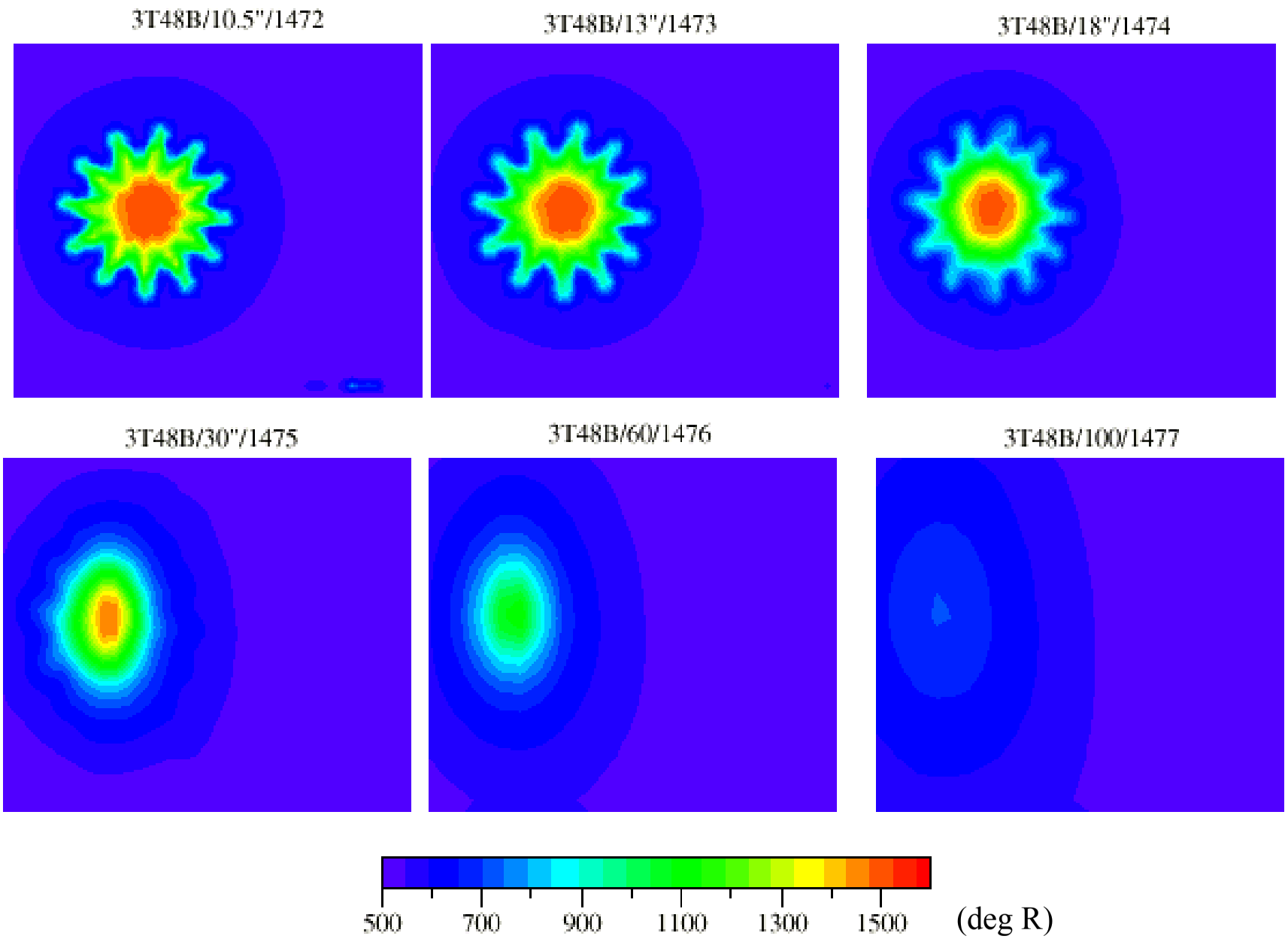


Figure 125b. Traverse Profiles for Nozzle Configuration 3T48B: Crossplanar View of Total Temperature (deg. R) at x=10, 13, 18, 30, 60, 100 inches.

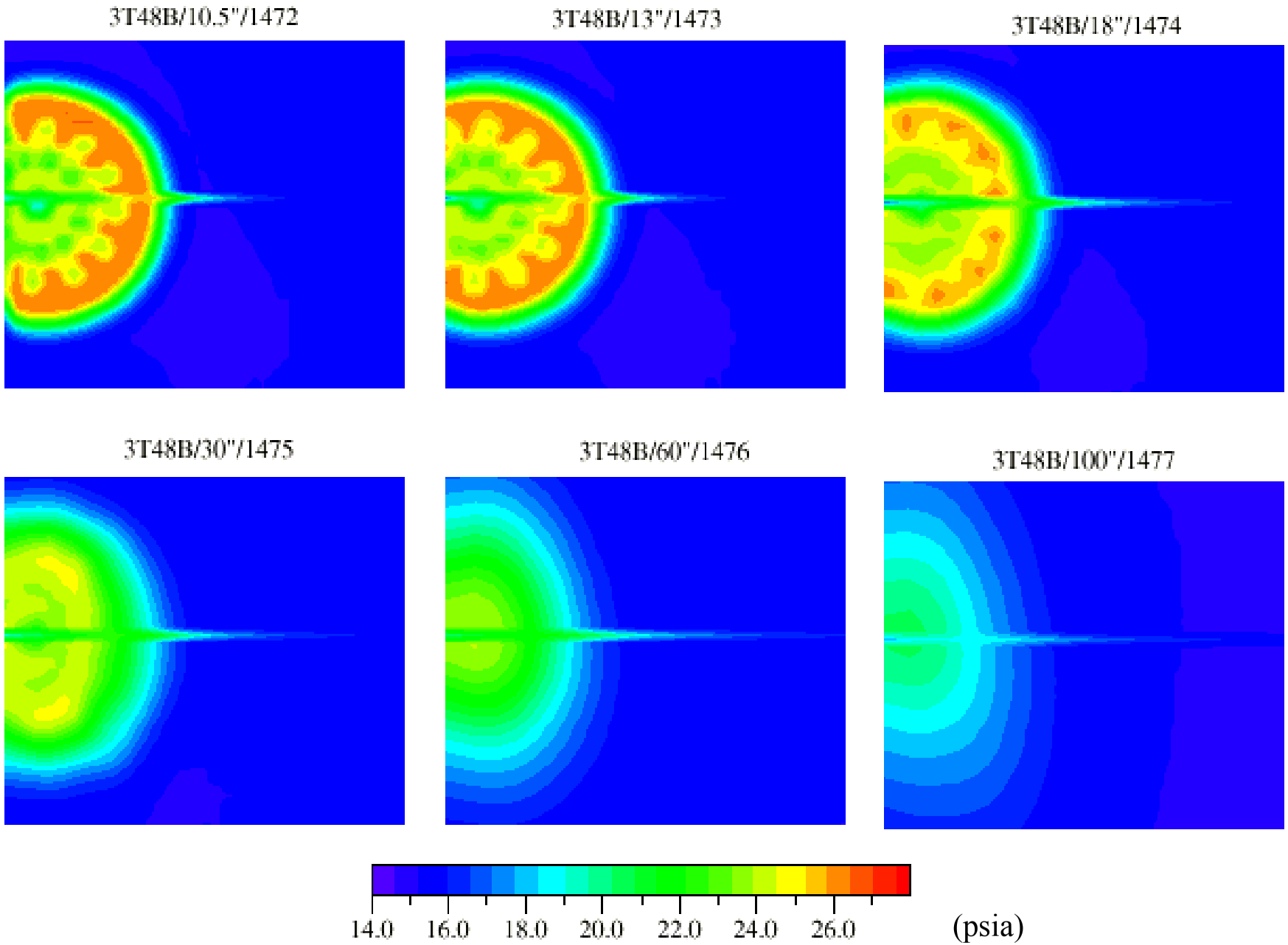


Figure 125c. Traverse Profiles for Nozzle Configuration 3T48B: Crossplanar View of Total Pressure (psia) at x=10, 13, 18, 30, 60, 100 inches.

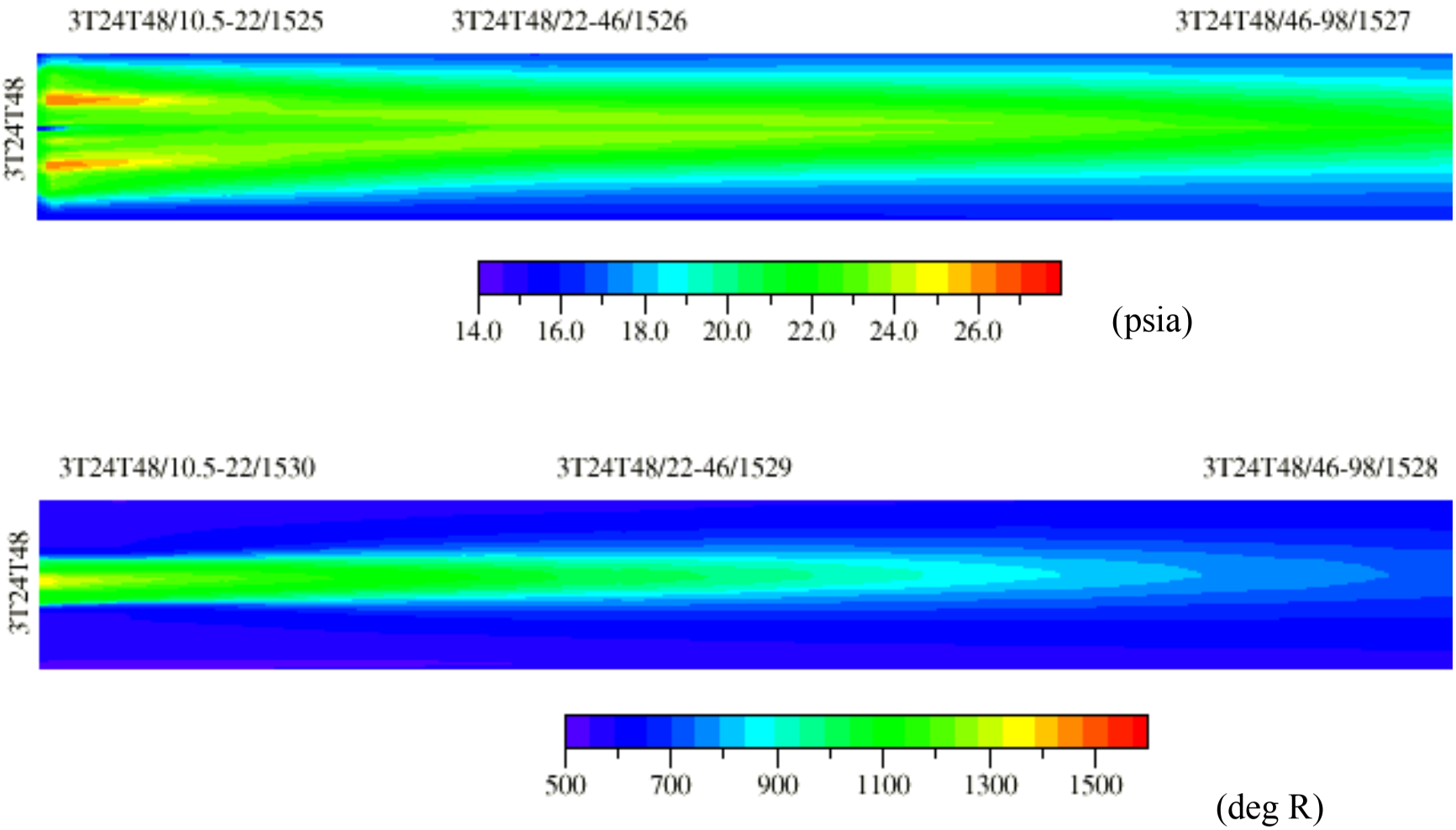


Figure 126a. Traverse Profiles for Nozzle Configuration 3T24T48: Axial View of Total Pressure (psia) and Total Temperature (deg. R) (Axial Distance x=10.5 to 98.0 inches)

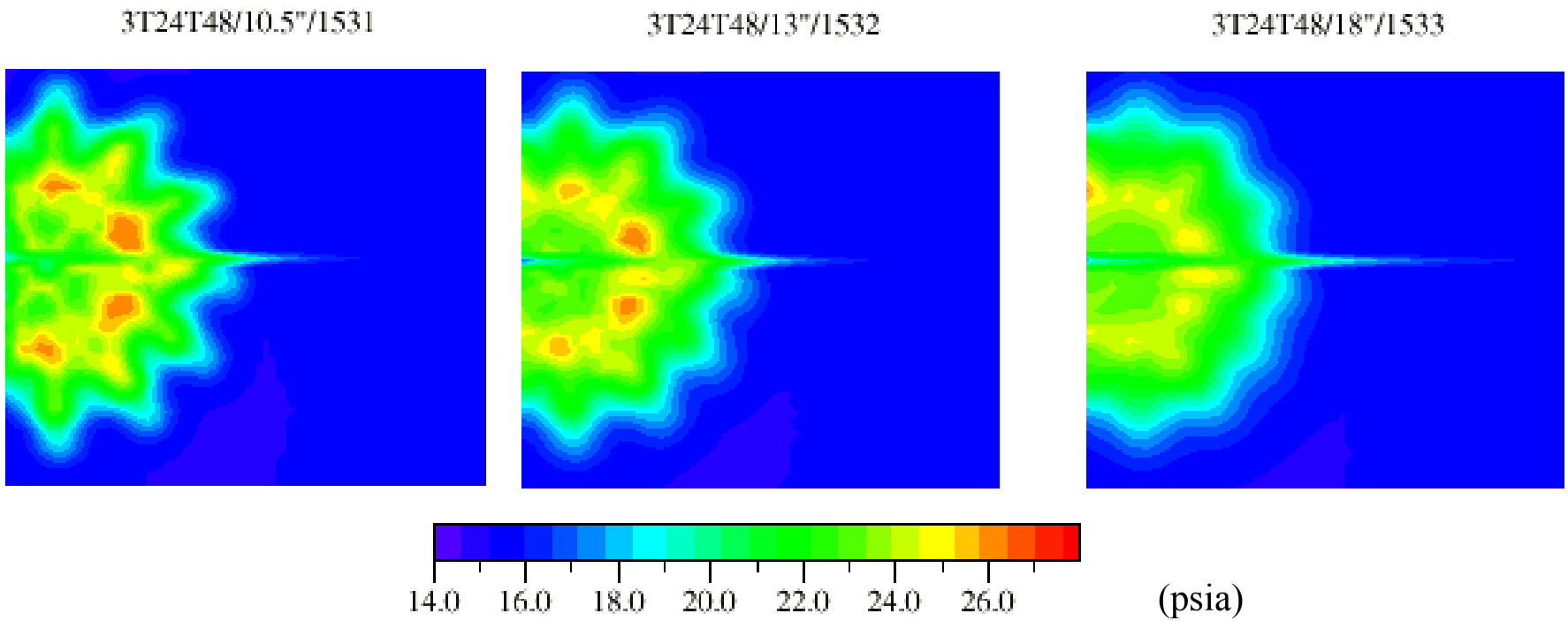


Figure 126b. Traverse Profiles for Nozzle Configuration 3T24T48: Crossplanar View of Total Temperature (deg. R) at x=10, 13, 18 inches.

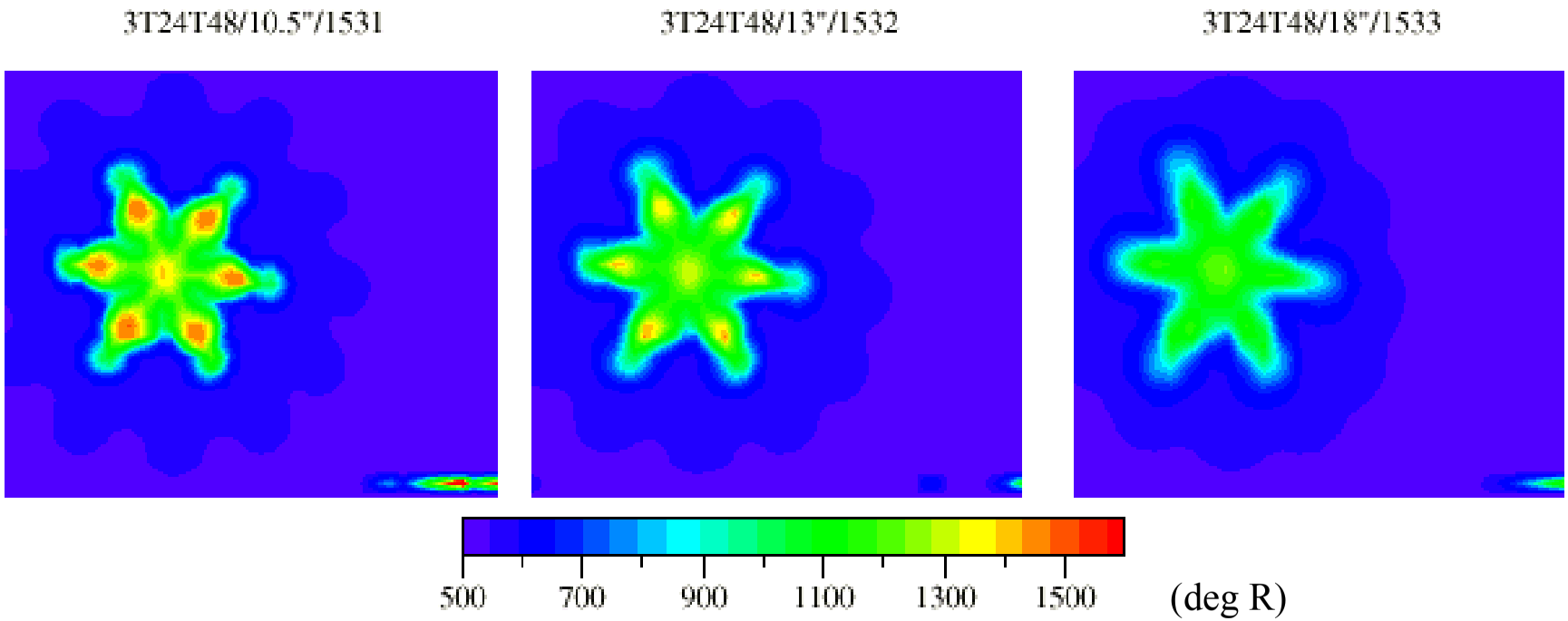


Figure 126c. Traverse Profiles for Nozzle Configuration 3T24T48: Crossplanar View of Total Pressure (psia) at x=10, 13, 18 inches

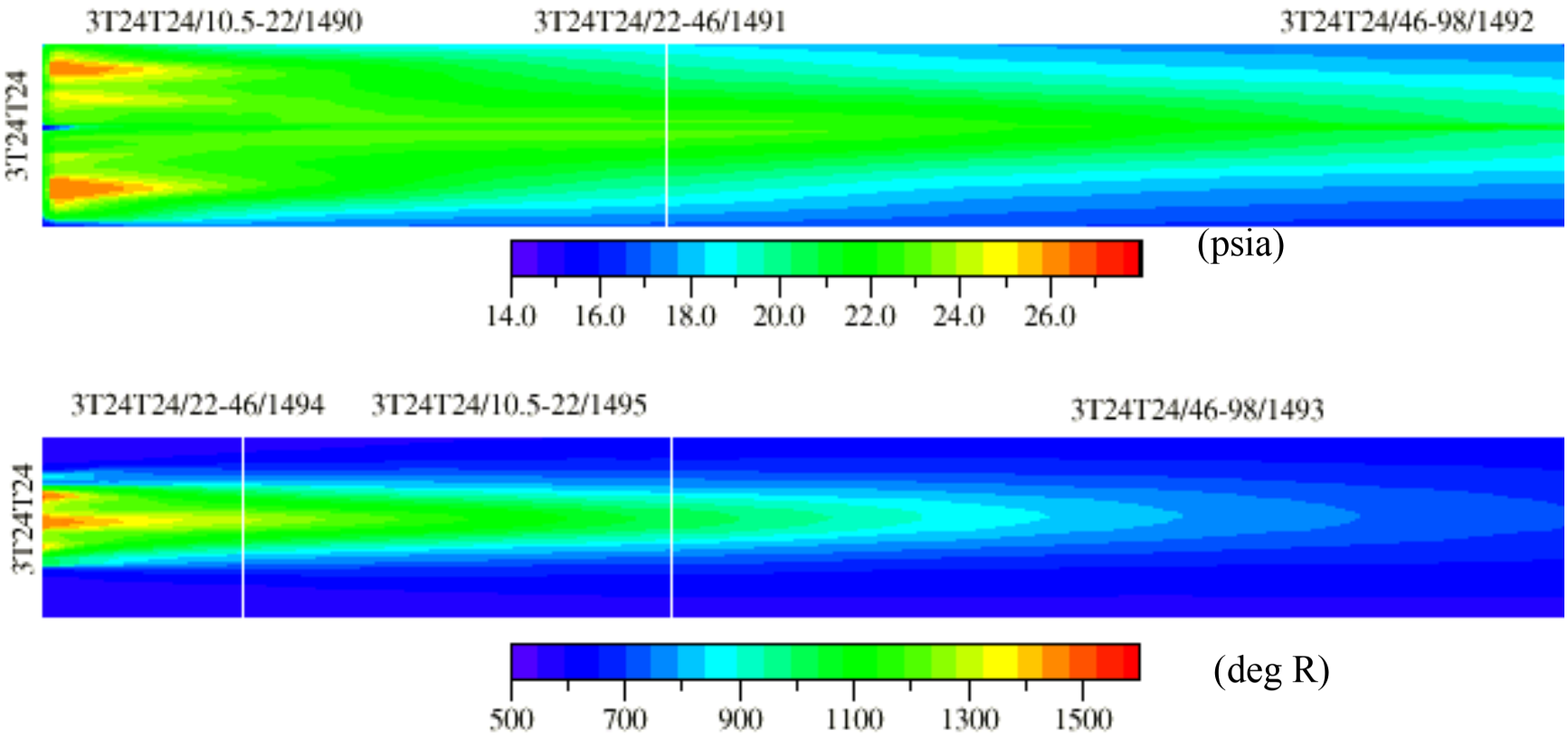


Figure 127a. Traverse Profiles for Nozzle Configuration 3T24T24: Axial View of Total Pressure (psia) and Total Temperature (deg. R) (Axial Distance x=10.5 to 98.0 inches)

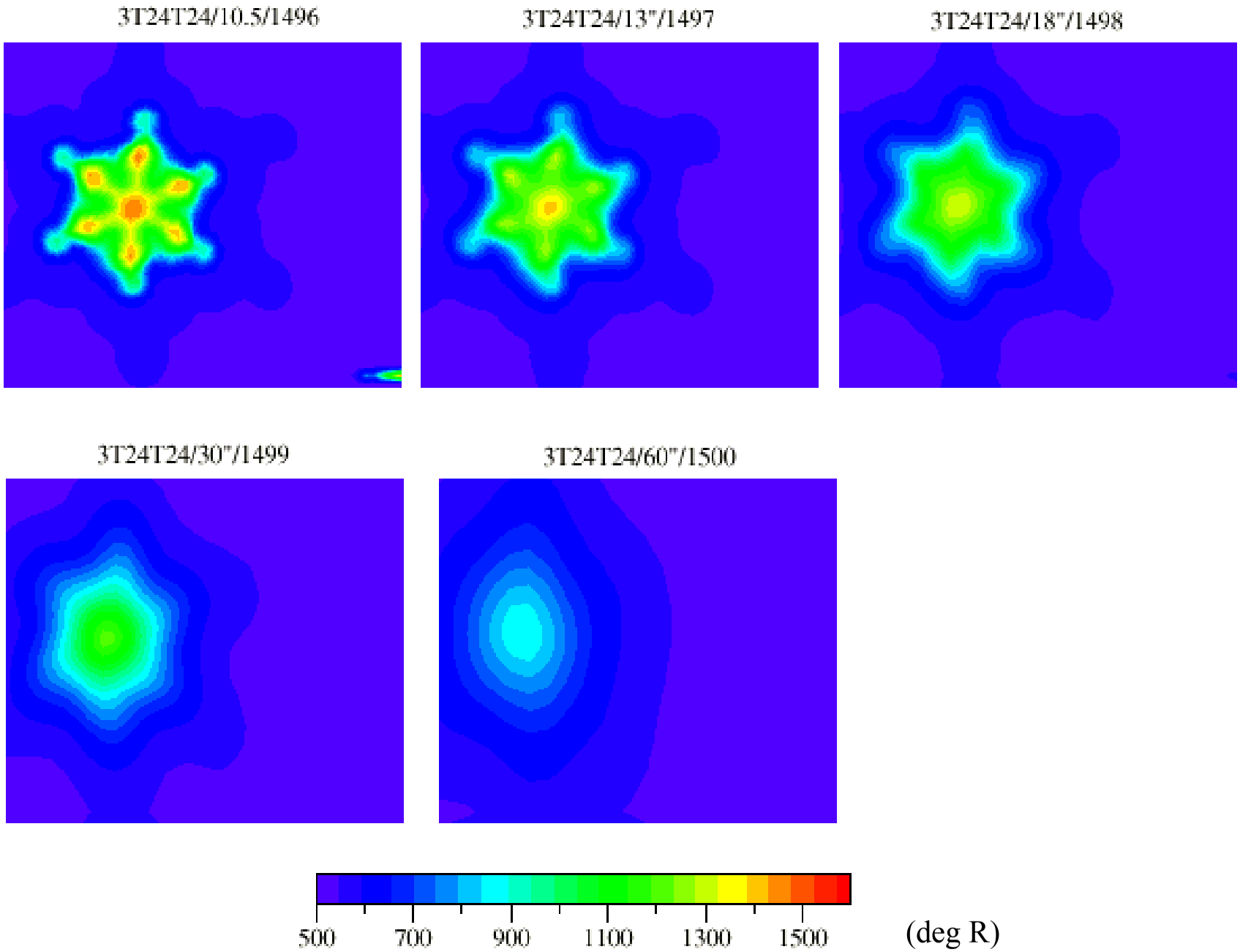


Figure 127b. Traverse Profiles for Nozzle Configuration 3T24T24: Crossplanar View of Total Temperature (deg. R) at x=10, 13, 18, 30, 60 inches.

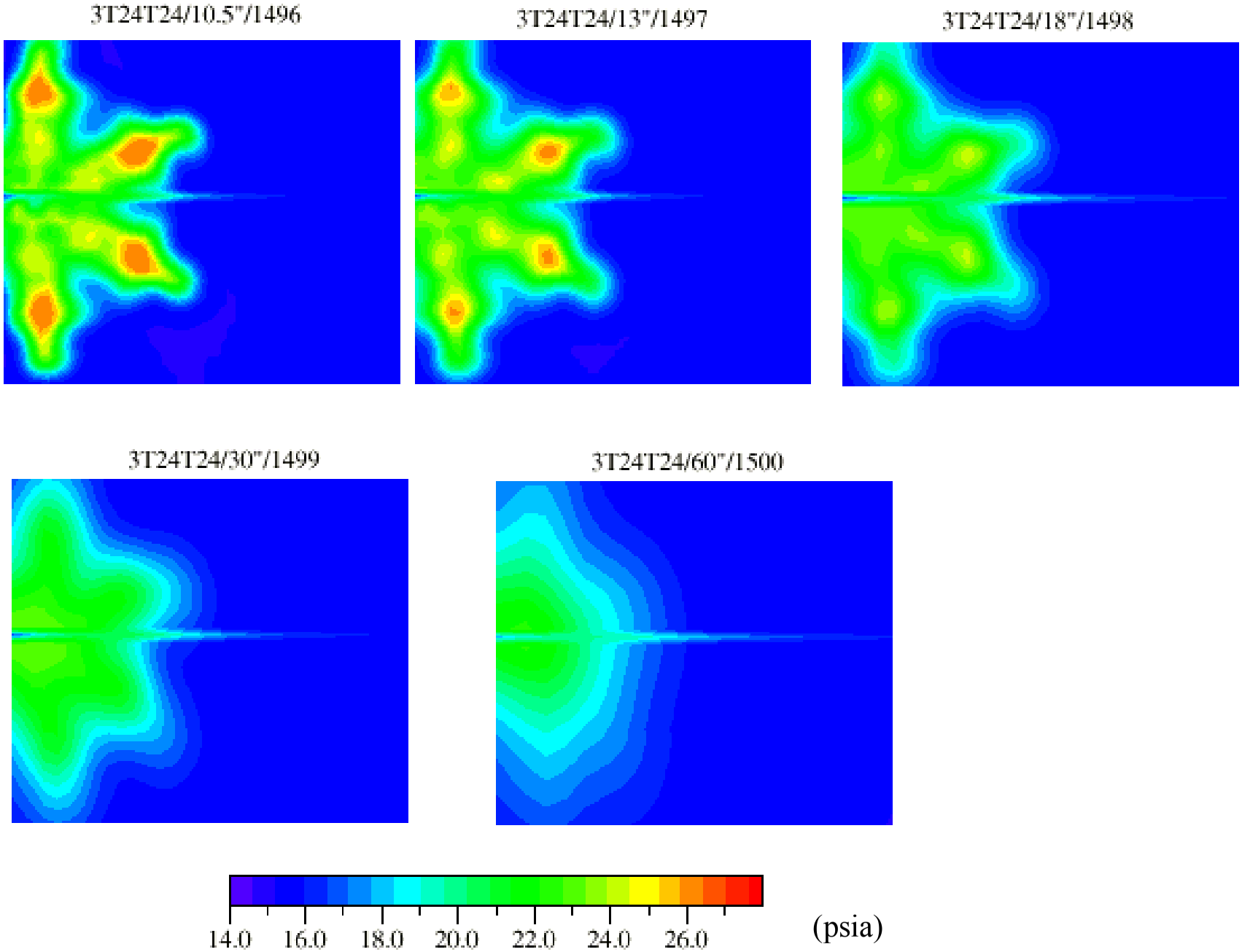


Figure 127c. Traverse Profiles for Nozzle Configuration 3T24T24: Crossplanar View of Total Pressure (psia) at x=10, 13, 18, 30, 60 inches

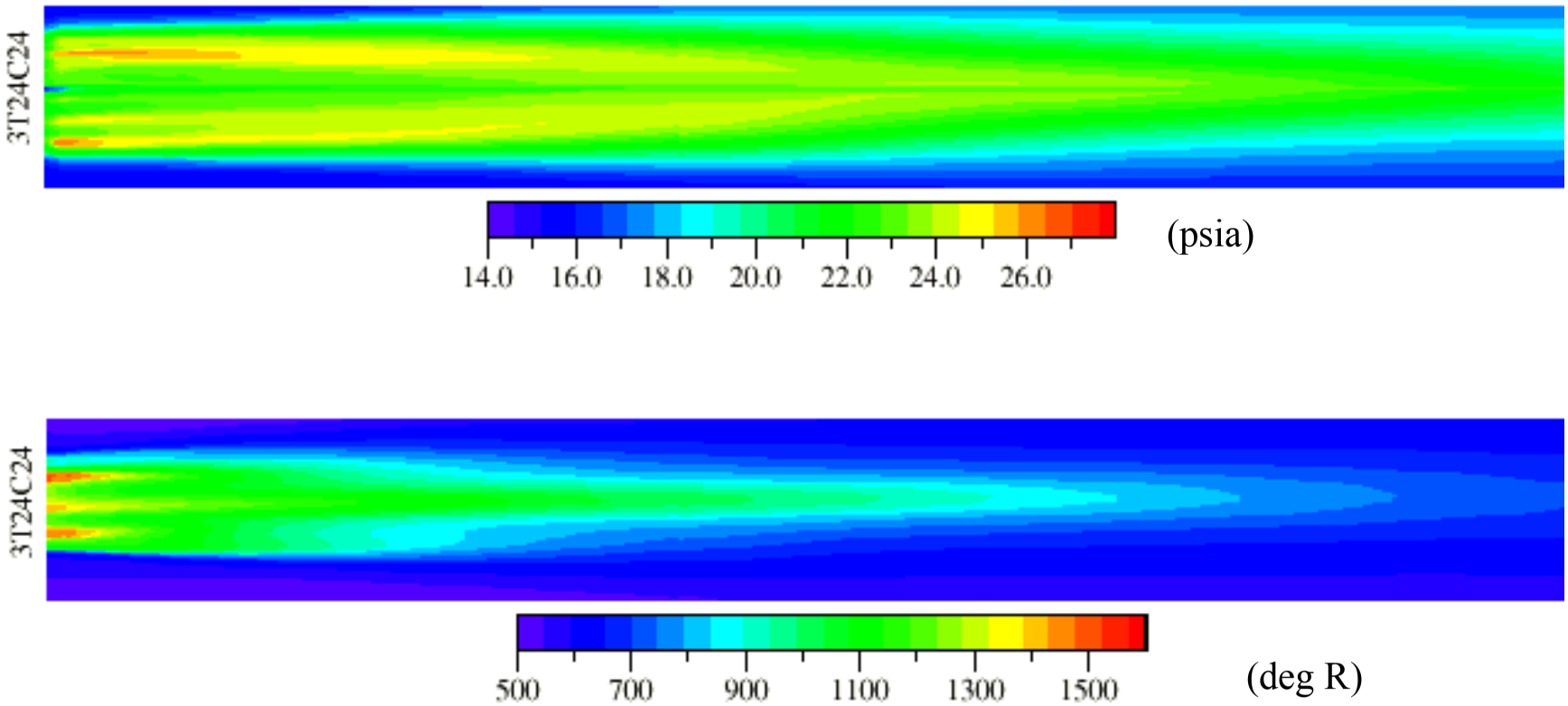


Figure 128a. Traverse Profiles for Nozzle Configuration 3T24C: Axial View of Total Pressure (psia) and Total Temperature (deg. R) (Axial Distance x=10.5 to 98.0 inches)

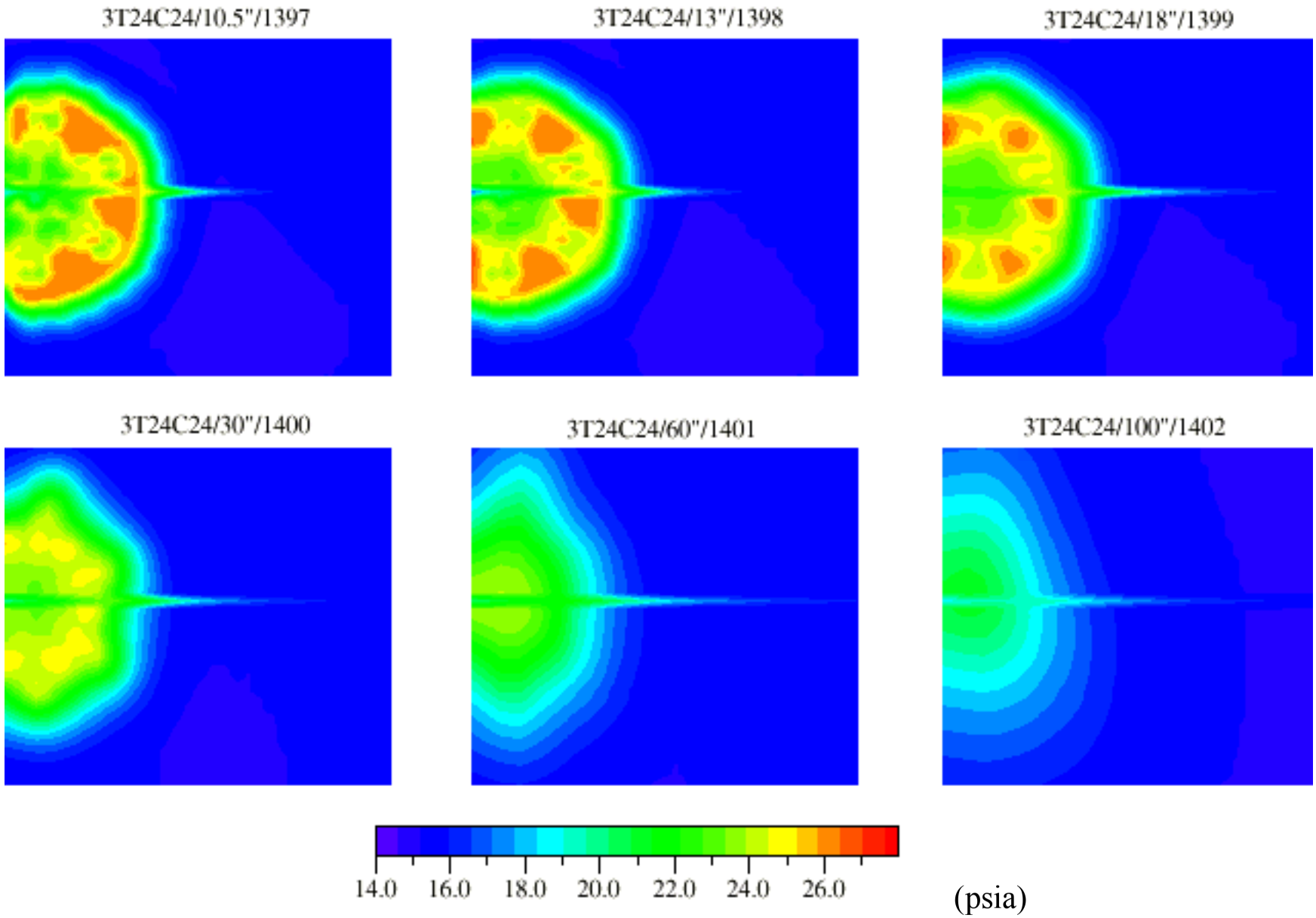


Figure 128b. Traverse Profiles for Nozzle Configuration 3T24C: Crossplanar View of Total Temperature (deg. R) at x=10, 13, 18, 30, 60, 100 inches.

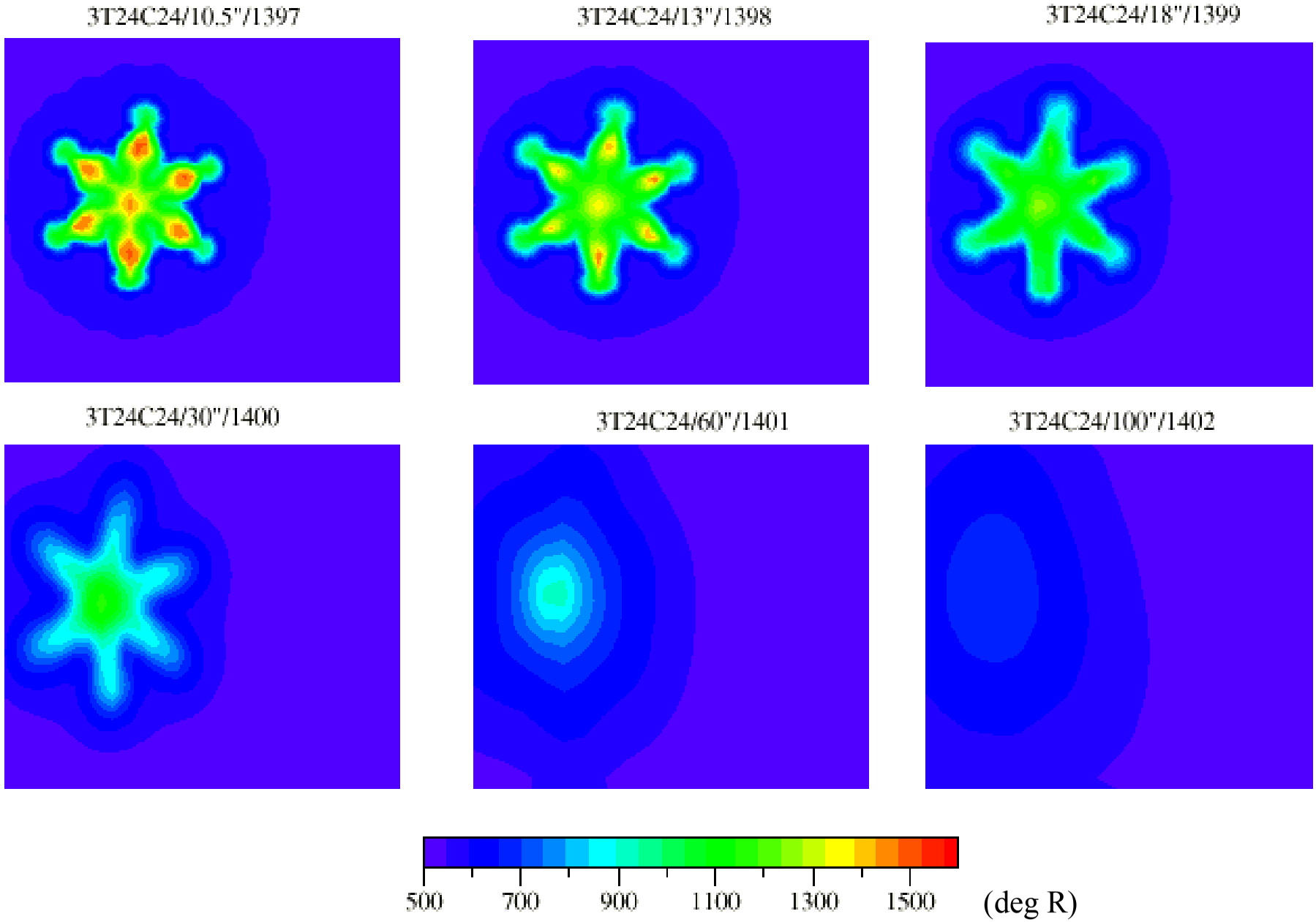


Figure 128c. Traverse Profiles for Nozzle Configuration 3T24C: Crossplanar View of Total Pressure (psia) at x=10, 13, 18, 30, 60, 100 inches

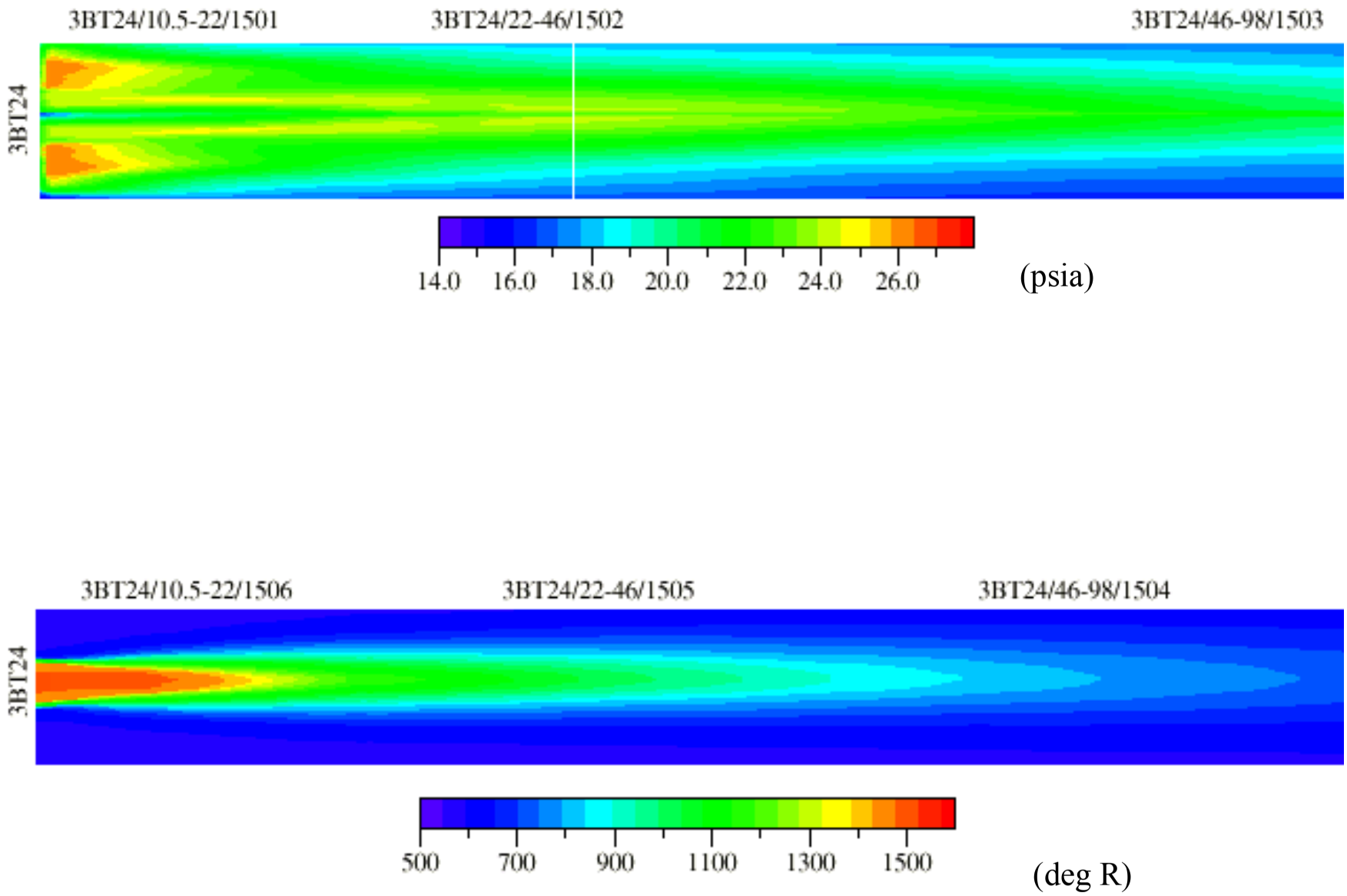


Figure 129a. Traverse Profiles for Nozzle Configuration 3BT24: Axial View of Total Pressure (psia) and Total Temperature (deg. R) (Axial Distance x=10.5 to 98.0 inches)

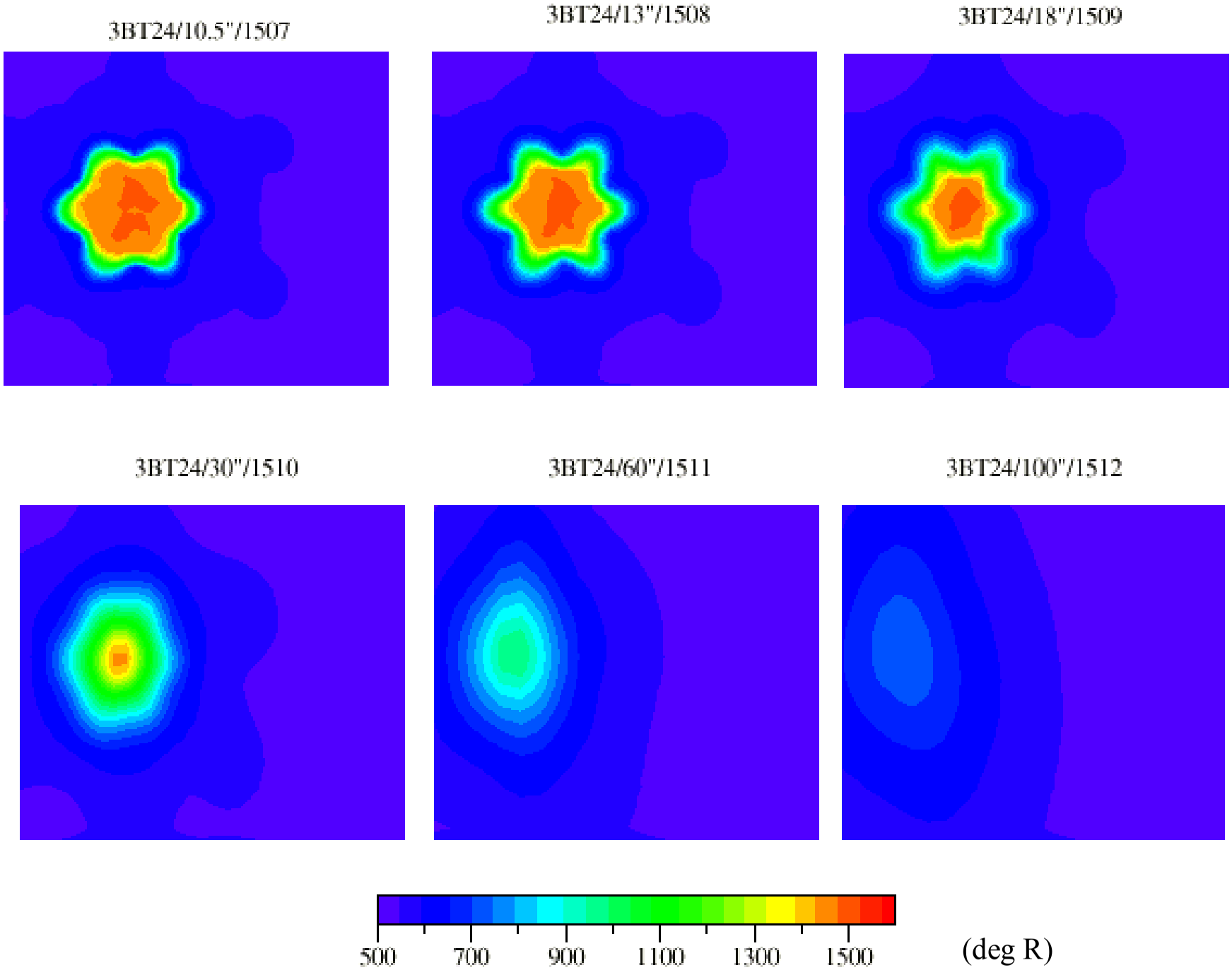


Figure 129b. Traverse Profiles for Nozzle Configuration 3BT24: Crossplanar View of Total Temperature (deg. R) at x=10, 13, 18, 30, 60, 100 inches.

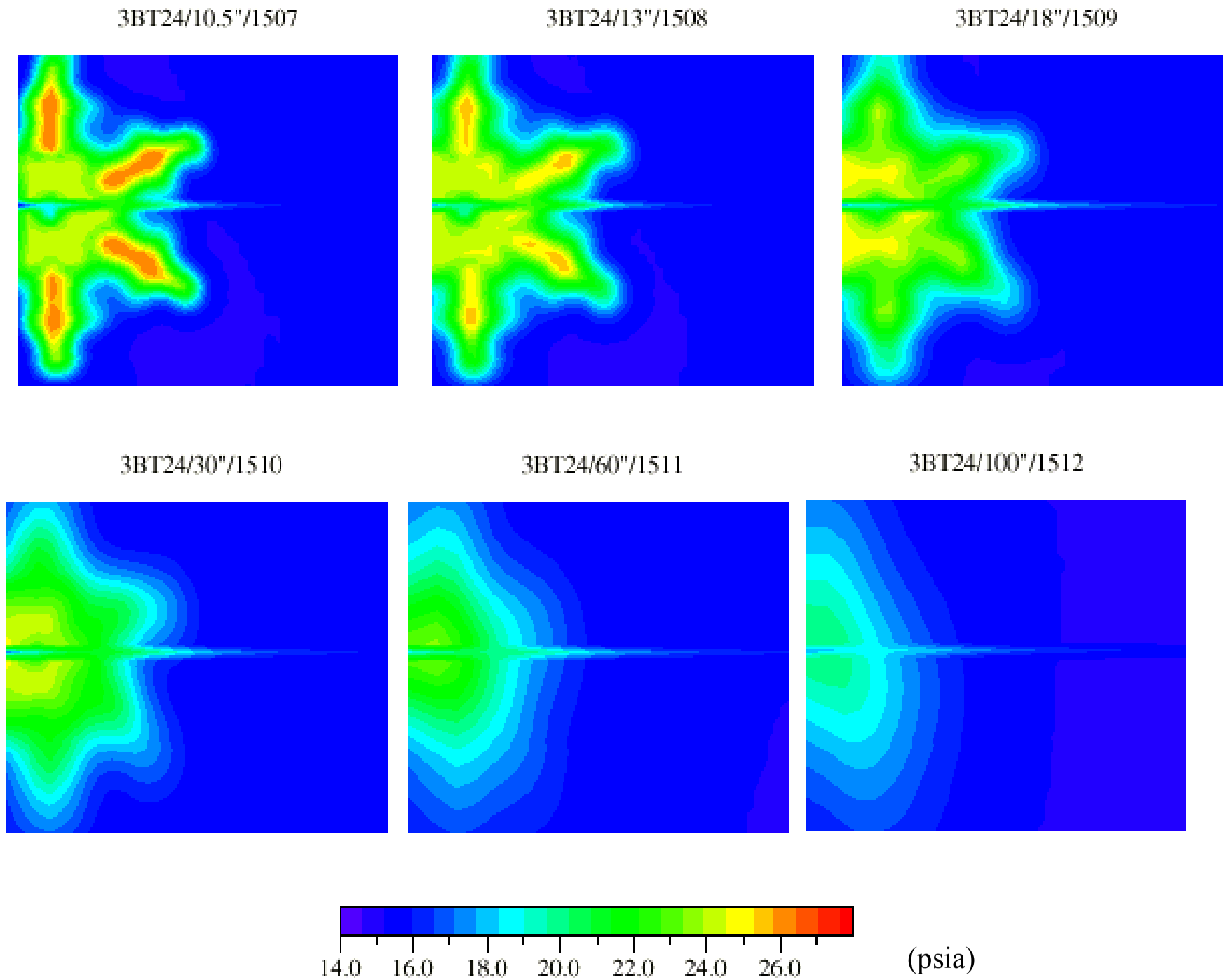


Figure 129c. Traverse Profiles for Nozzle Configuration 3BT24: Crossplanar View of Total Pressure (psia) at x=10, 13, 18, 30, 60, 100 inches

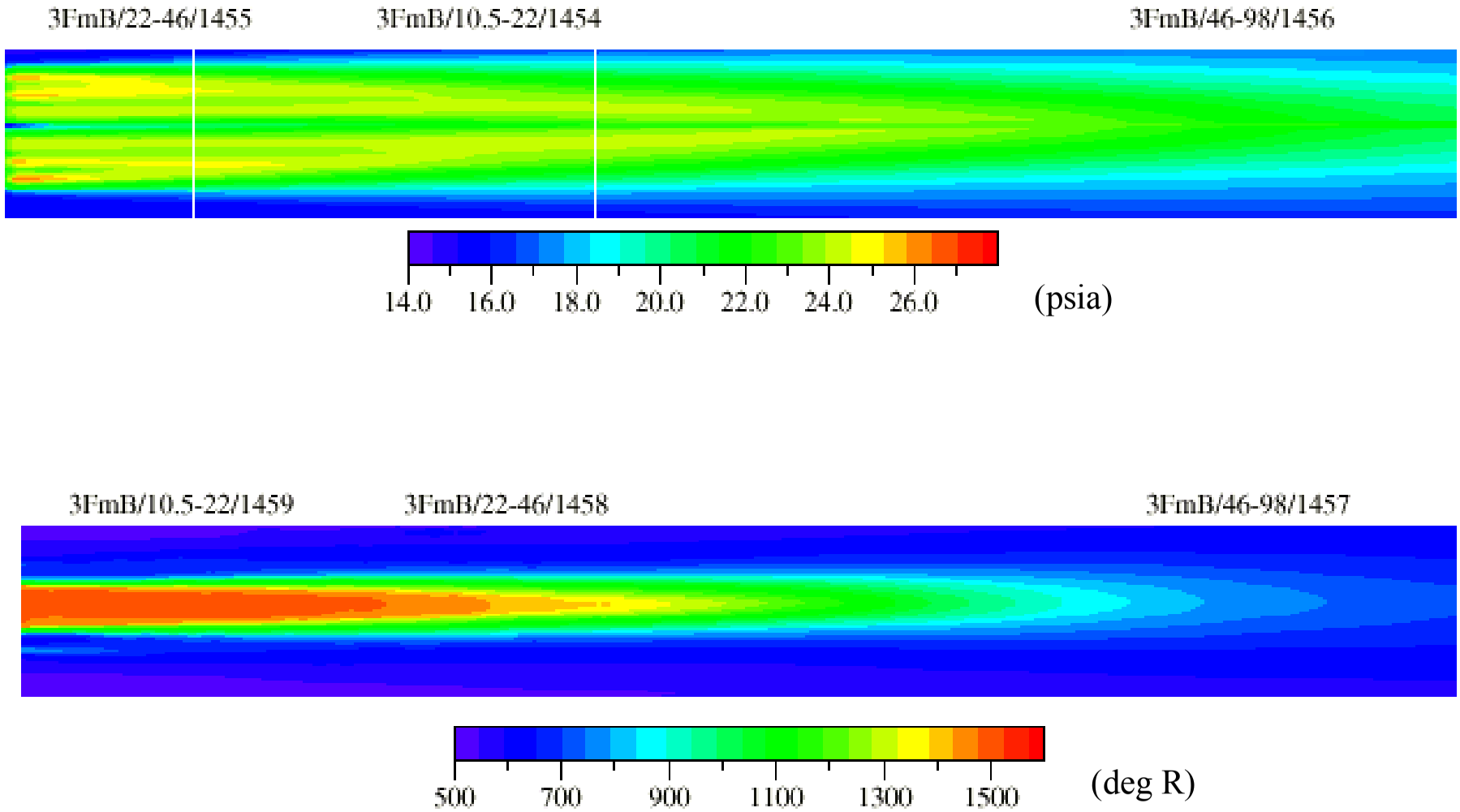


Figure 130a. Traverse Profiles for Nozzle Configuration 3FmB: Axial View of Total Pressure (psia) and Total Temperature (deg. R) (Axial Distance x=10.5 to 98.0 inches)

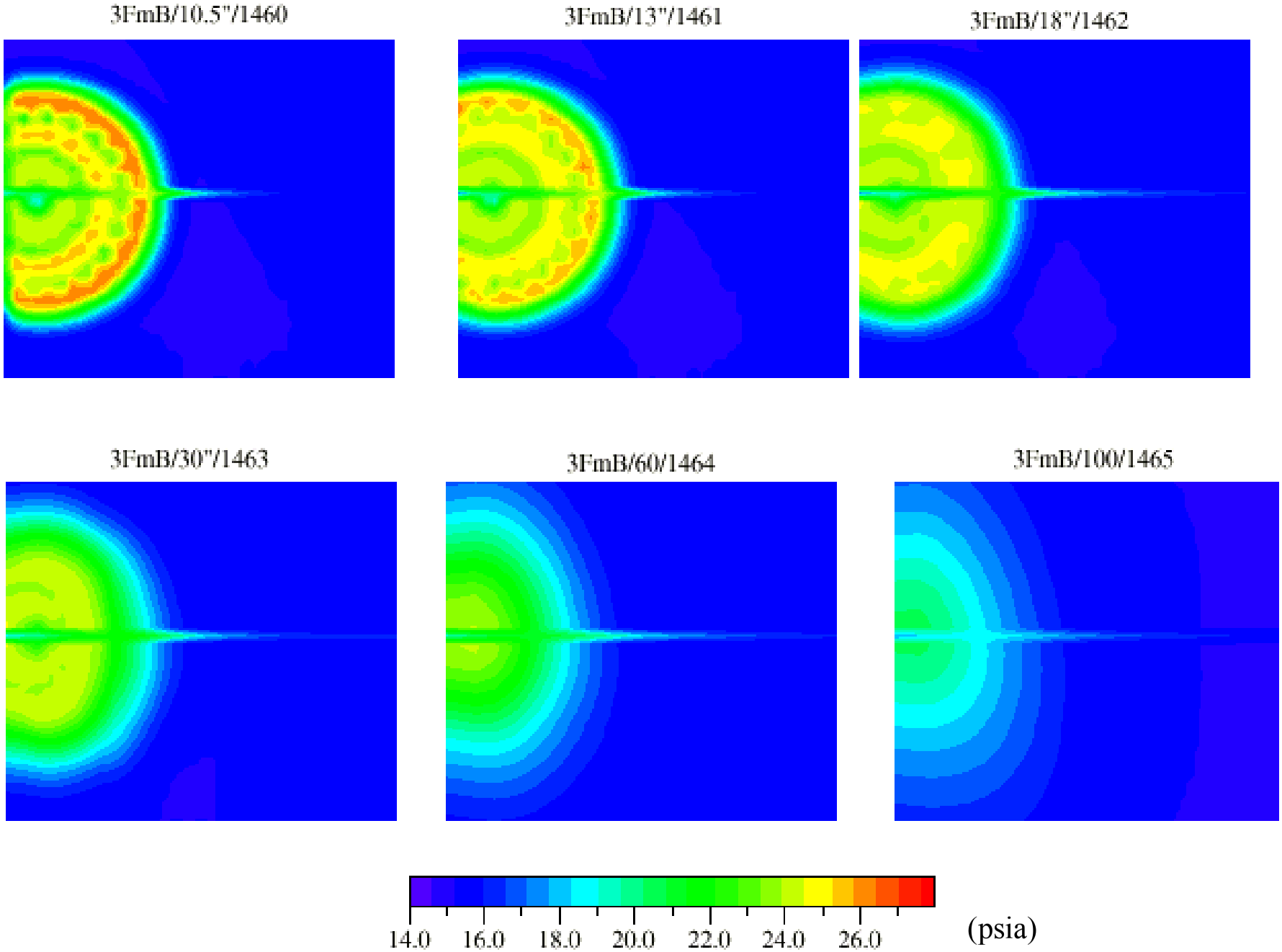


Figure 130b. Traverse Profiles for Nozzle Configuration 3FmB: Crossplanar View of Total Temperature (deg. R) at x=10, 13, 18, 30, 60, 100 inches.

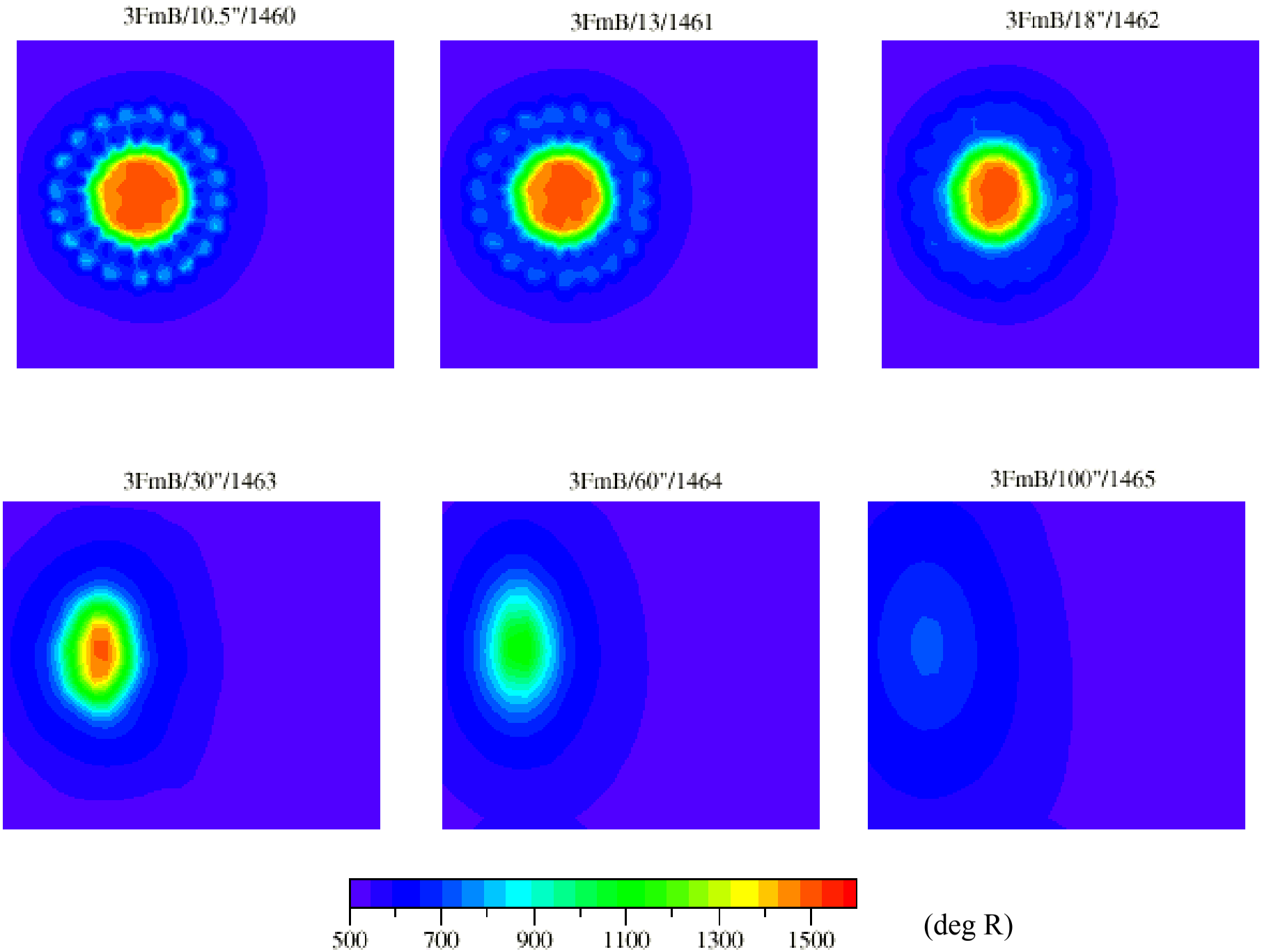


Figure 130c. Traverse Profiles for Nozzle Configuration 3FmB: Crossplanar View of Total Pressure (psia) at x=10, 13, 18, 30, 60, 100 inches

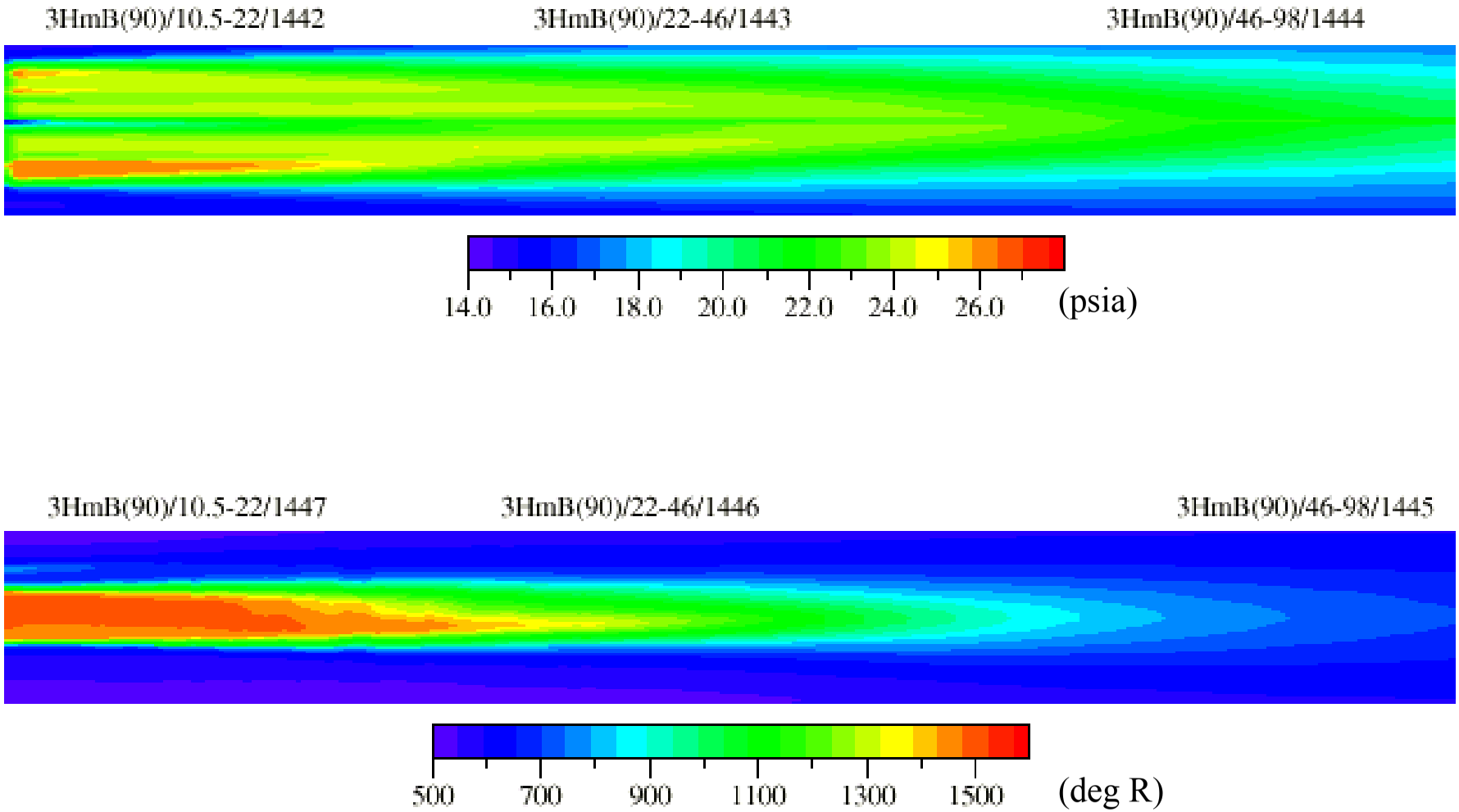


Figure 131a. Traverse Profiles for Nozzle Configuration 3HmB: Axial View of Total Pressure (psia) and Total Temperature (deg. R) (Axial Distance x=10.5 to 98.0 inches)

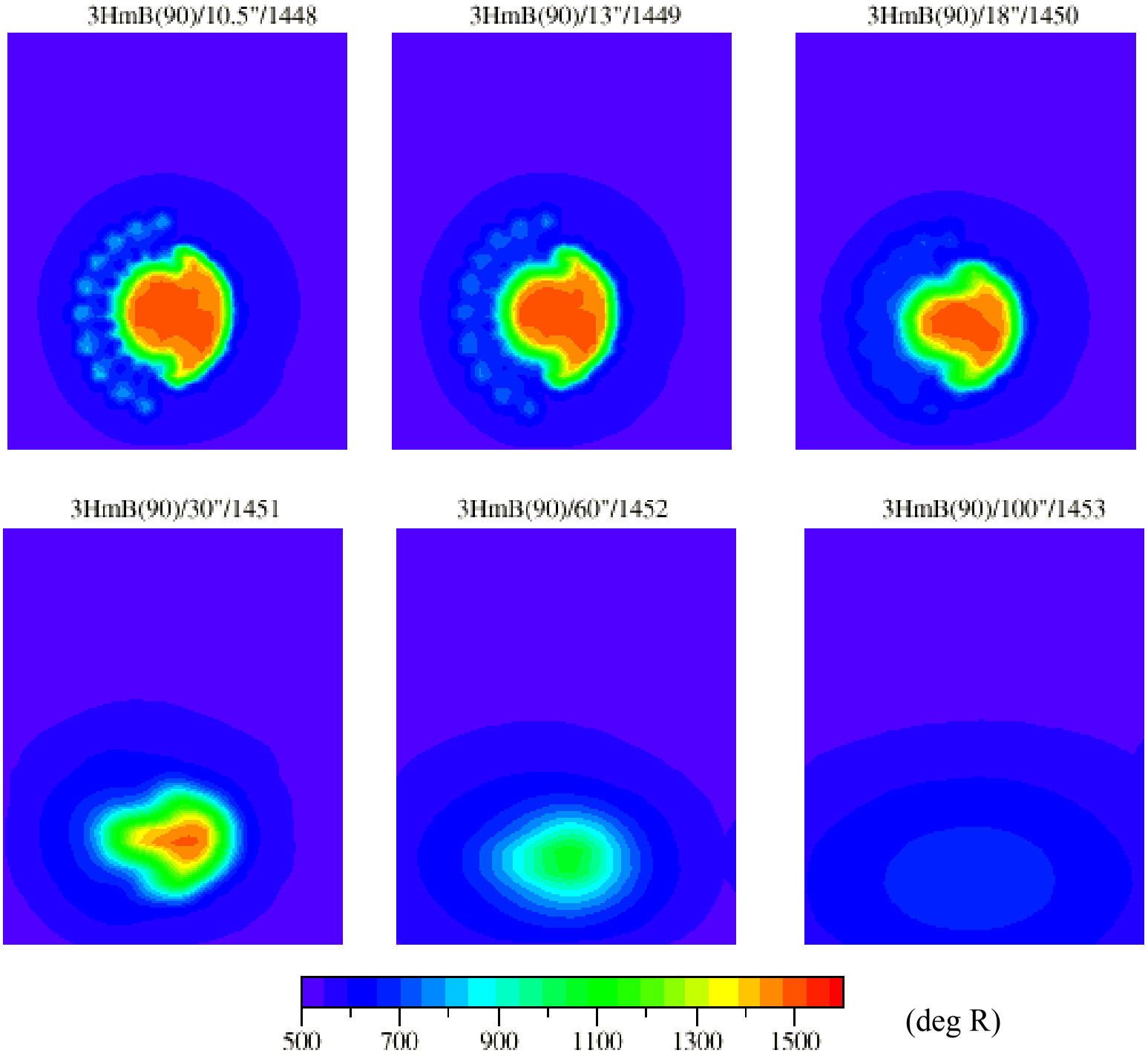


Figure 131b. Traverse Profiles for Nozzle Configuration 3HmB: Crossplanar View of Total Temperature (deg. R) at x=10, 13, 18, 30, 60, 100 inches.

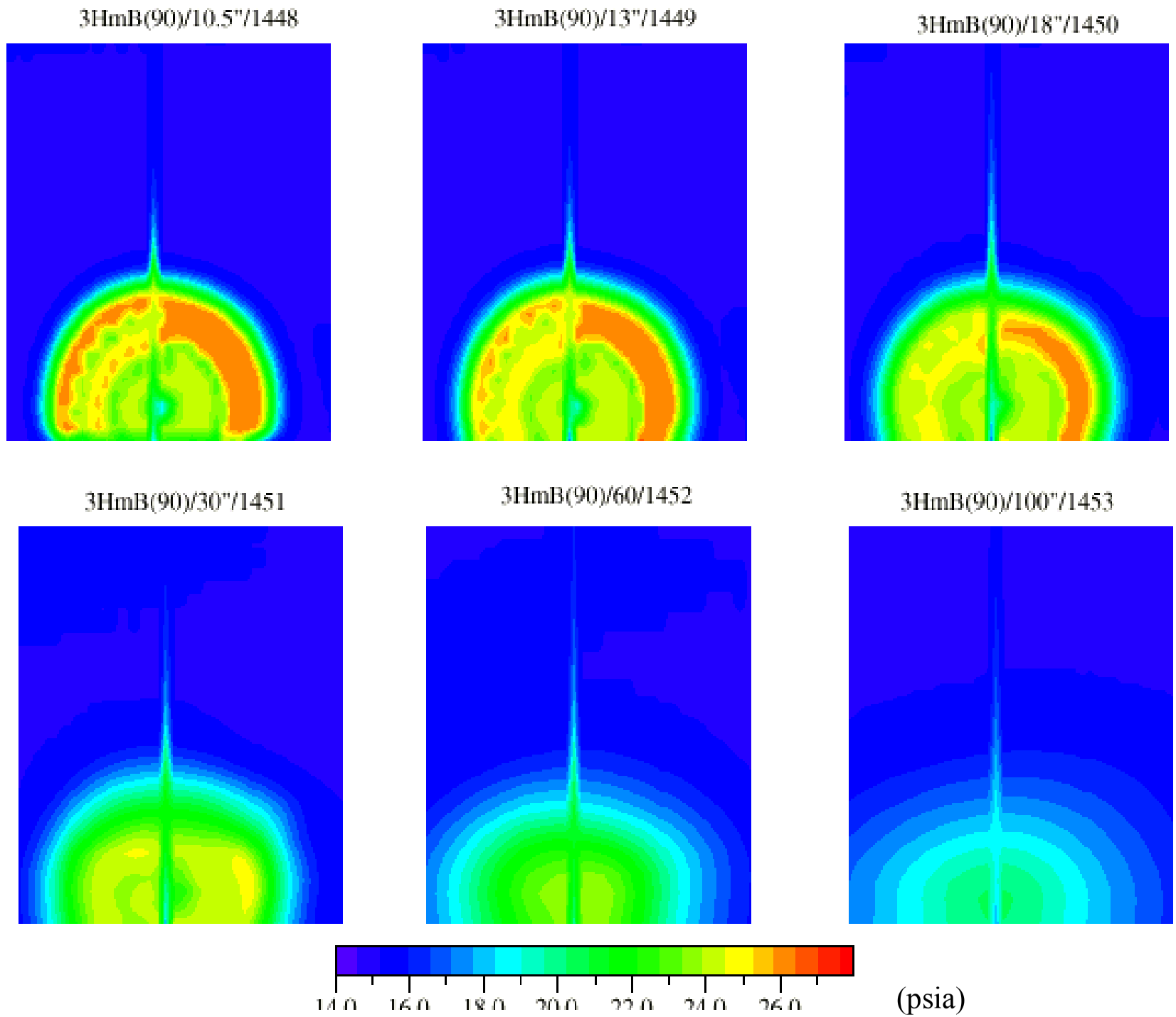


Figure 131c. Traverse Profiles for Nozzle Configuration 3HmB: Crossplanar View of Total Pressure (psia) at x=10, 13, 18, 30, 60, 100 inches

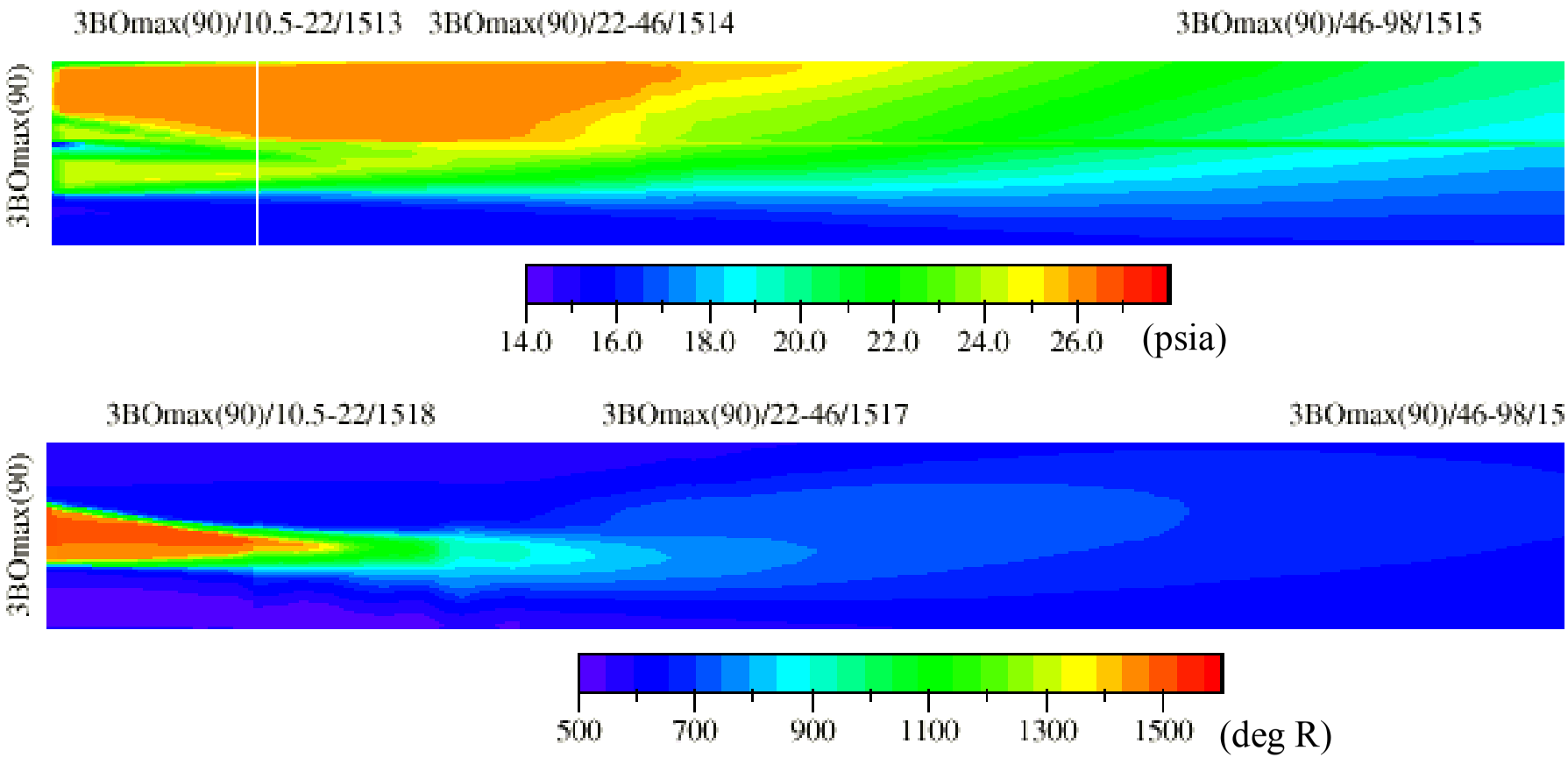


Figure 132a. Traverse Profiles for Nozzle Configuration 3BOmax: Axial View of Total Pressure (psia) and Total Temperature (deg. R) (Axial Distance x=10.5 to 98.0 inches)

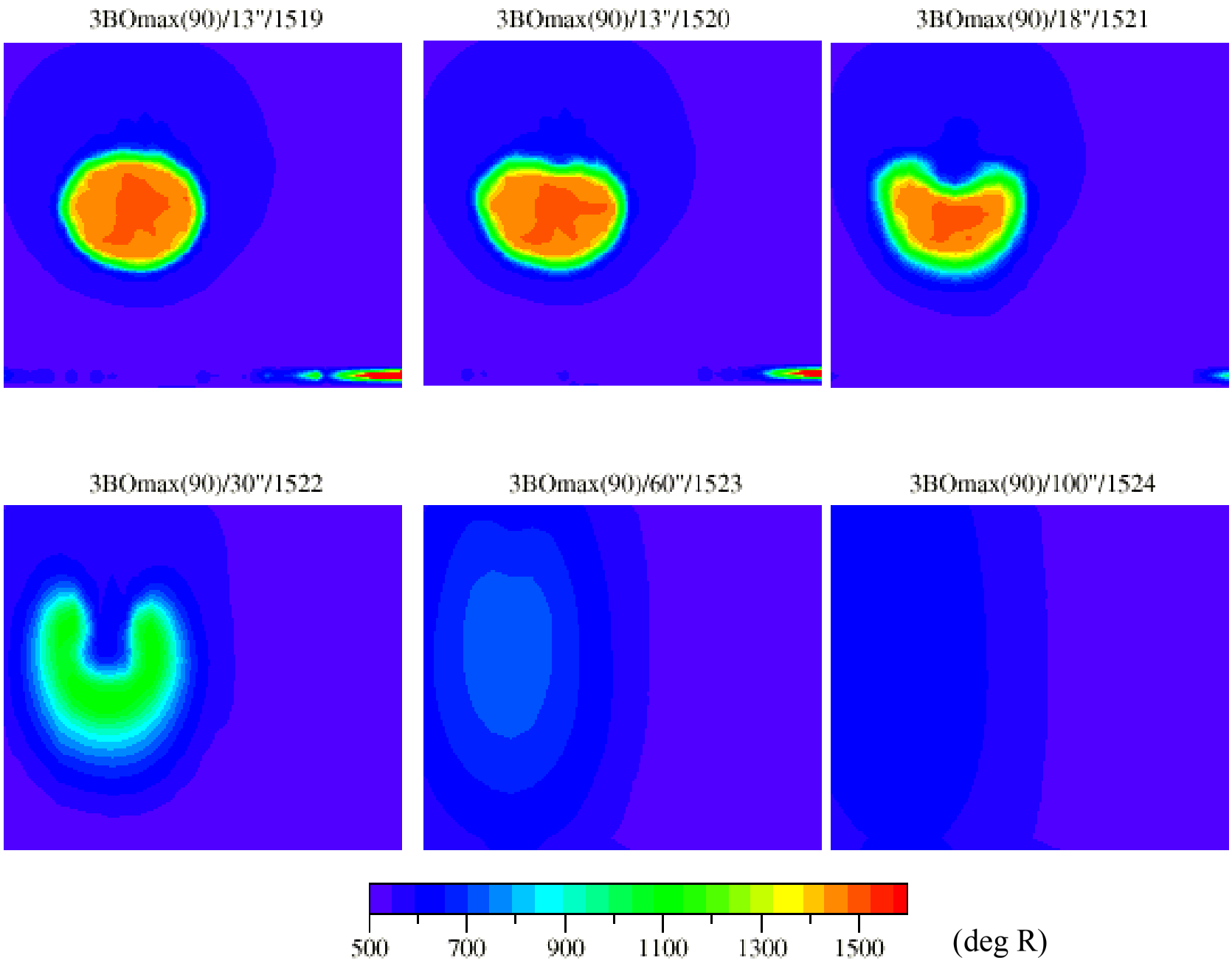


Figure 132b. Traverse Profiles for Nozzle Configuration 3BOmax: Crossplanar View of Total Temperature (deg. R) at x=10, 13, 18, 30, 60, 100 inches.

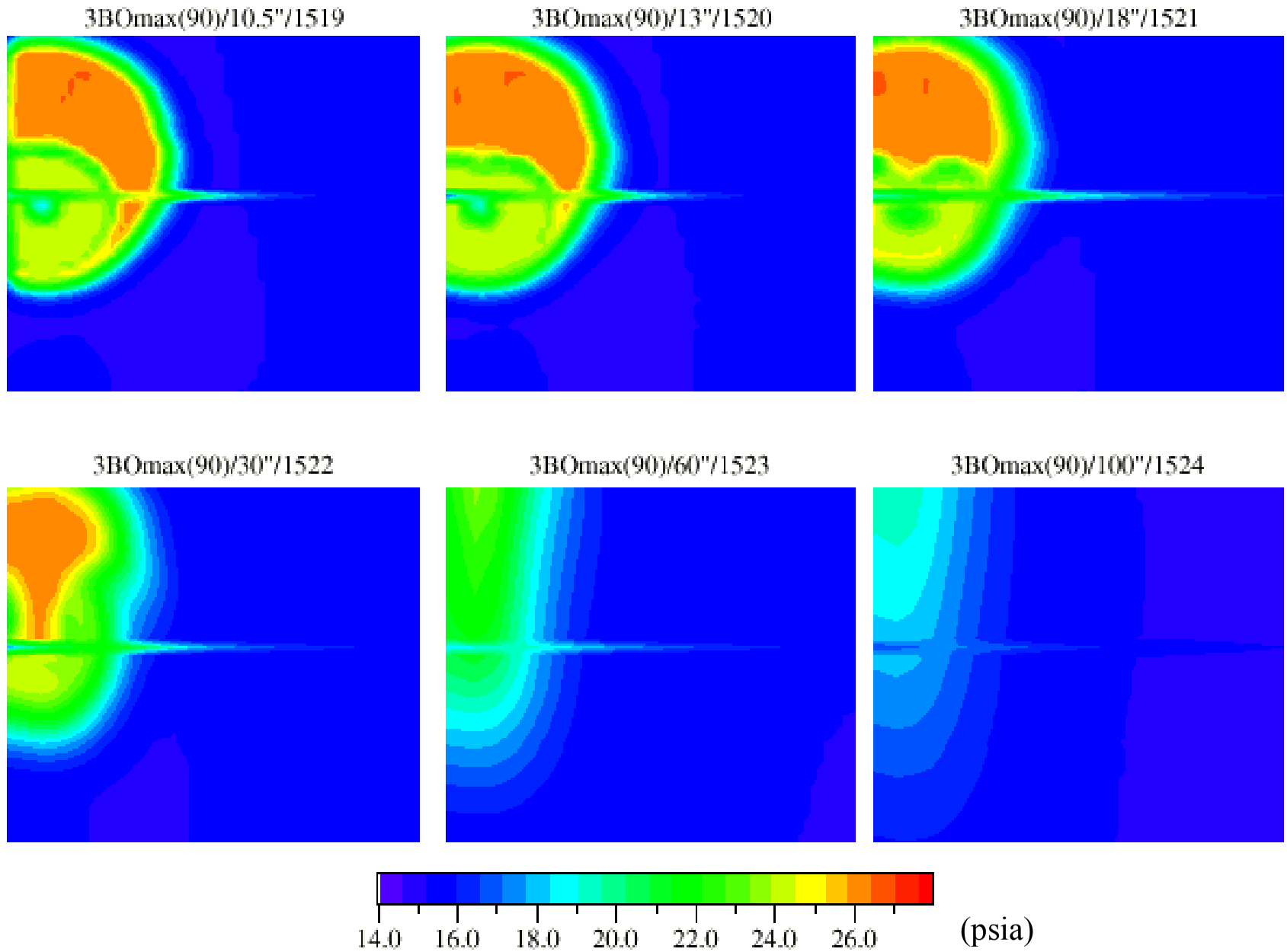


Figure 132c. Traverse Profiles for Nozzle Configuration 3BOmax: Crossplanar View of Total Pressure (psia) at x=10, 13, 18, 30, 60, 100 inches

9.0 APPENDIXES

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APPENDIX A-1

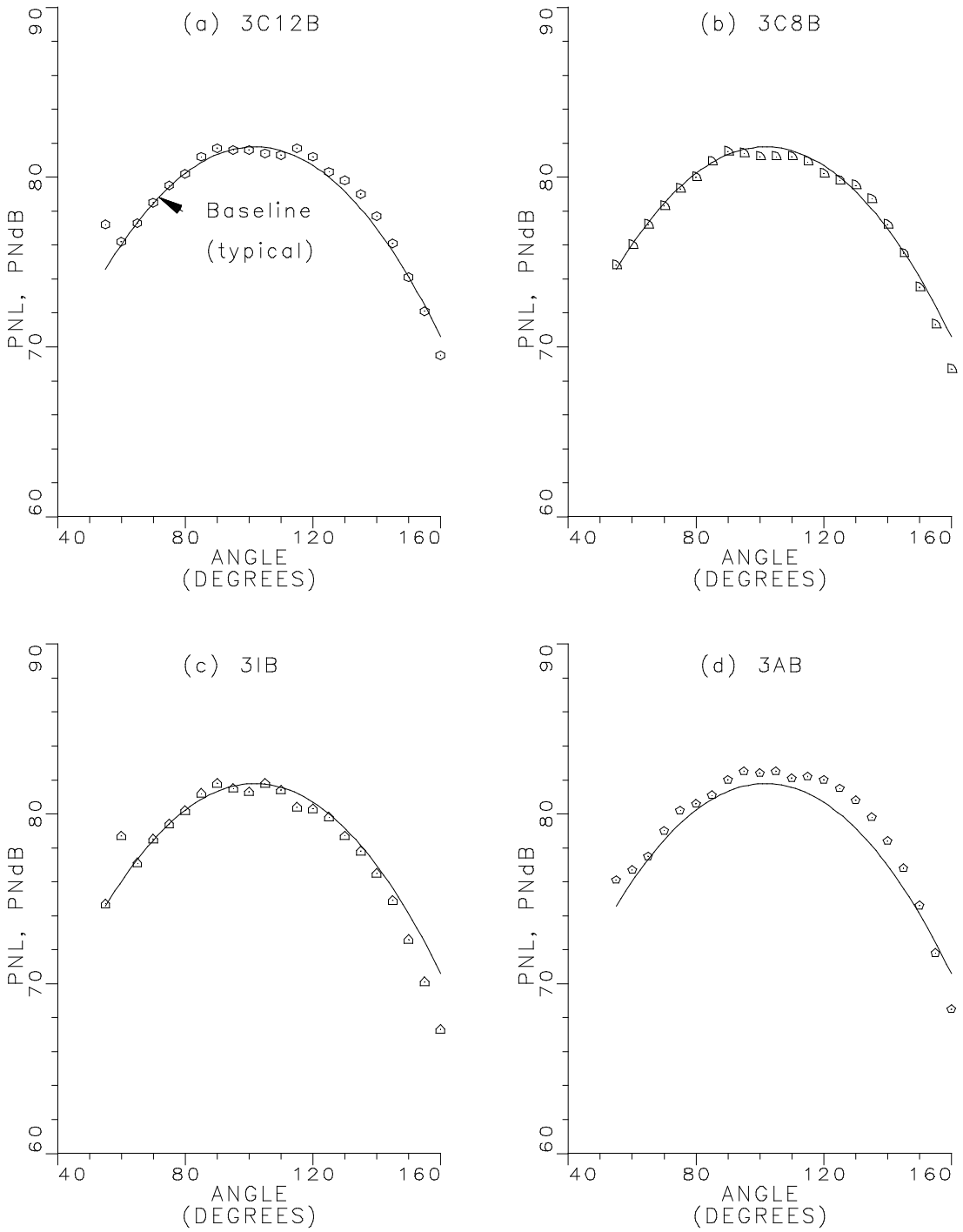


Figure A-1. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3C12B, (b) 3C8B, (c) 3IB and (d) 3AB.

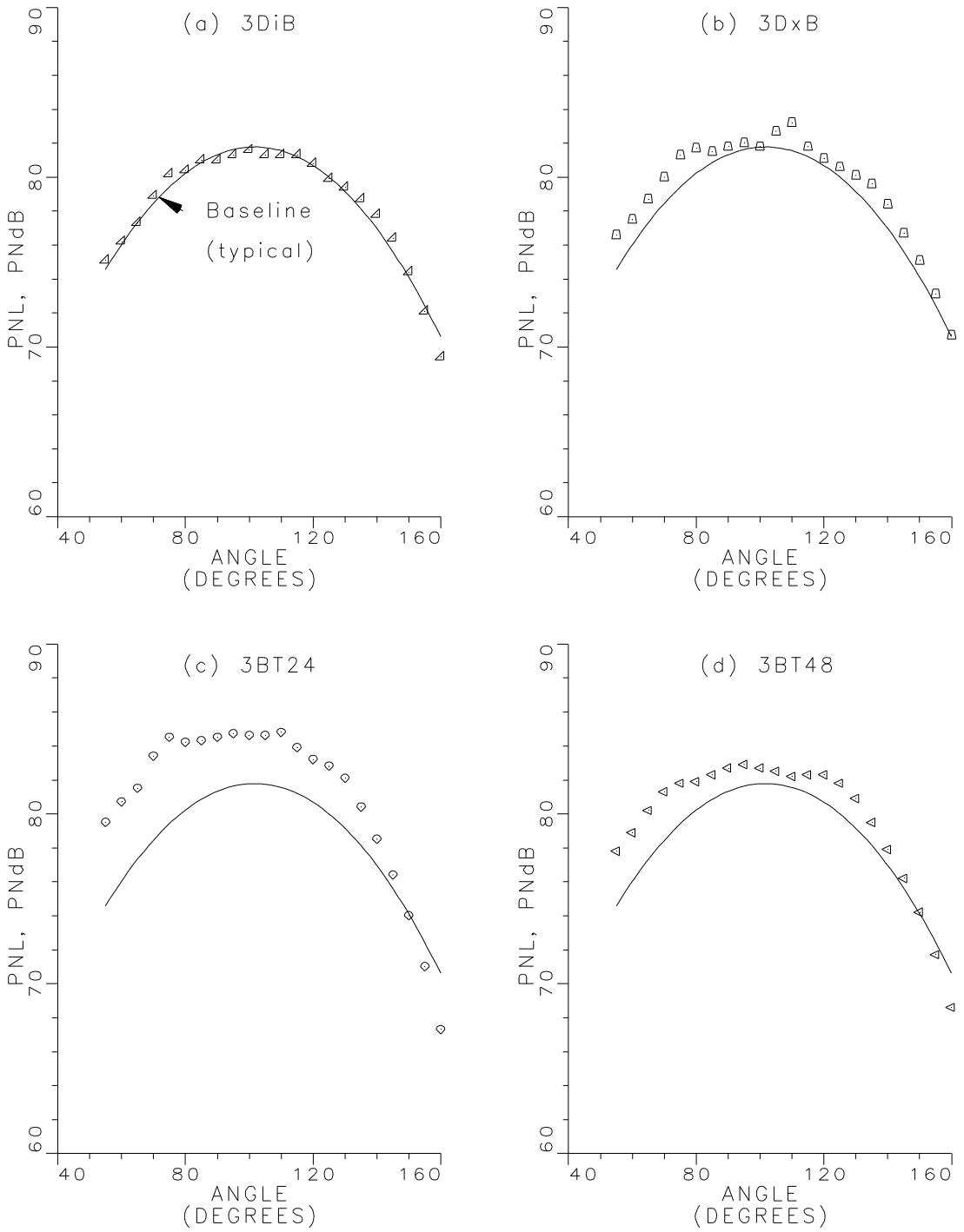


Figure A-2. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3DiB, (b) 3DxB, (c) 3BT24 and (d) 3BT48.

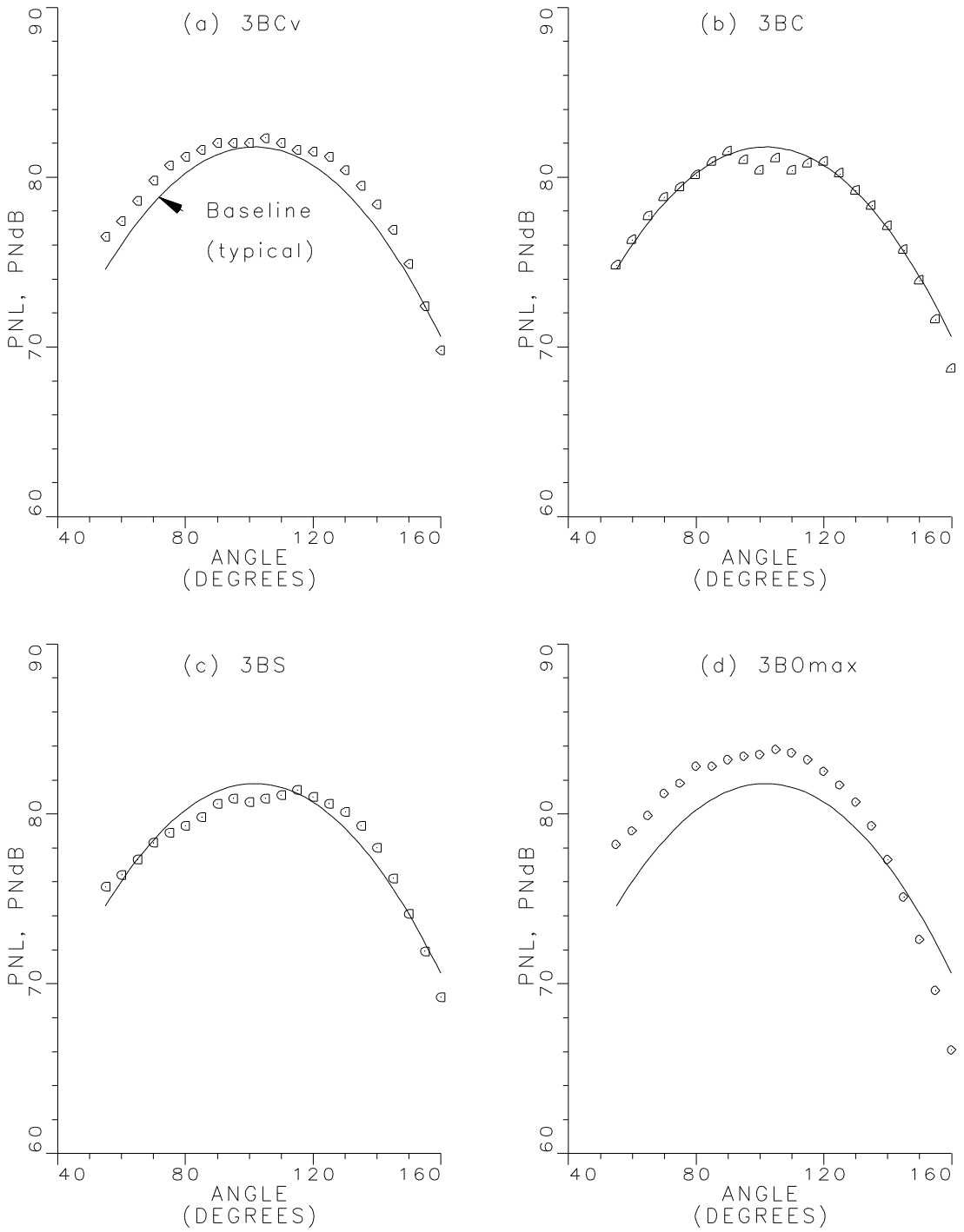


Figure A-3. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3BCv, (b) 3BC, (c) 3BS and (d) 3BOmax.

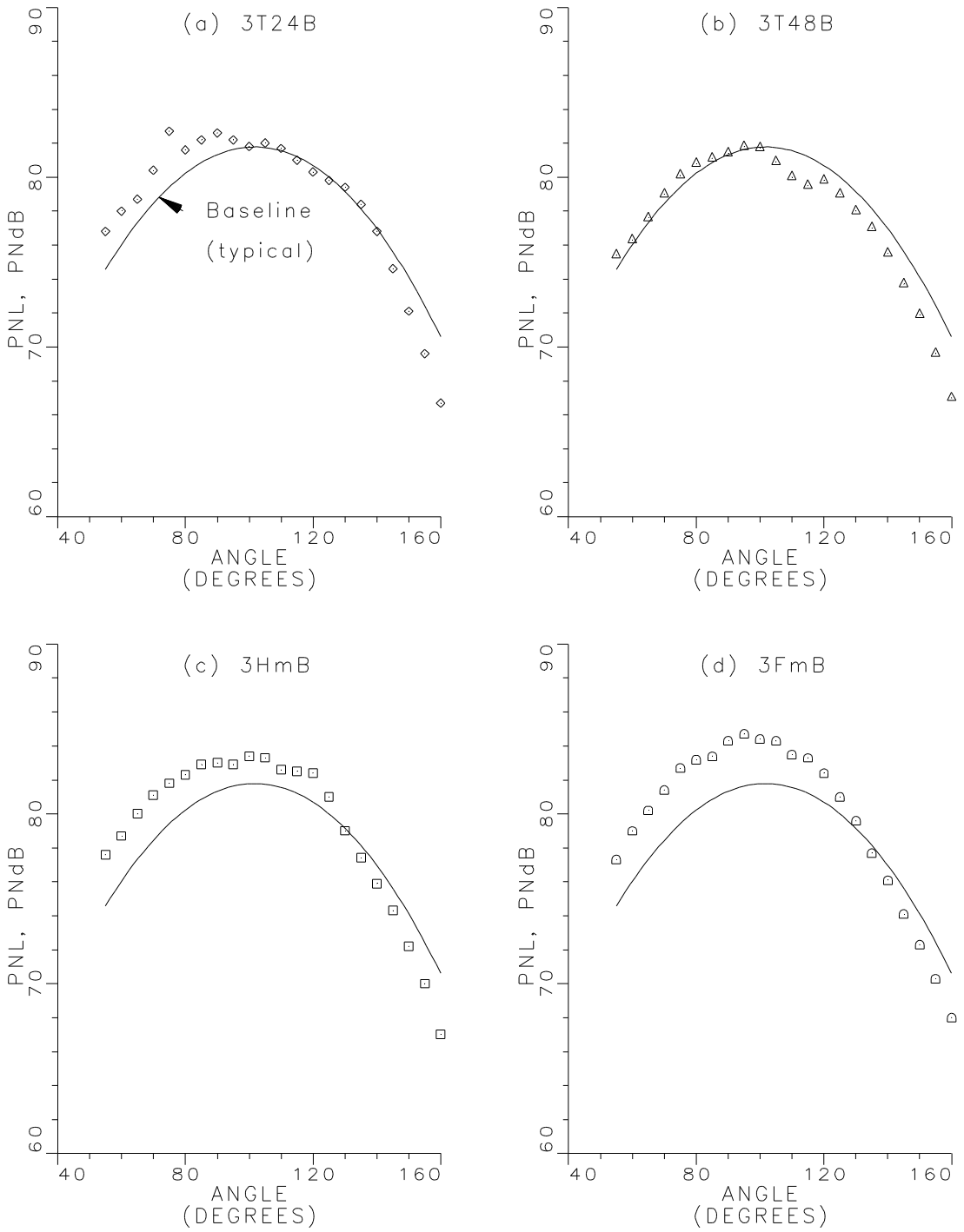


Figure A-4. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3T24B, (b) 3T48B, (c) 3HmB and (d) 3FmB.

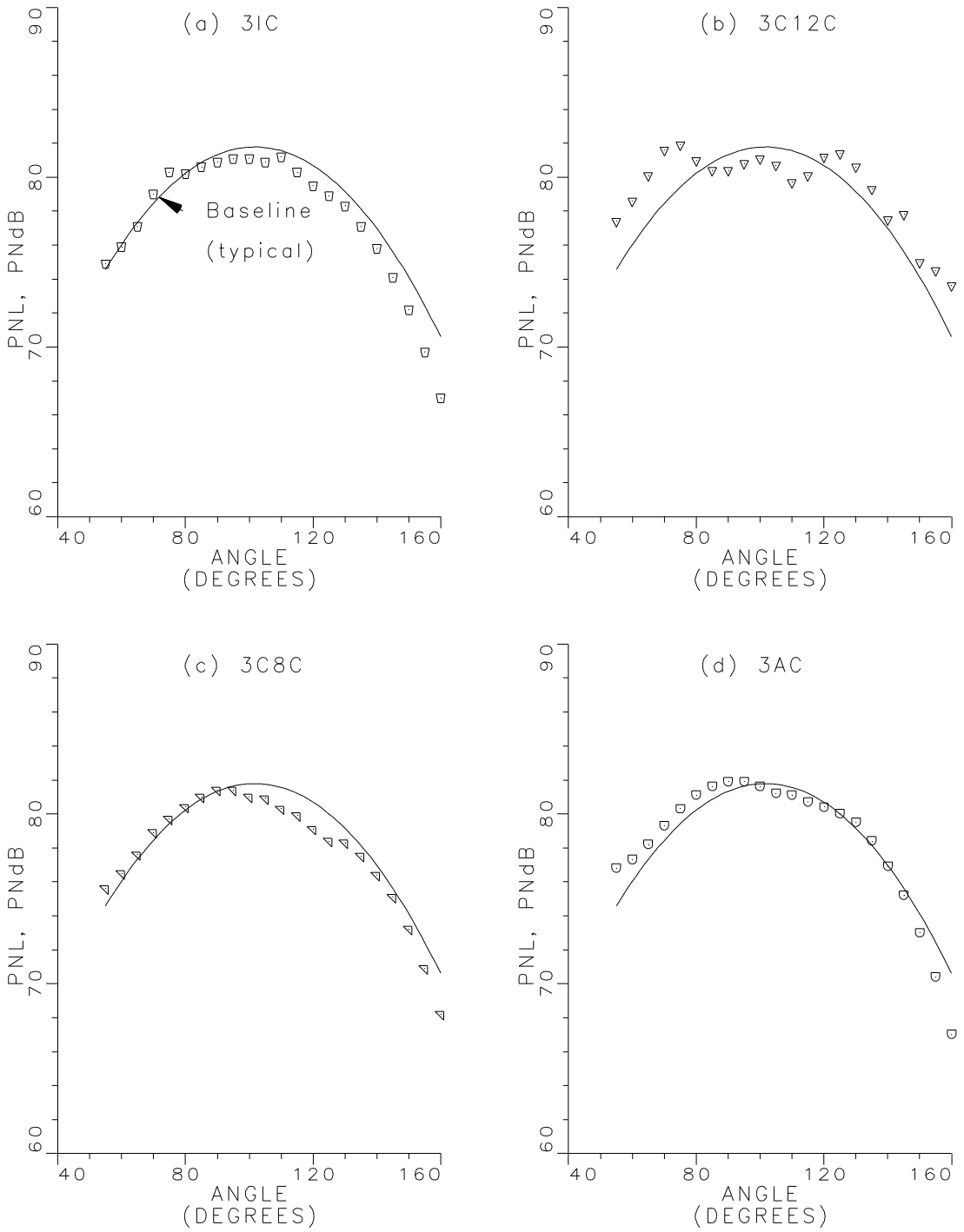


Figure A-5. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3IC, (b) 3C12C, (c) 3C8C and (d) 3AC.

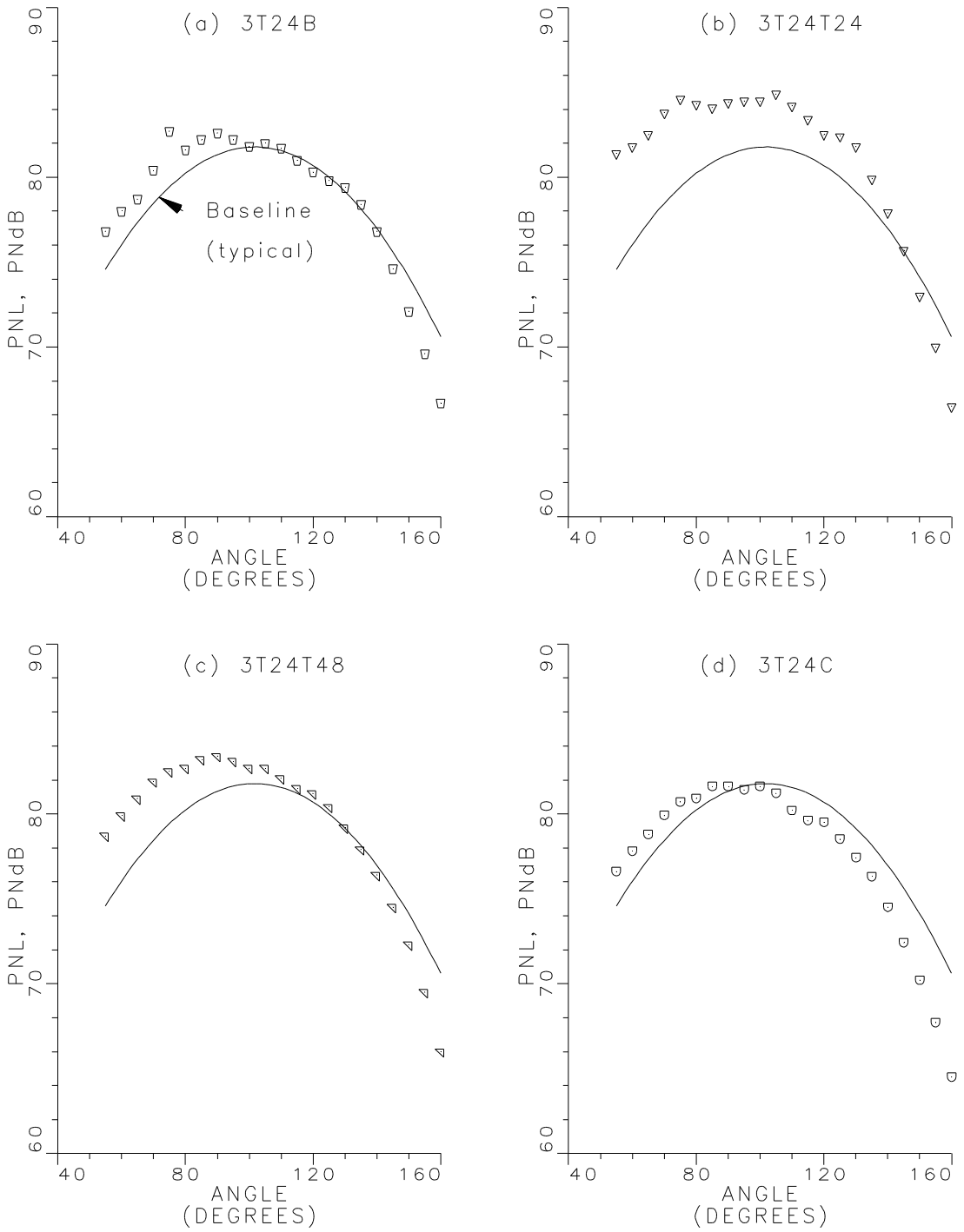


Figure A-6. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3T24B, (b) 3T24T24, (c) 3T24T48 and (d) 3T24C.

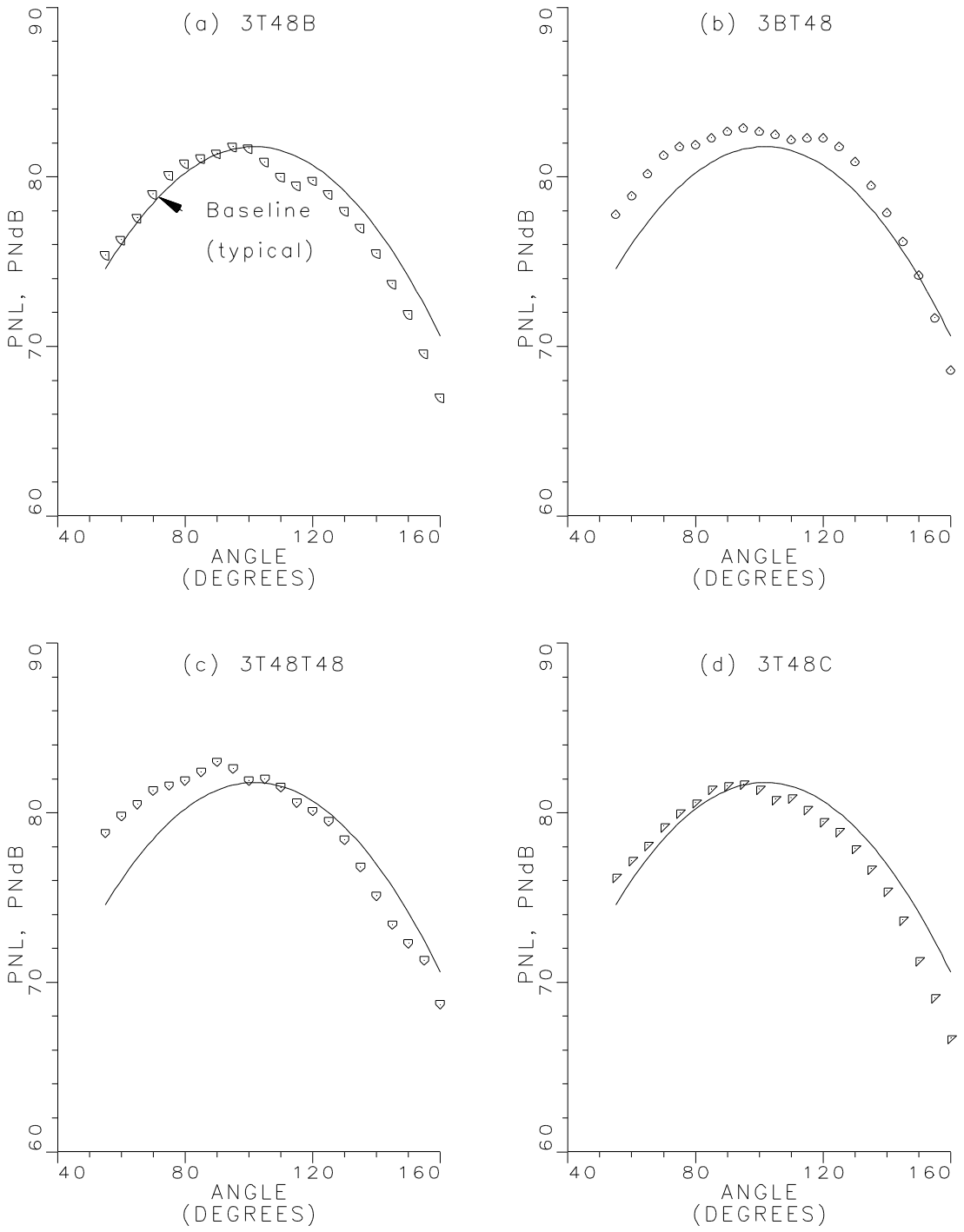


Figure A-7. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3T48B, (b) 3BT48, (c) 3T48T48 and (d) 3T48C.

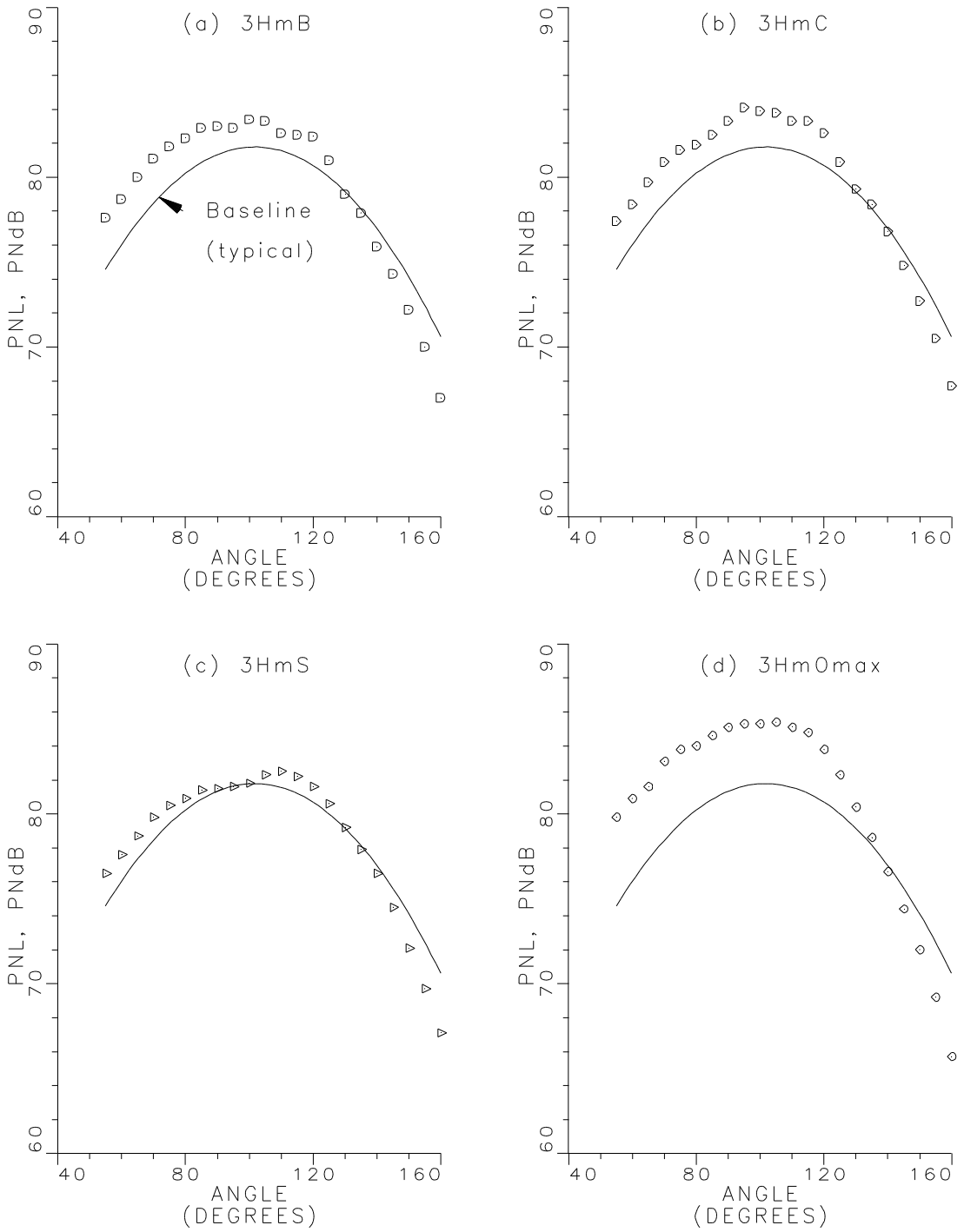


Figure A-8. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3HmB, (b) 3HmC, (c) 3HmS and (d) 3HmOmax.

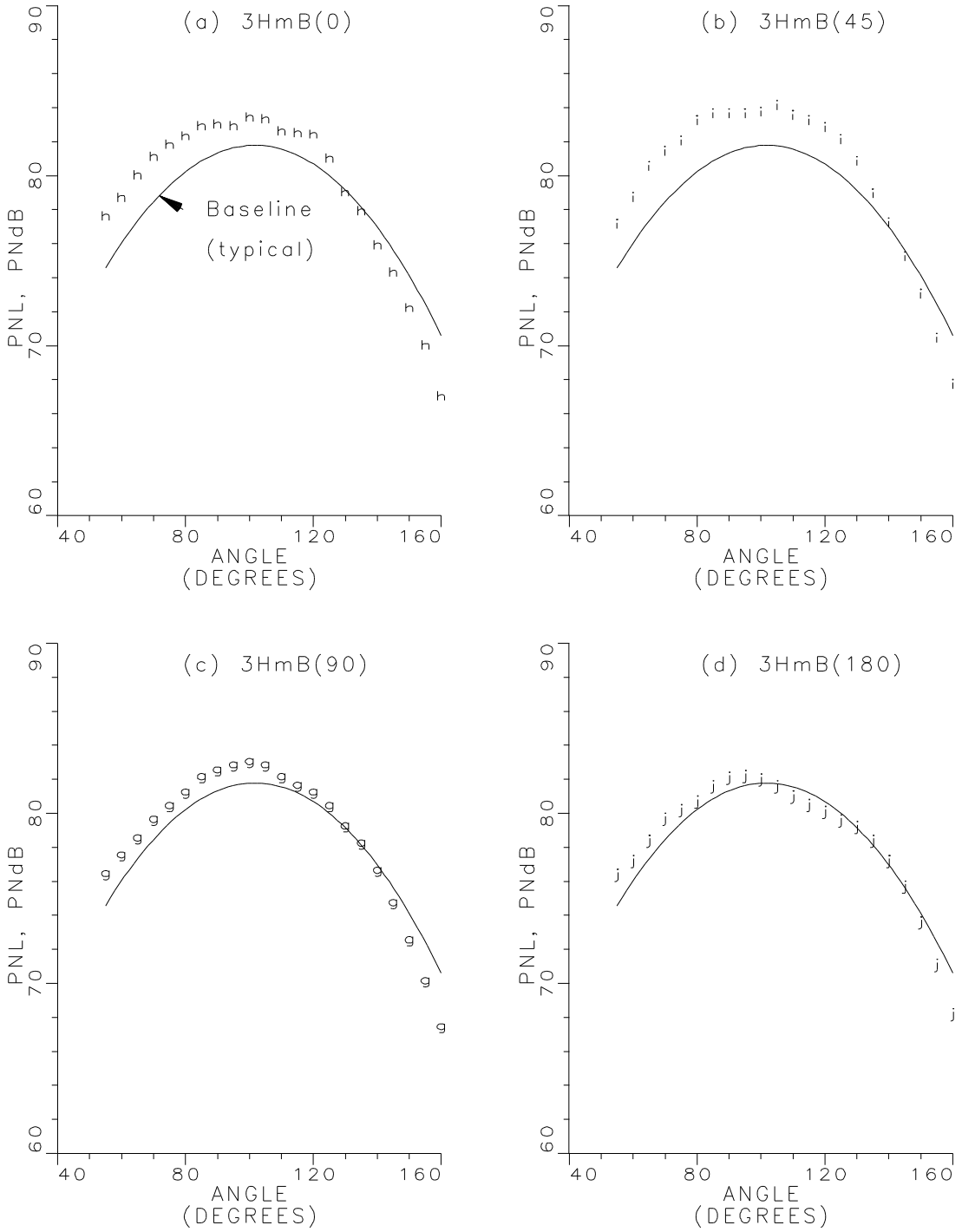


Figure A-9. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3HmB) at Four Different Azimuthal Angles ; (a) 0 deg. (b) 45 deg. (c) 90 deg. and (d) 180 deg.

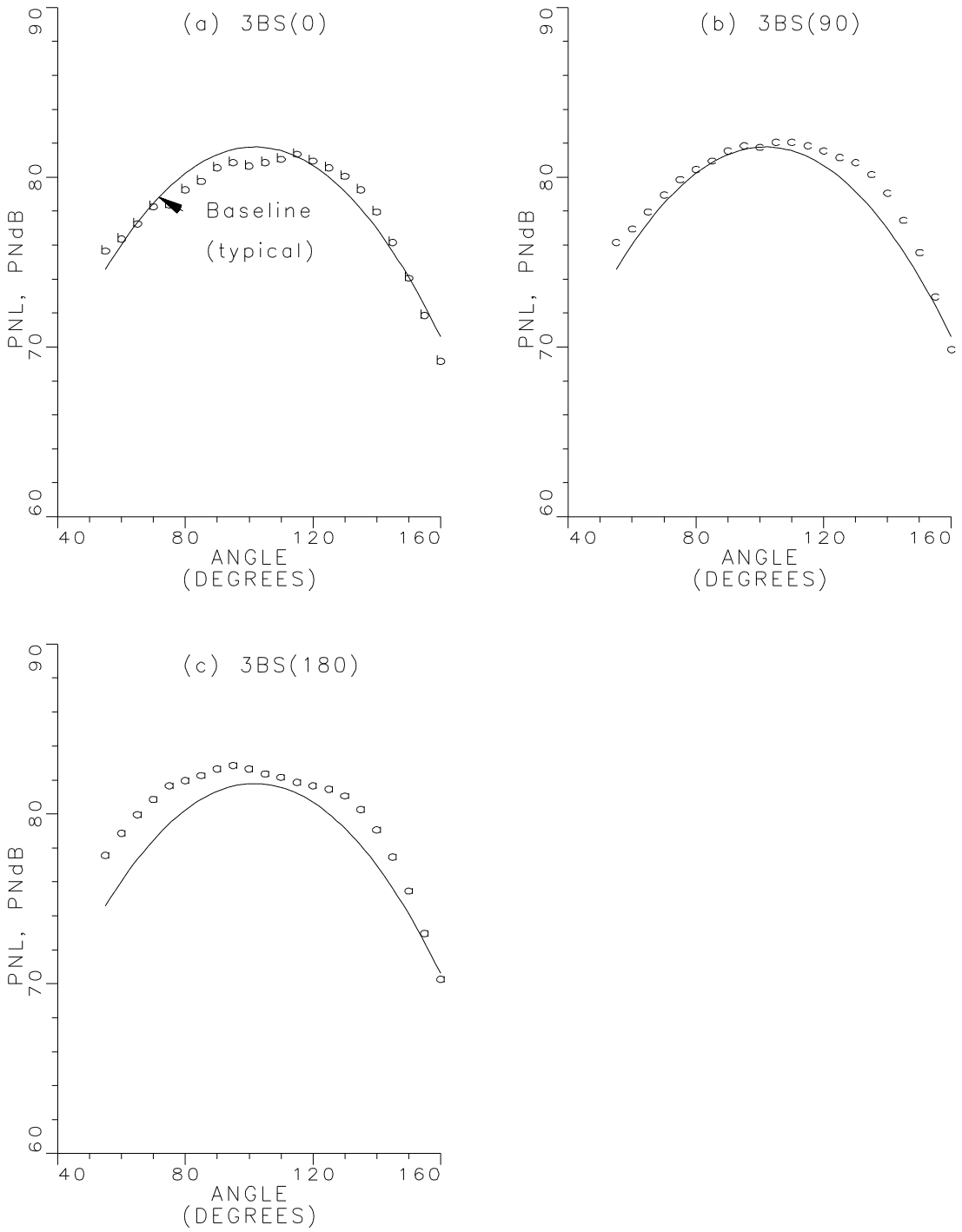


Figure A-10. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3BS) Measured at Three Different Azimuthal Angles ; (a) 0 deg. (b) 90 deg. and (c) 180 deg.

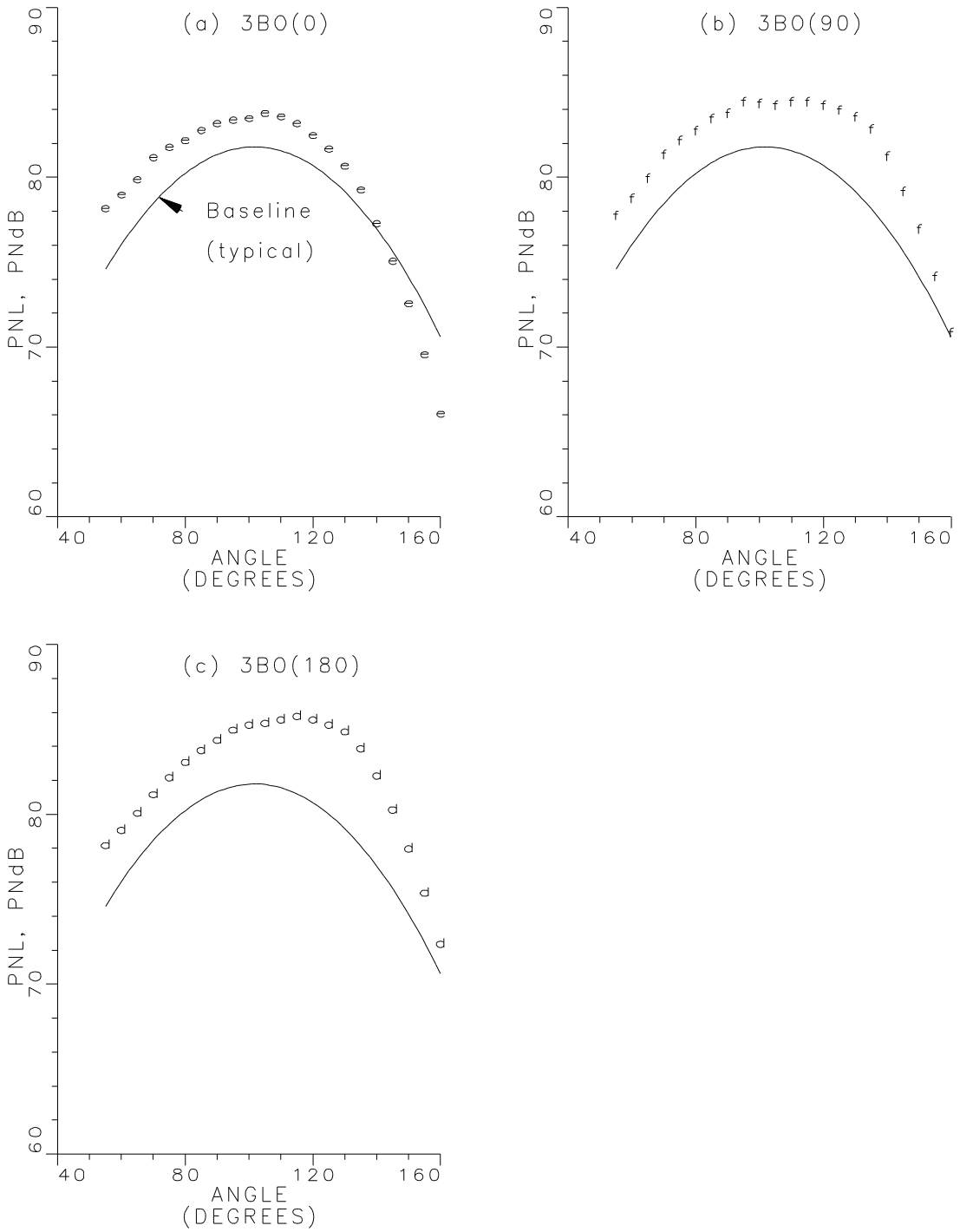


Figure A-11. PNL Directivities (at Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3BOmax) Measured at Three Different Azimuthal Angles ; (a) 0 deg. (b) 90 deg. and (c) 180 deg.

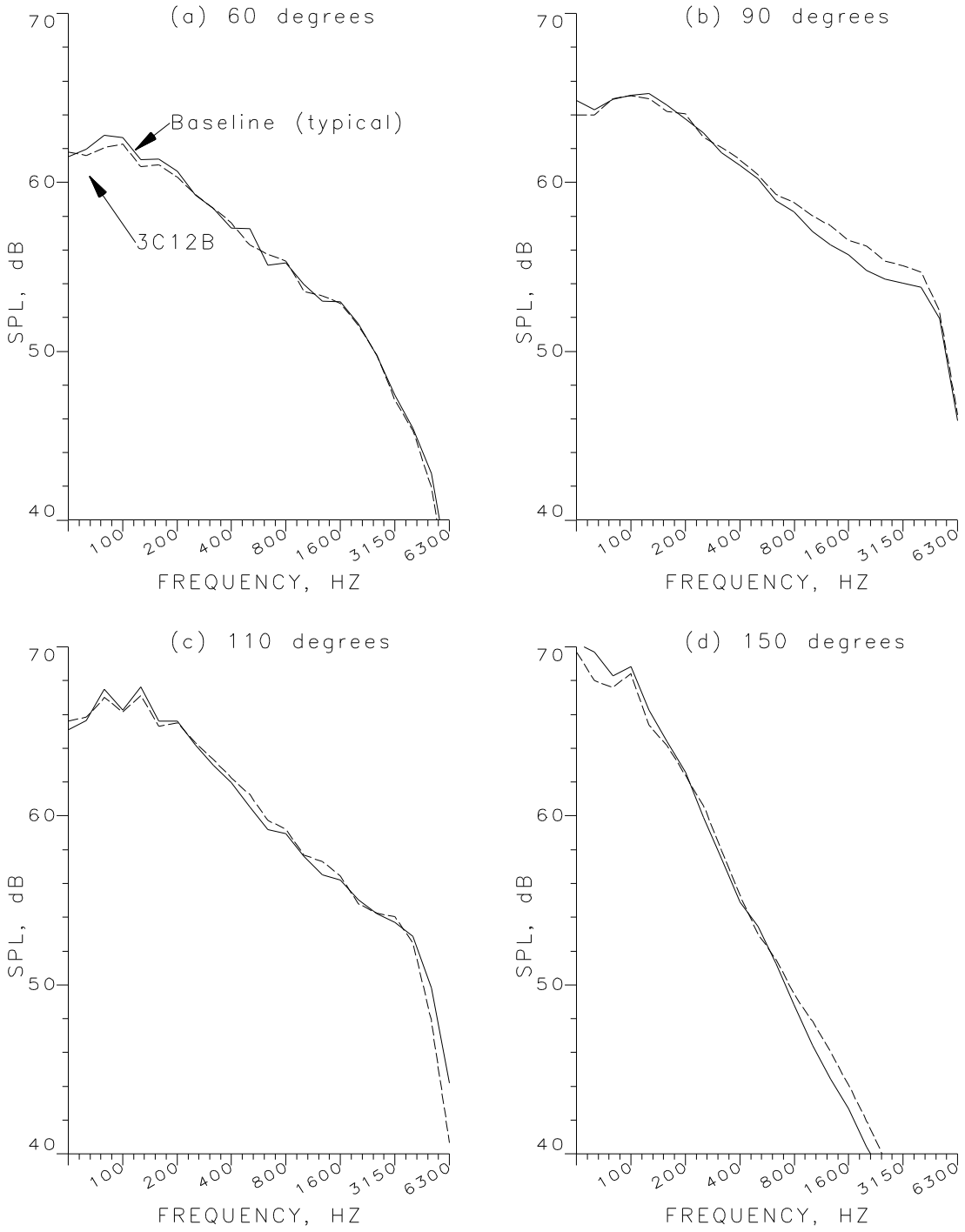


Figure A-12. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3C12B) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

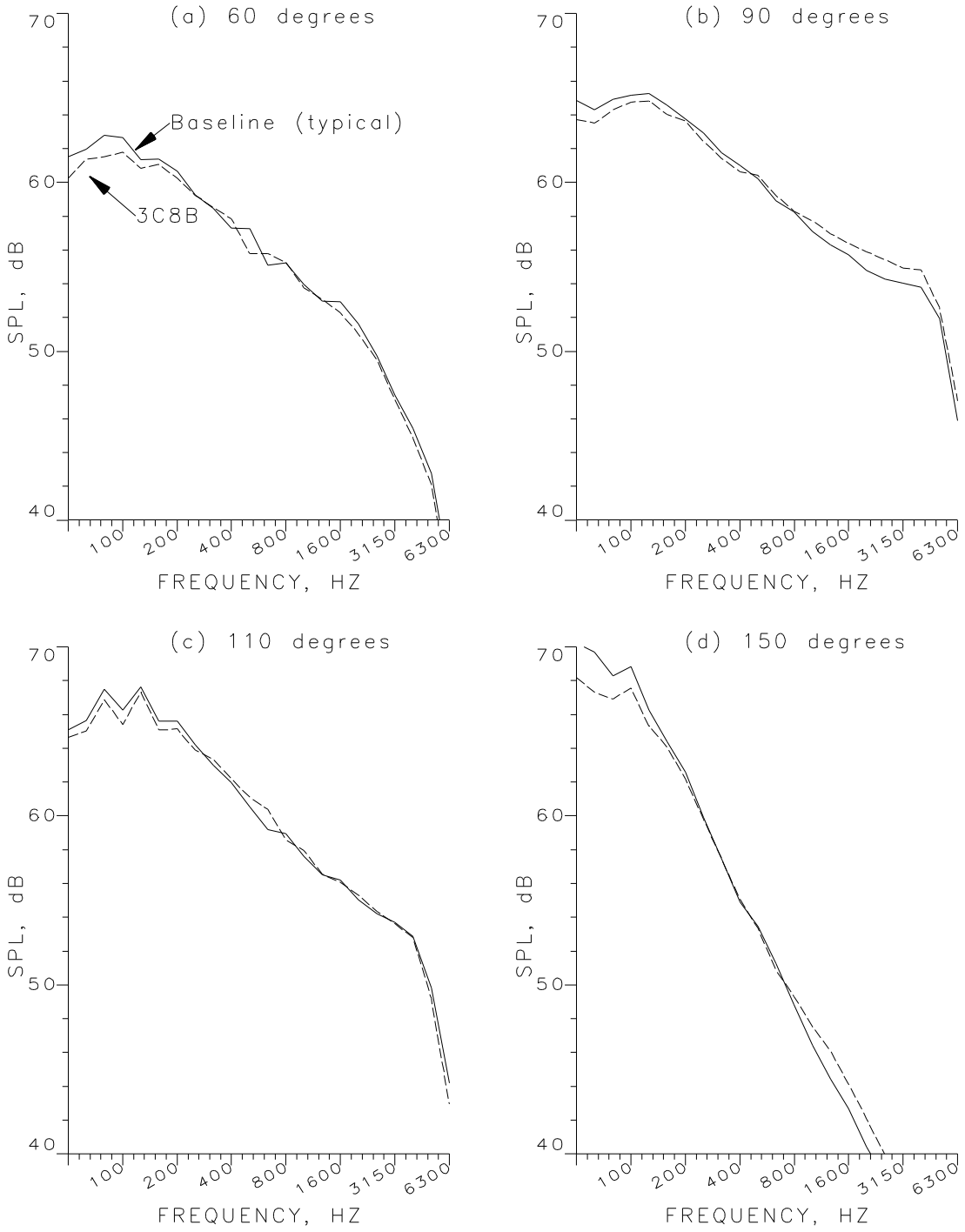


Figure A-13. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3C8B) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

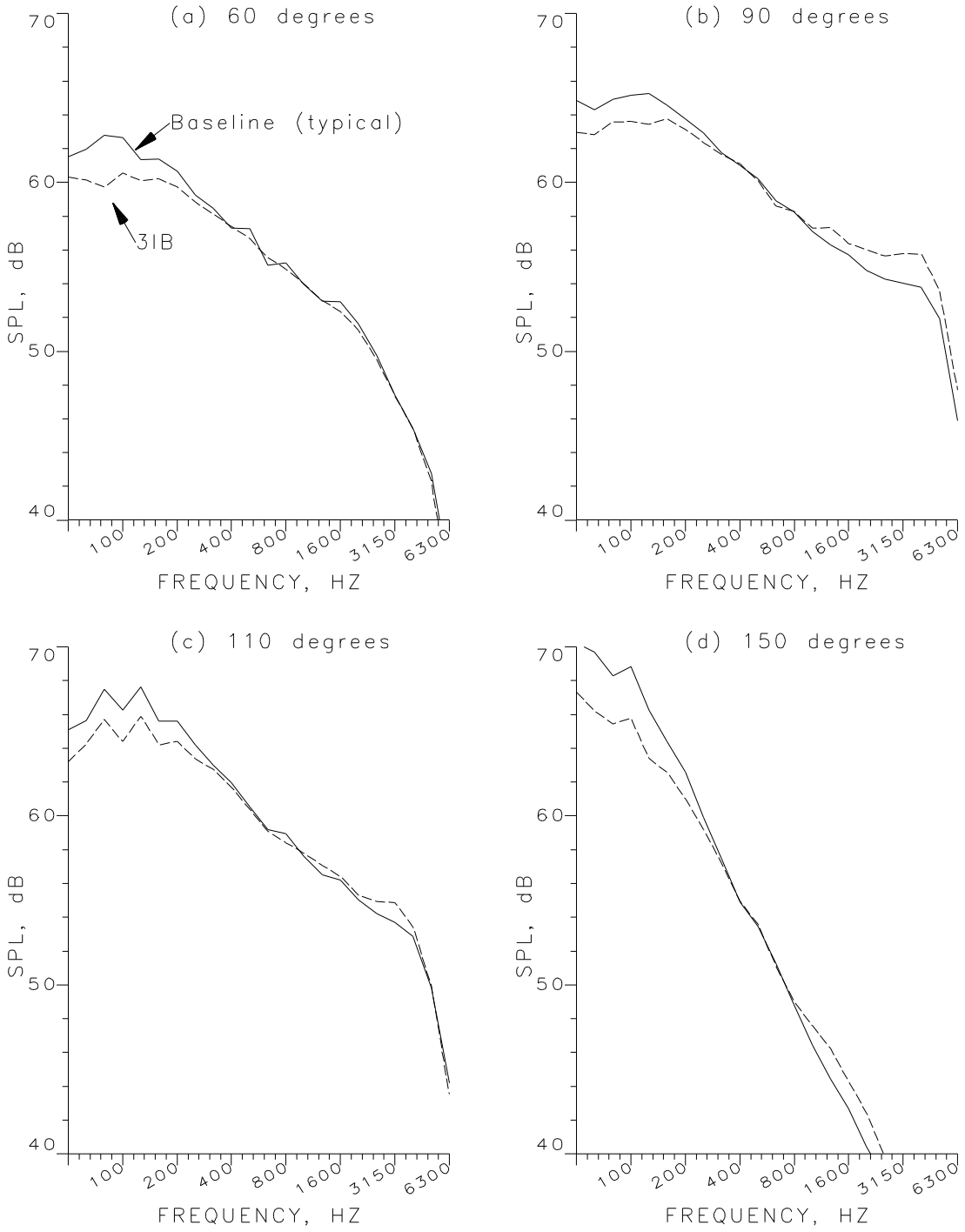


Figure A-14. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3IB) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

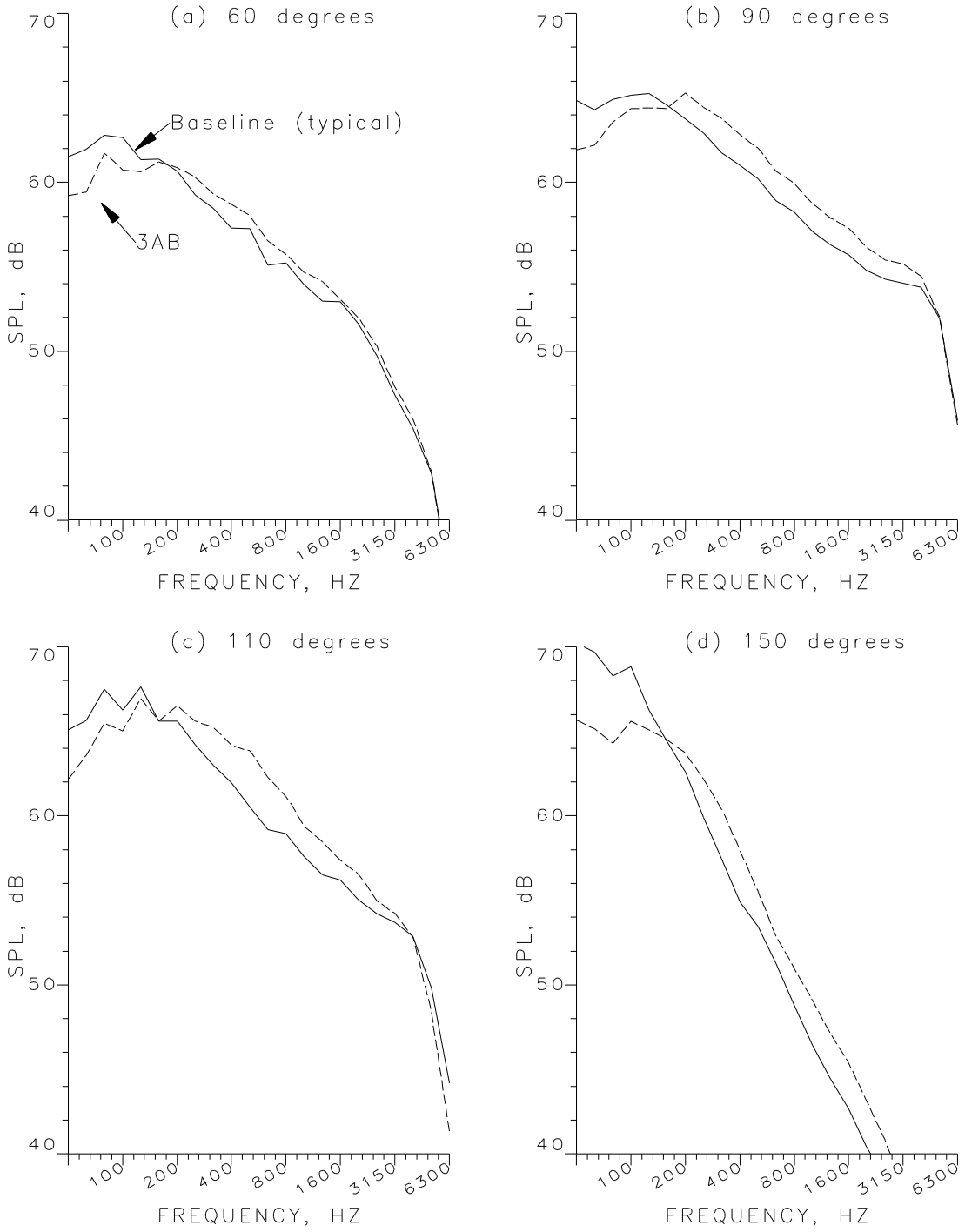


Figure A-15. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3AB) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

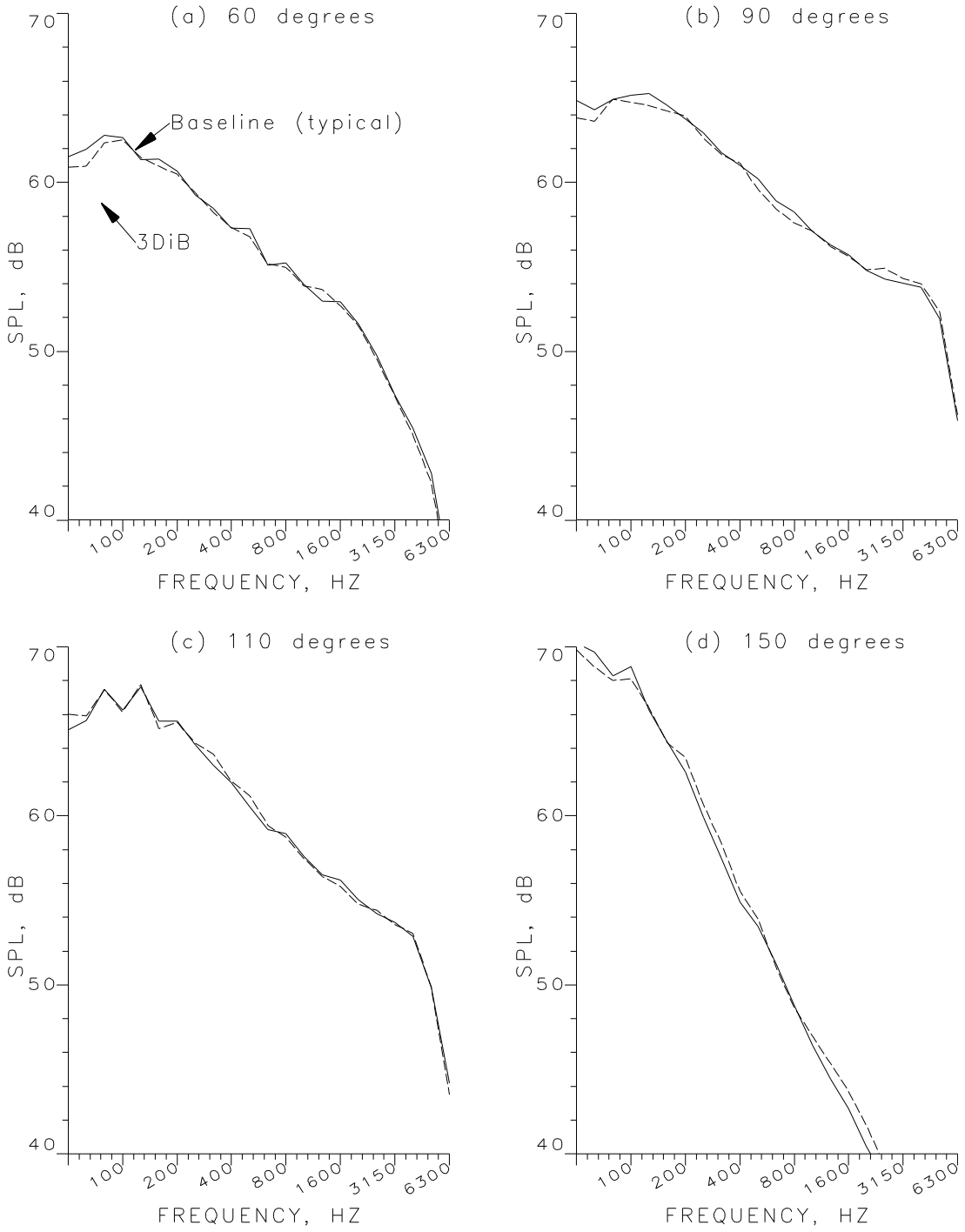


Figure A-16. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3DiB) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

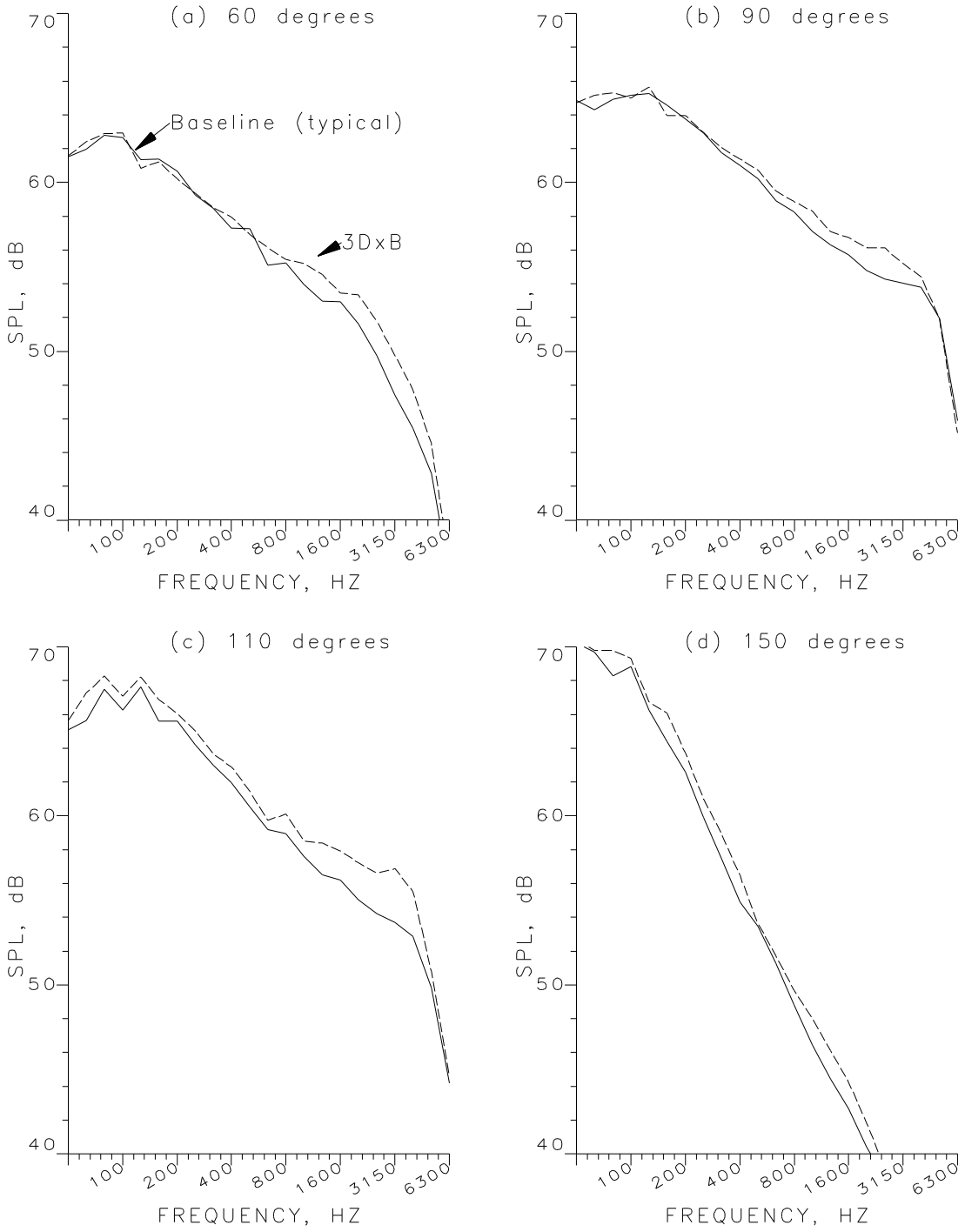


Figure A-17. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3DxB) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

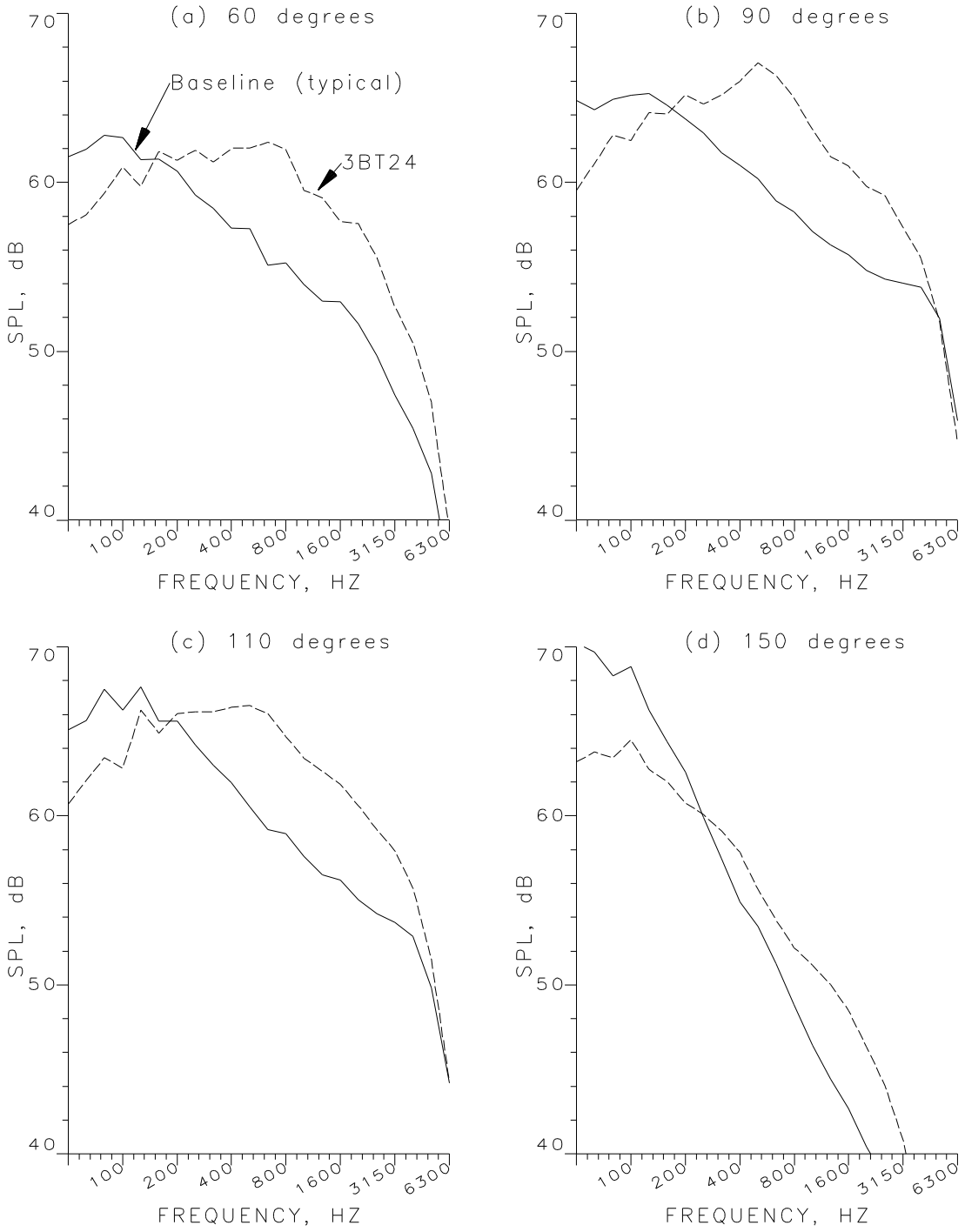


Figure A-18. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3BT24) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

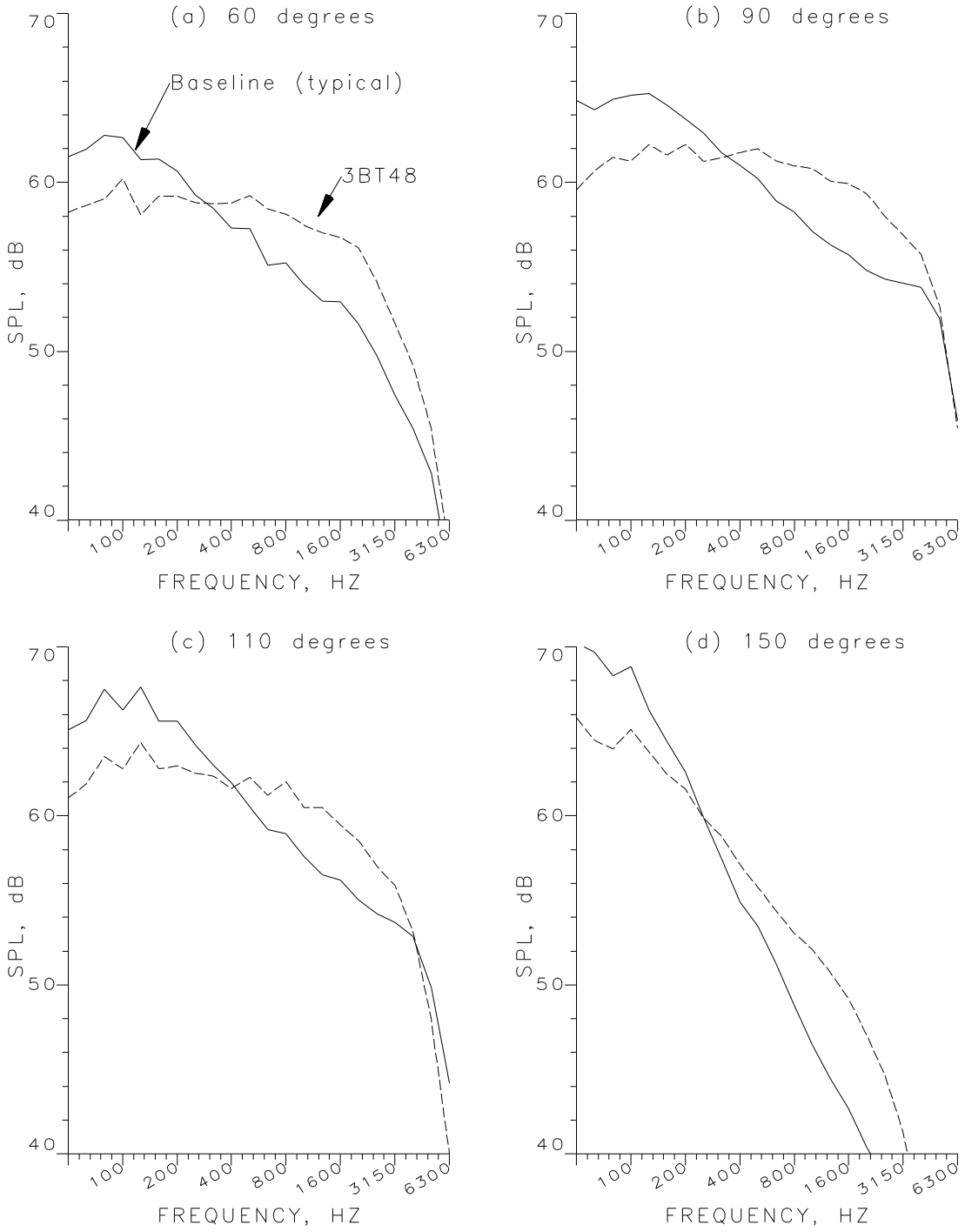


Figure A-19. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3BT48) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

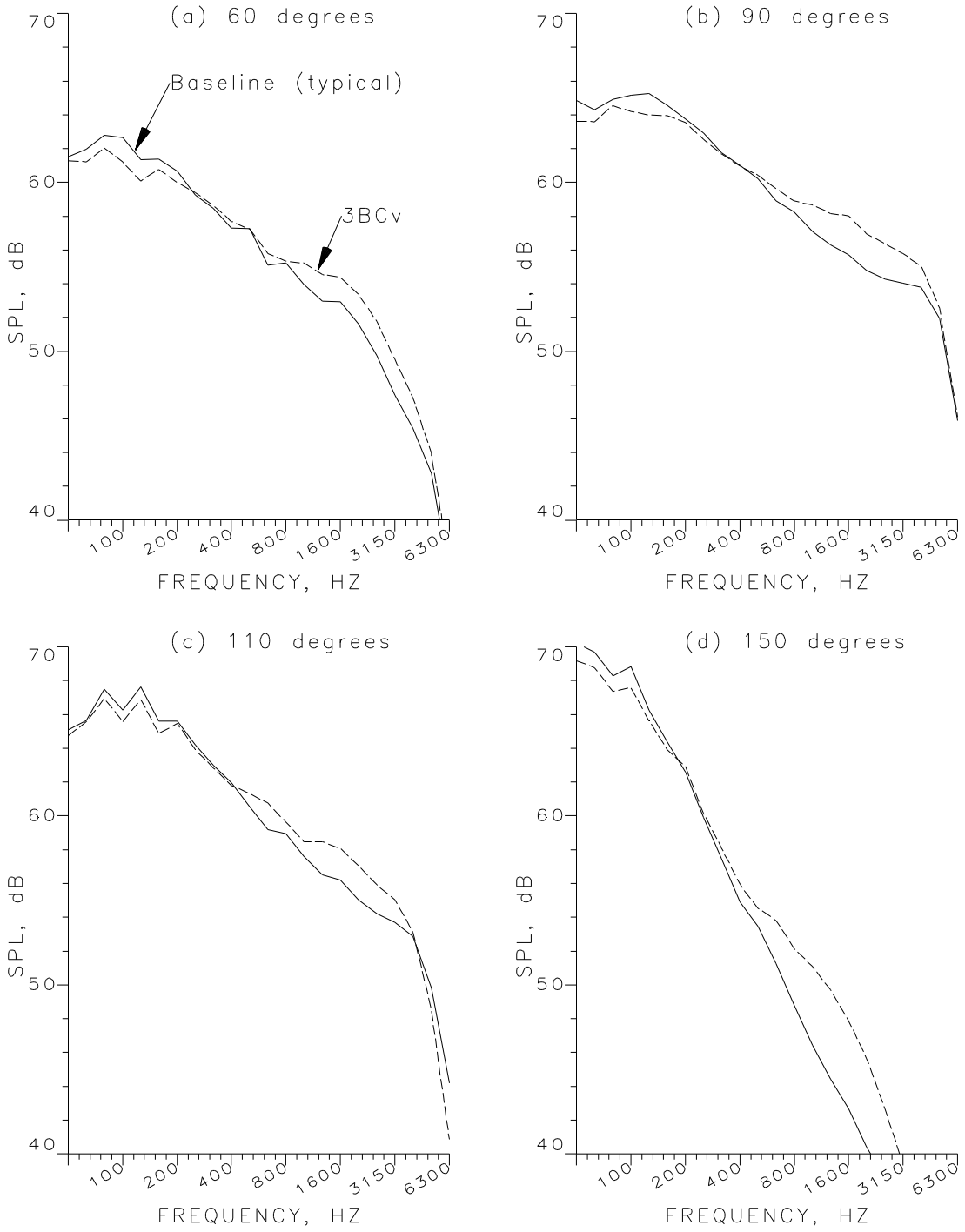


Figure A-20. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3BCv) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

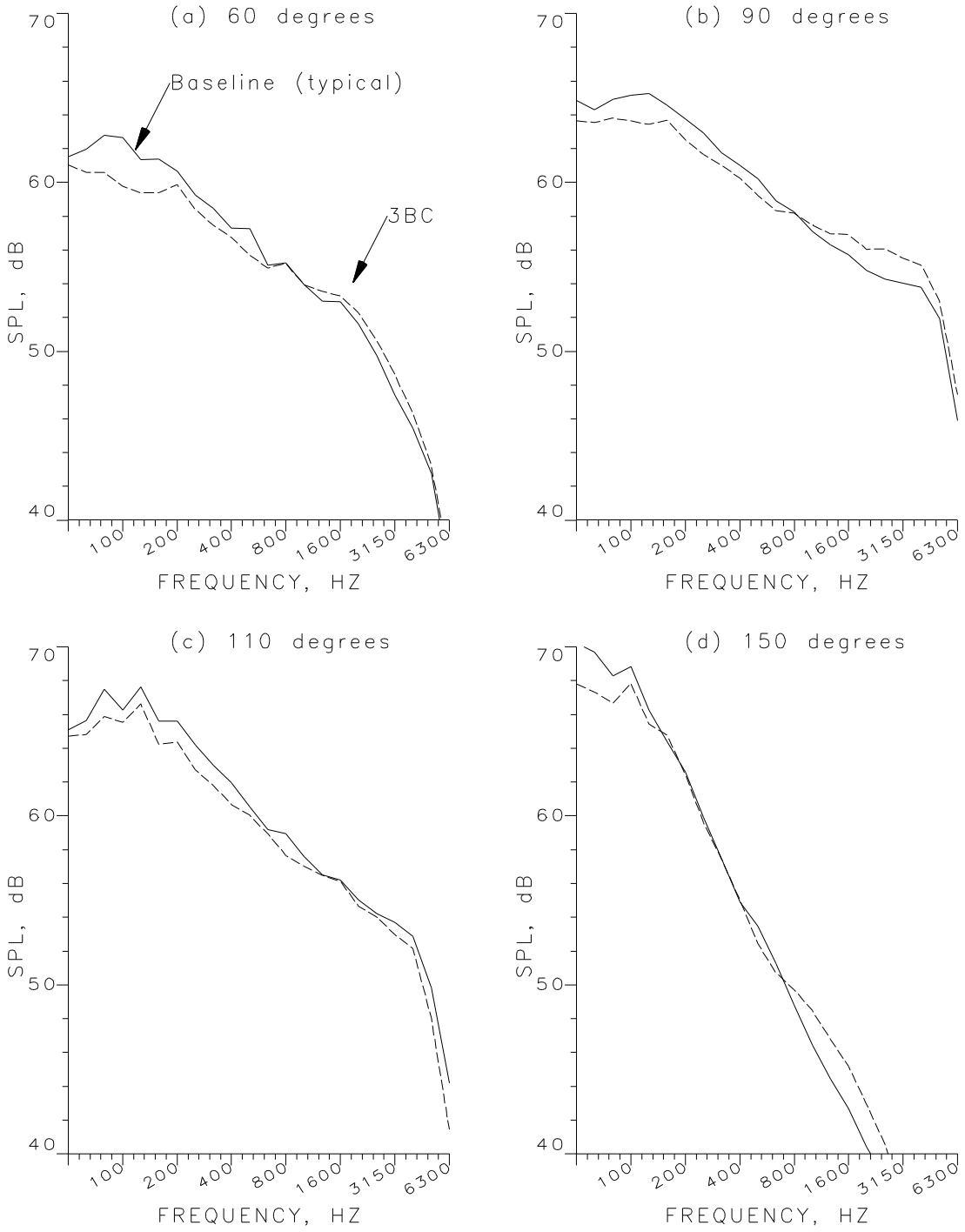


Figure A-21. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3BC) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

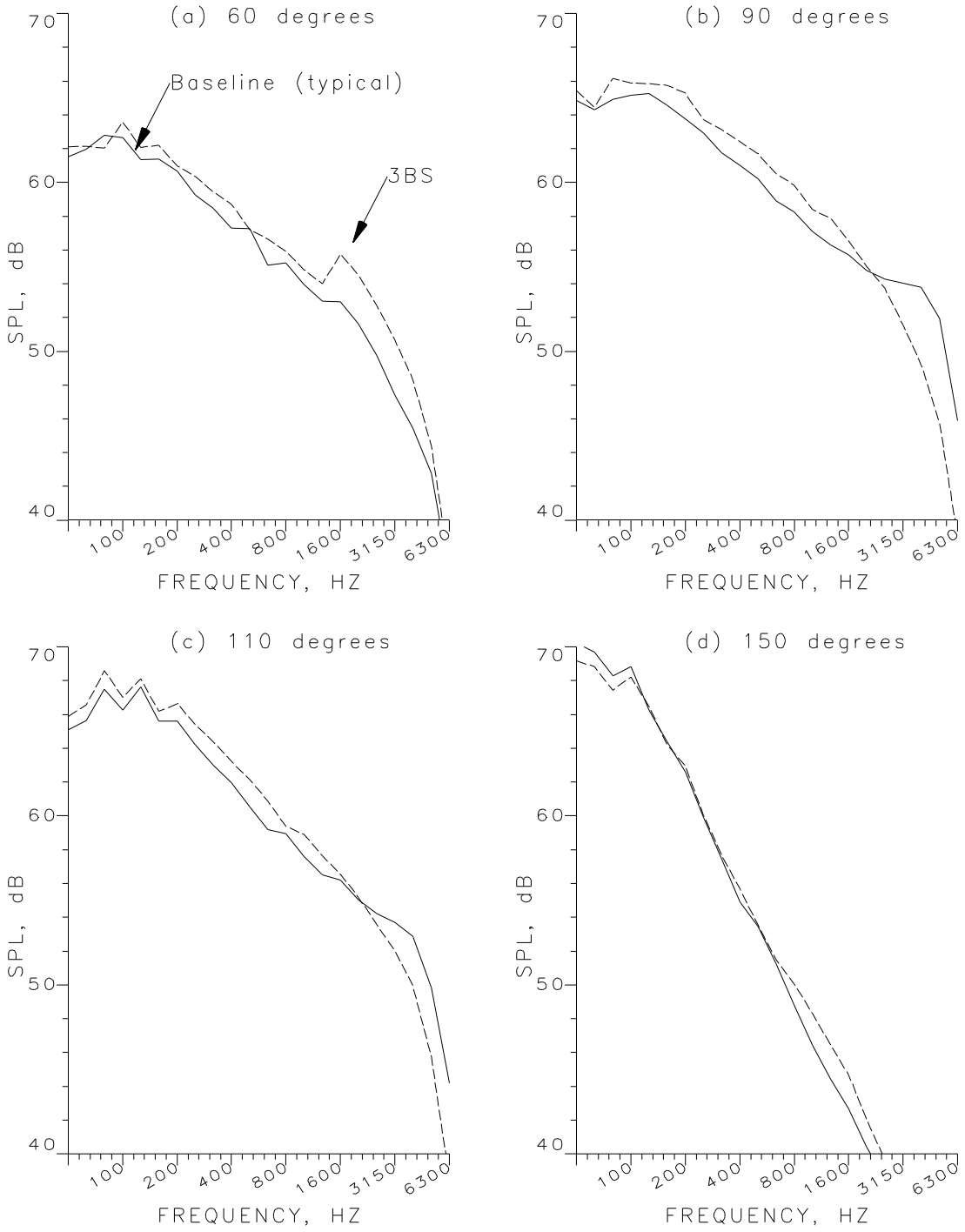


Figure A-22. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3BS) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

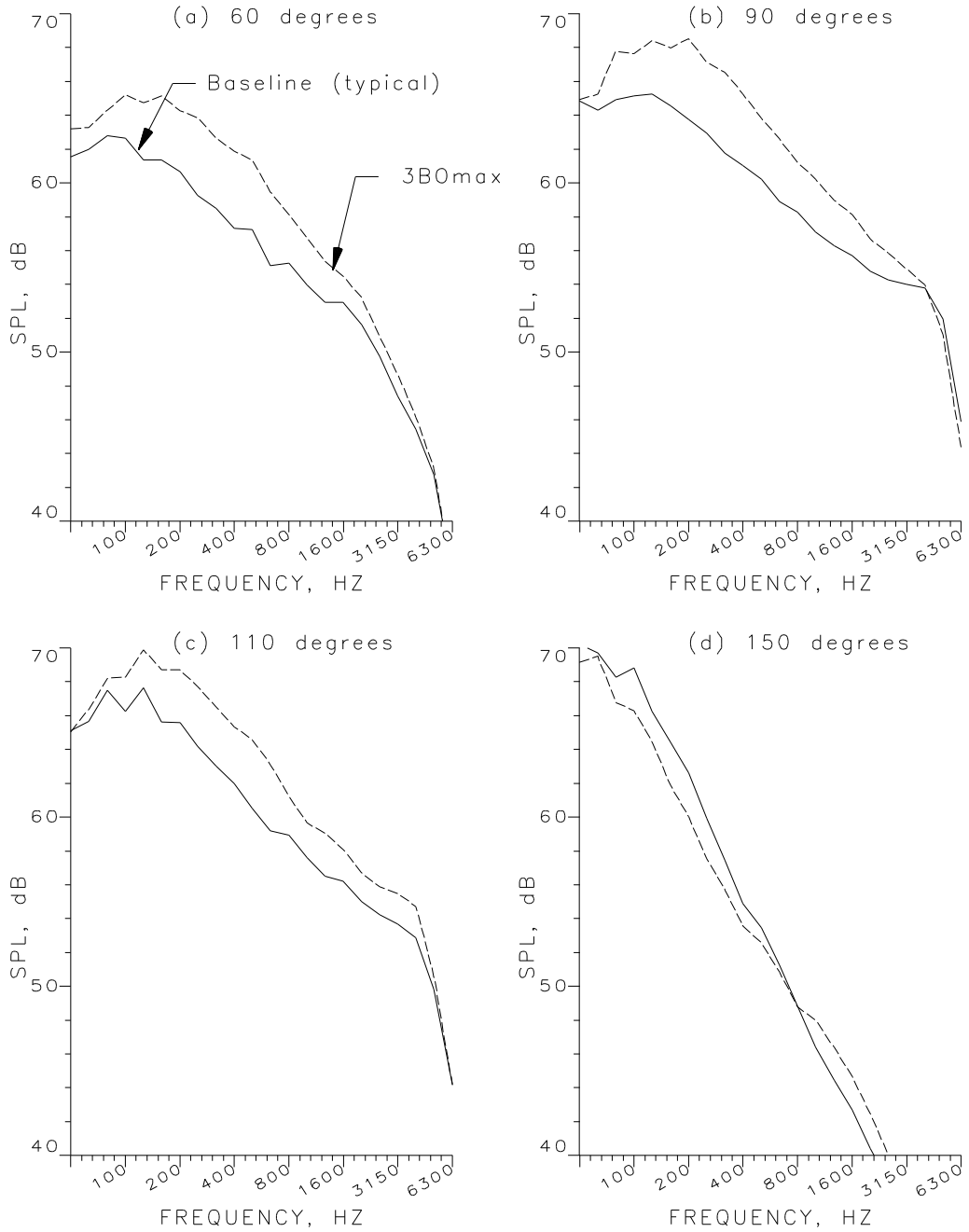


Figure A-23. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3BOmax) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

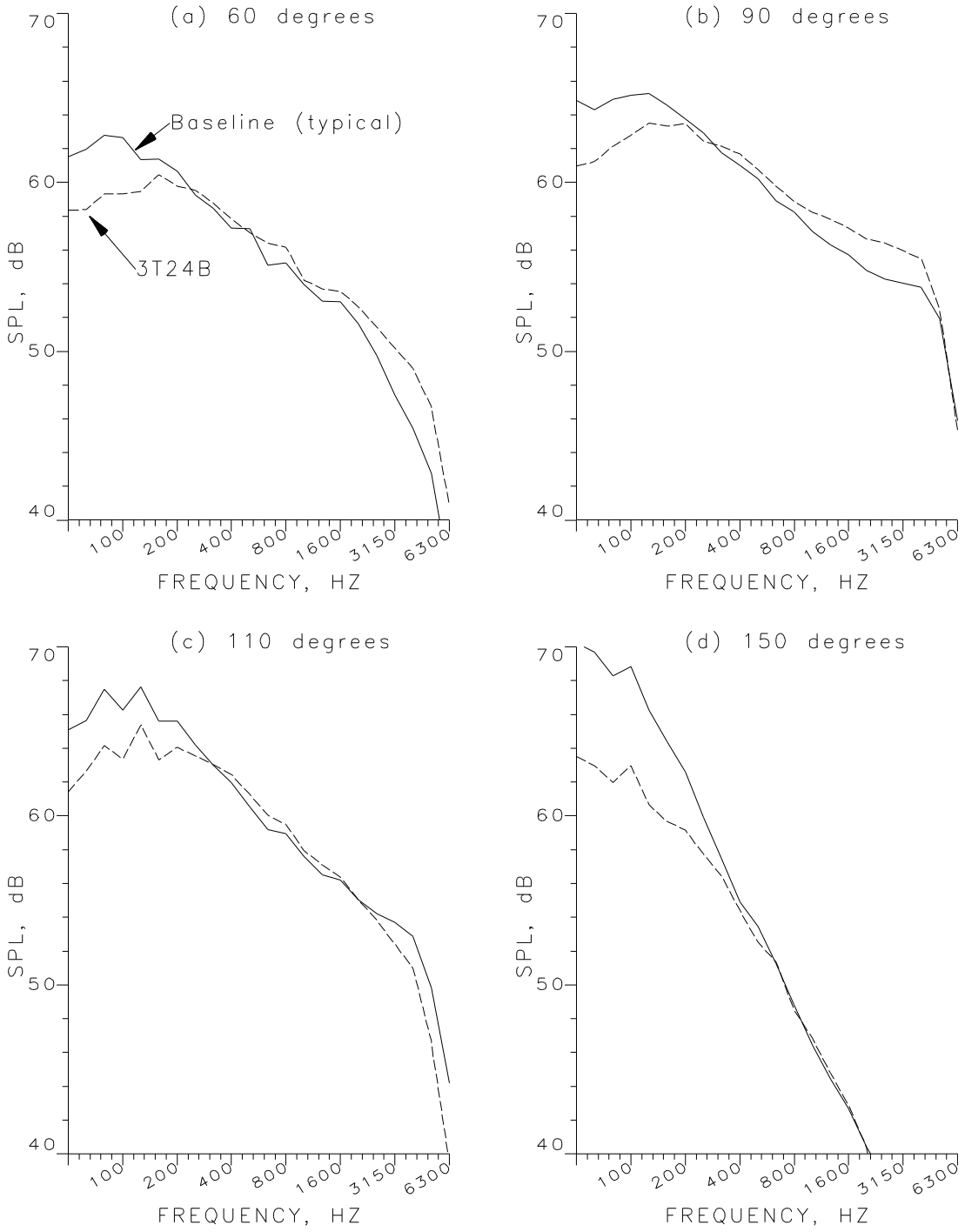


Figure A-24. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3T24B) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

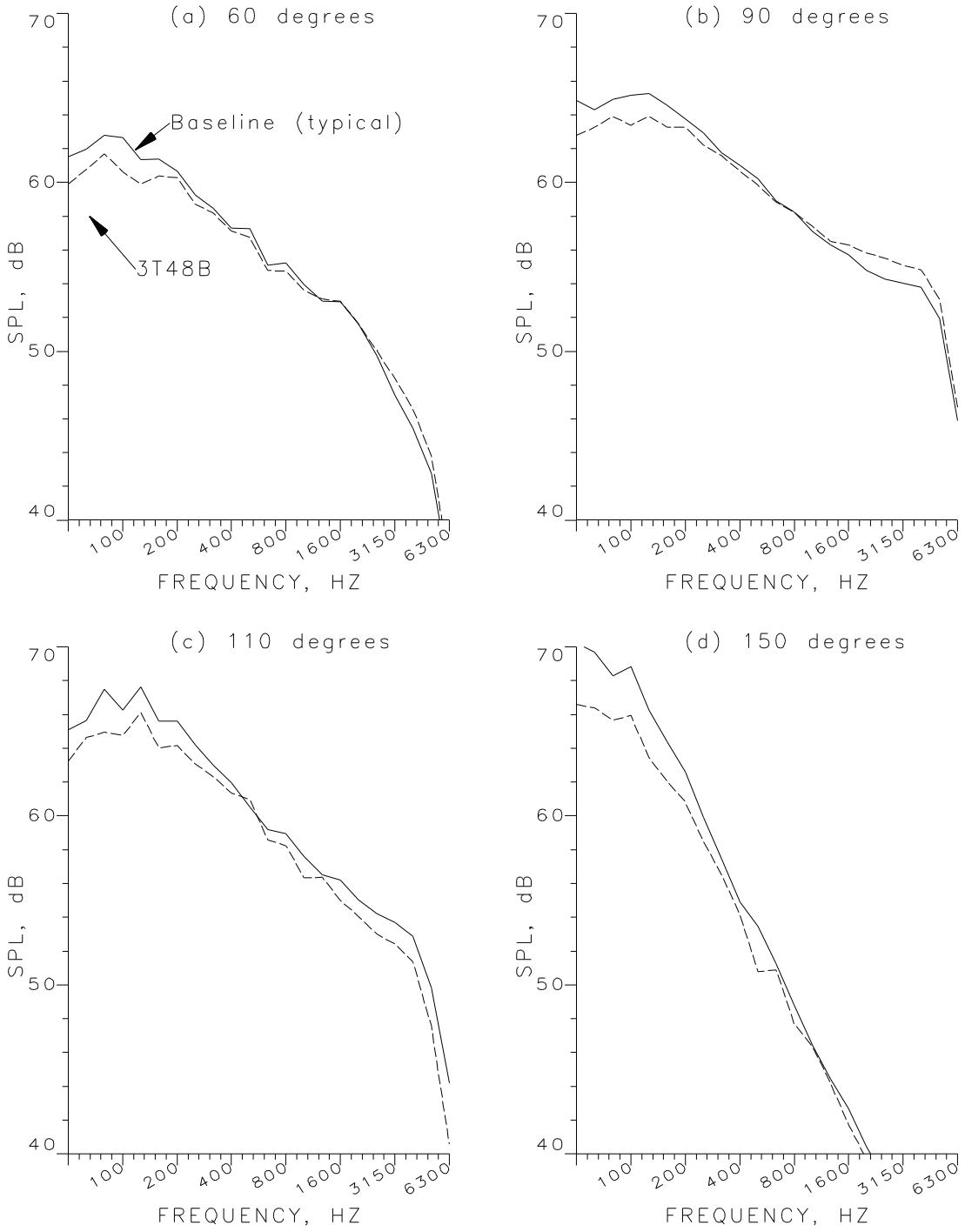


Figure A-25. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3T48B) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

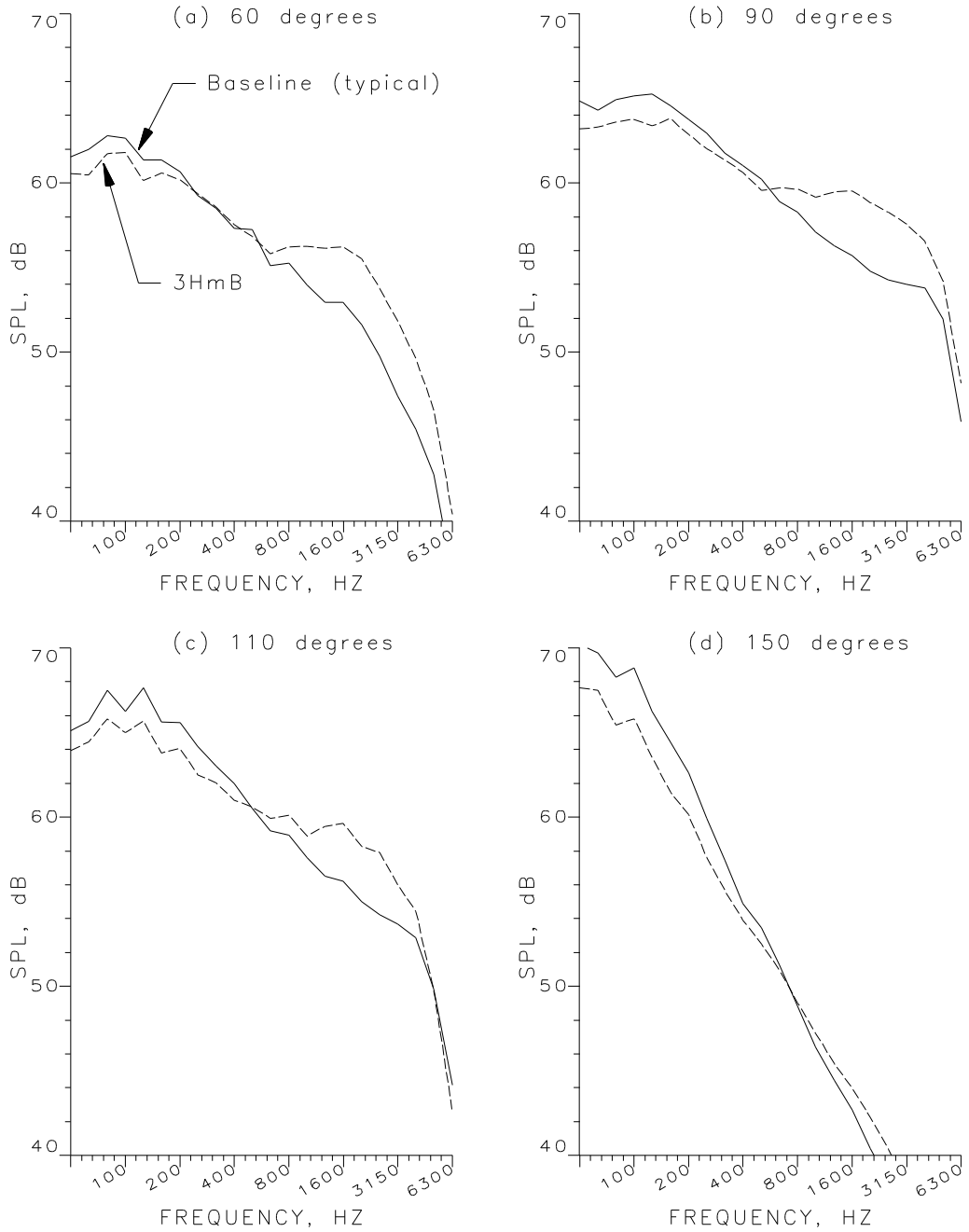


Figure A-26. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3HmB) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

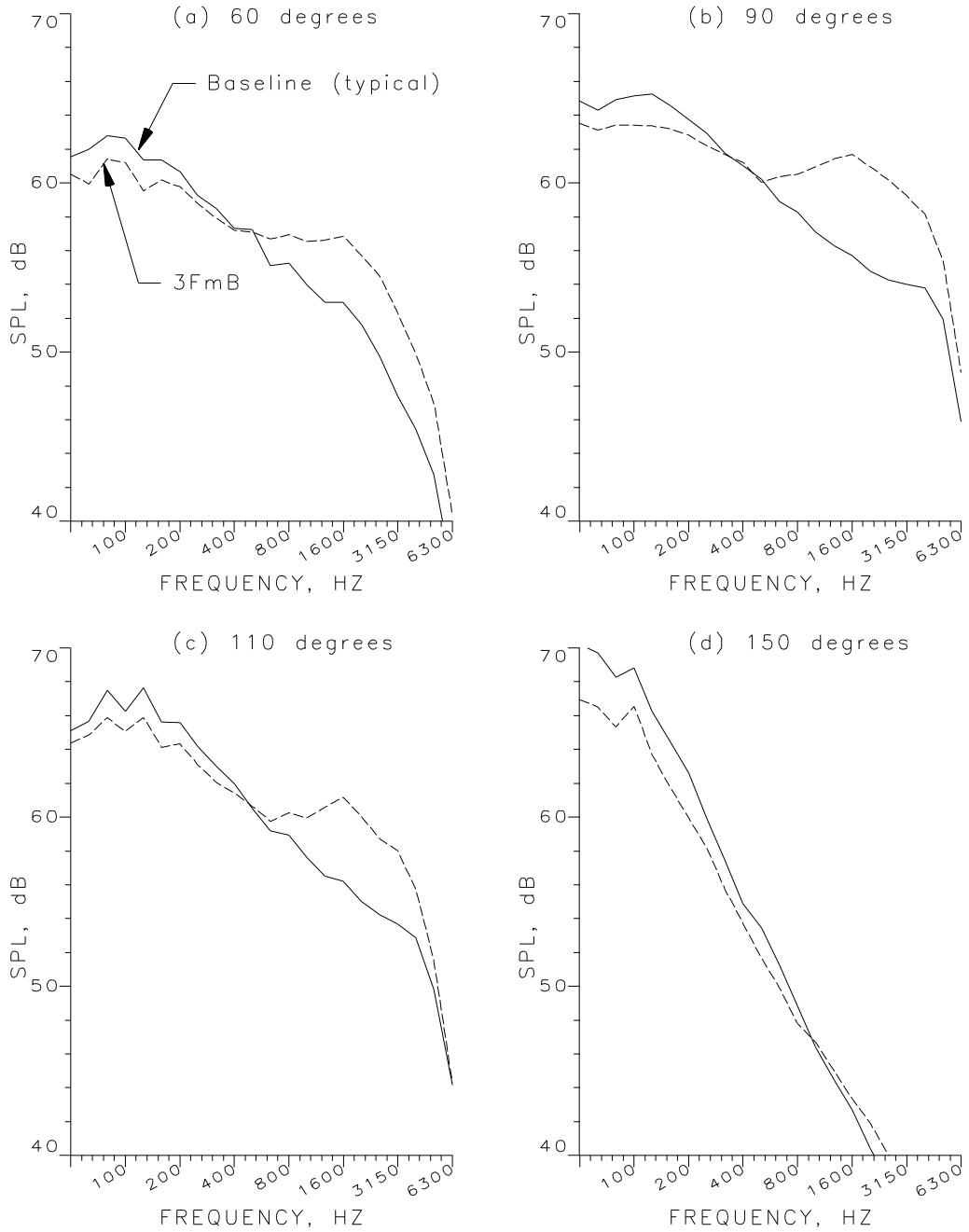


Figure A-27. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3FmB) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

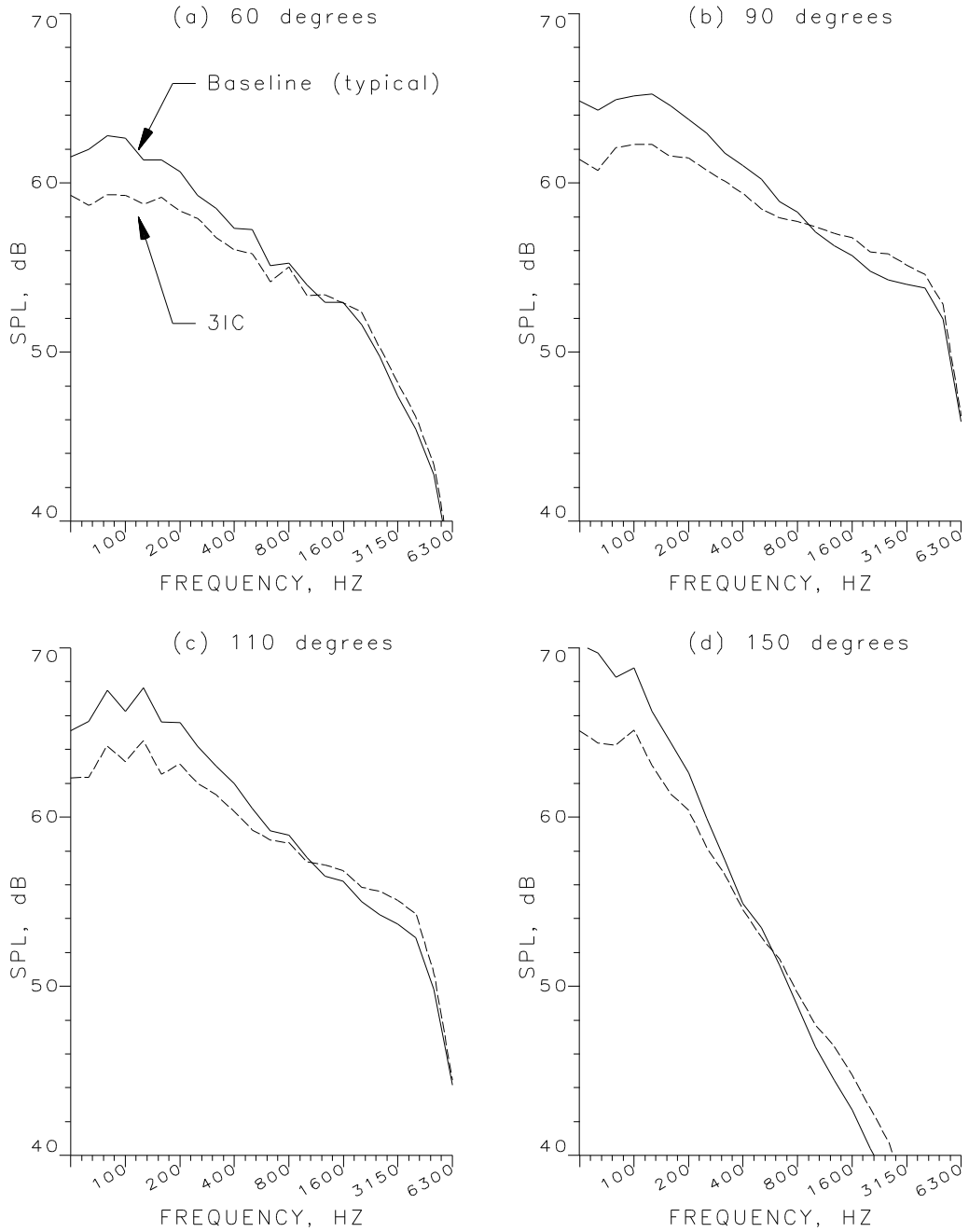


Figure A-28. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3IC) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

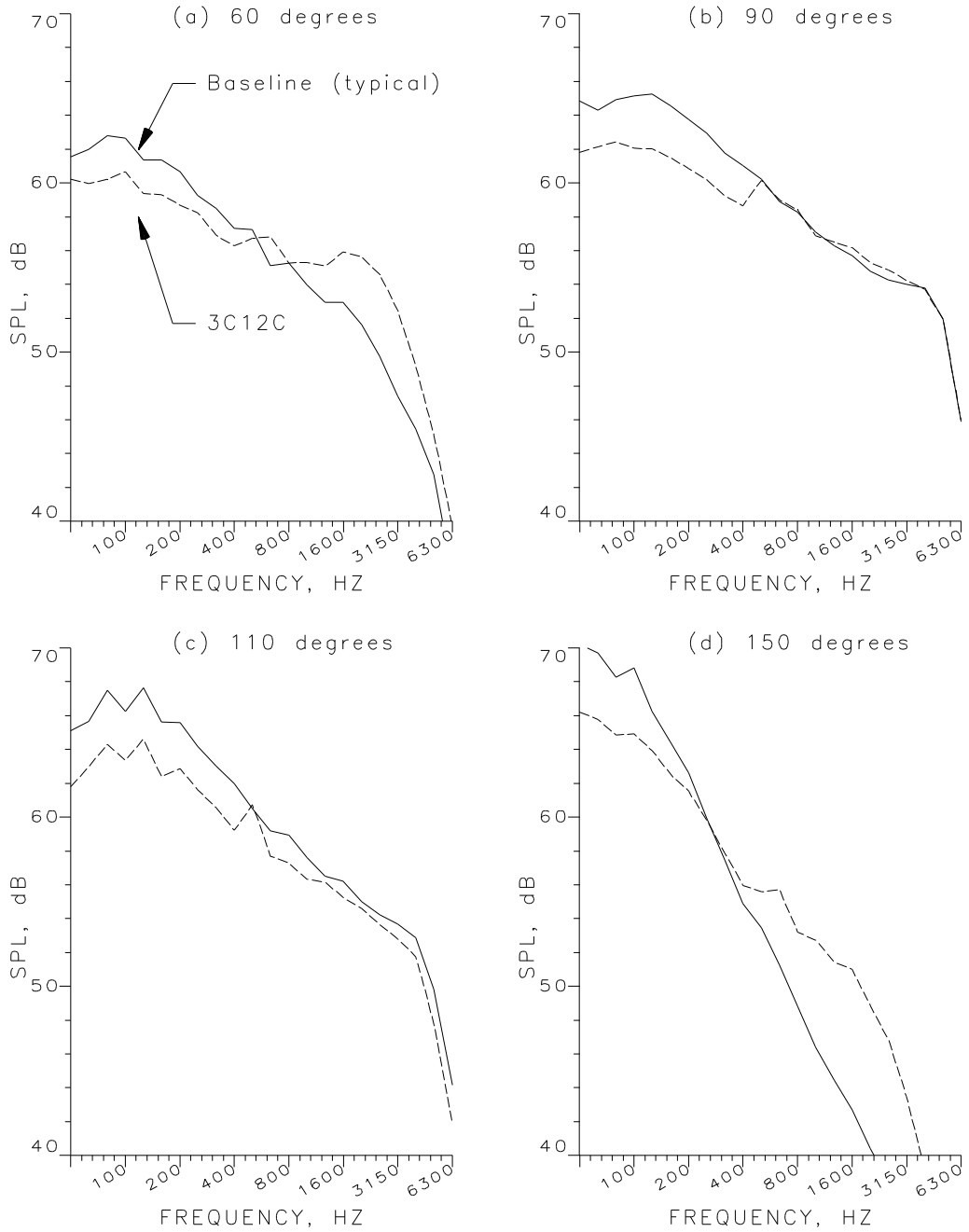


Figure A-29. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3C12C) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

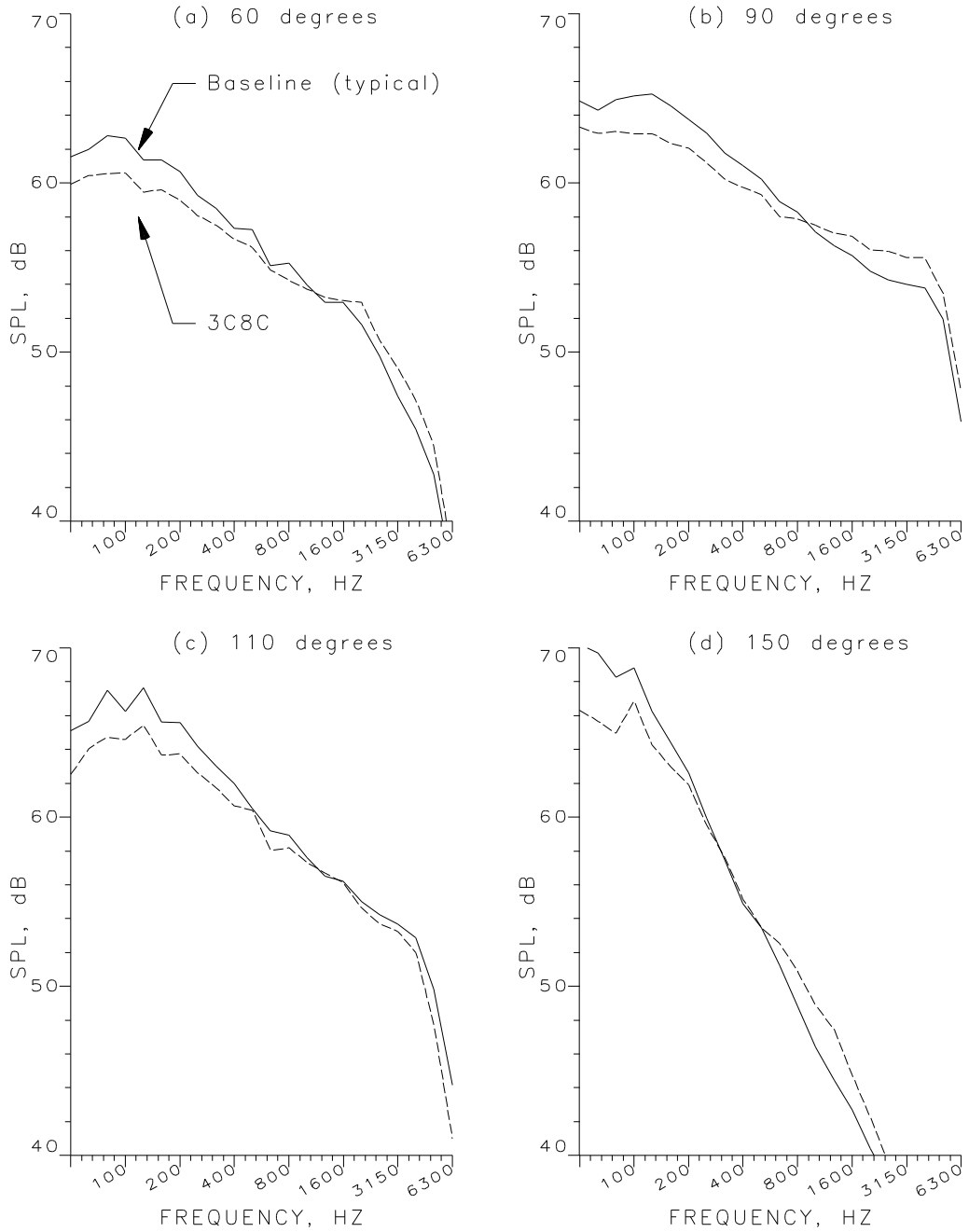


Figure A-30. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3C8C) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

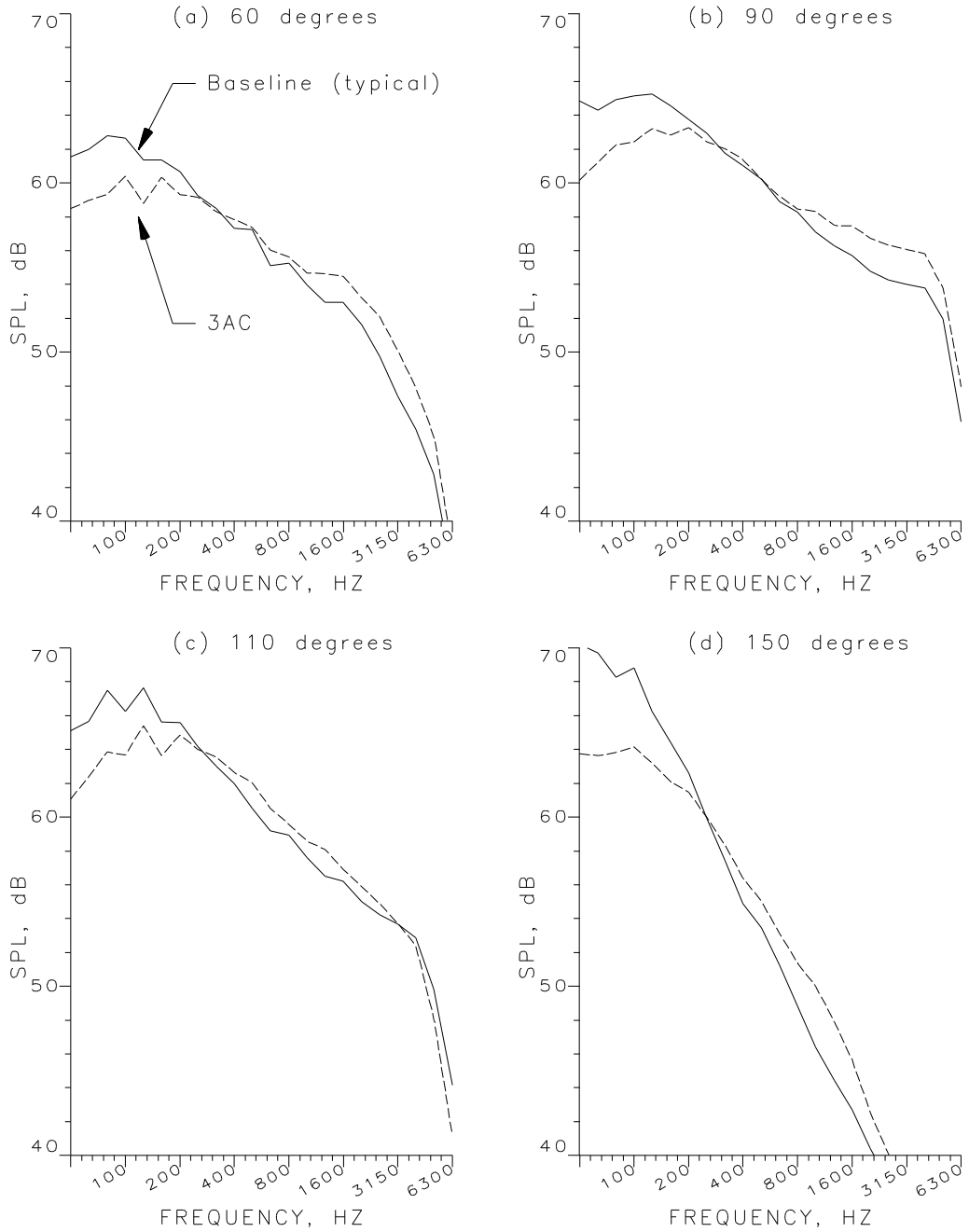


Figure A-31. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3AC) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

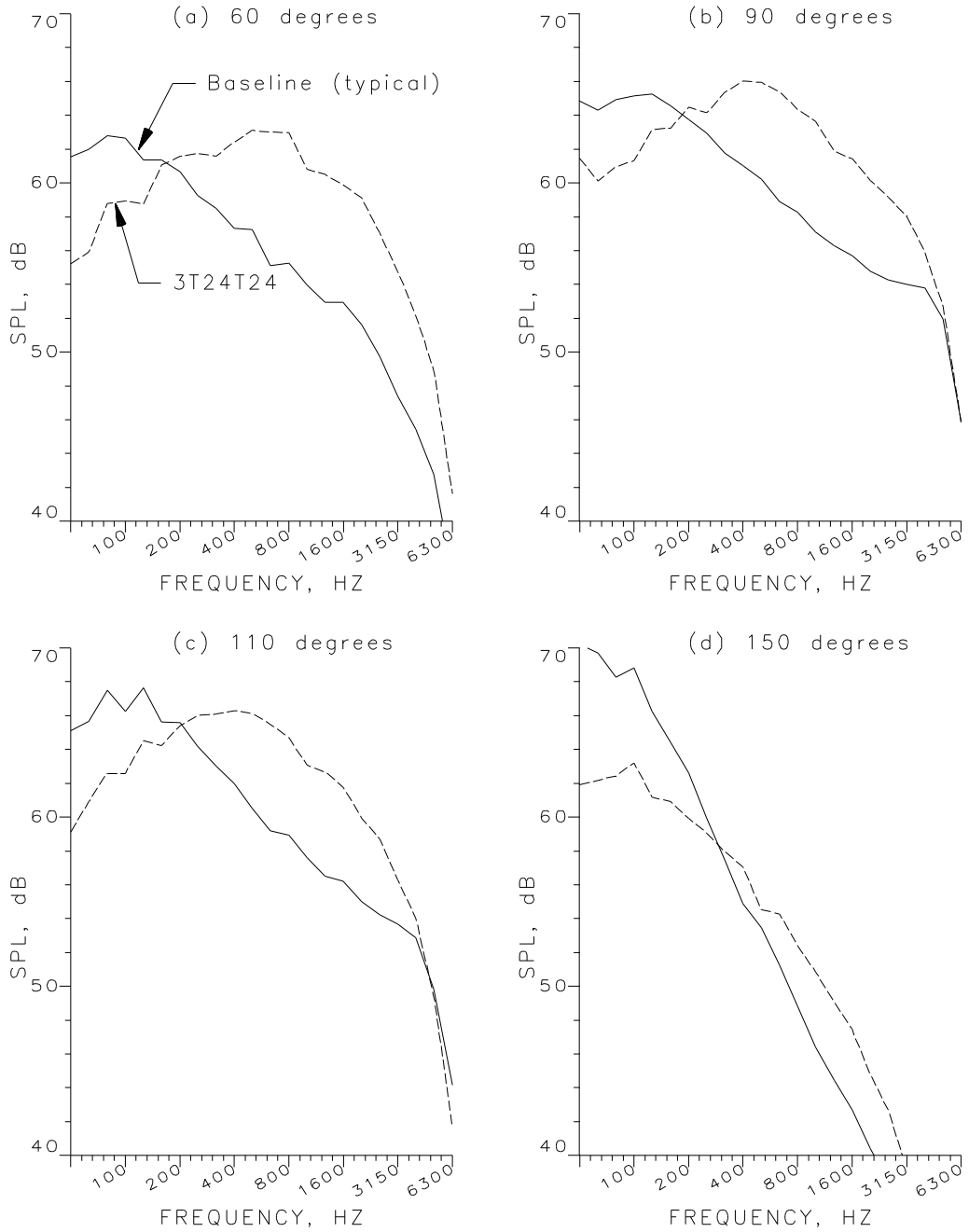


Figure A-32. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3T24T24) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

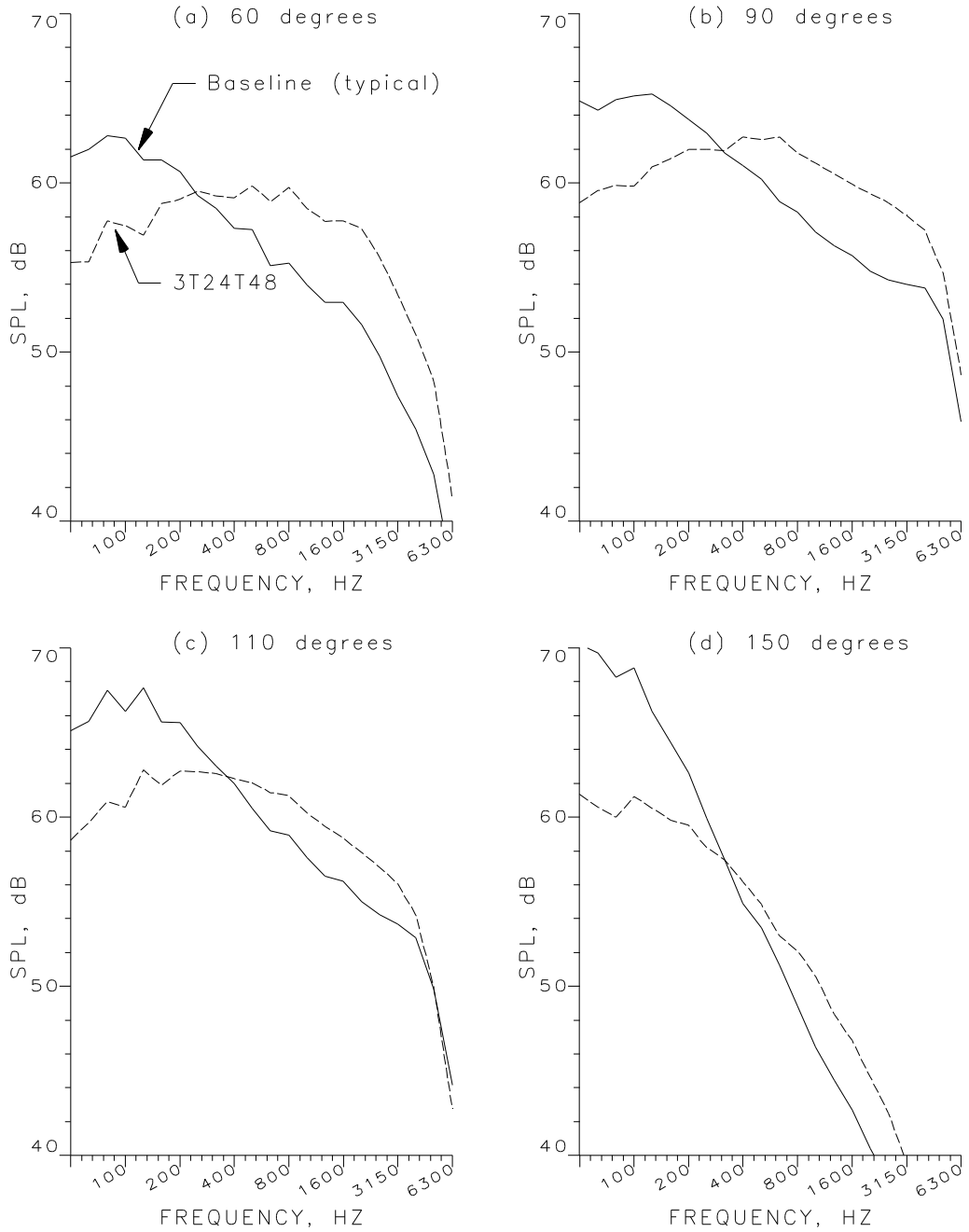


Figure A-33. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3T24T48) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

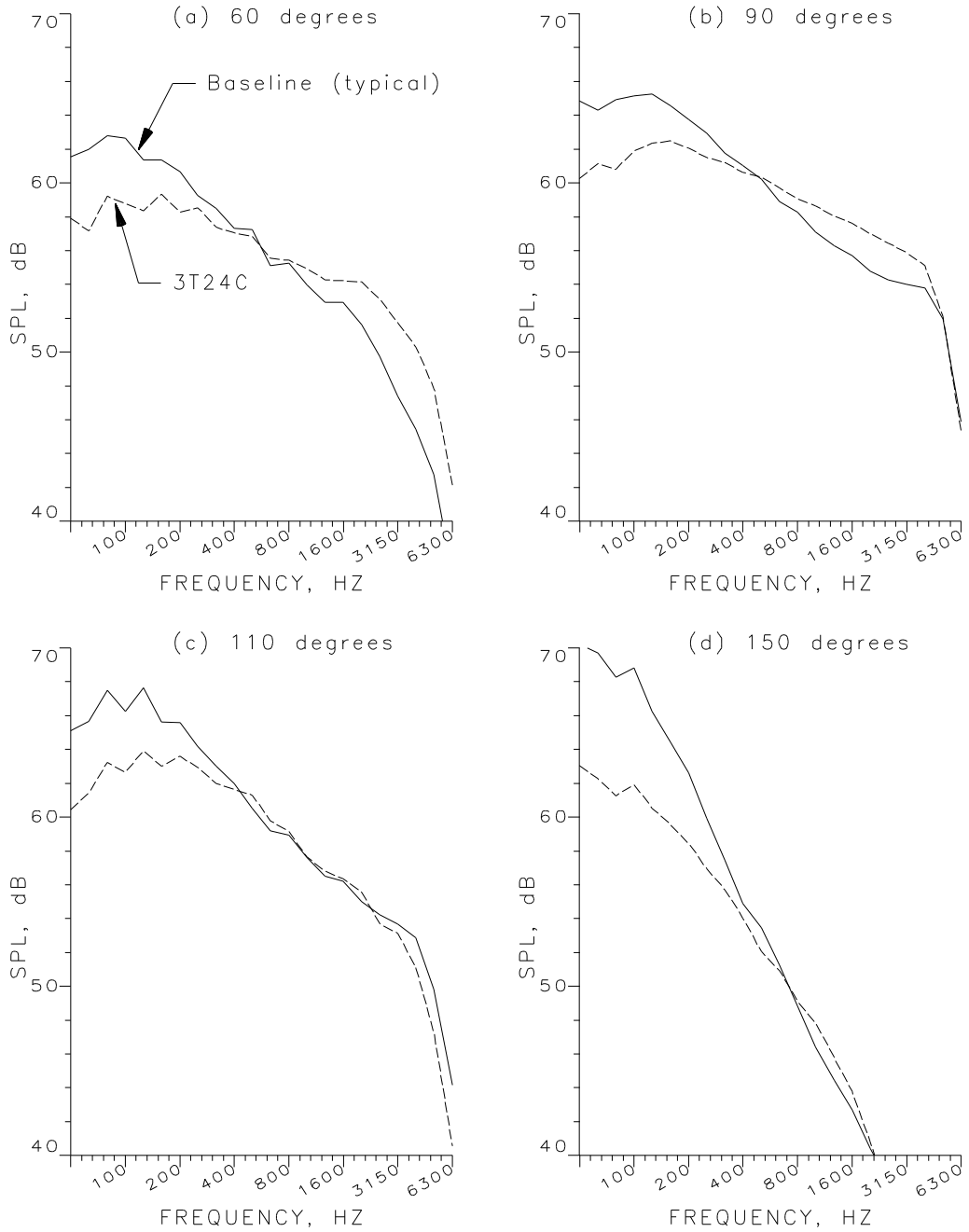


Figure A-34. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3T24C) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

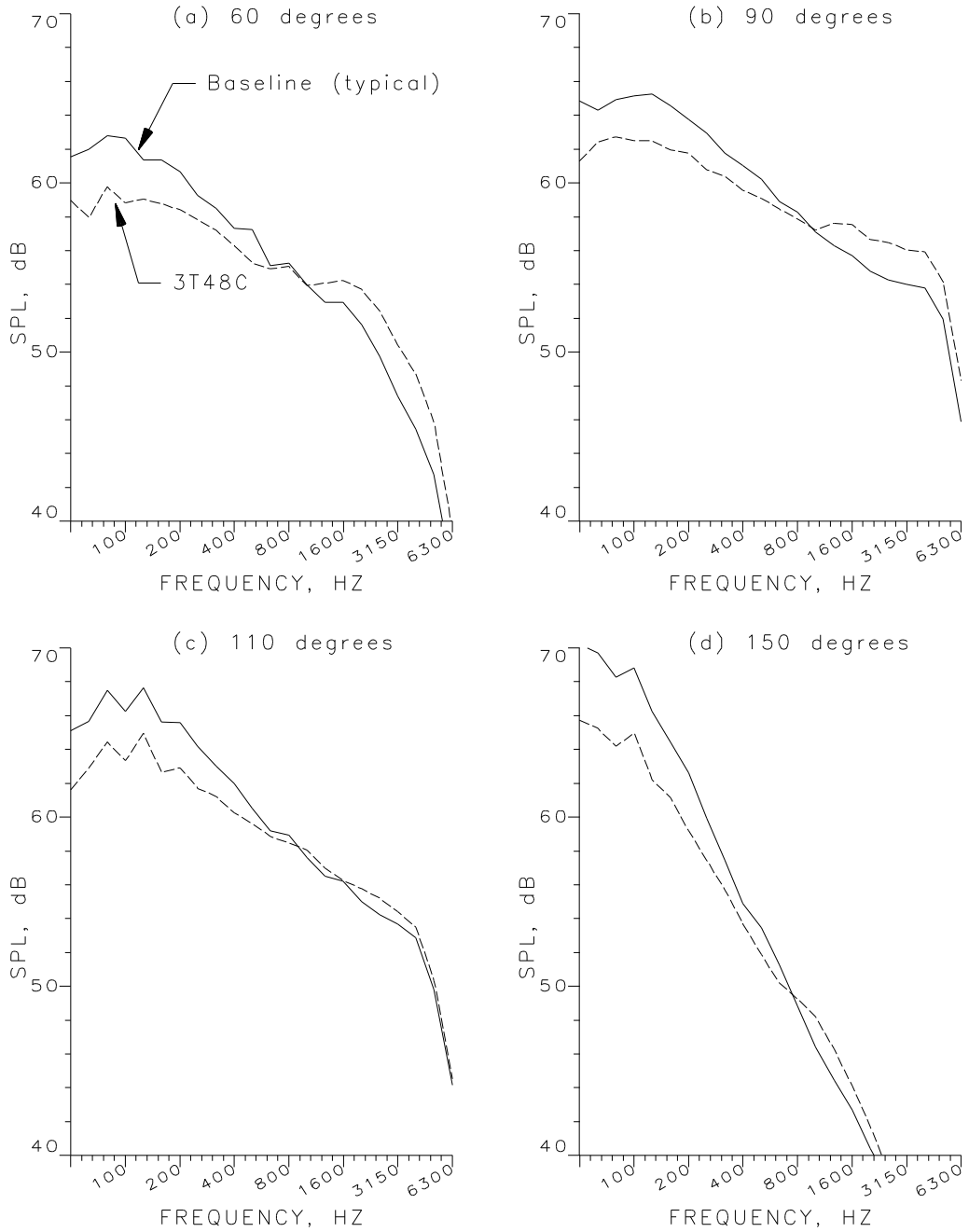


Figure A-35. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3T48C) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

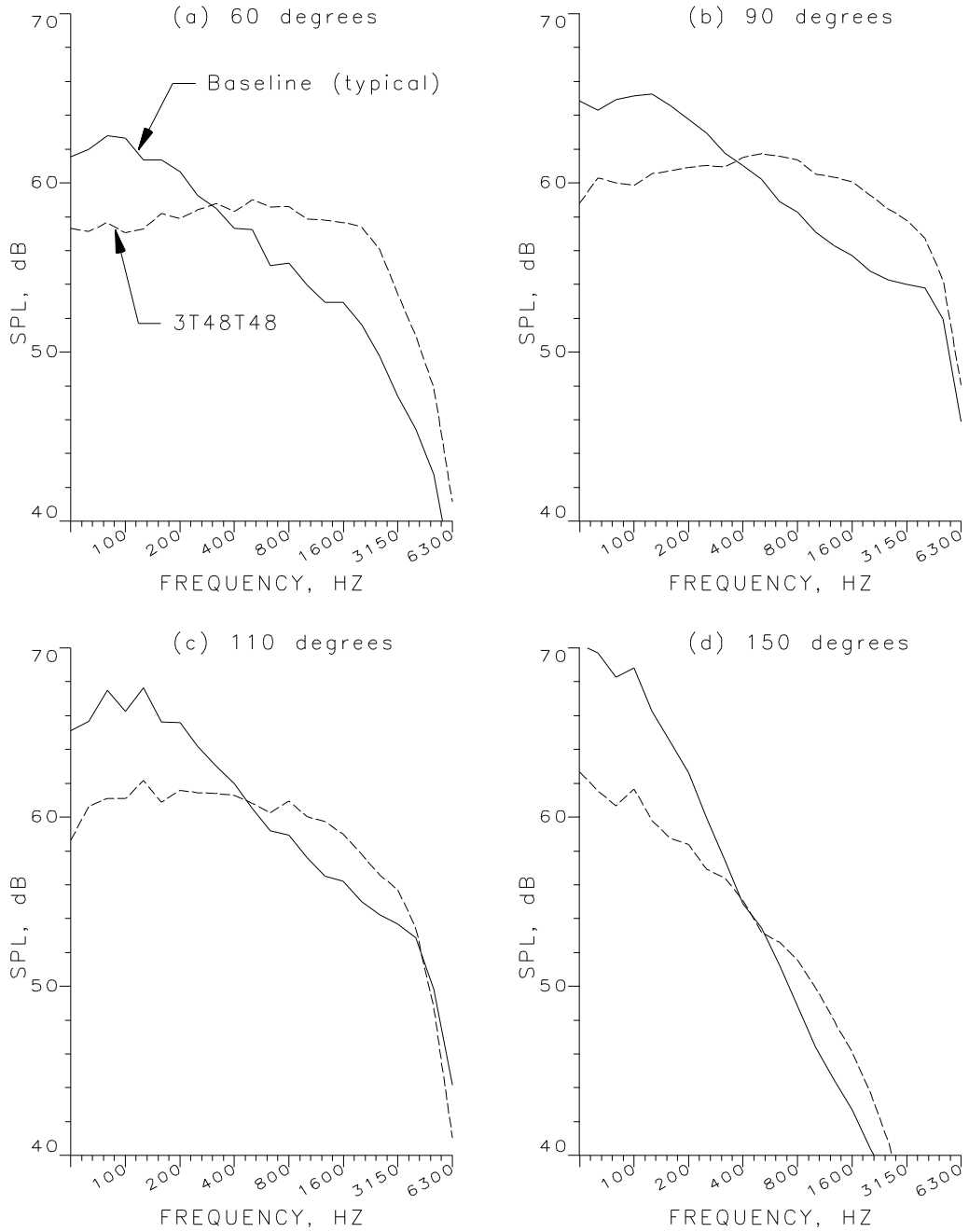


Figure A-36. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3T48T48) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

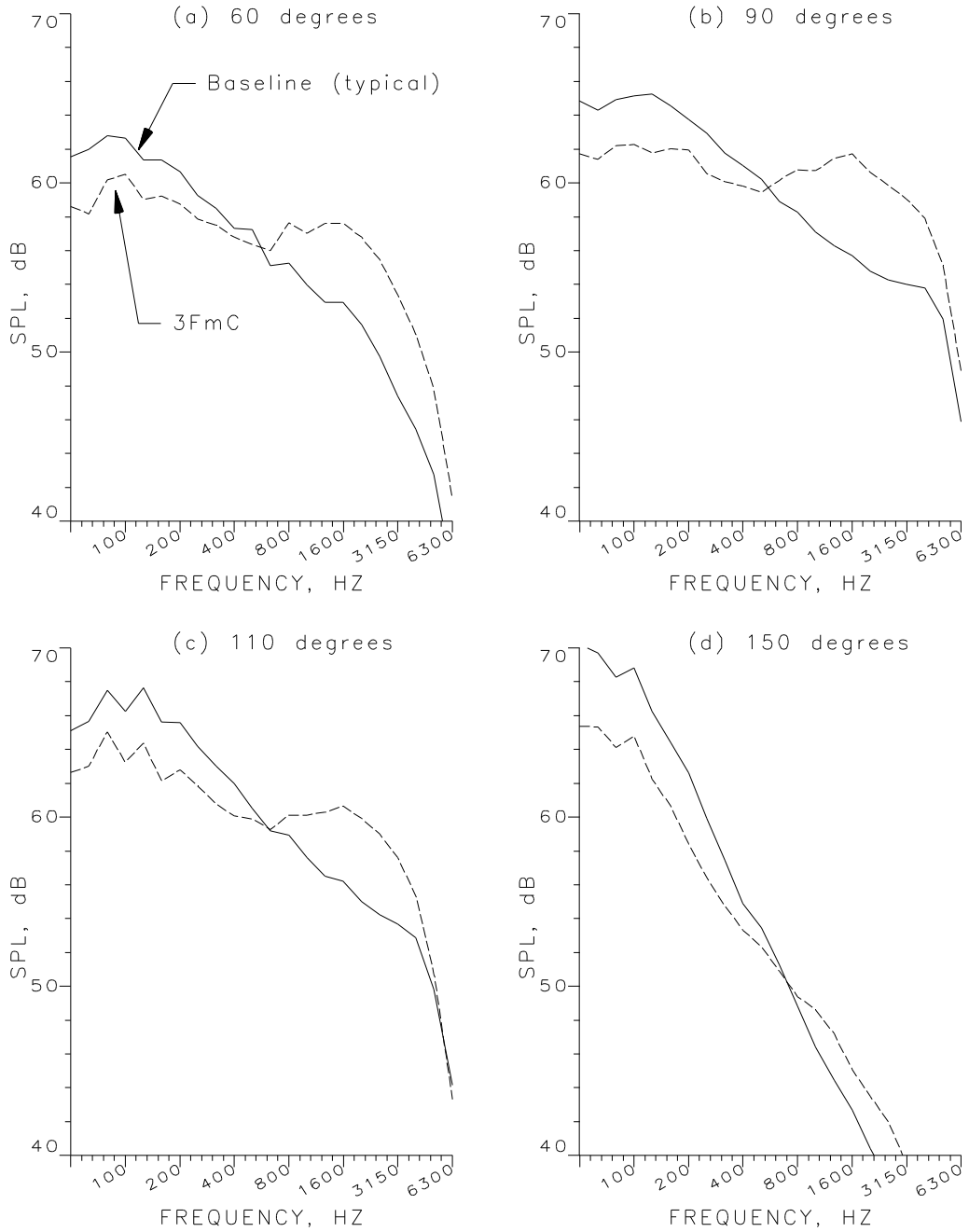


Figure A-37. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3FmC) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.,

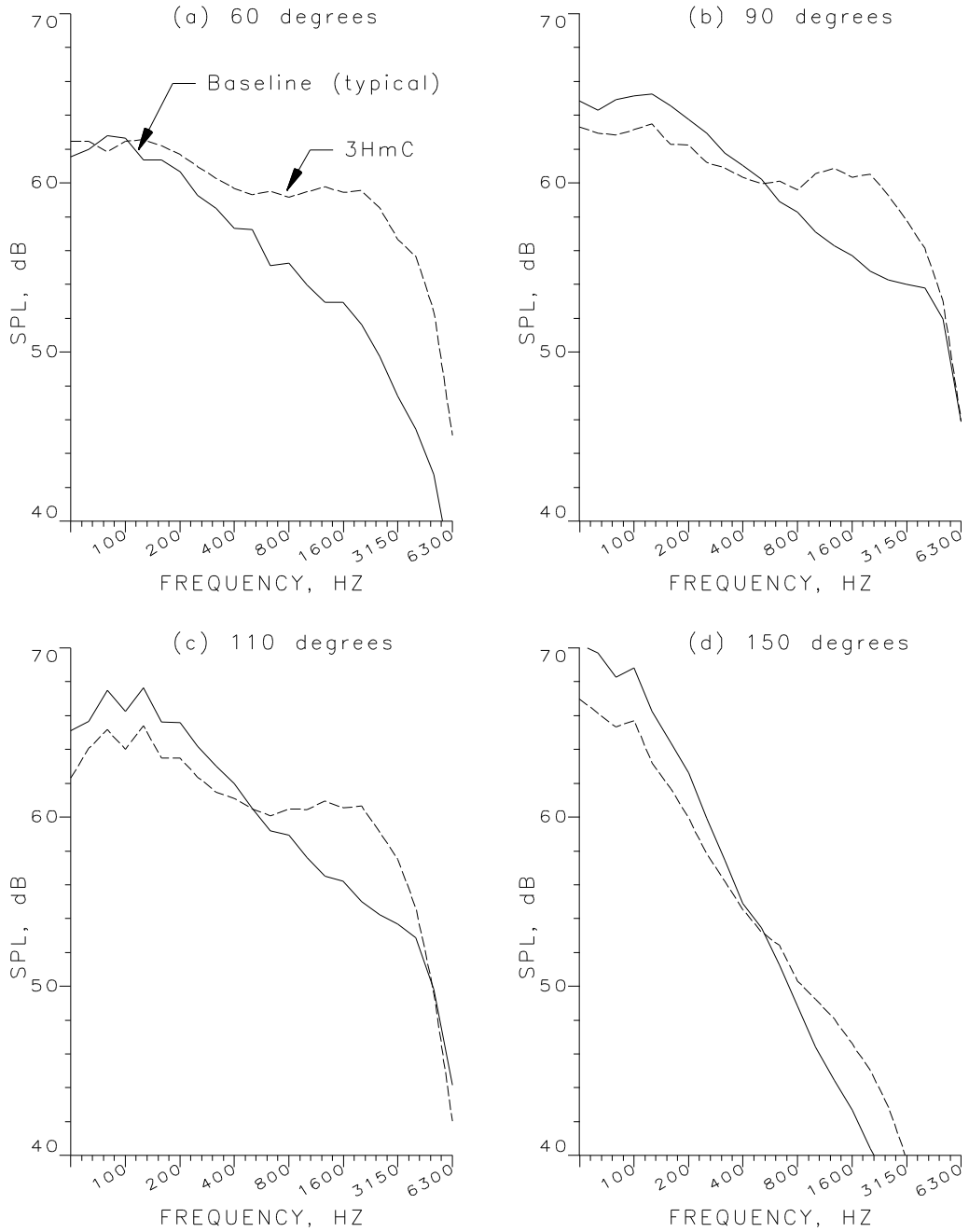


Figure A-38. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3HmC) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

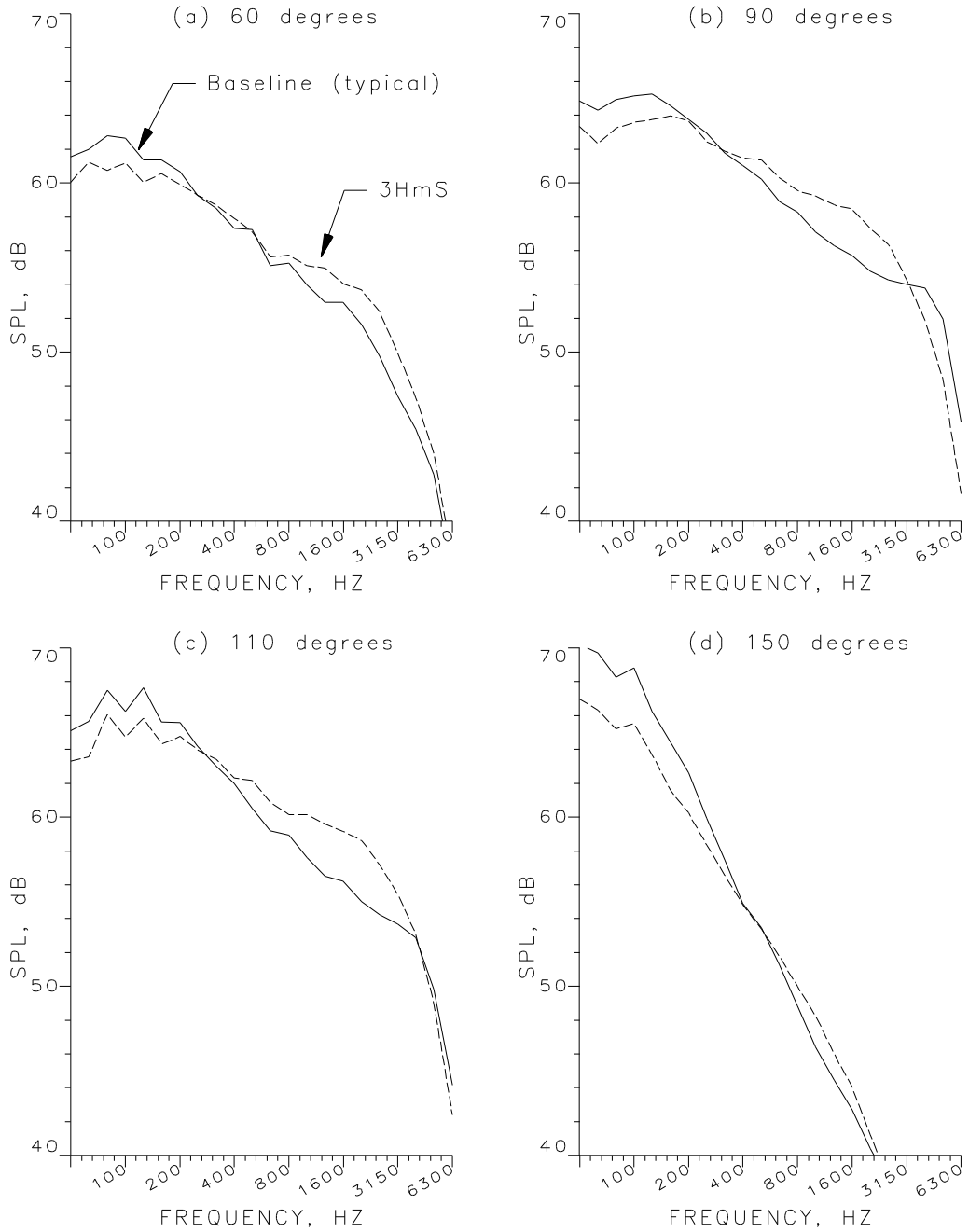


Figure A-39. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3HmS) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

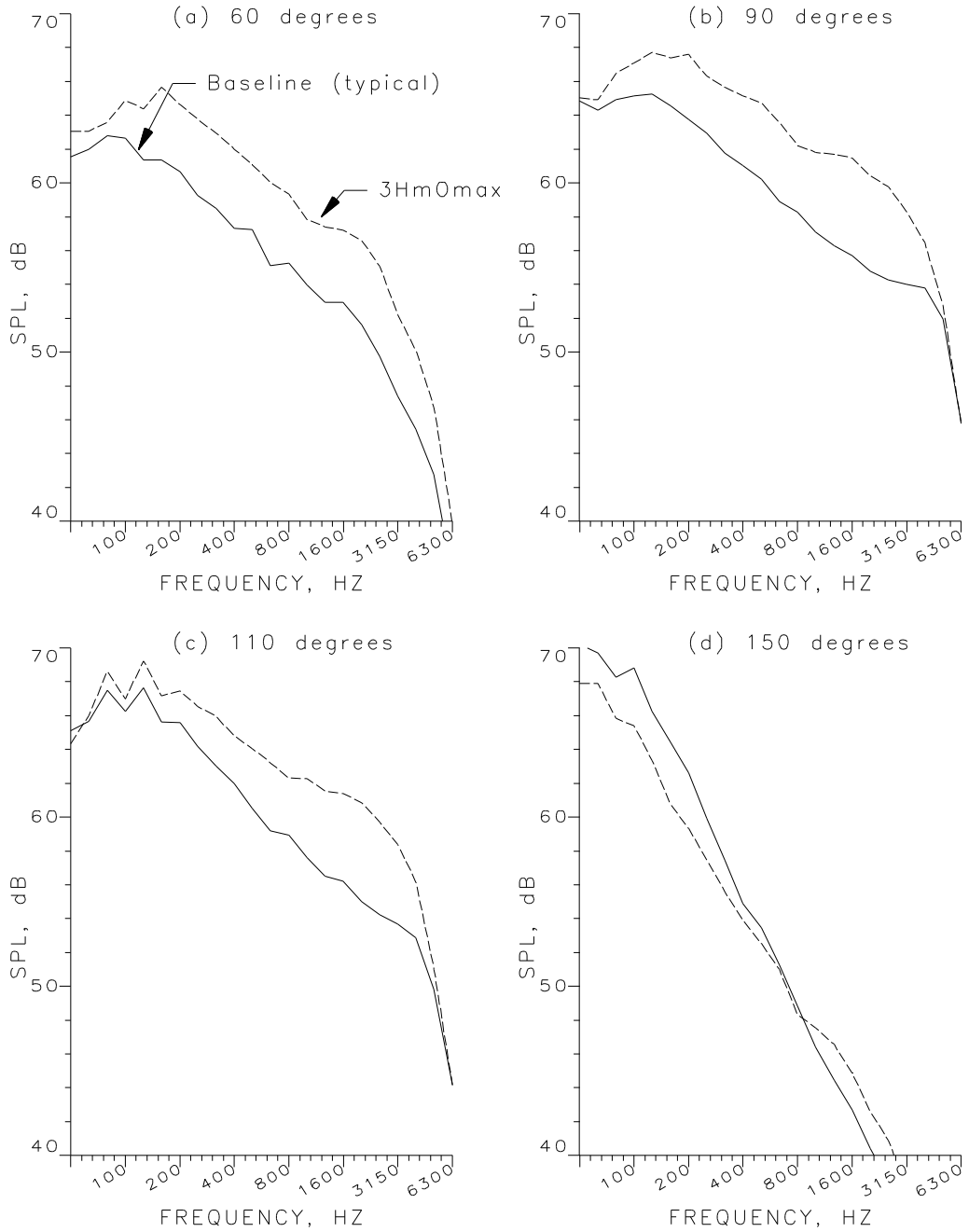


Figure A-40. SPL Spectral Comparisons (Vmix=980 ft/sec) for Model 3 Jet Noise Suppression Device (3HmOmax) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 110 deg. (peak PNL angle) and (d) 150 deg.

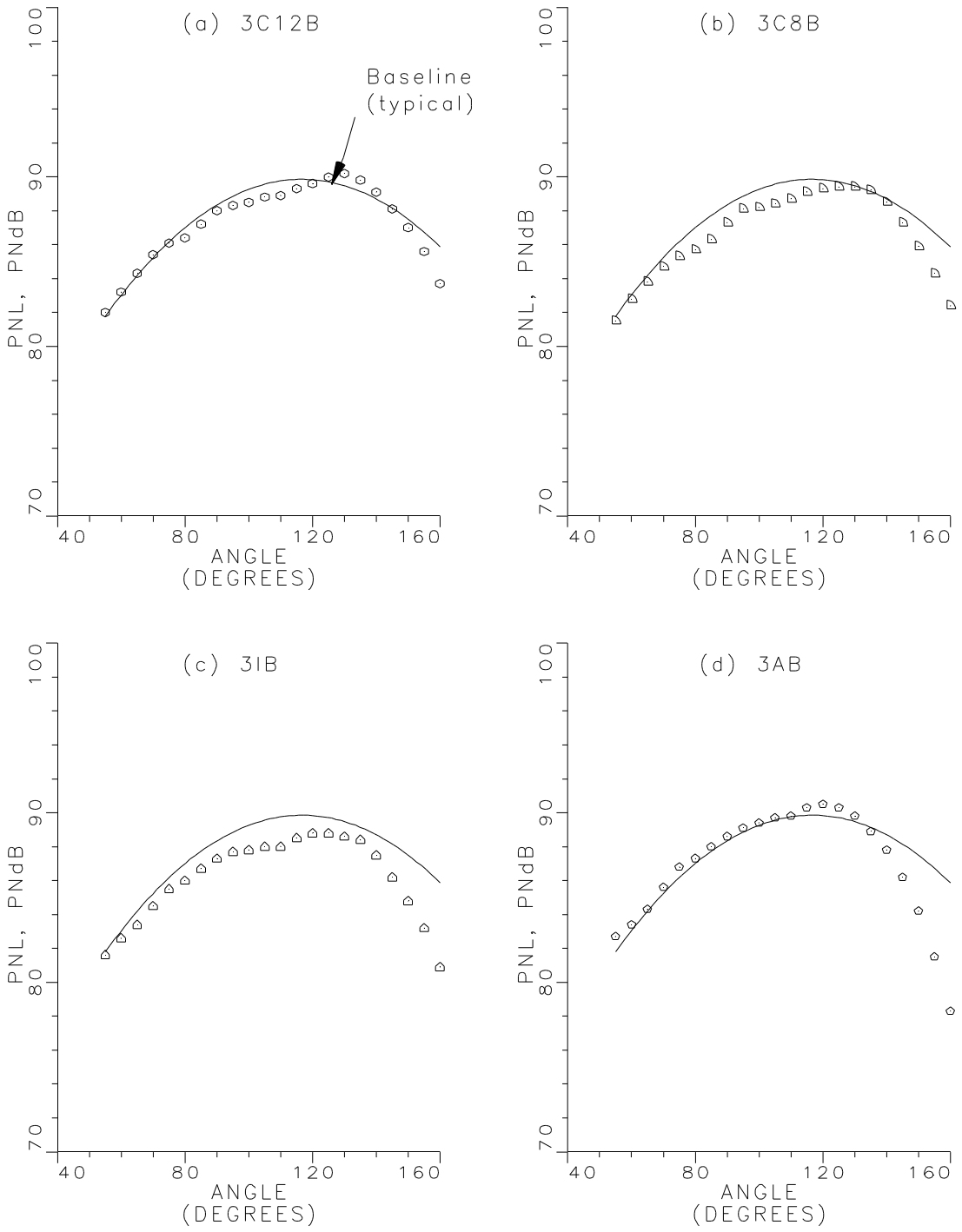


Figure A-41. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3C12B, (b) 3C8B, (c) 3IB and (d) 3AB.

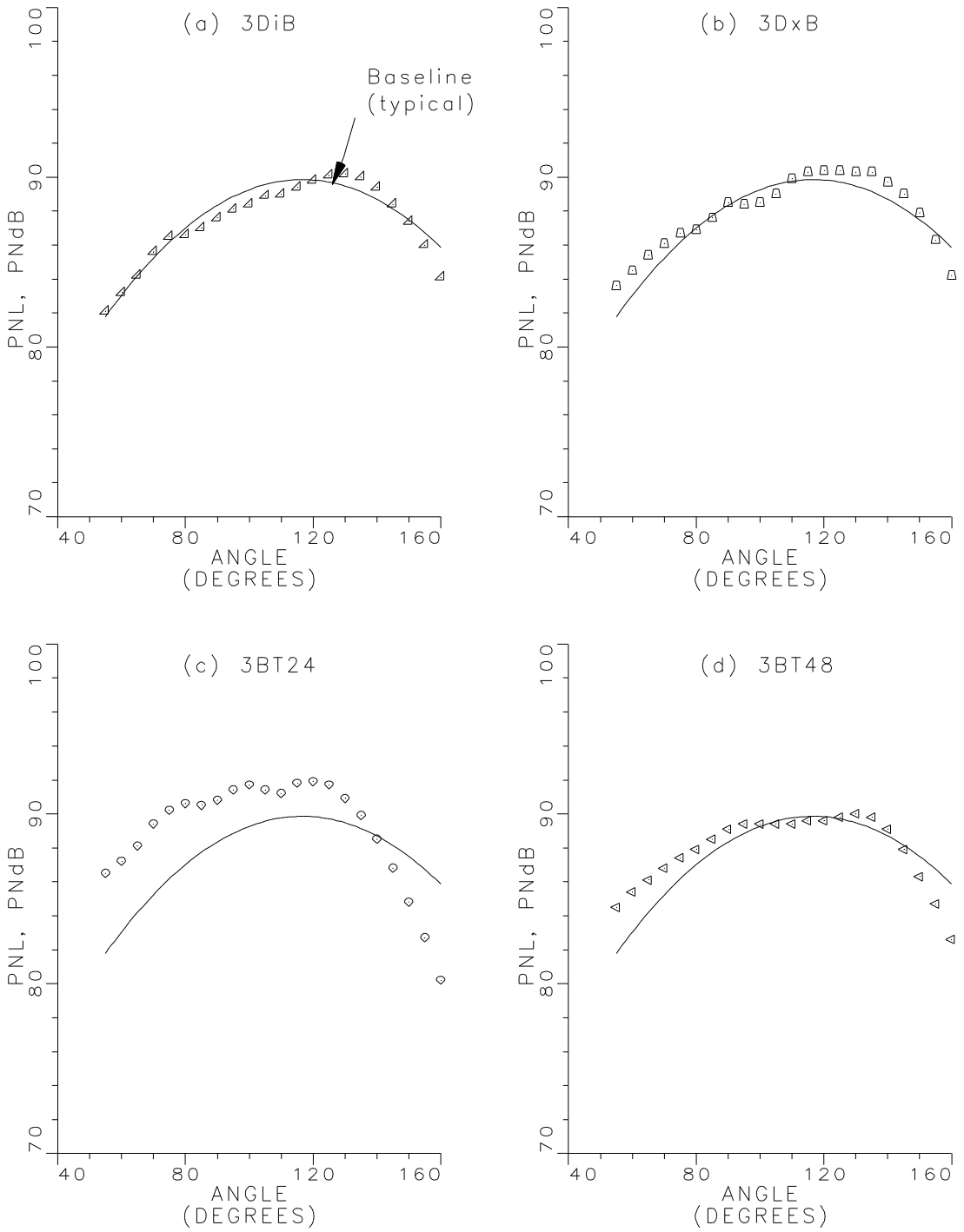


Figure A-42. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3DiB, (b) 3DxB, (c) 3BT24 and (d) 3BT48.

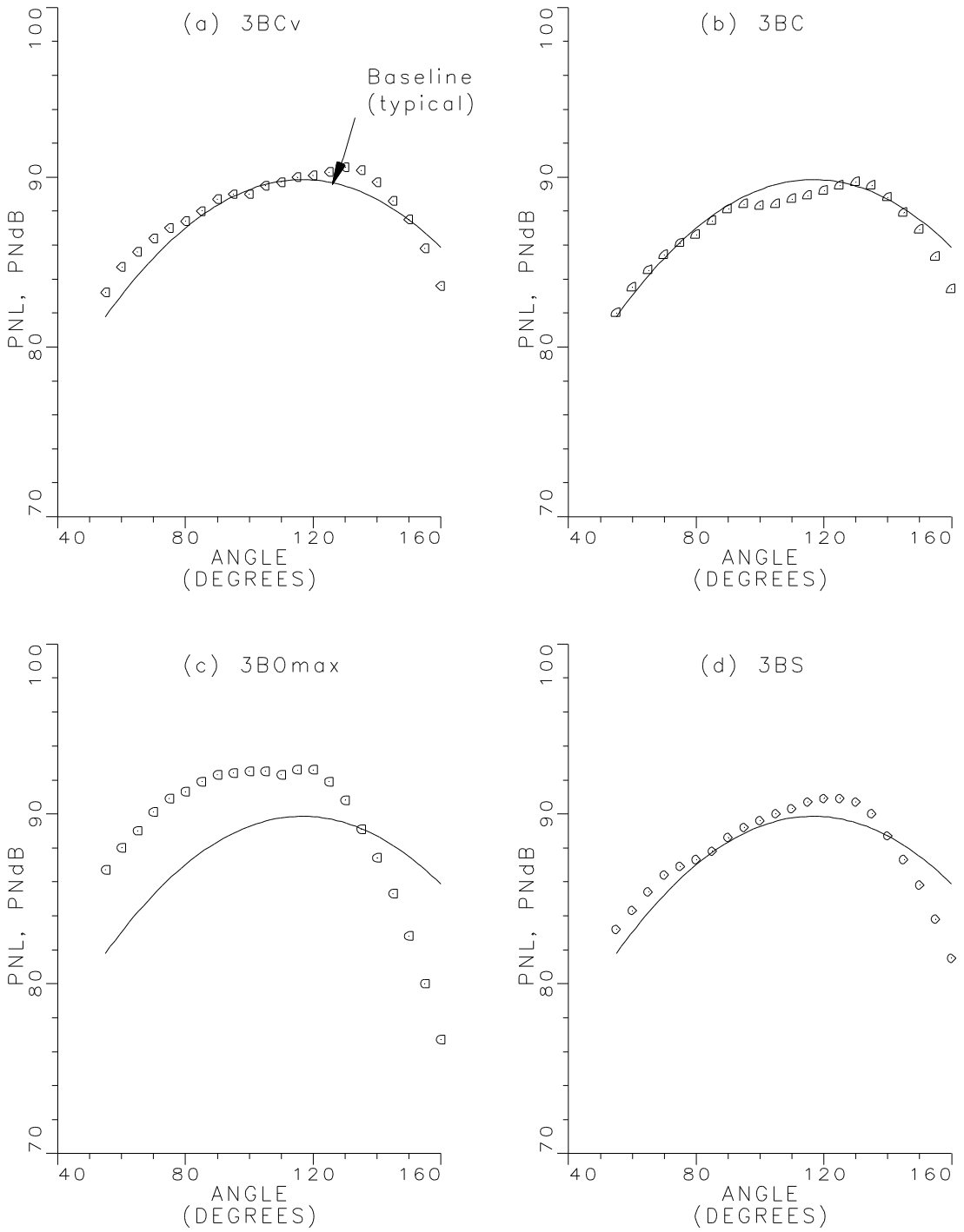


Figure A-43. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3BCv, (b) 3BC, (c) 3BOmax and (d) 3BS.

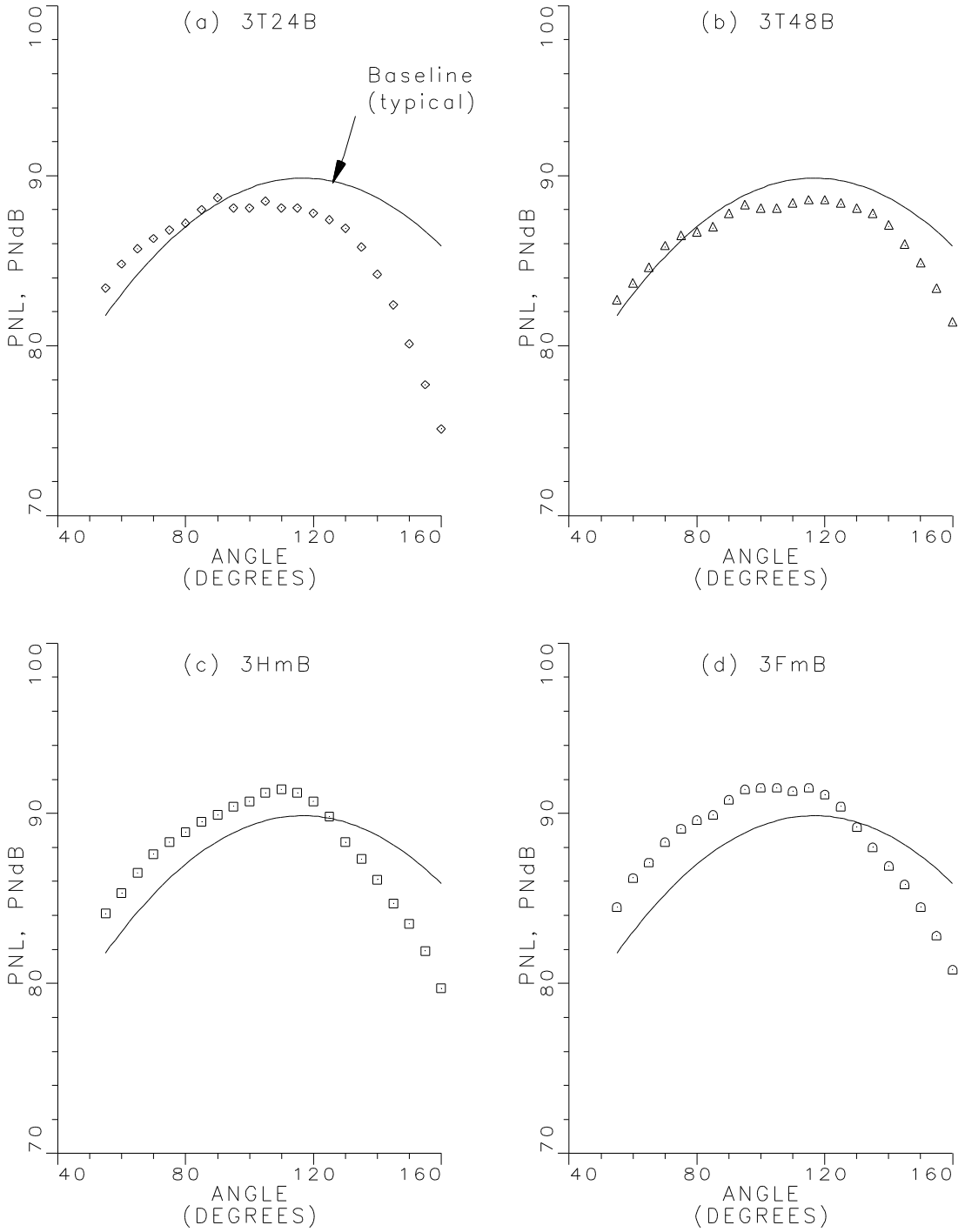


Figure A-44. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 jet Noise Suppression Devices ; (a) 3T24B, (b) 3T48B, (c) 3HmB and (d) 3FmB.

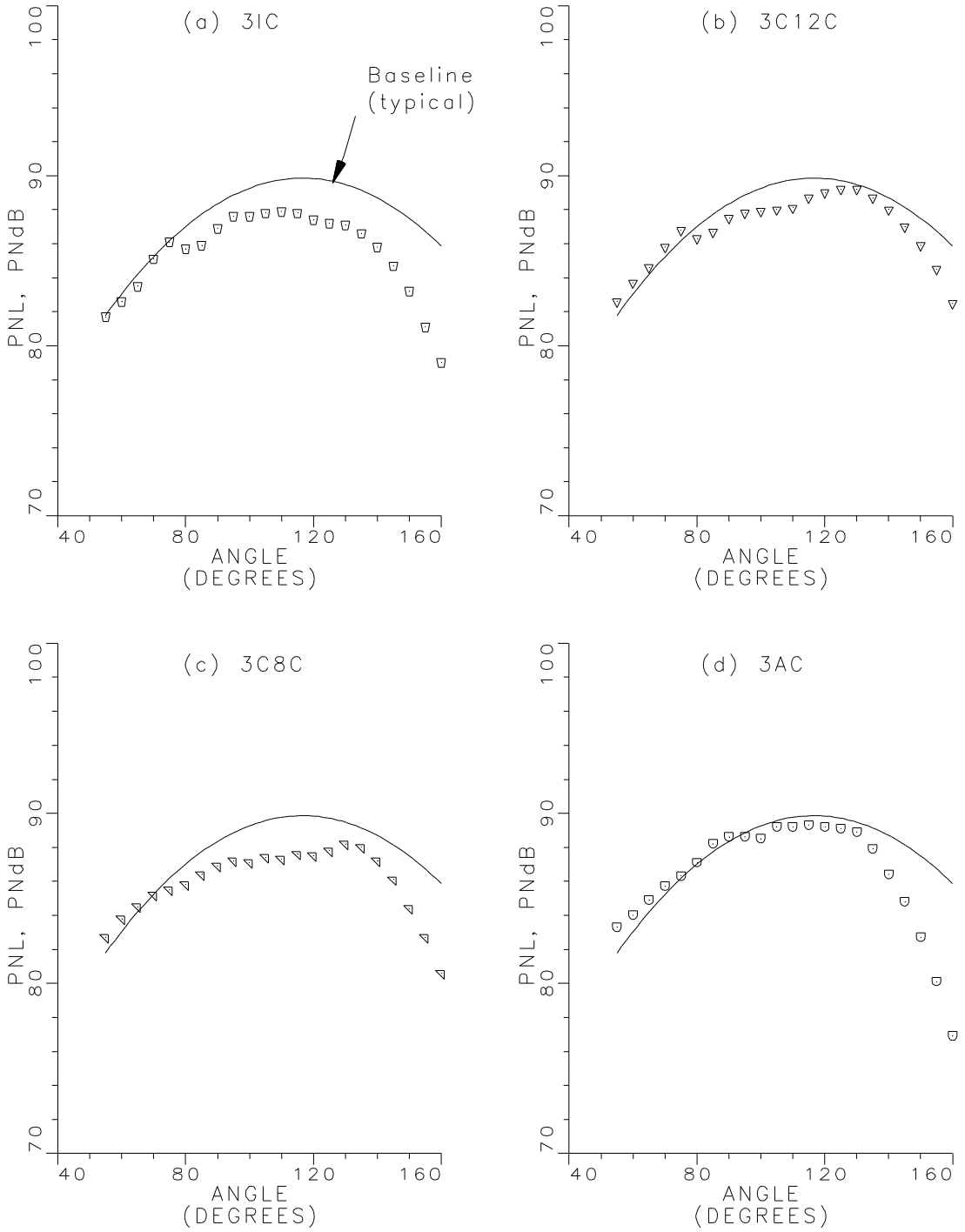


Figure A-45. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3IC, (b) 3C12C, (c) 3C8C and (d) 3AC.

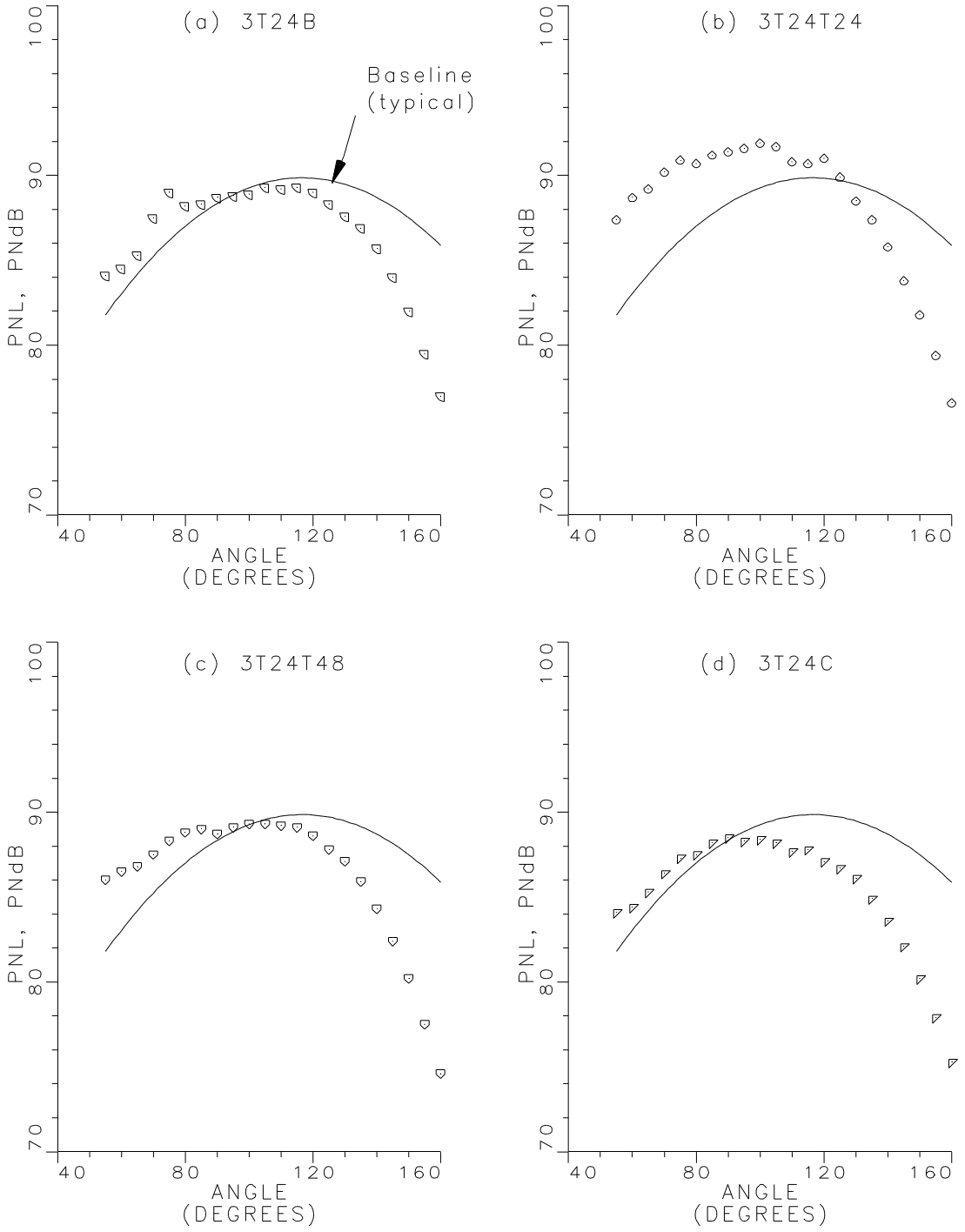


Figure A-46. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3T24B, (b) 3T24T24, (c) 3T24T48 and (d) 3T24C.

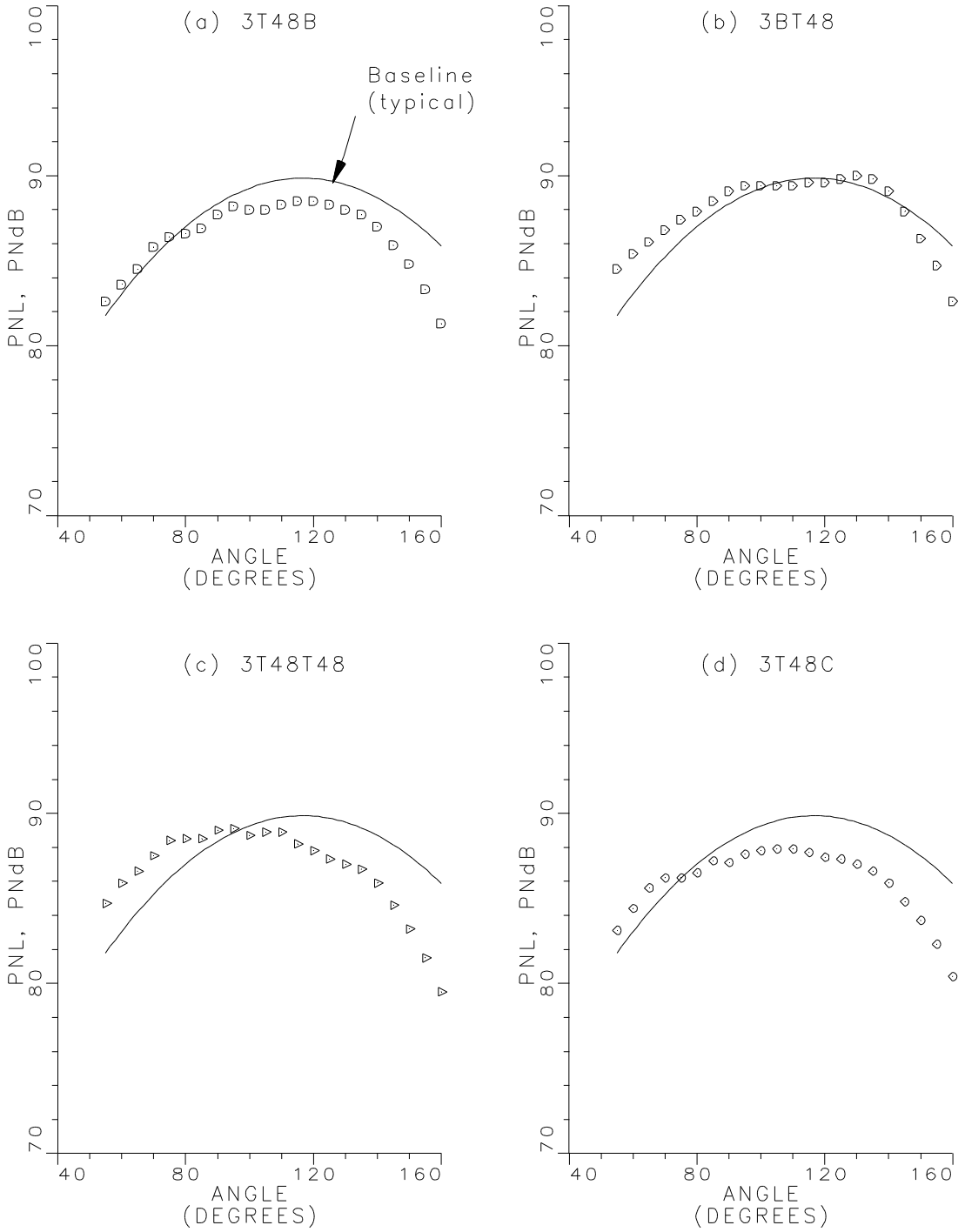


Figure A-47. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3T48B, (b) 3BT48, (c) 3T48T48 and (d) 3T48C.

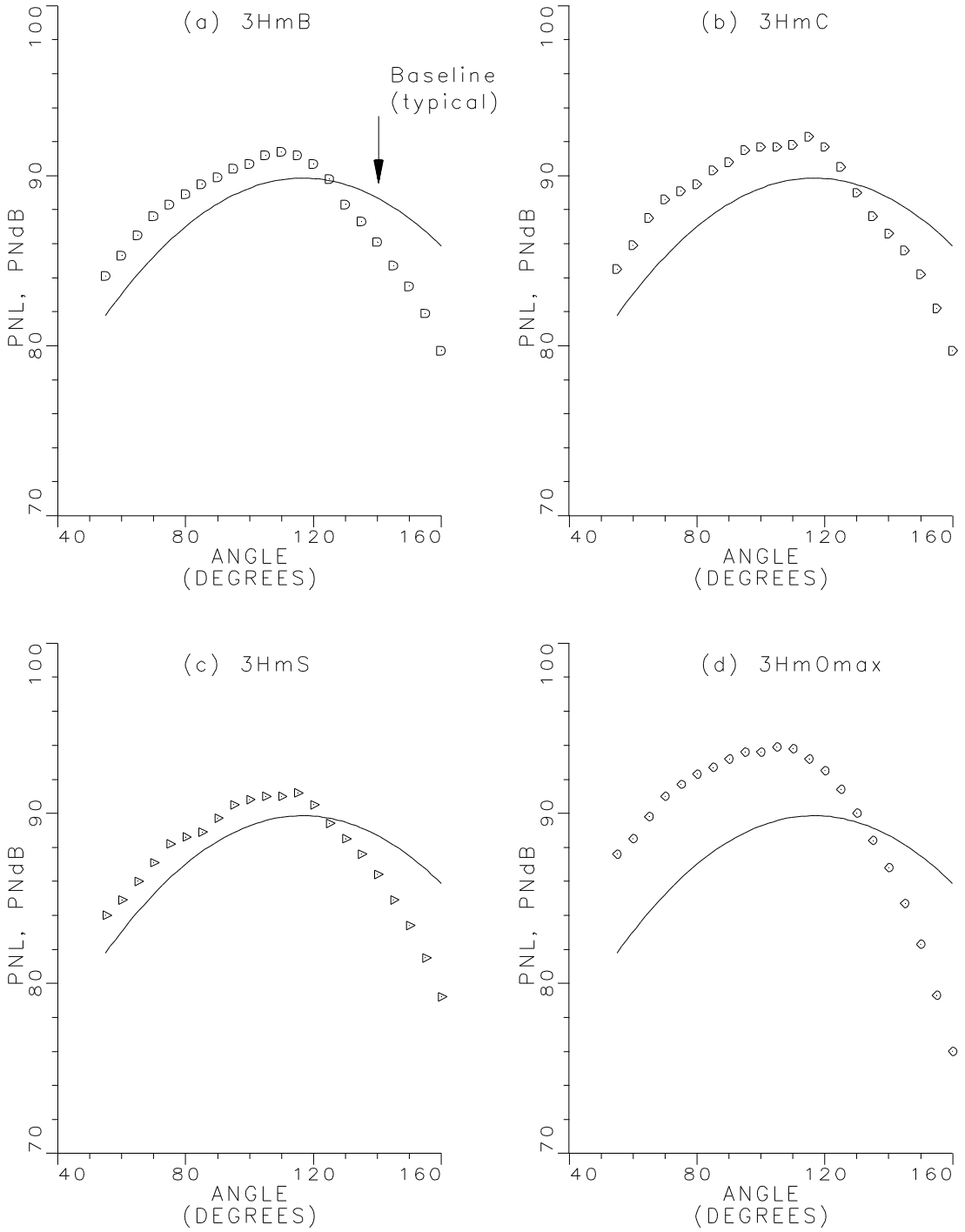


Figure A-48. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Devices ; (a) 3HmB, (b) 3HmC, (c) 3HmS and (d) 3HmOmax.

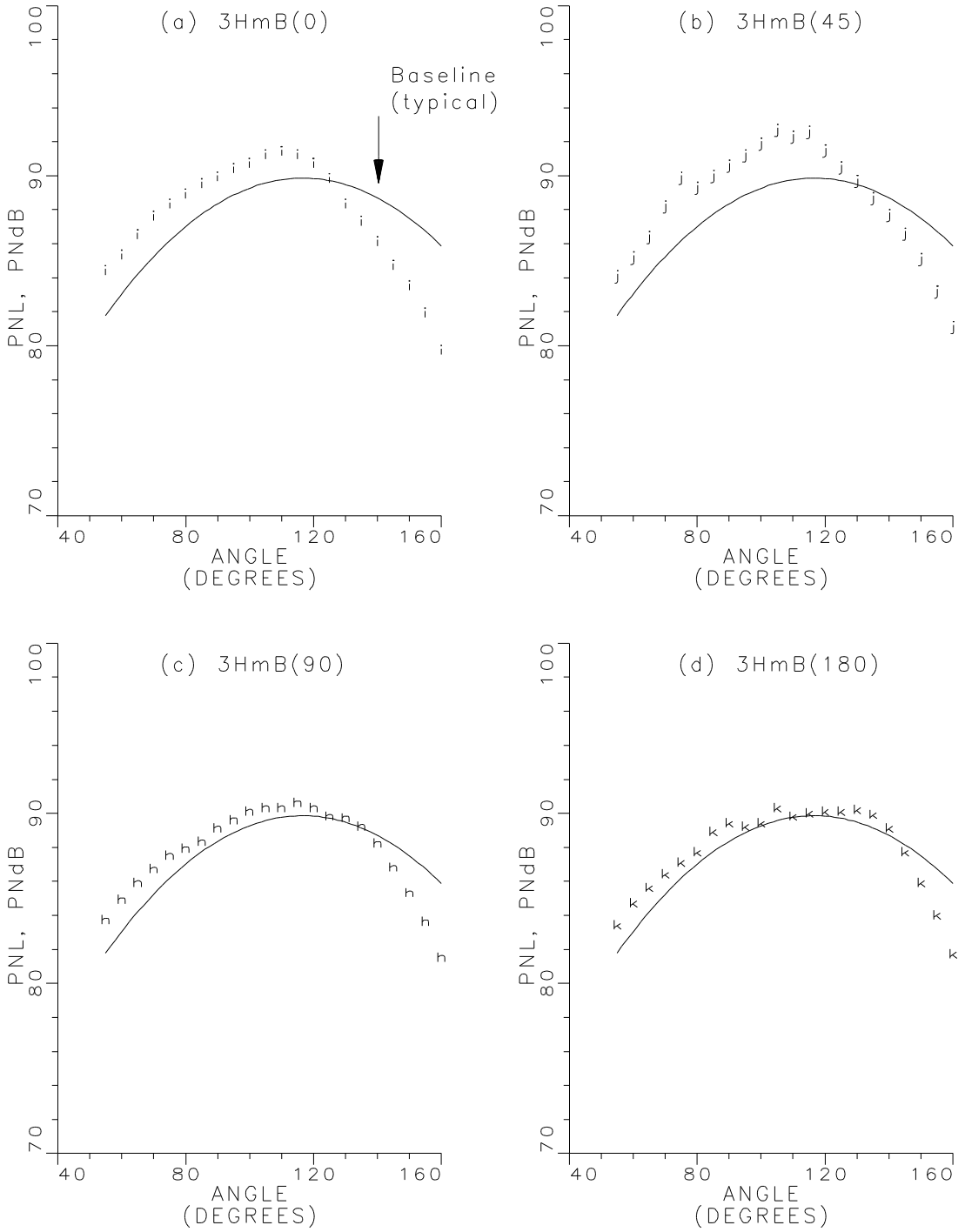


Figure A-49. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3HmB) Measured at Four Different Azimuthal Angles ; (a) 0 deg., (b) 45 deg., (c) 90 deg. and (d) 180 deg.

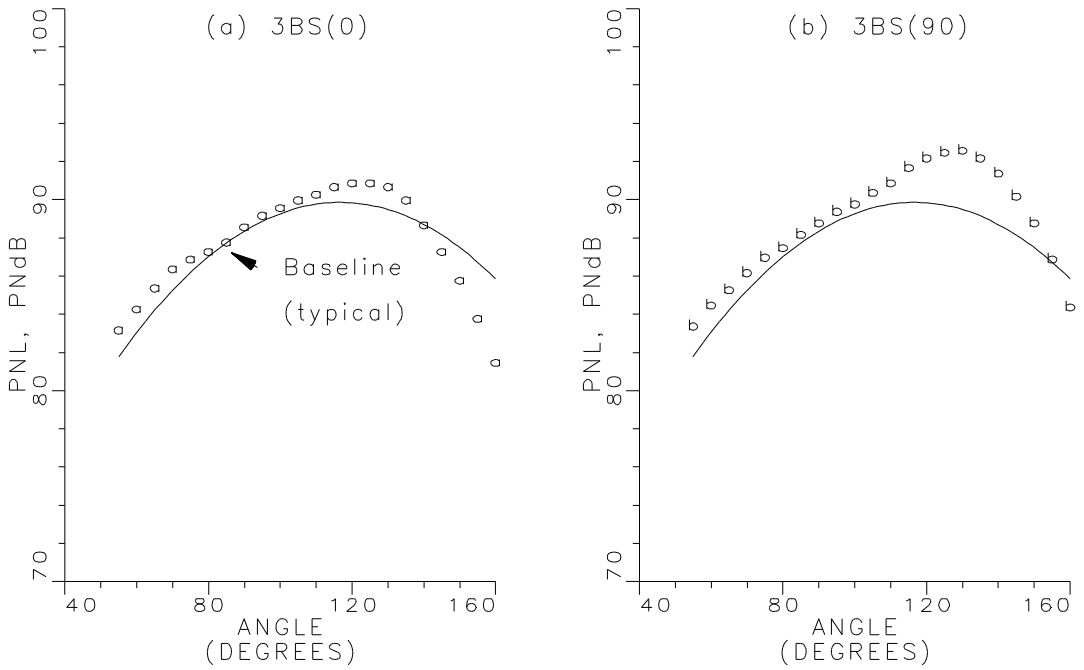


Figure A-50. PNL Directivities (at Vmix=1155 ft/sec) for Model Jet Noise Suppression Device (3BS) Measured at Two Different Azimuthal Angles ; (a) 0 deg. and (b) 90 deg.

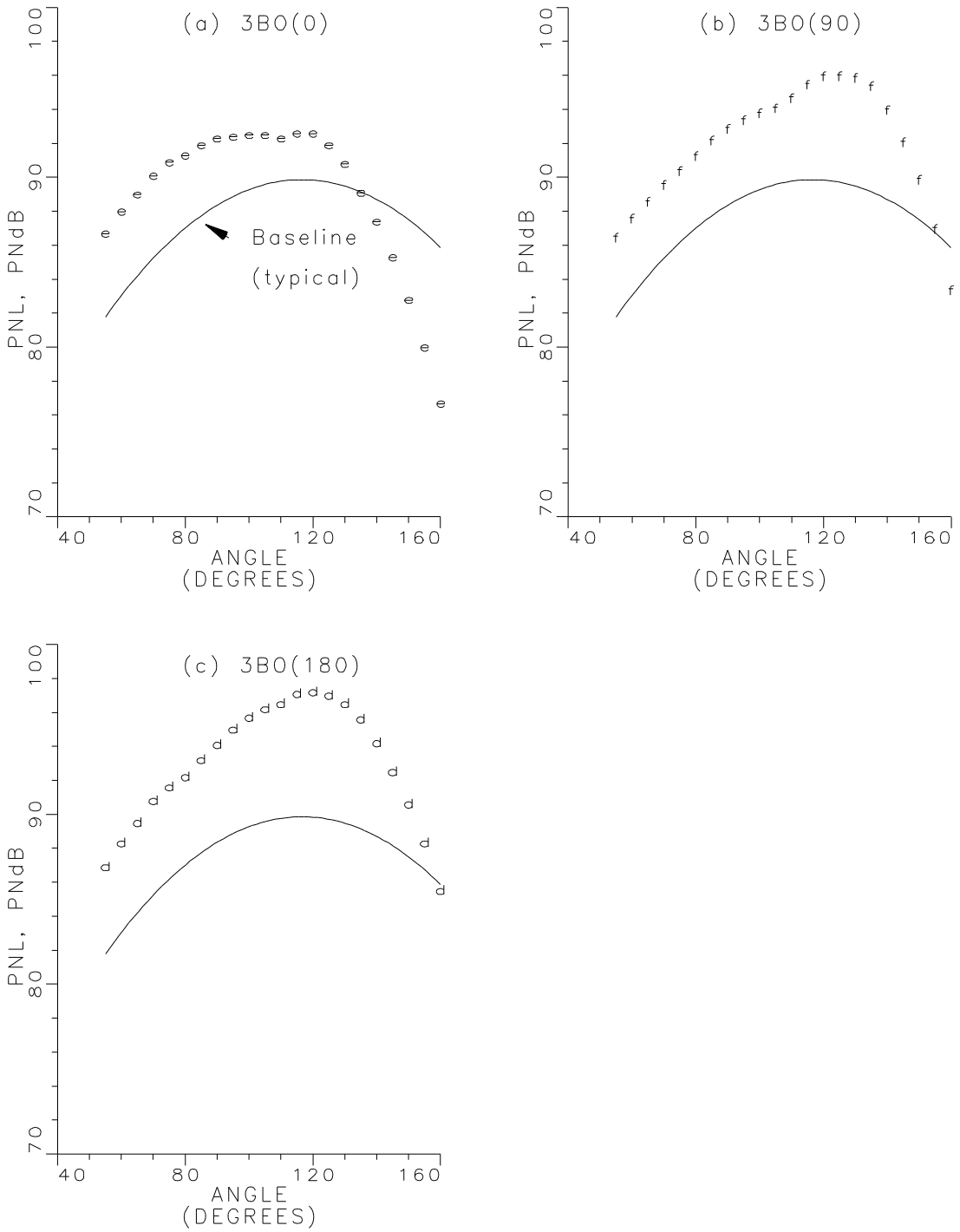


Figure A-51. PNL Directivities (at Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3bomax) Measured at Three Different Azimuthal Angles ; (a) 0 deg., (b) 90 deg., and (c) 180 deg.

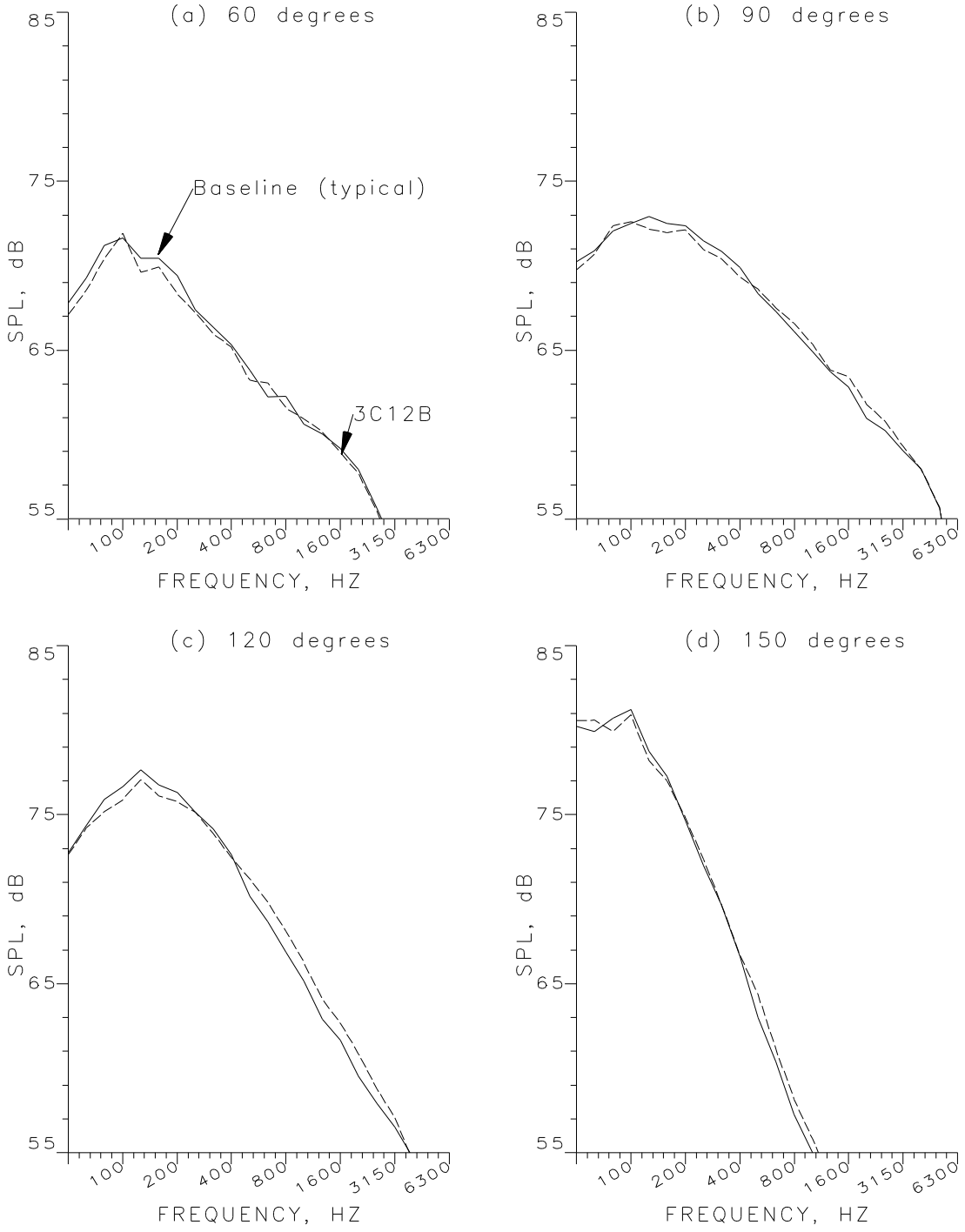


Figure A-52. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3C12B) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. (peak PNL angle) and (d) 150 deg.

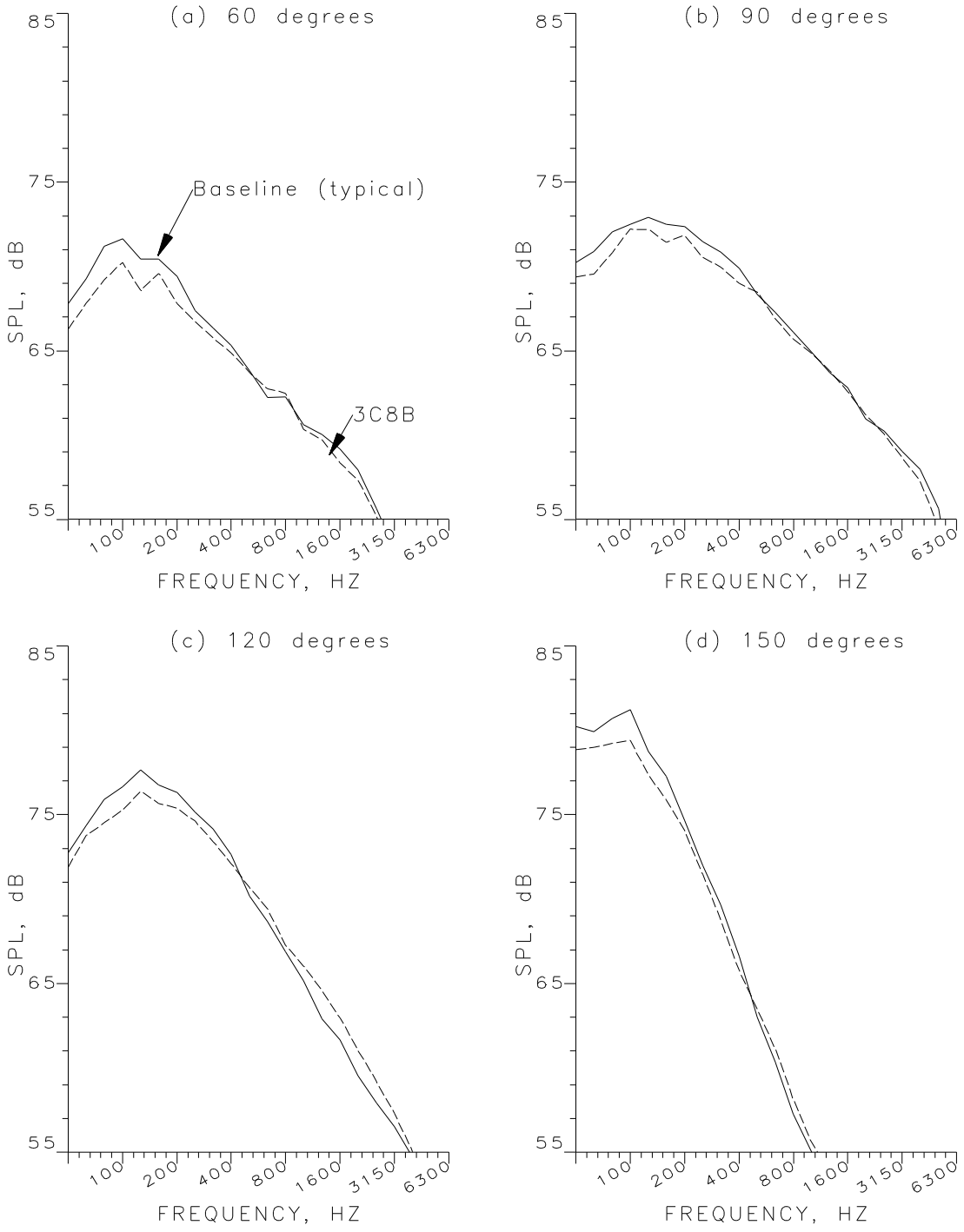


Figure A-53. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3C8B) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. (peak PNL angle) and (d) 150 deg.

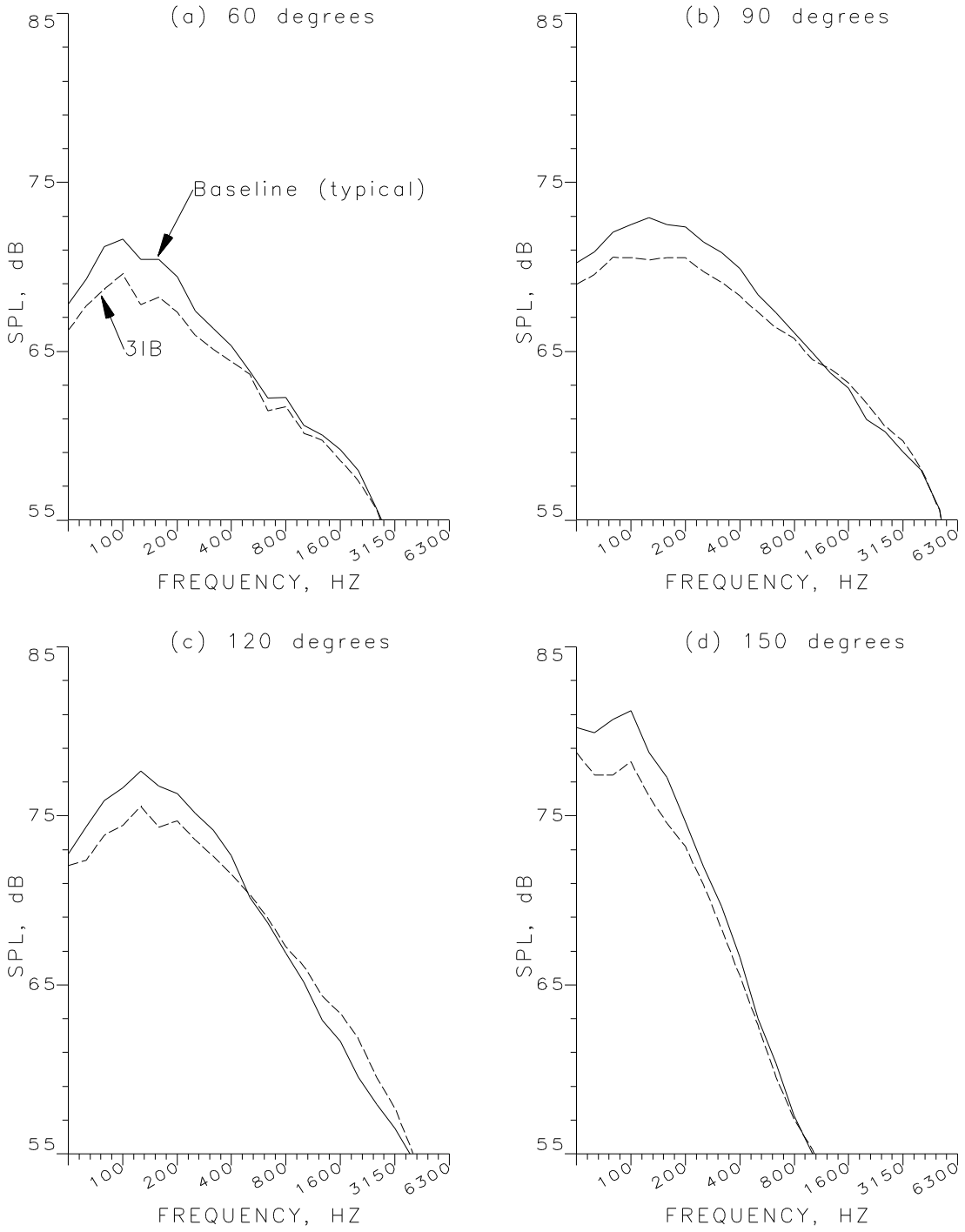


Figure A-54. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3IB) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. (peak PNL angle) and (d) 150 deg.

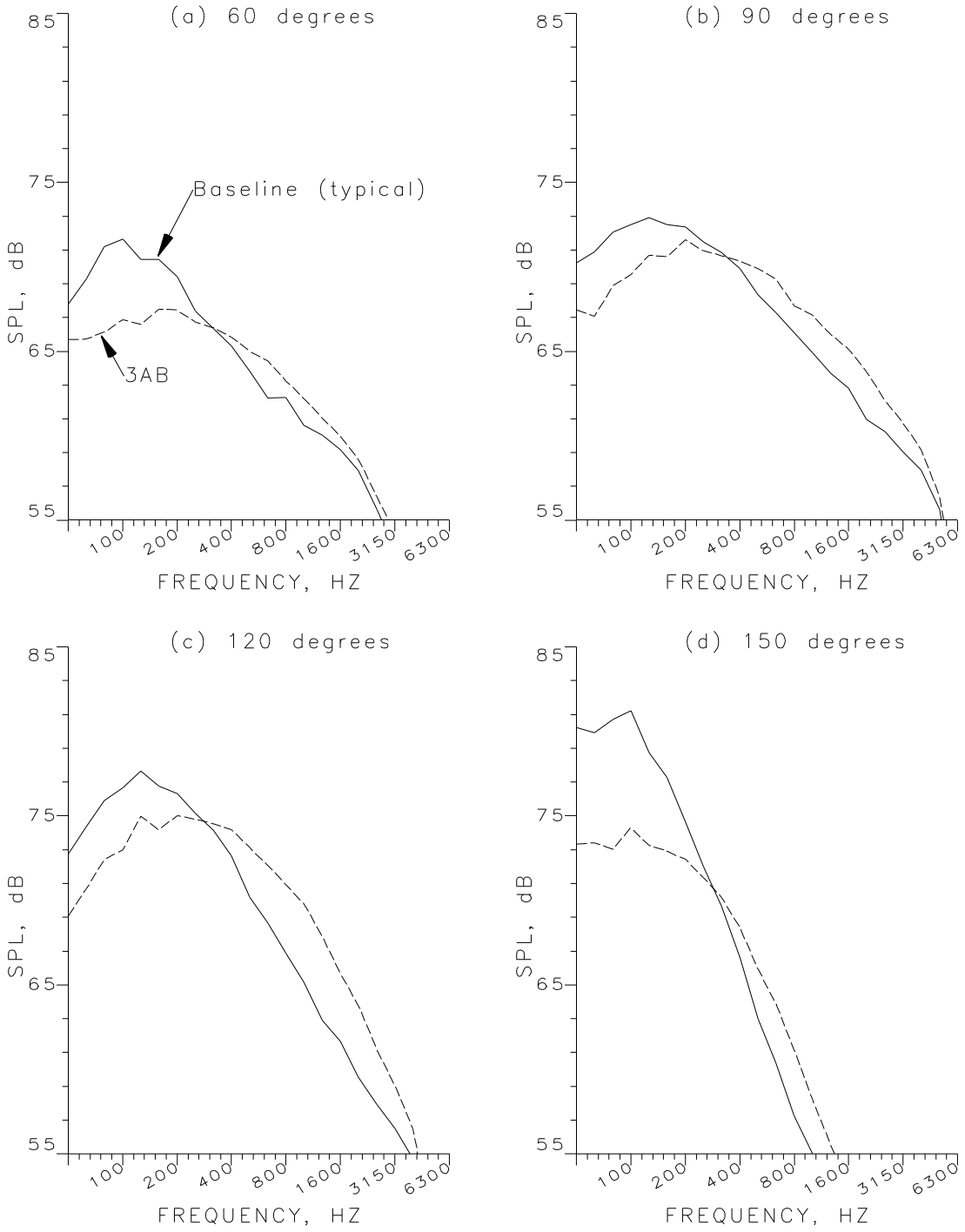


Figure A-55. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3AB) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. (peak PNL angle) and (d) 150 deg.

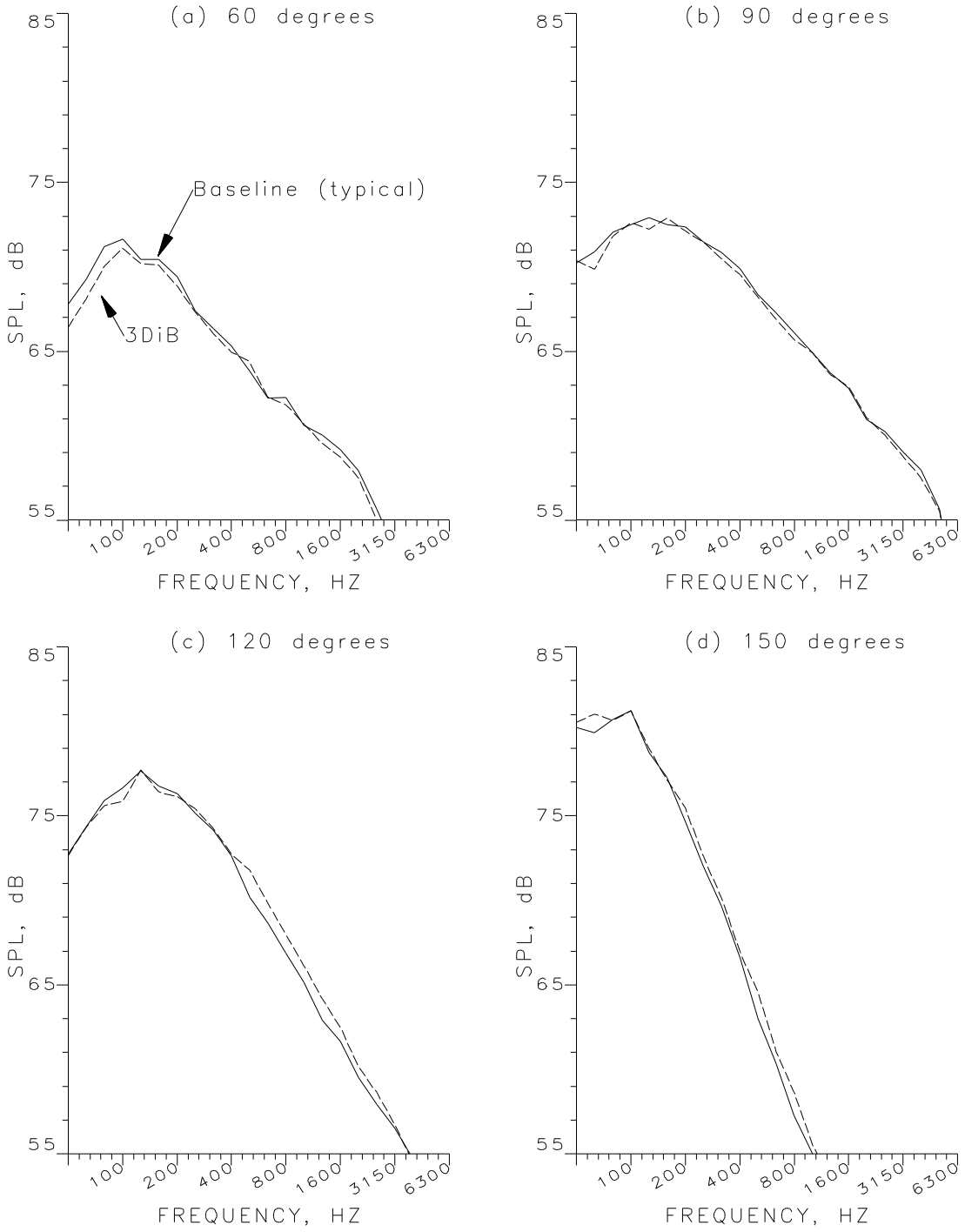
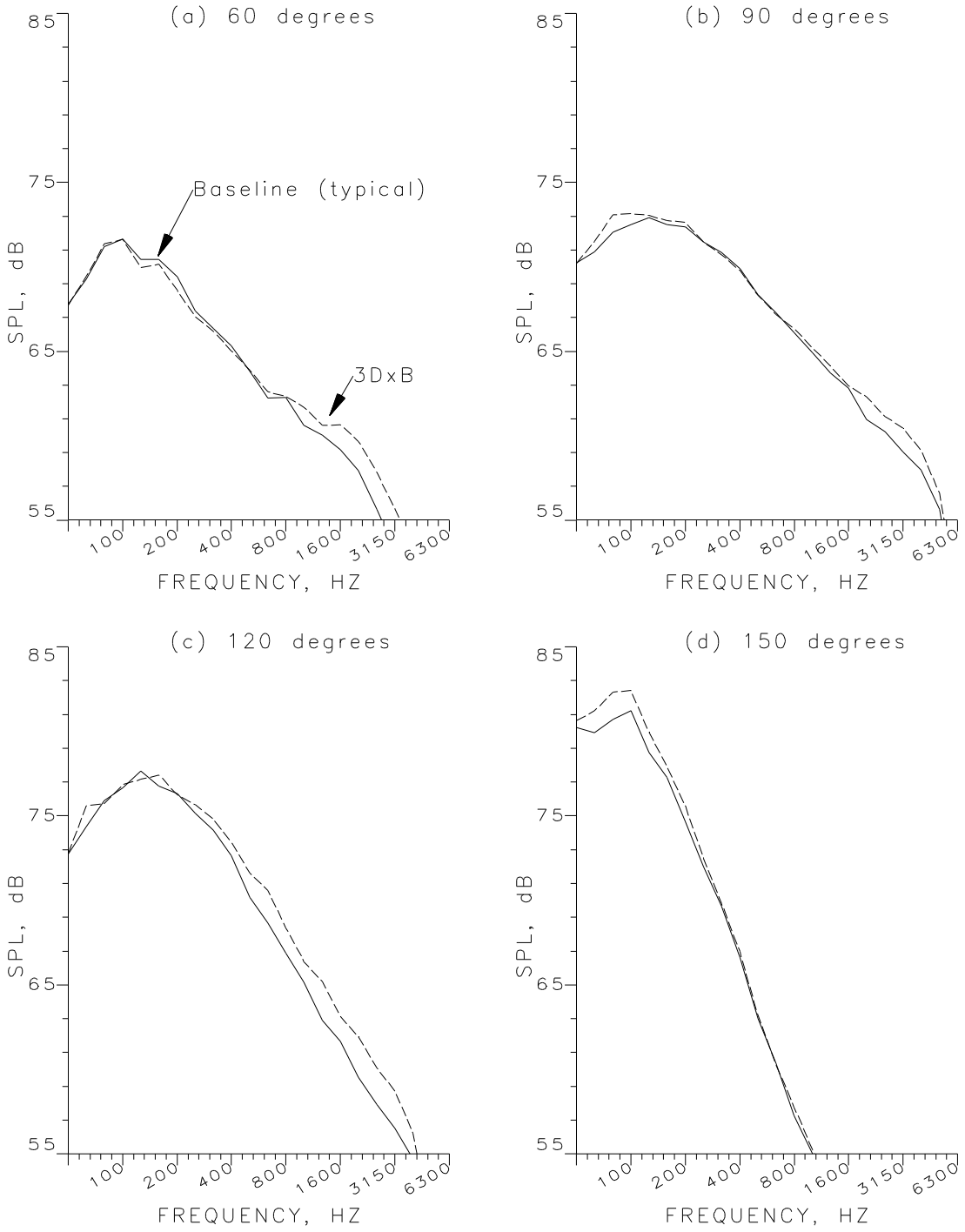


Figure A-56. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3DiB) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. (peak PNL angle) and (d) 150 deg.



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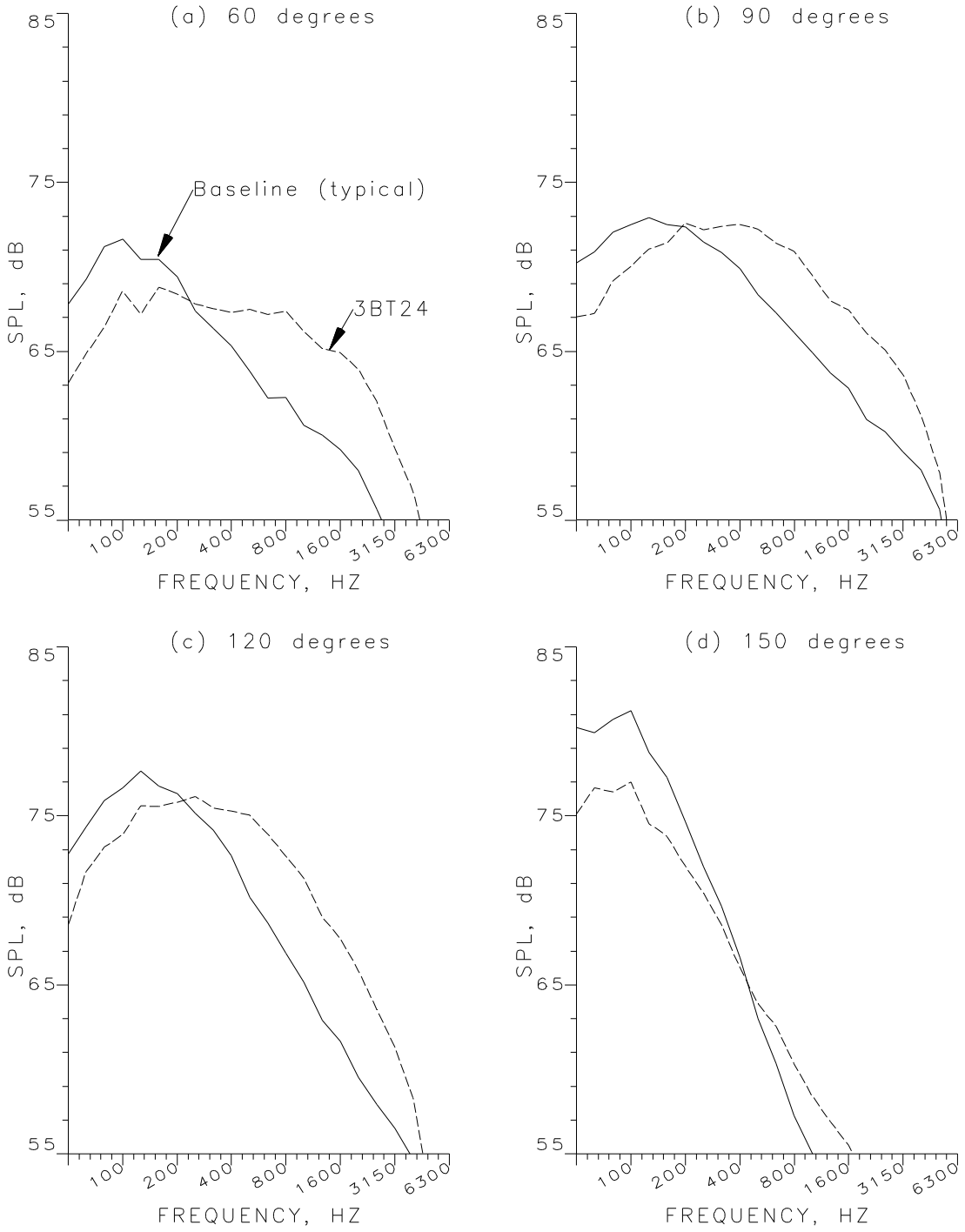

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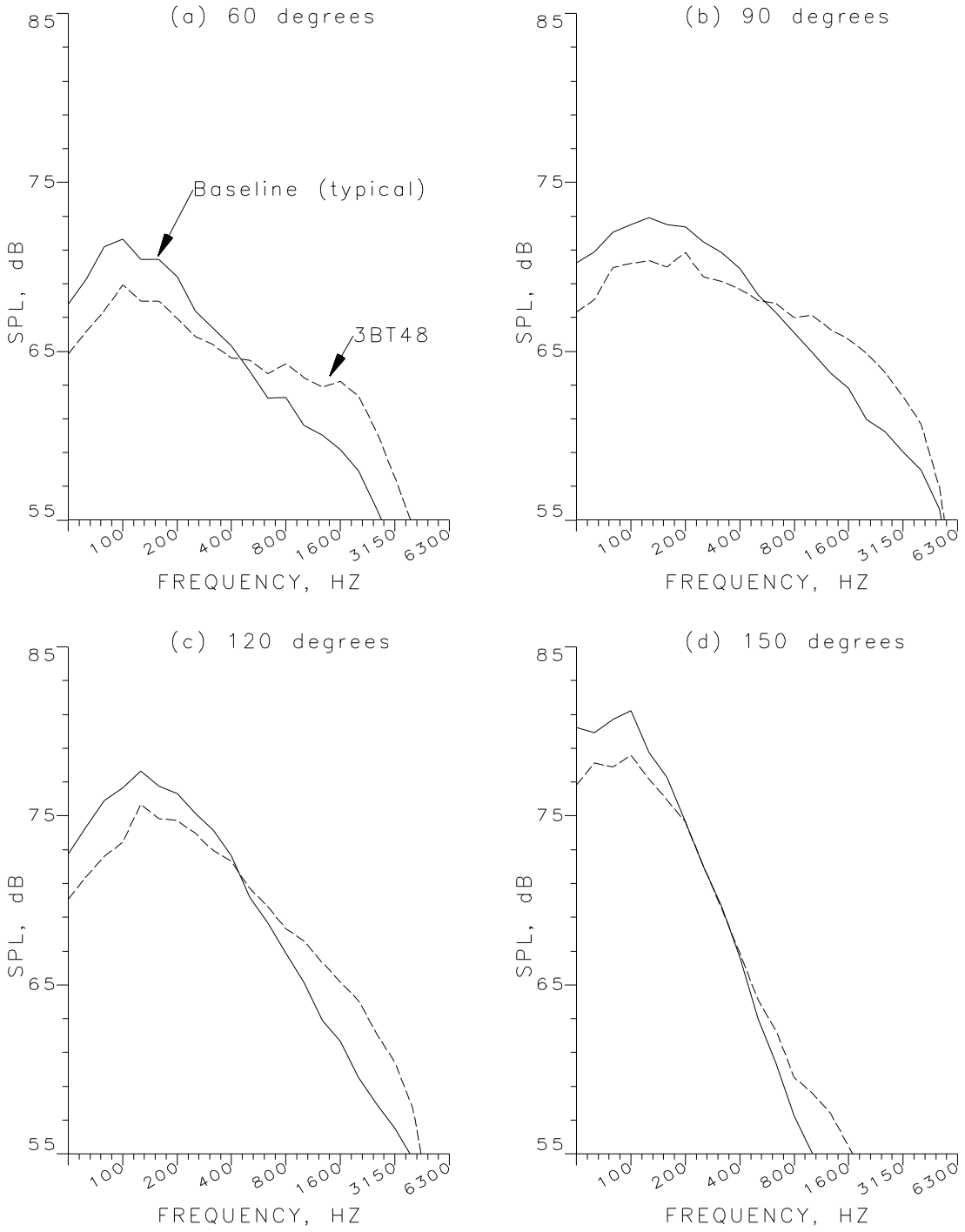

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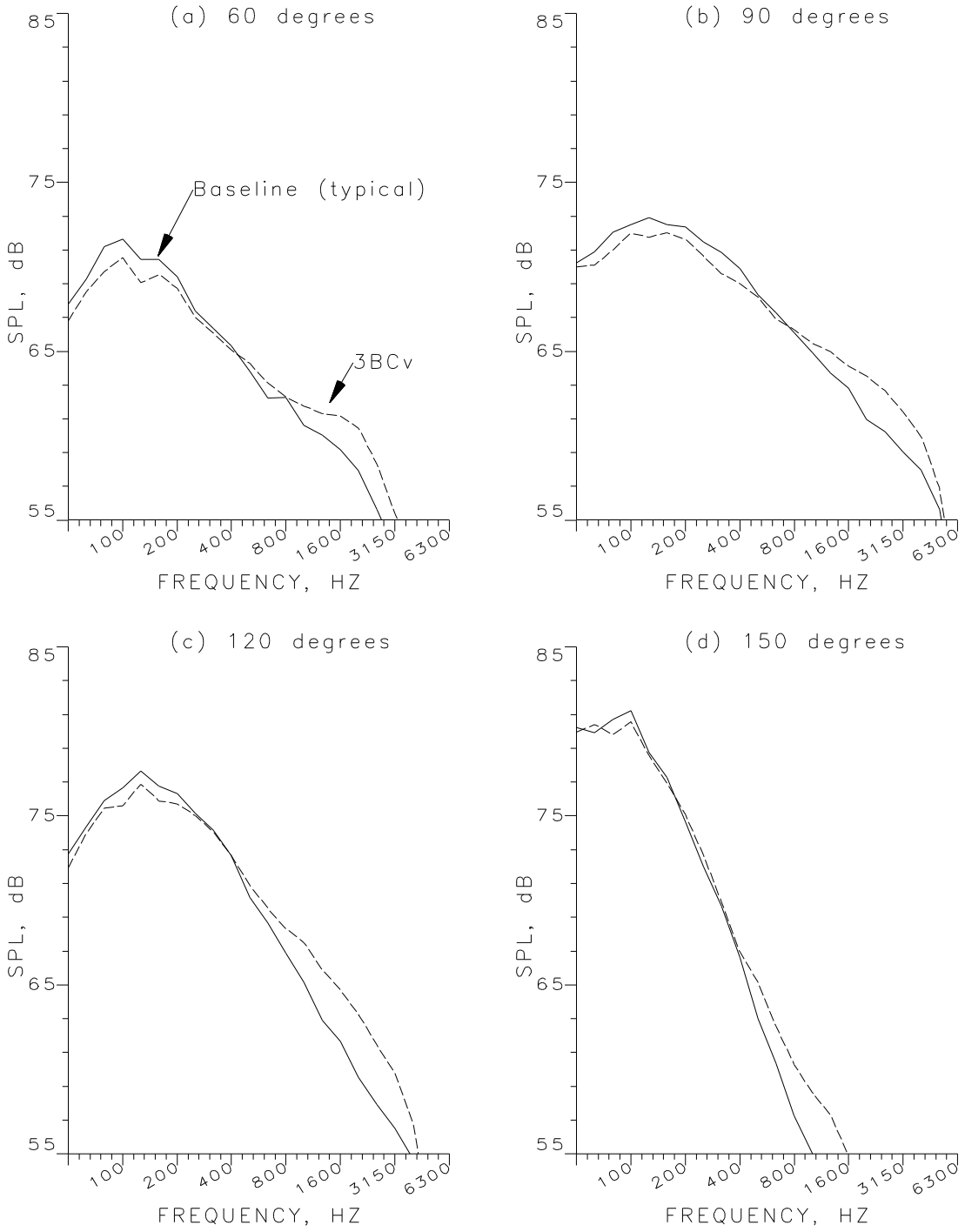

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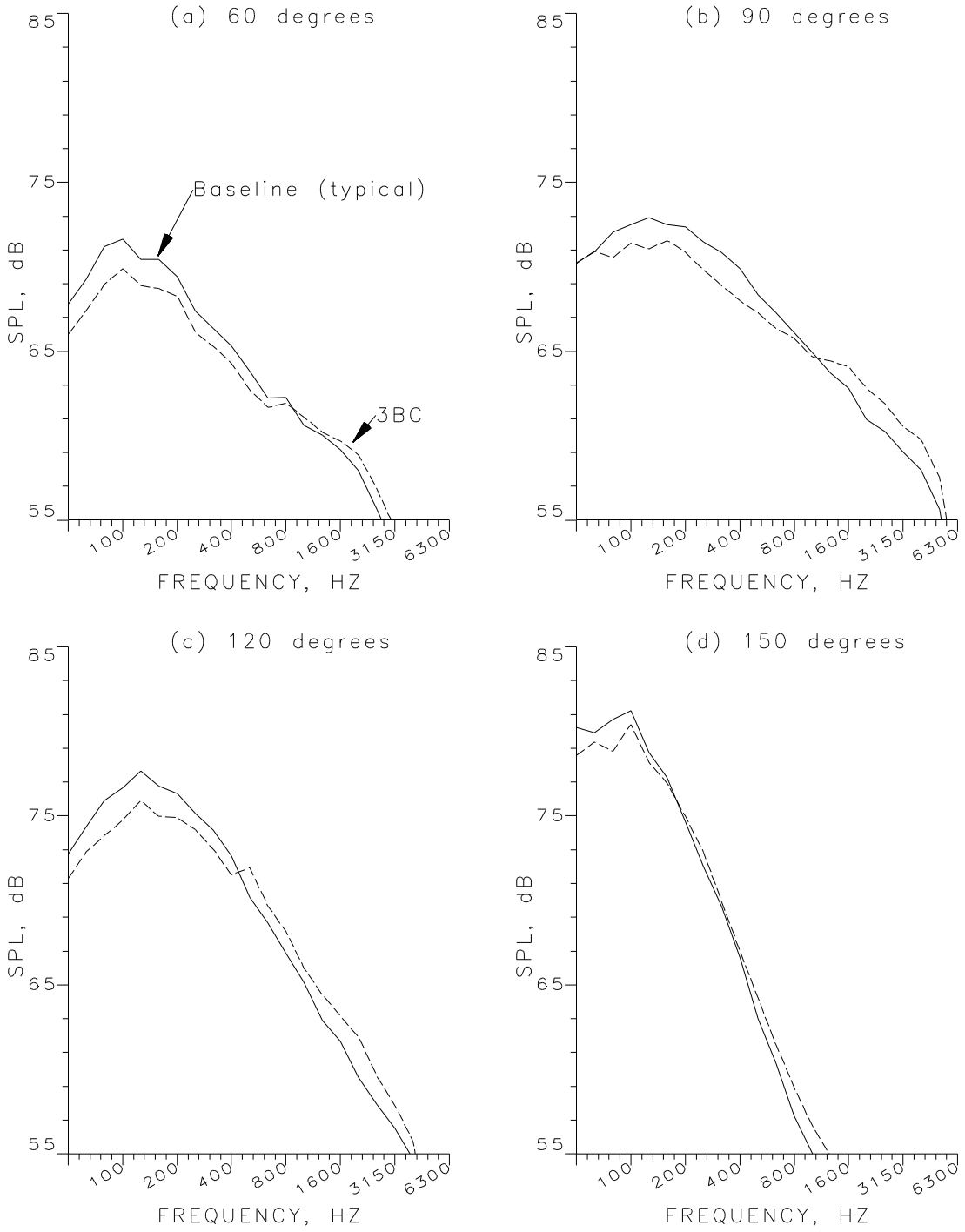
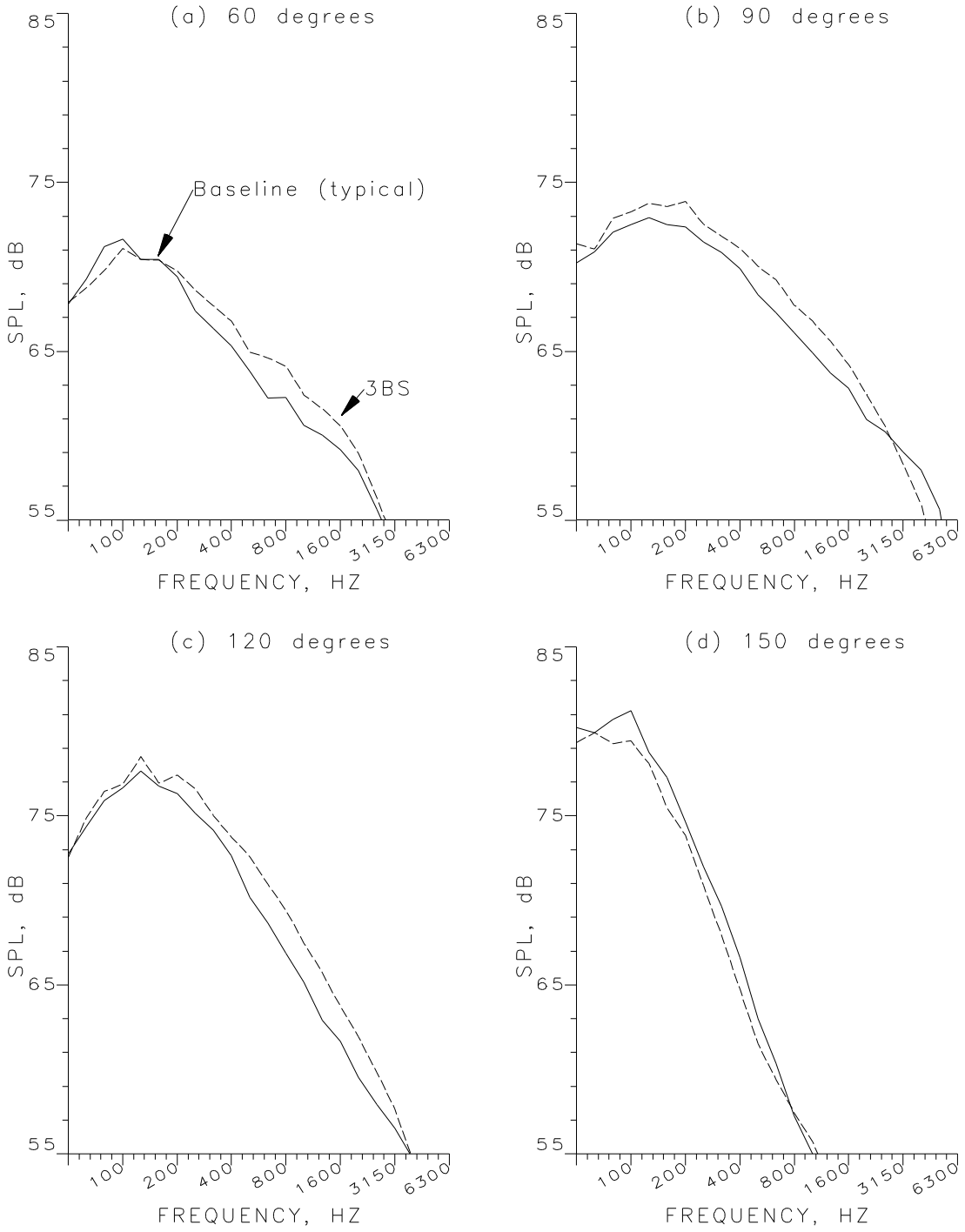


Figure A-61. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3BC) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. (peak PNL angle) and (d) 150 deg.



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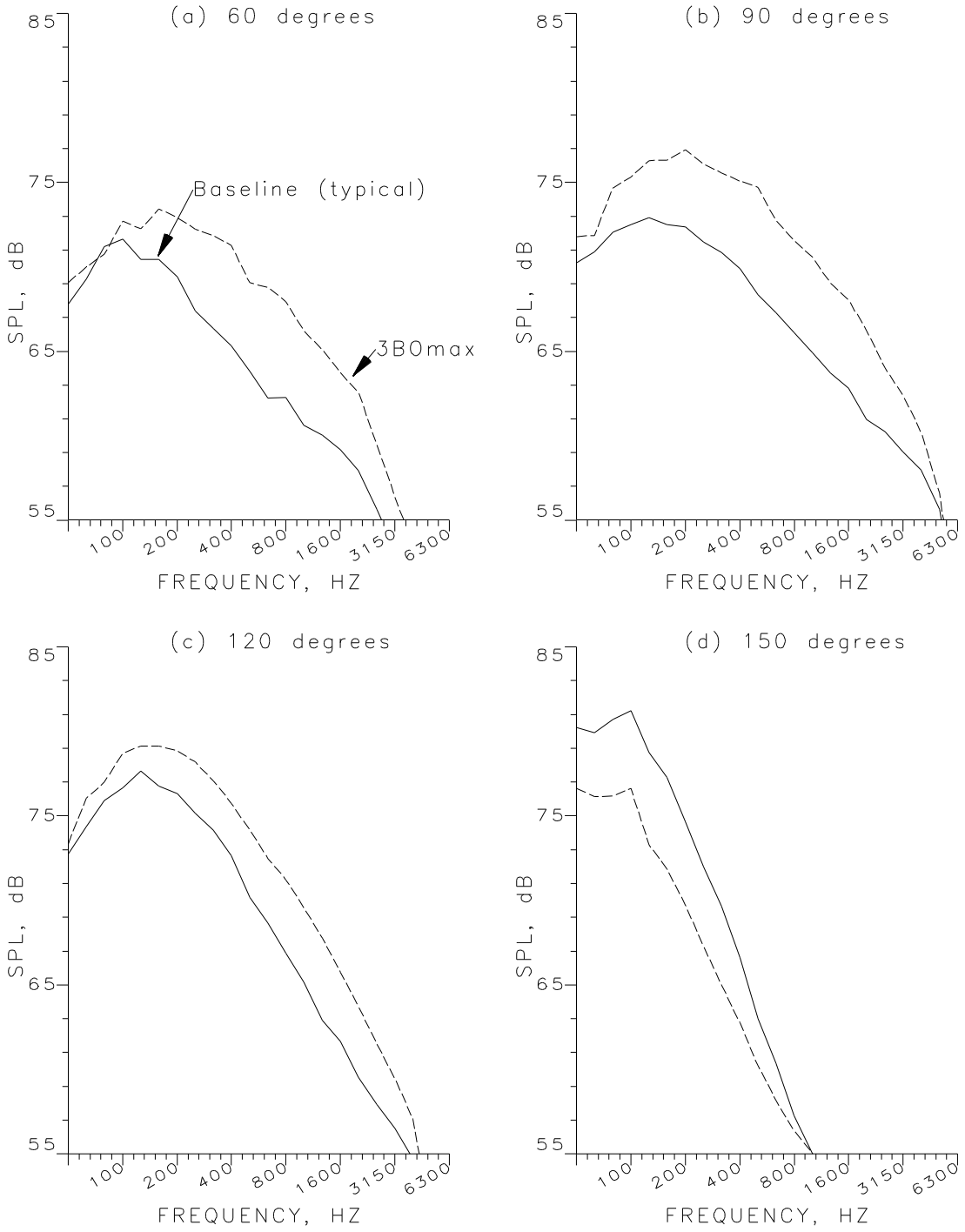

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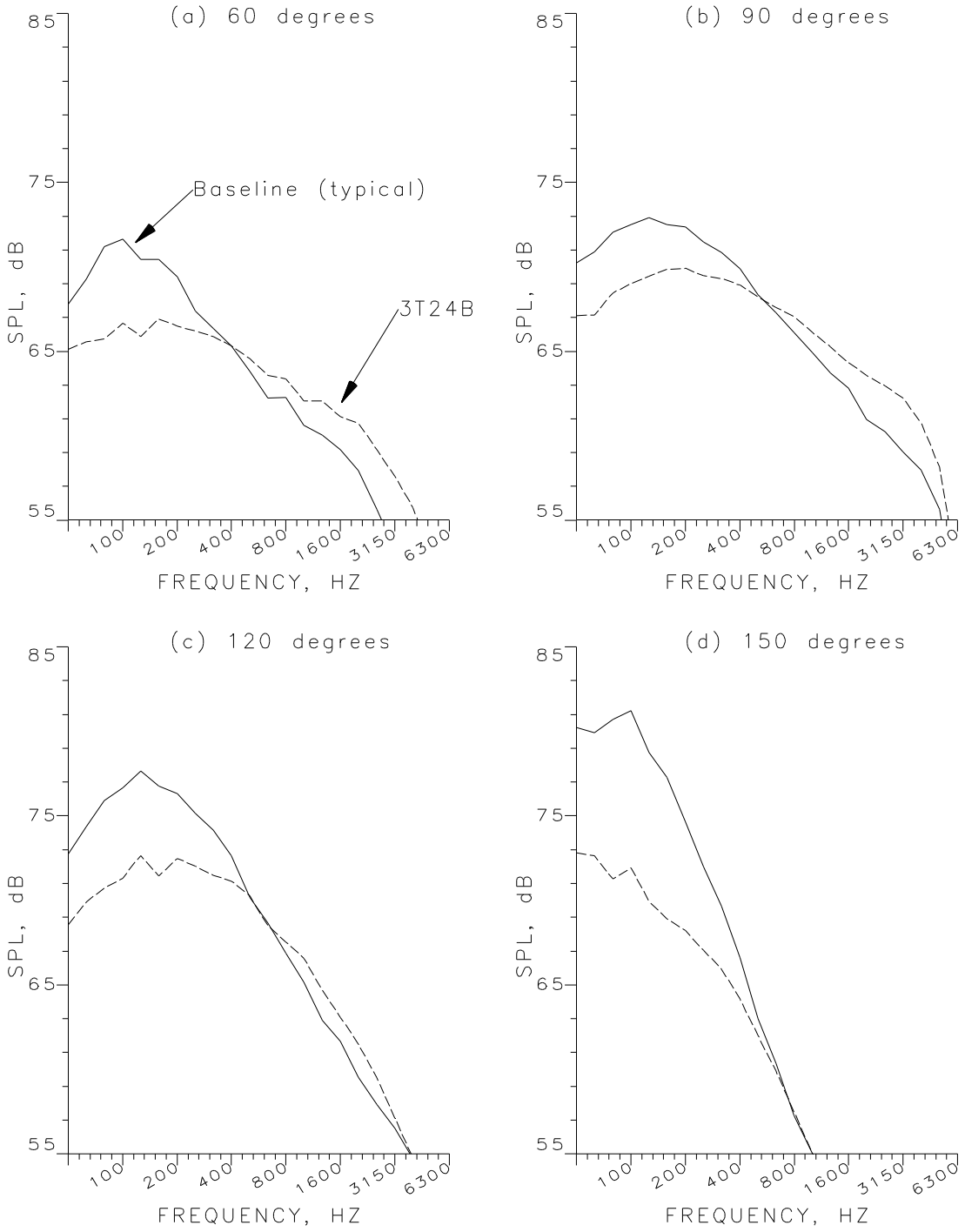

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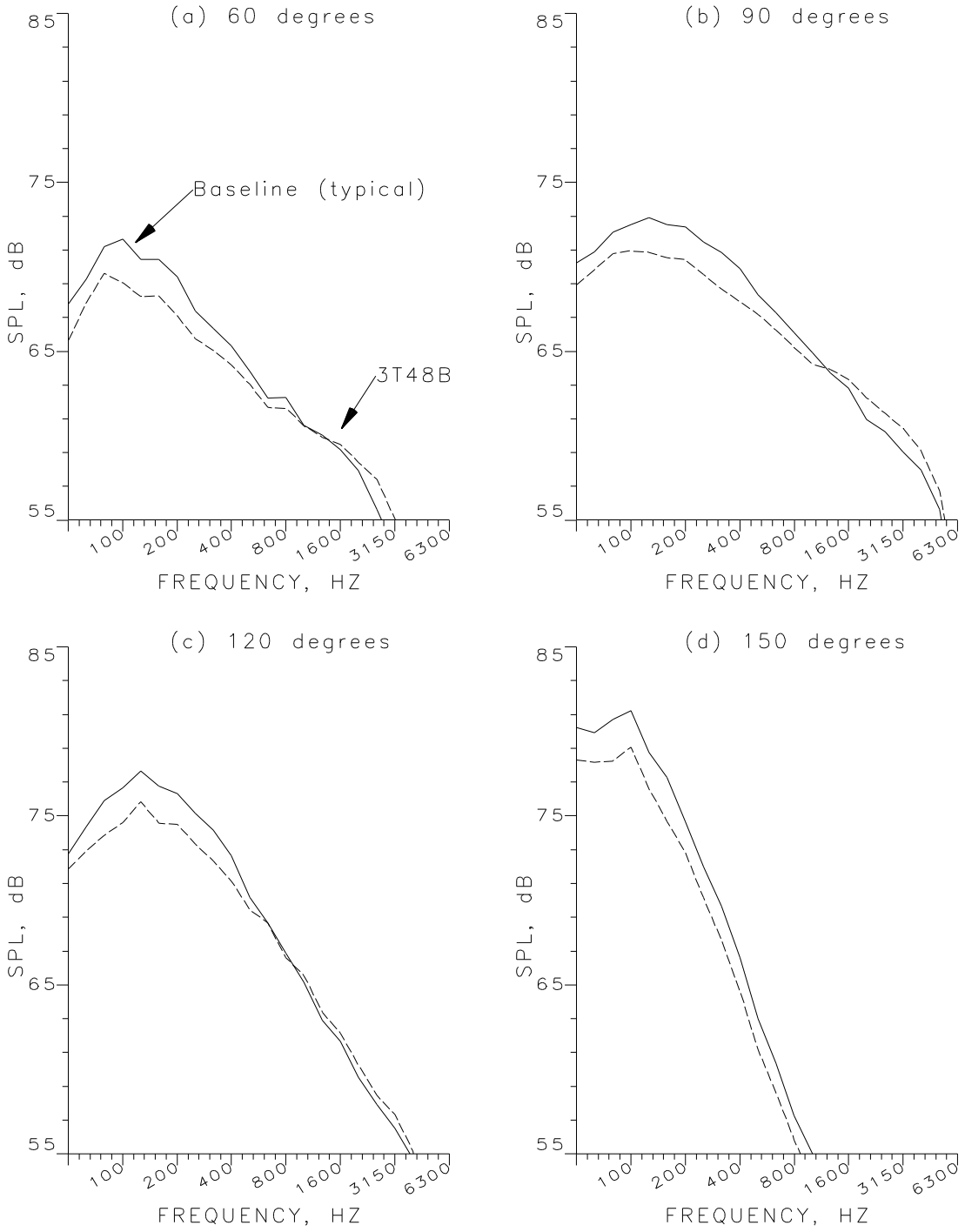

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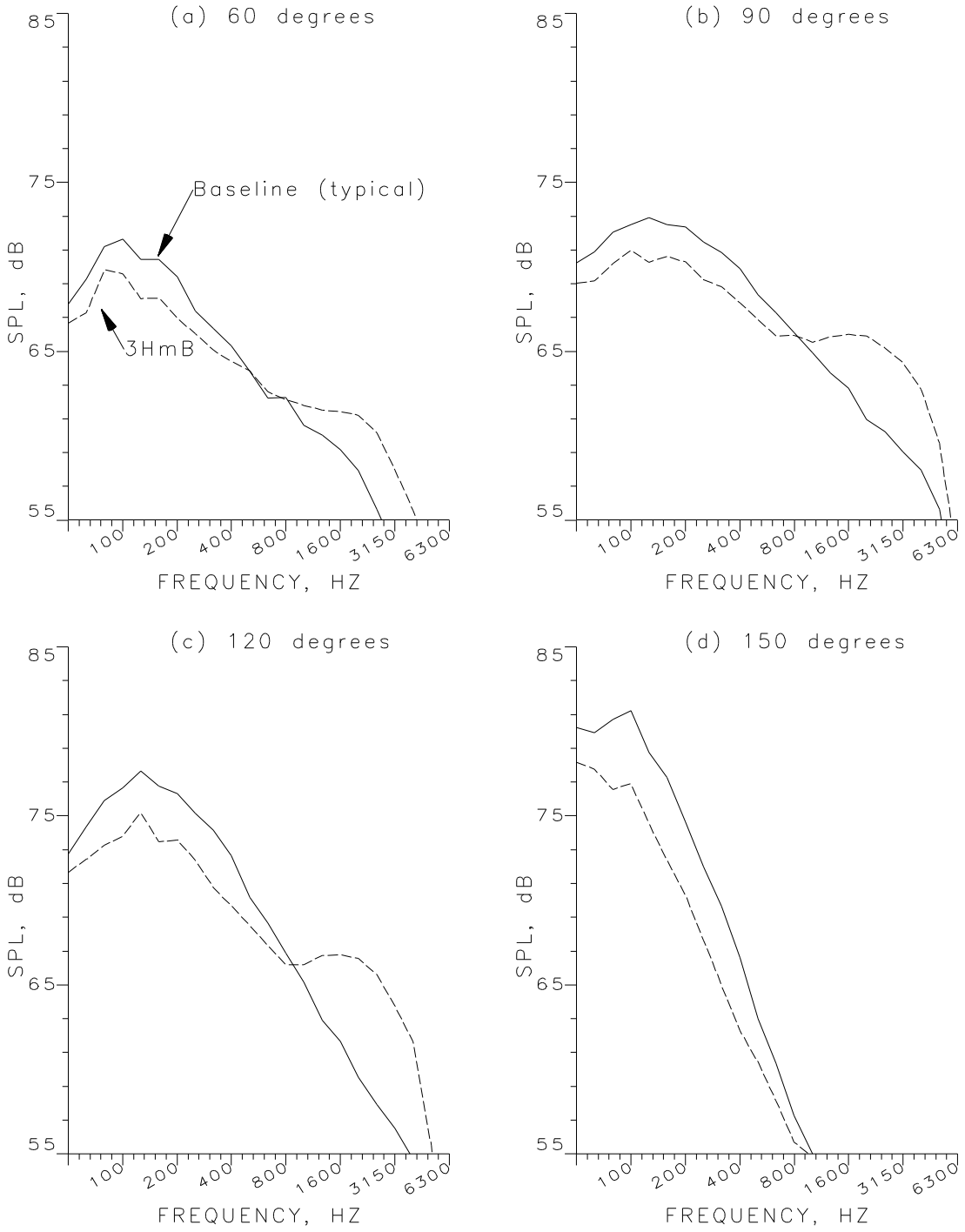
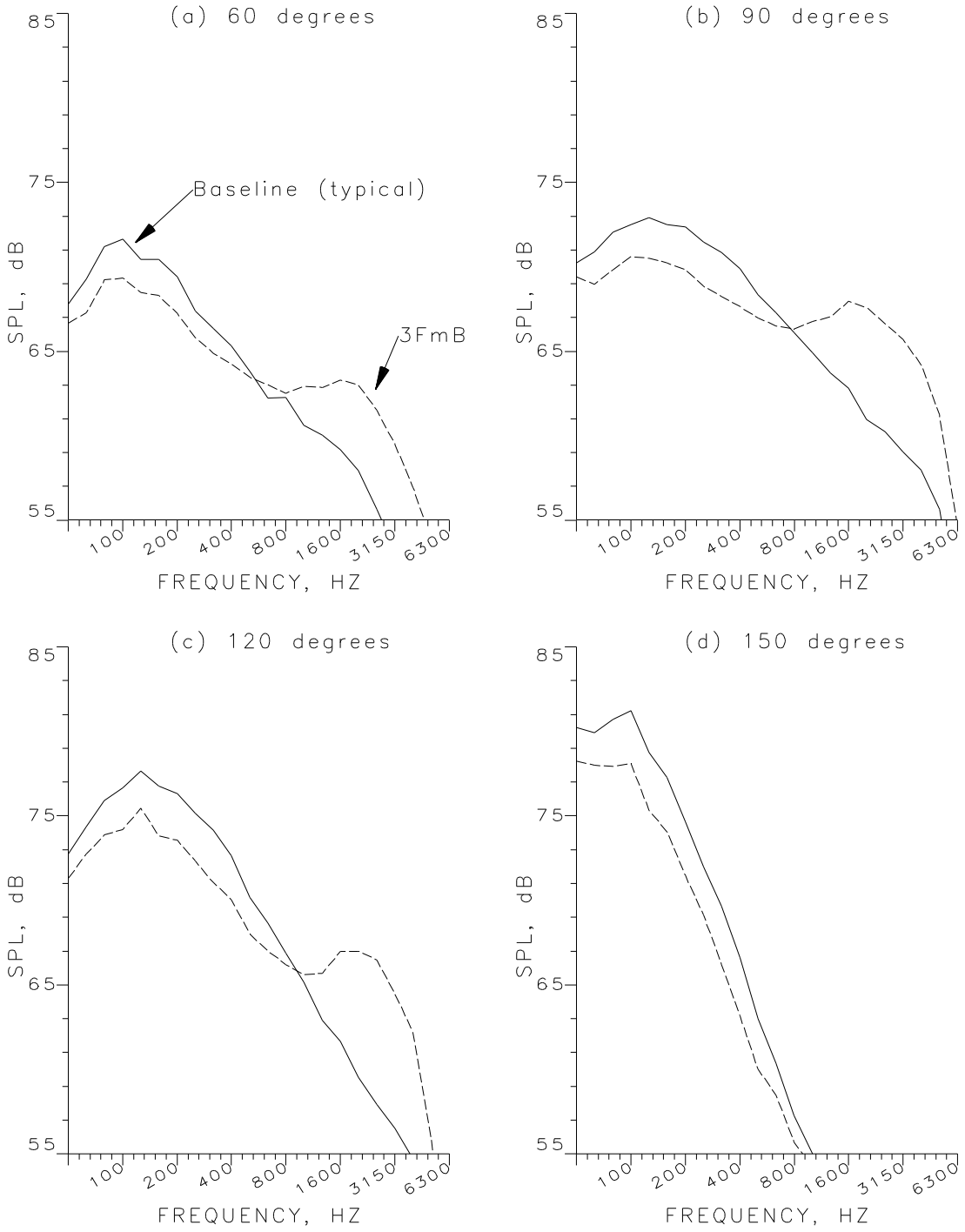


Figure A-66. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 Jet Noise Suppression Device (3HmB) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. and (d) 150 deg.



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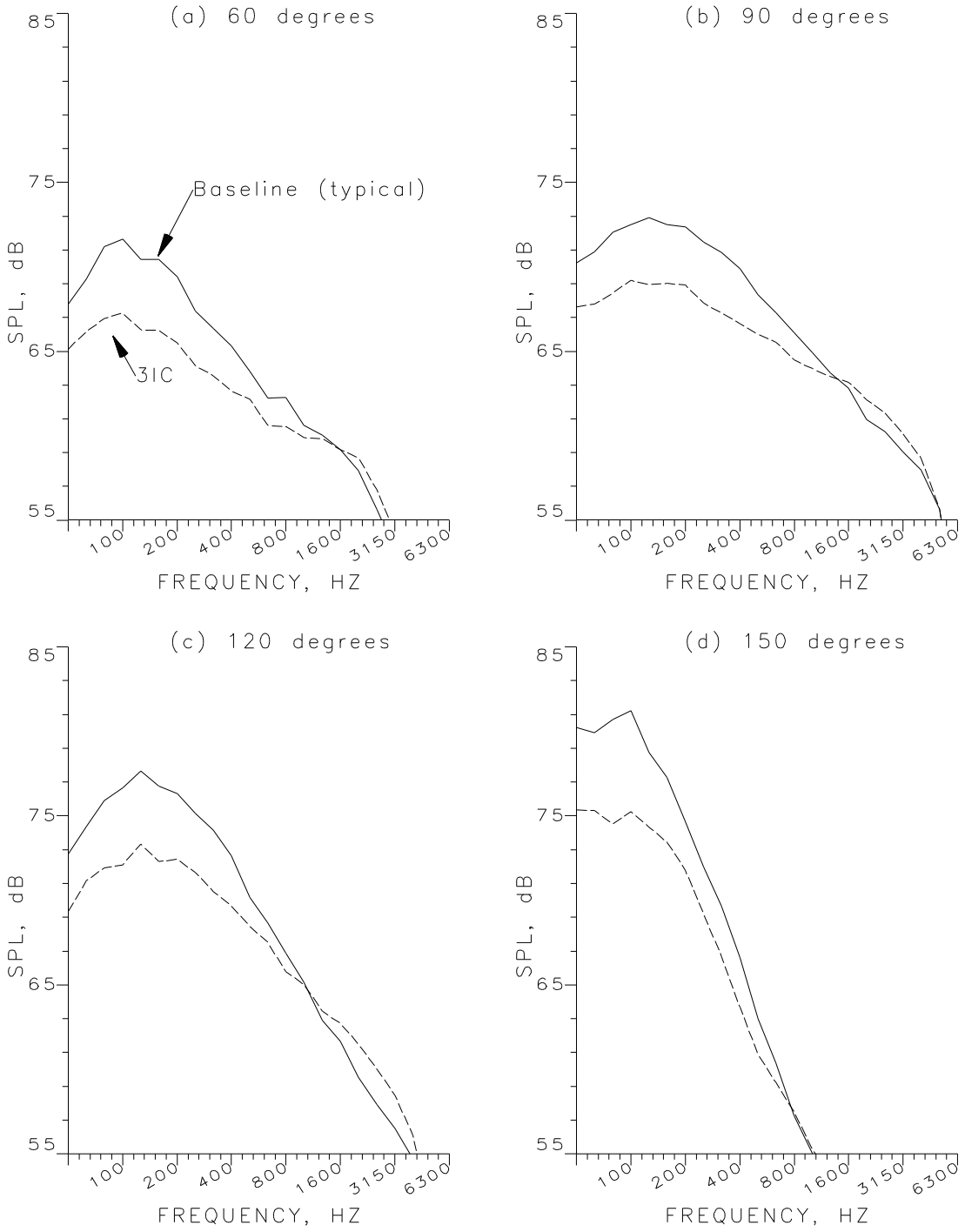

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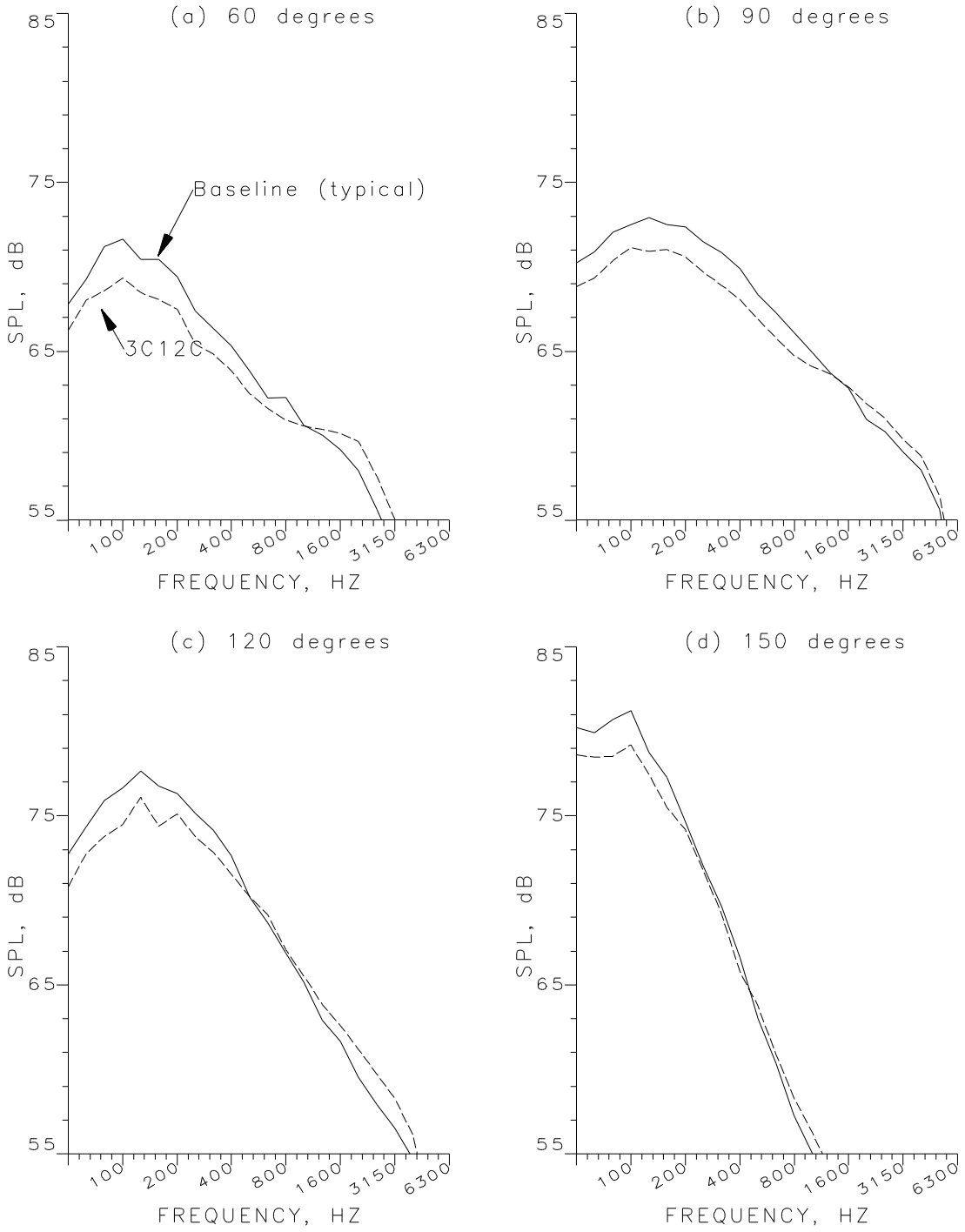

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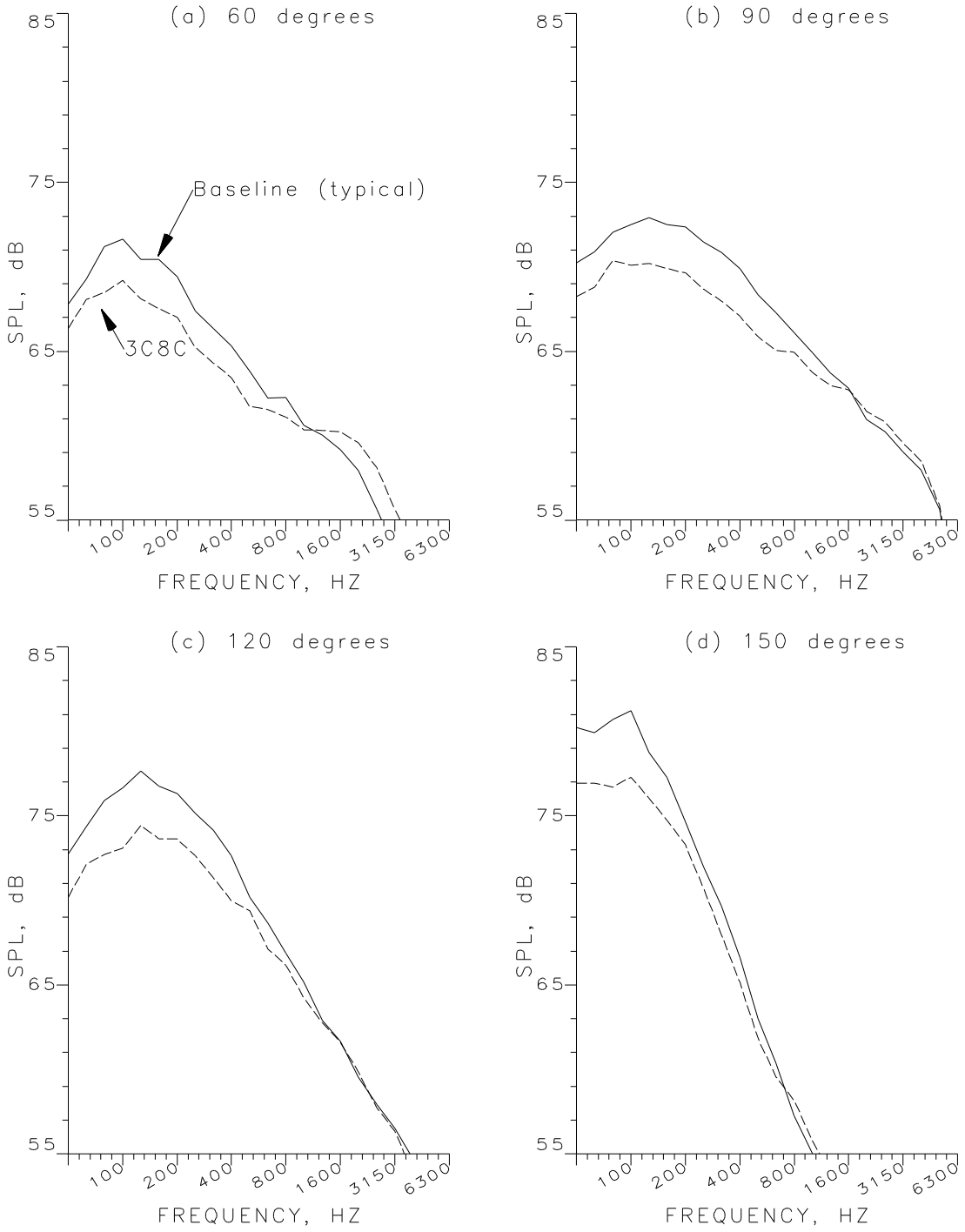

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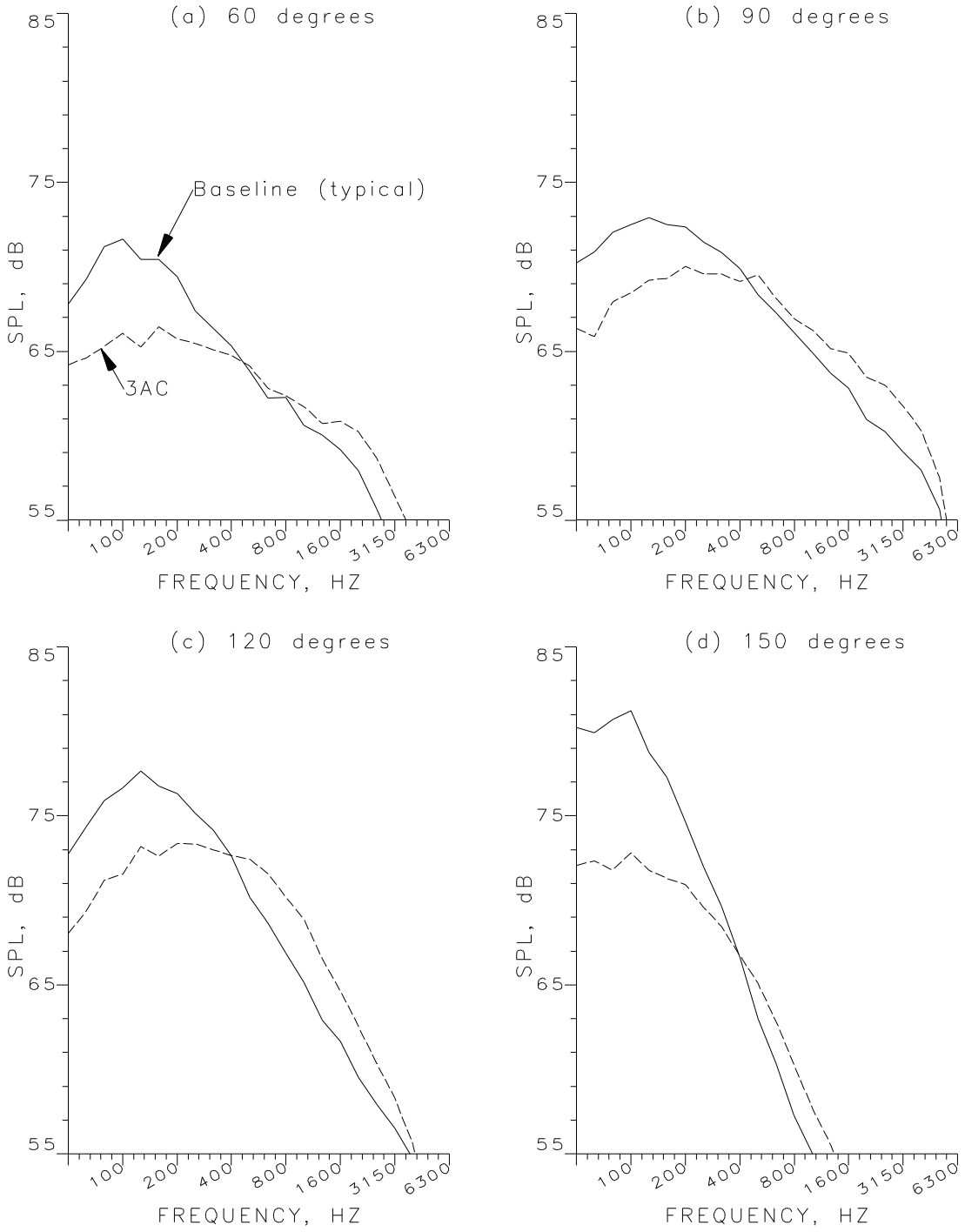

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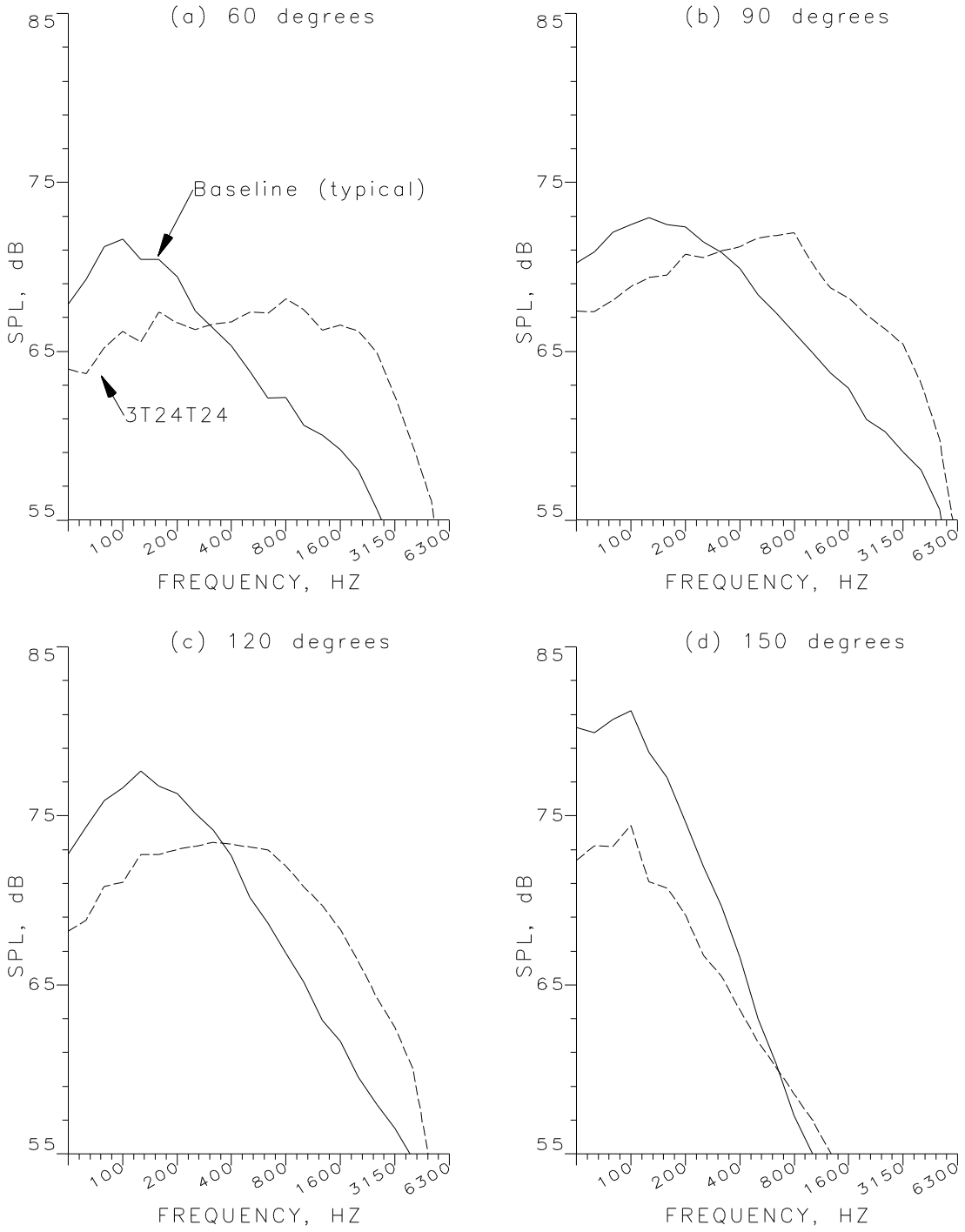
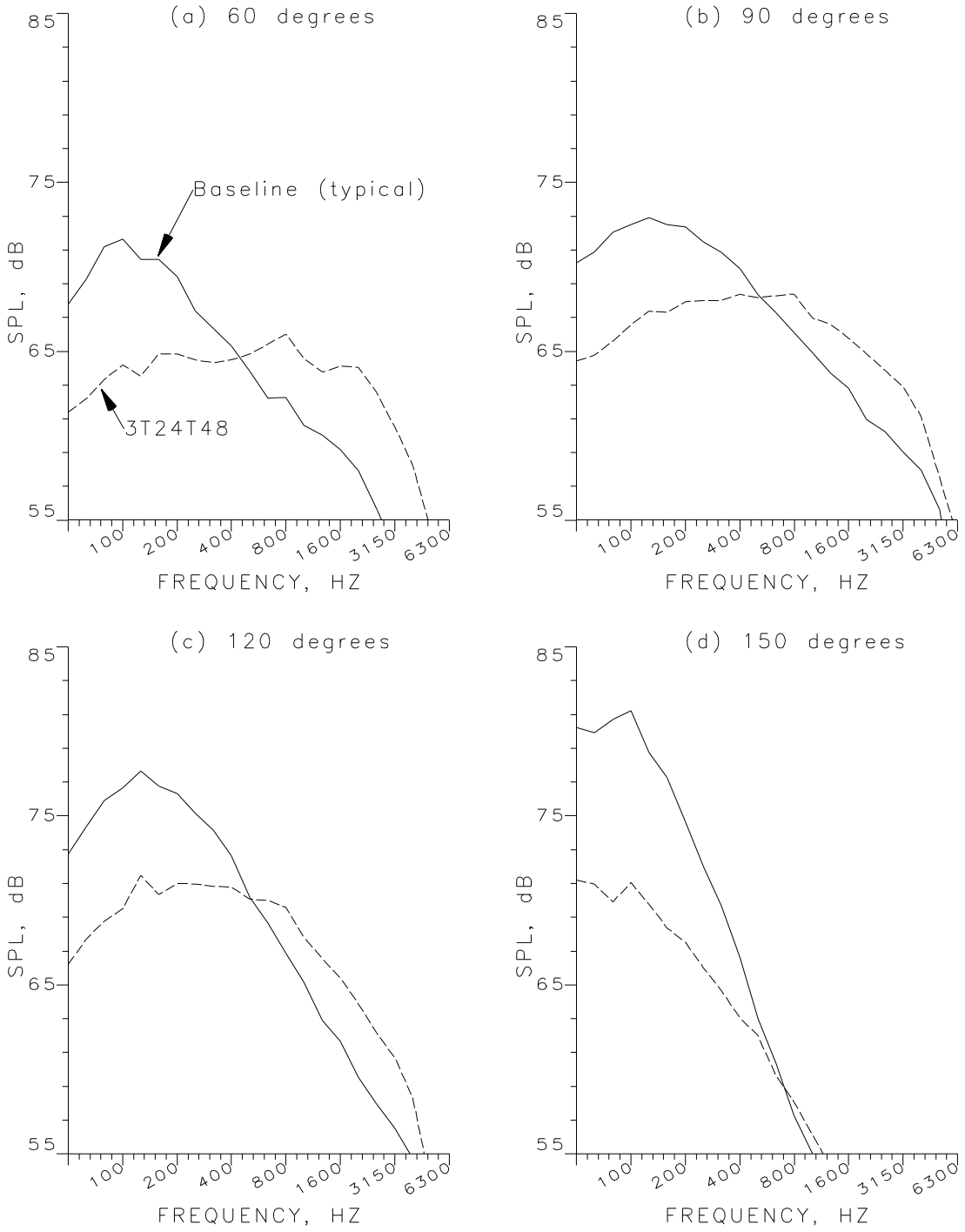


Figure A-72. SPL Spectral Comparisons (Vmix=1155 ft/sec) for Model 3 jet Noise Suppression Device (3T24T24) for Far-field Angles ; (a) 60 deg., (b) 90 deg., (c) 120 deg. and (d) 150 deg.



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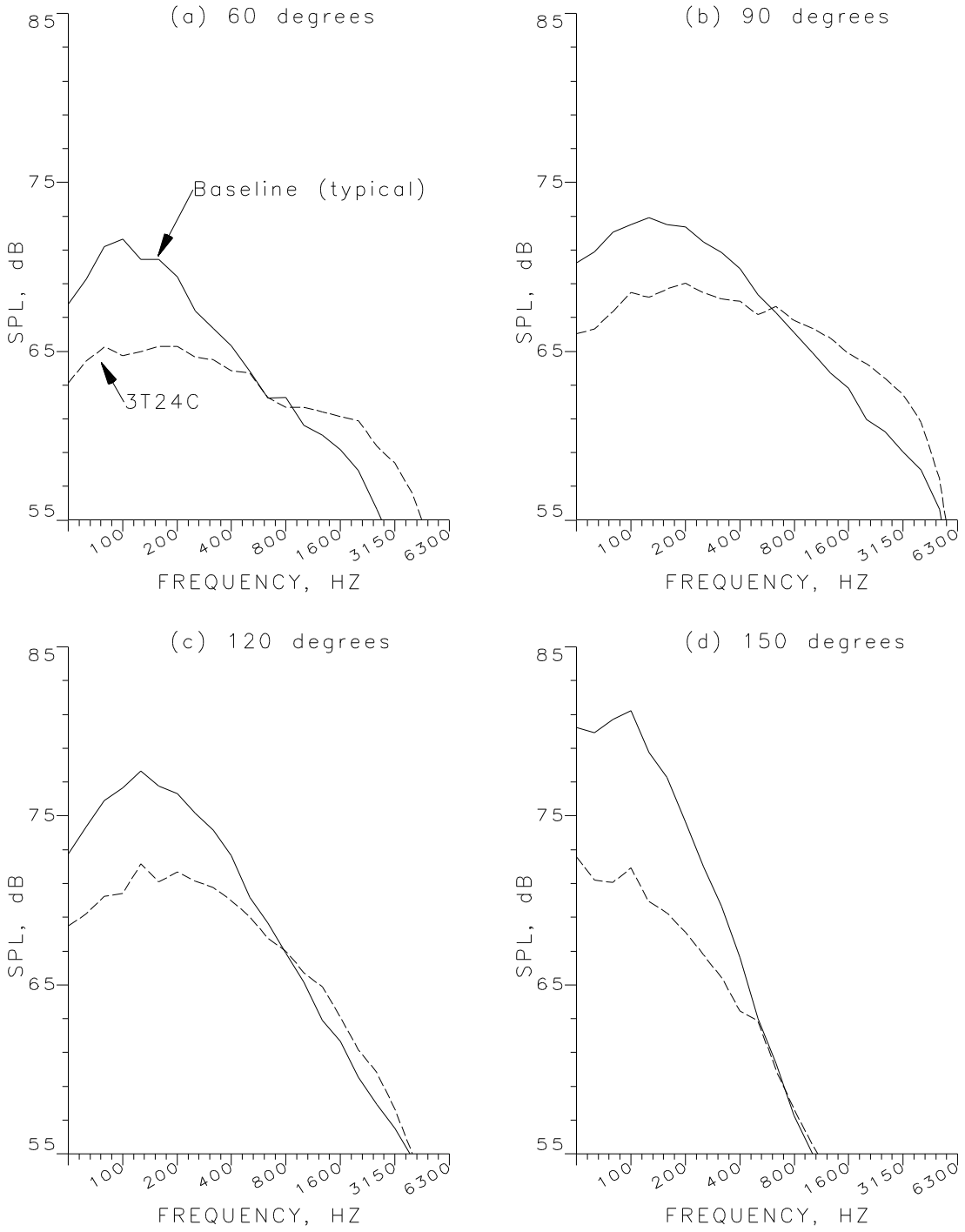

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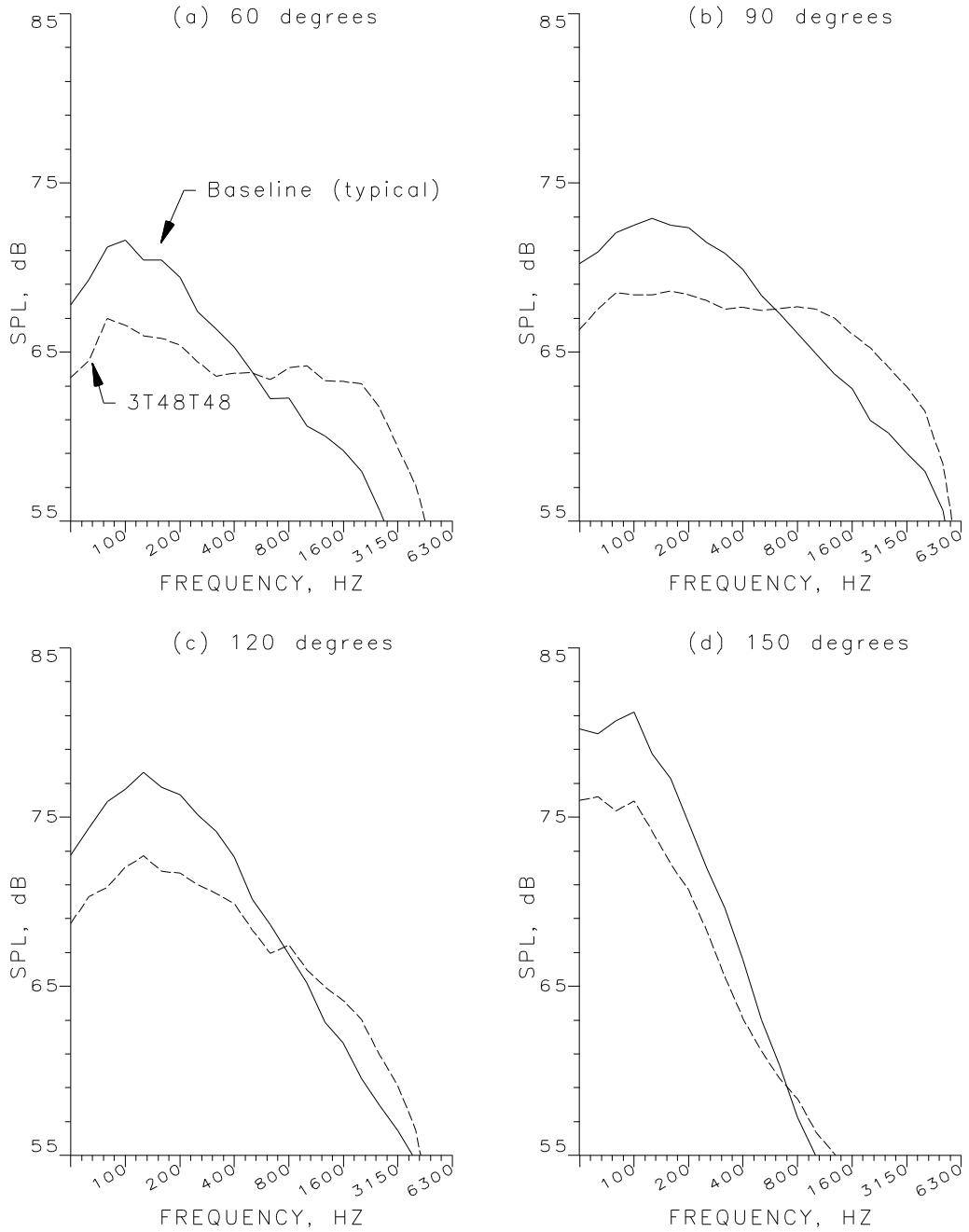

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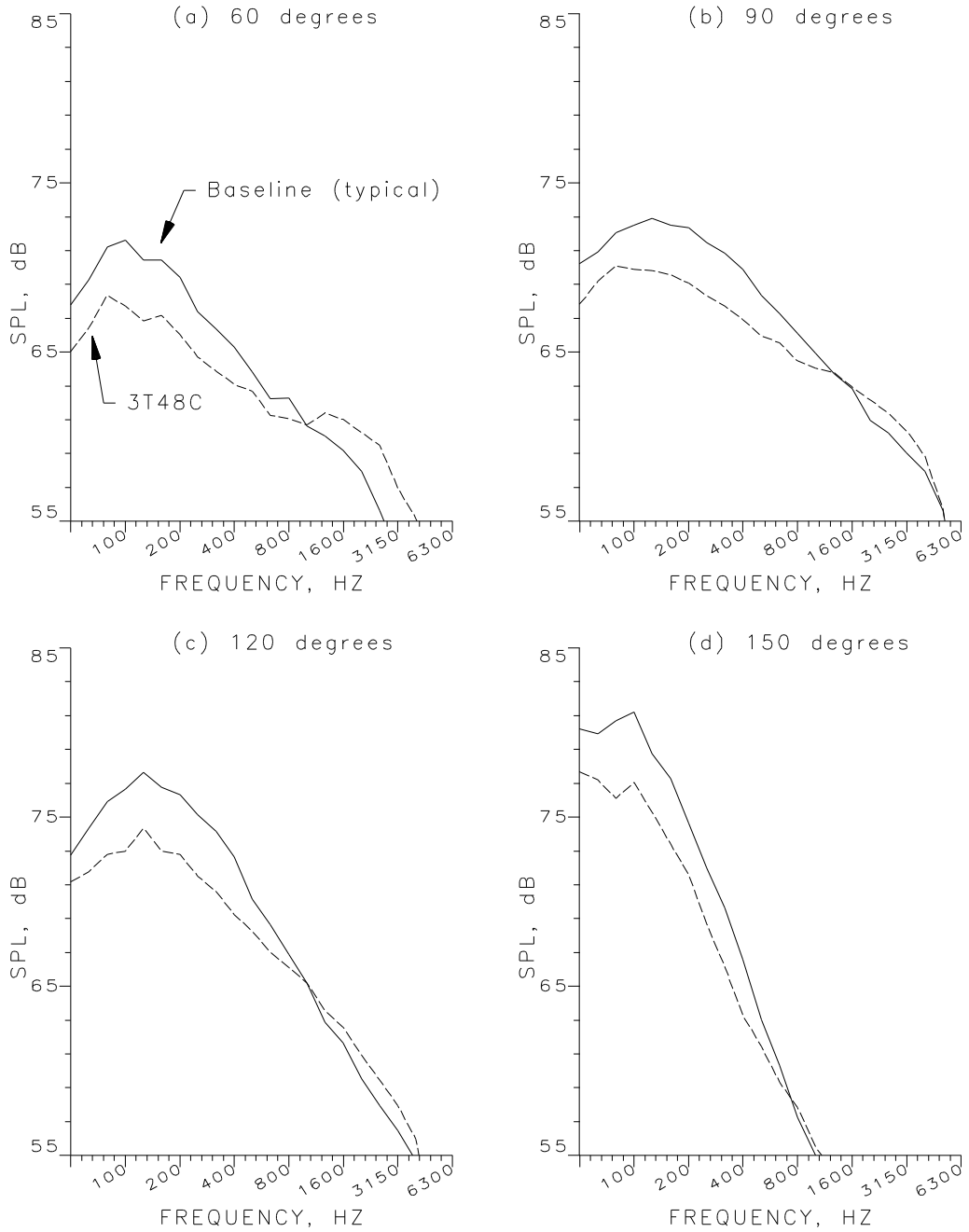

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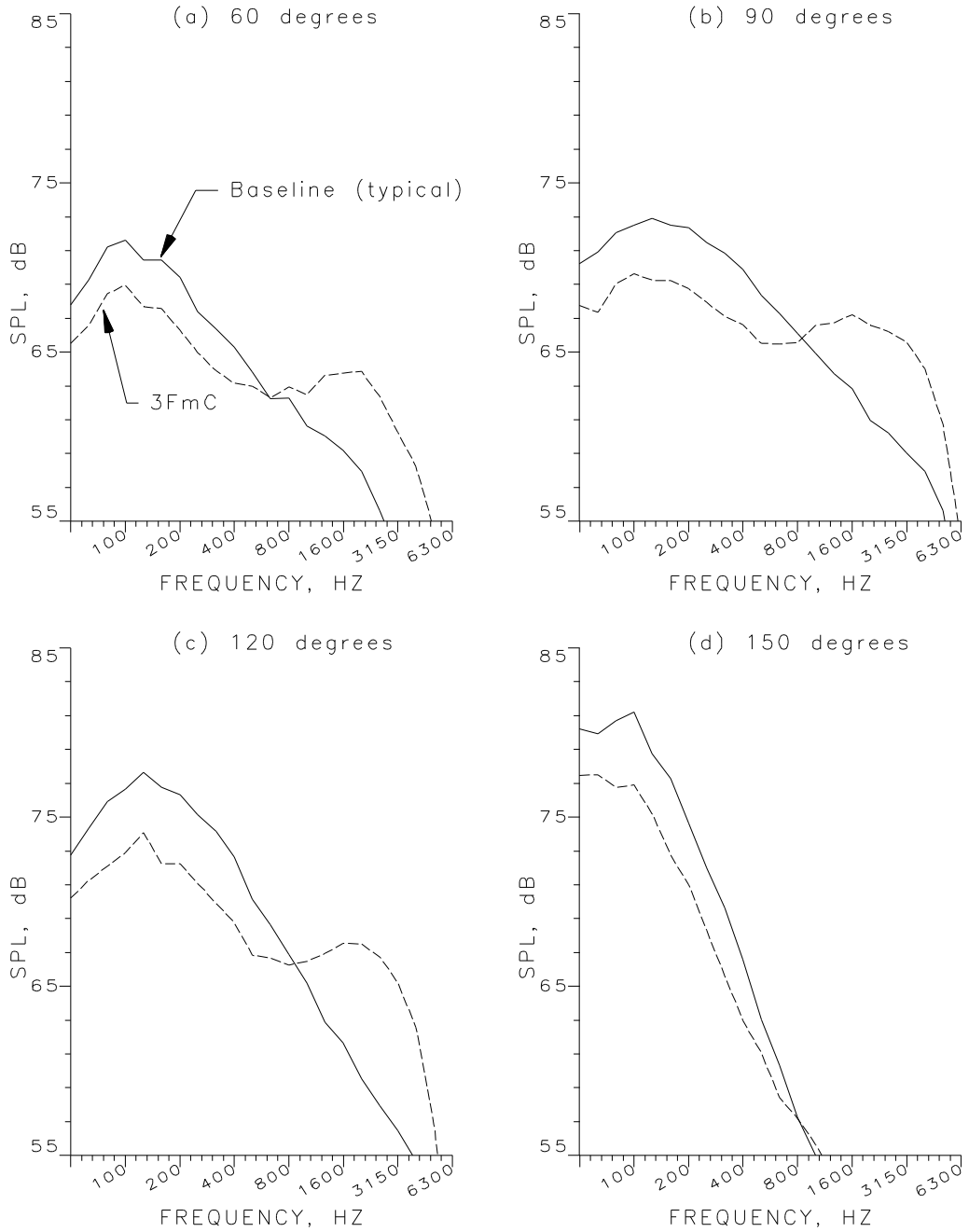

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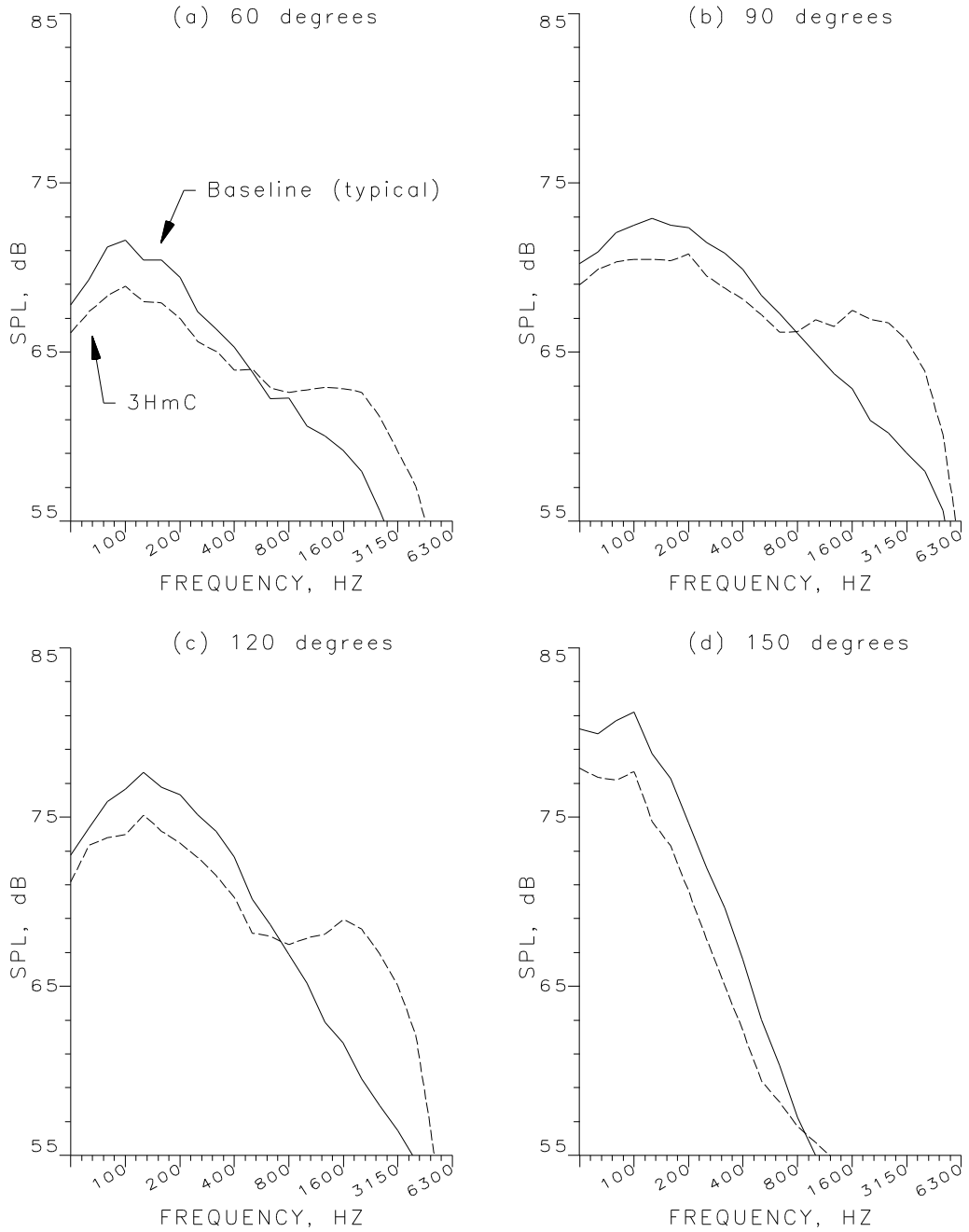

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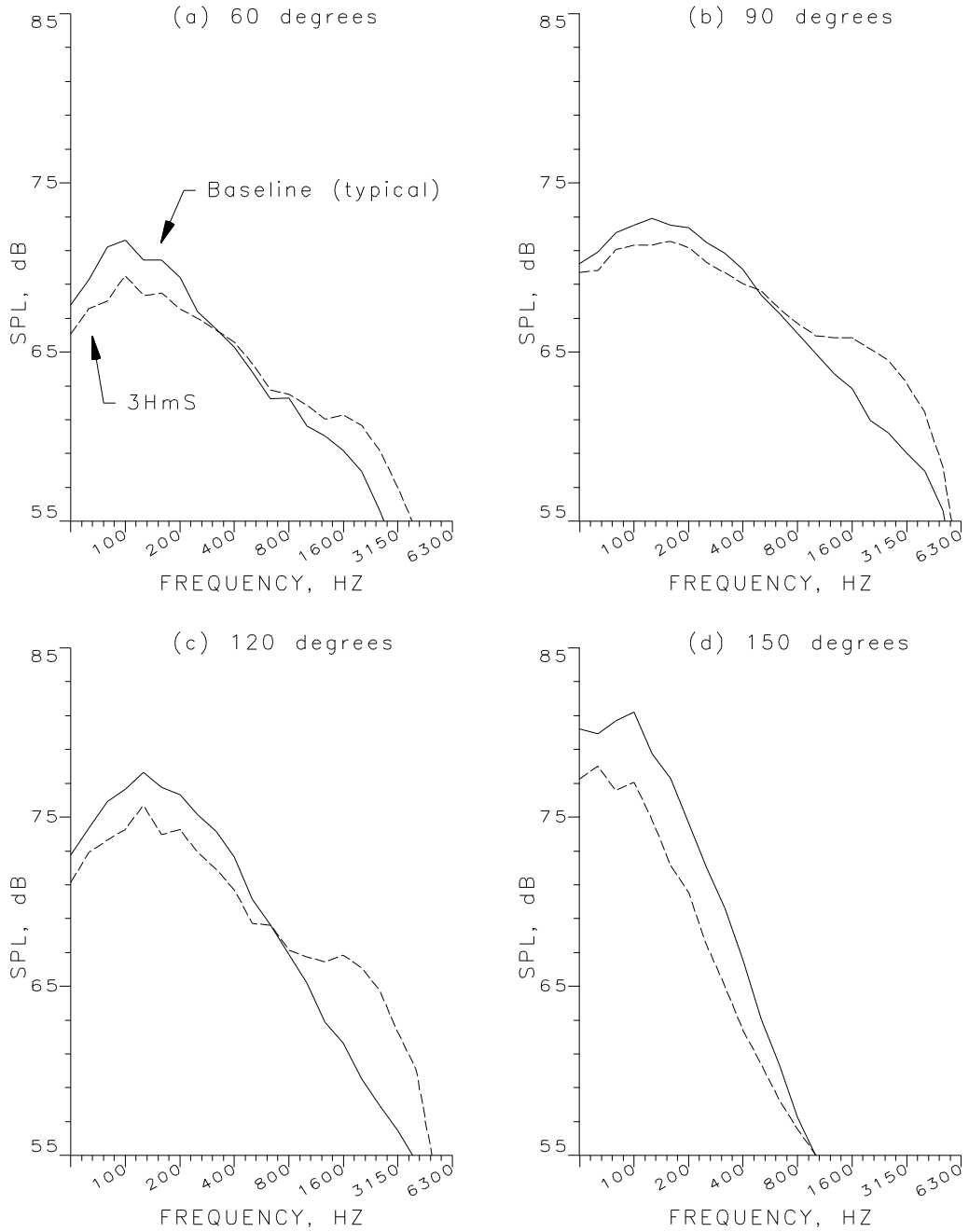

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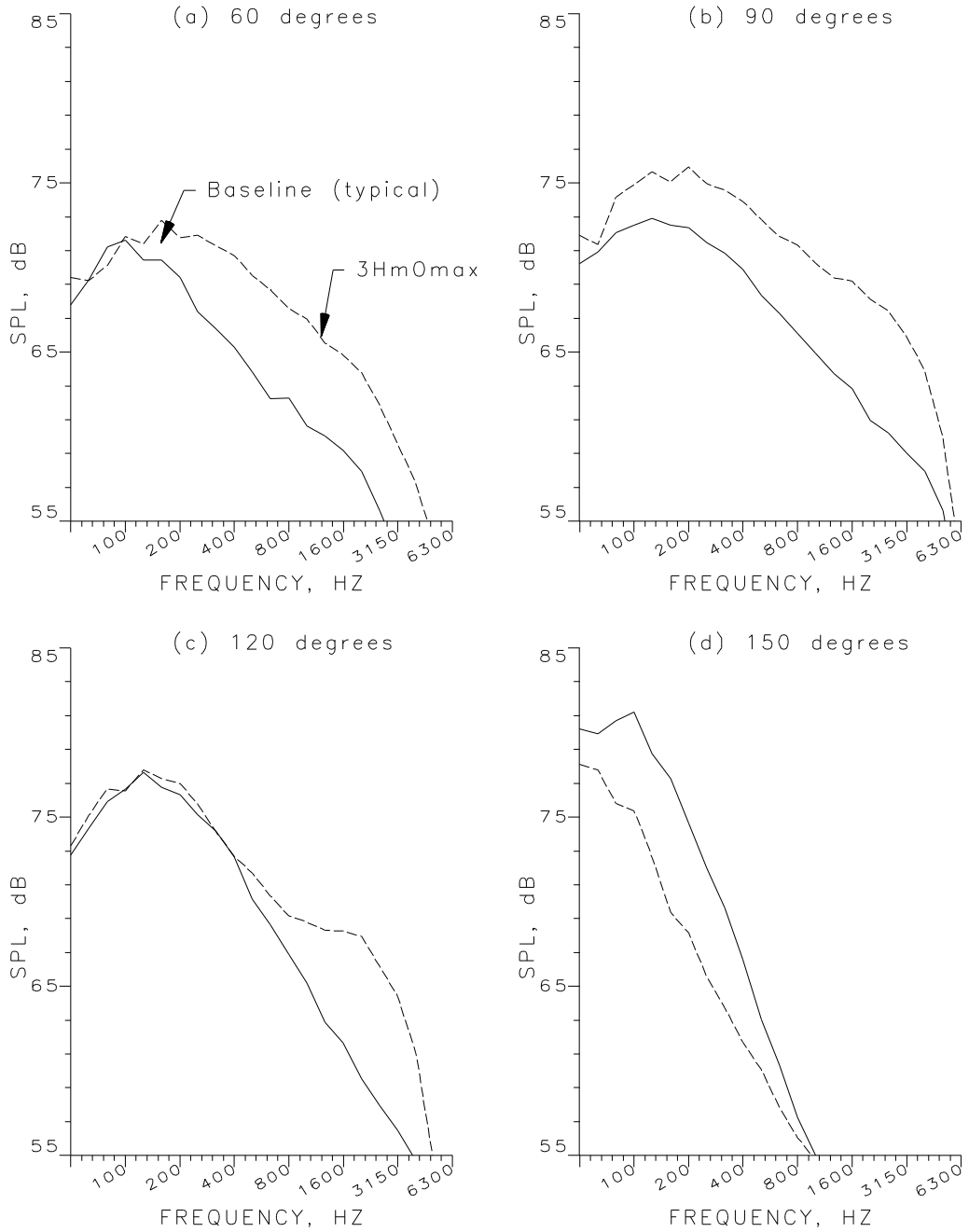

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9.2 MODEL HARDWARE DESCRIPTIONS

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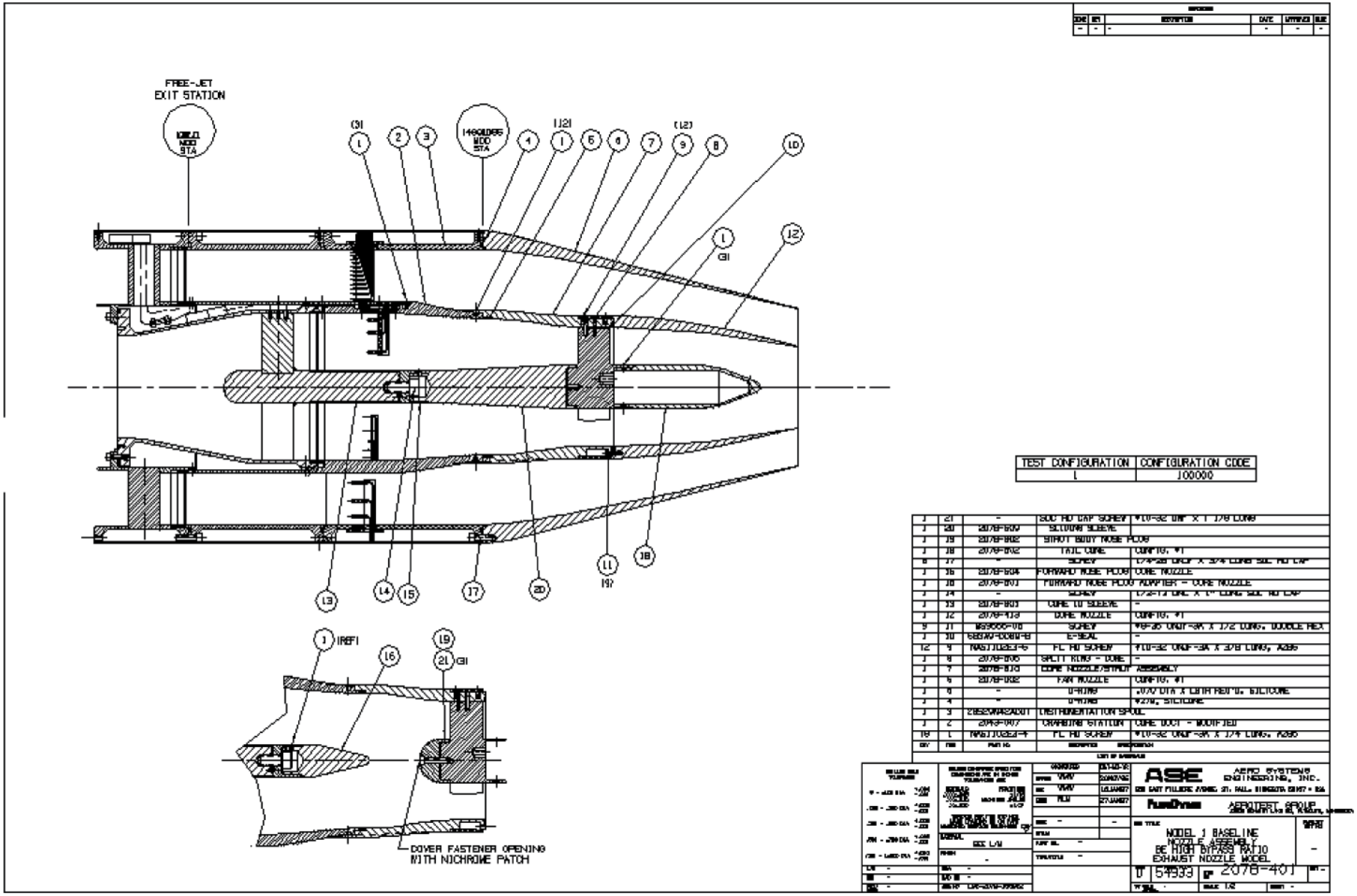


Figure B-1. Cross-section of Model #1 Baseline Nozzle (1BB), BPR=5, Internal Plug Coplanar Nozzle.

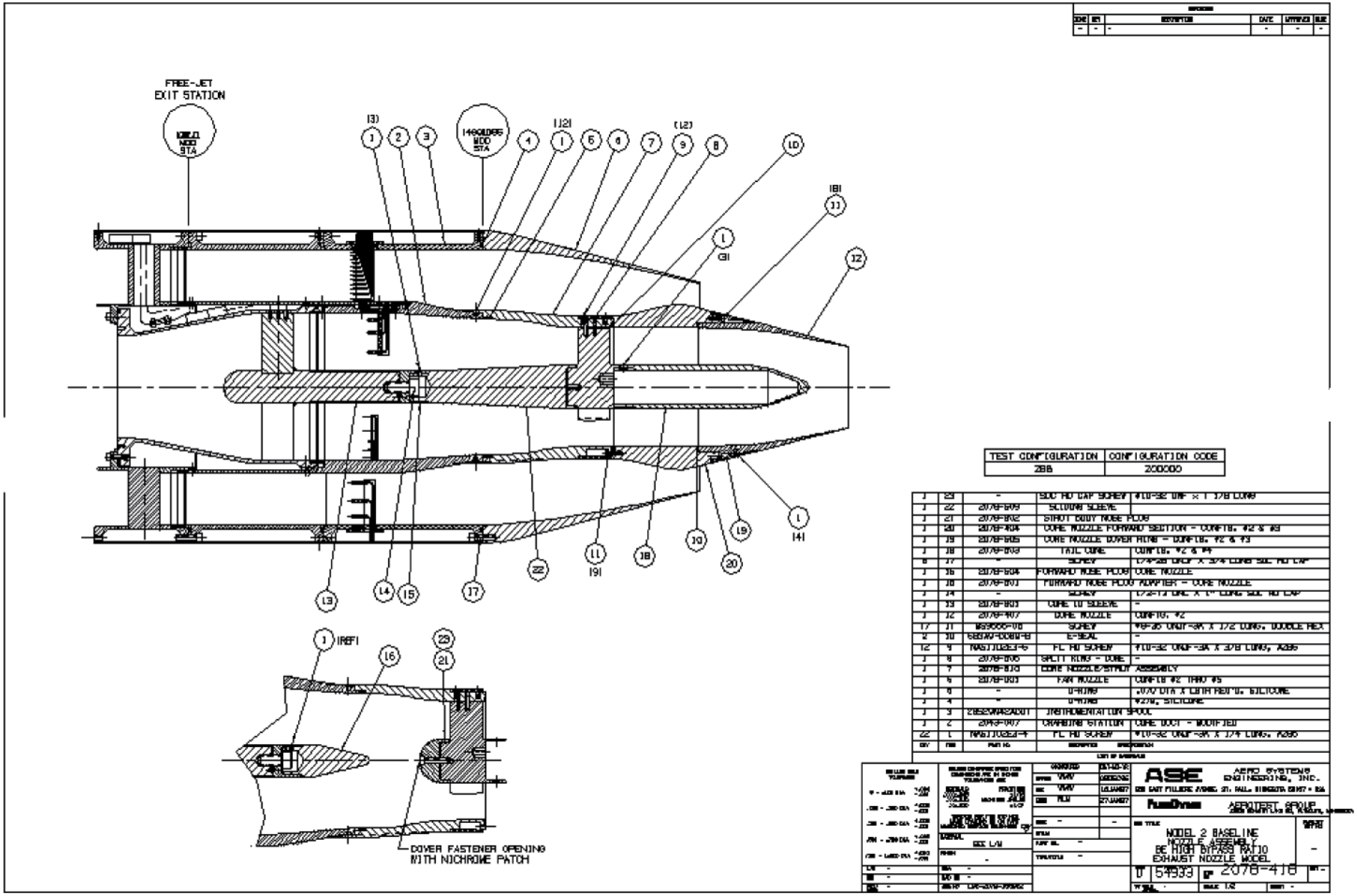


Figure B-2. Cross-section of Model #2 Baseline Nozzle (2BB), BPR=5, Internal Plug Separate-Flow Nozzle.

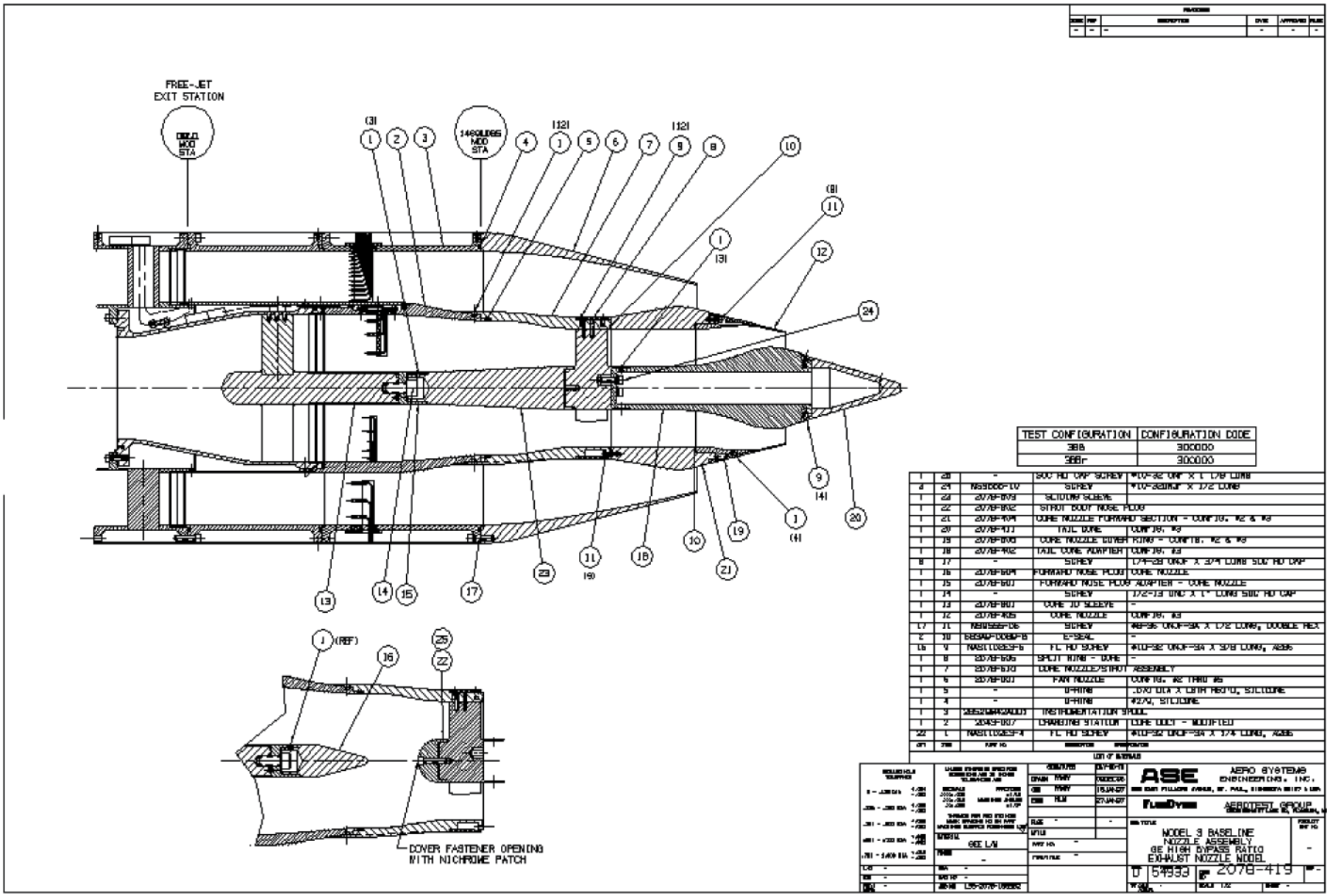


Figure B-3. Cross-section of Model #3 Baseline Nozzle (3BB), BPR=5, External Plug Separate-Flow Nozzle.

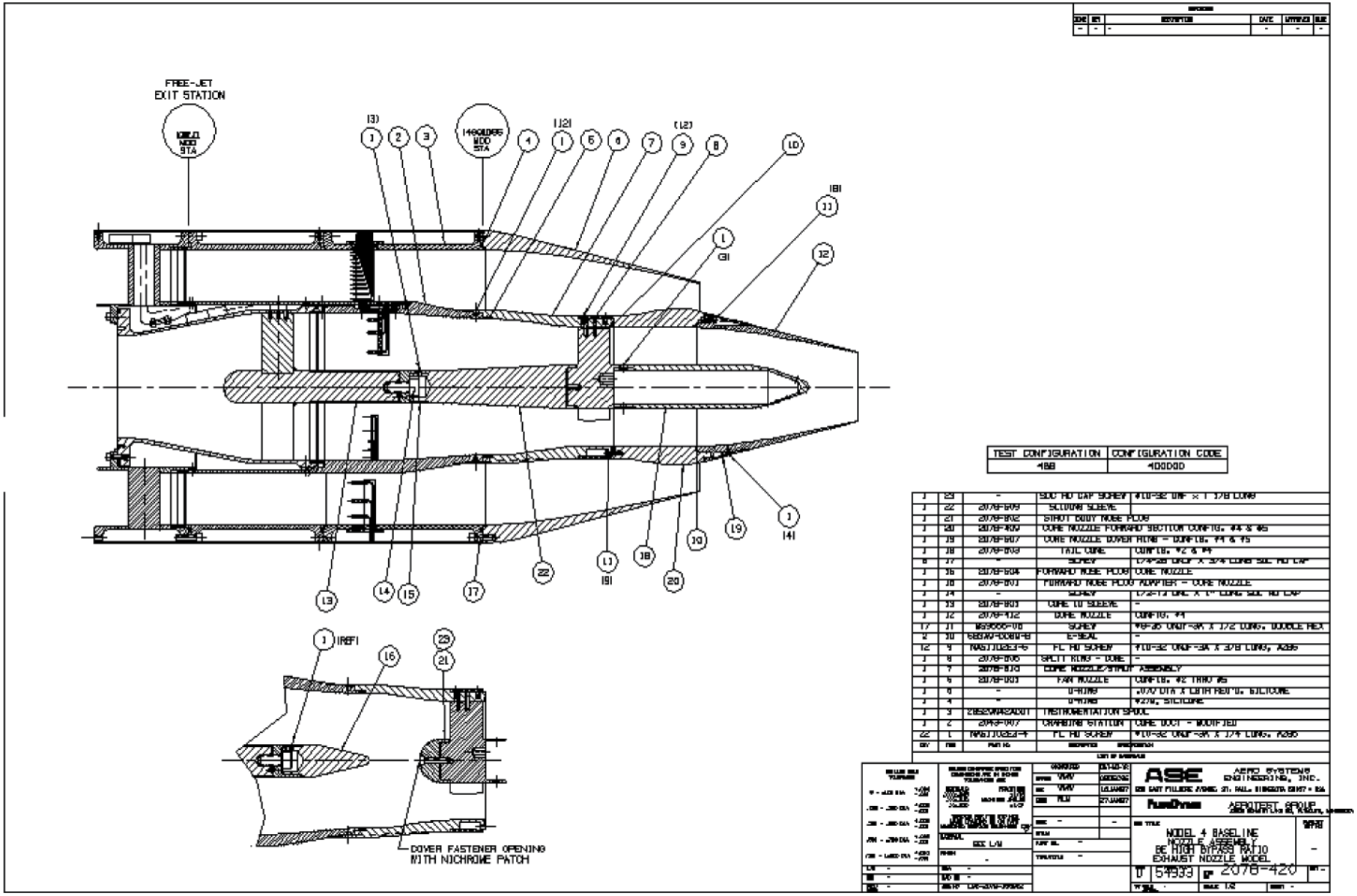


Figure B-4. Cross-section of Model #4 Baseline Nozzle (4BB), BPR=8, Internal Plug Separate-Flow Nozzle.

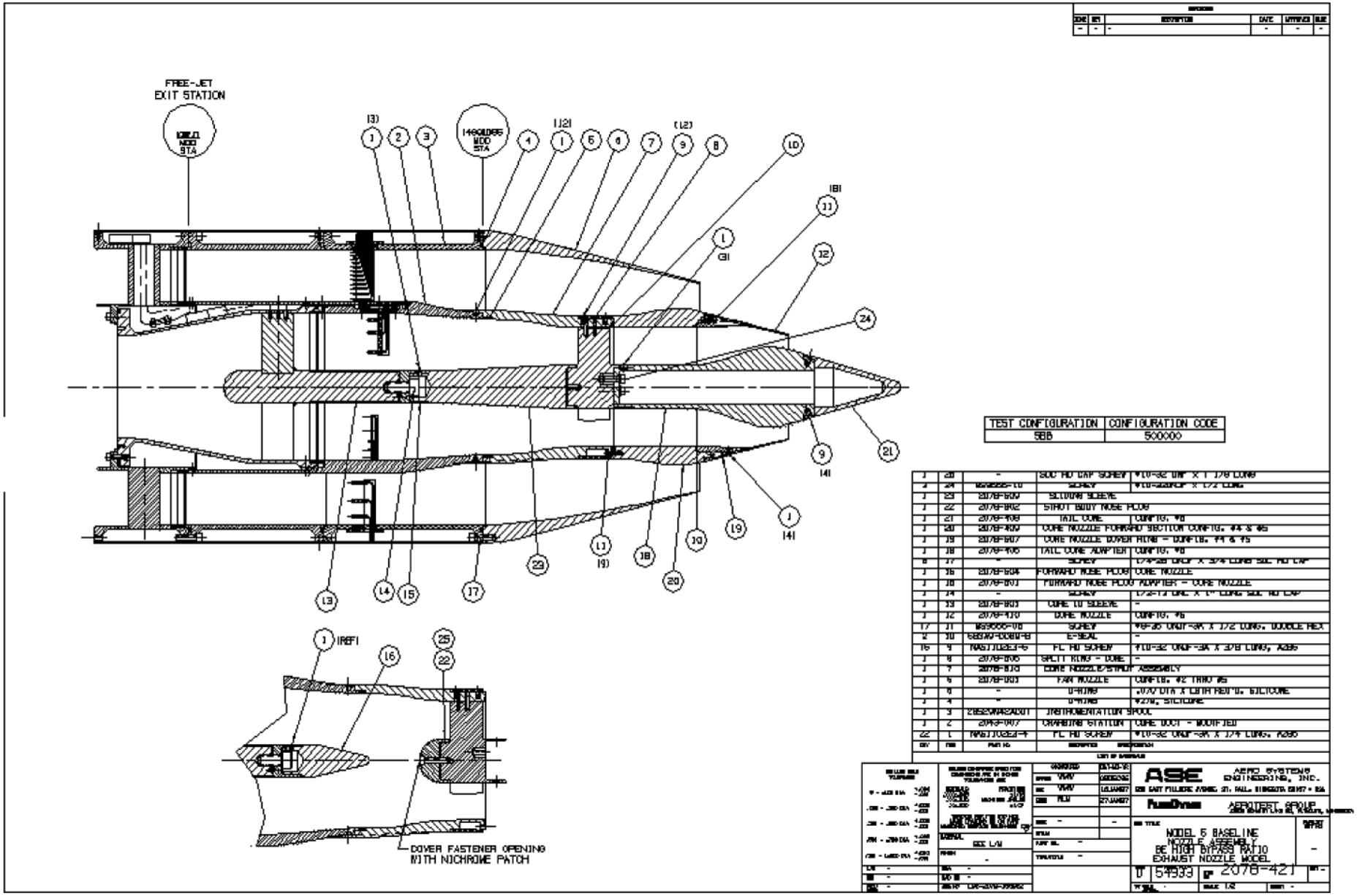


Figure B-5. Cross-section of Model #5 Baseline Nozzle (5BB), BPR=8, External Plug Separate-Flow Nozzle.

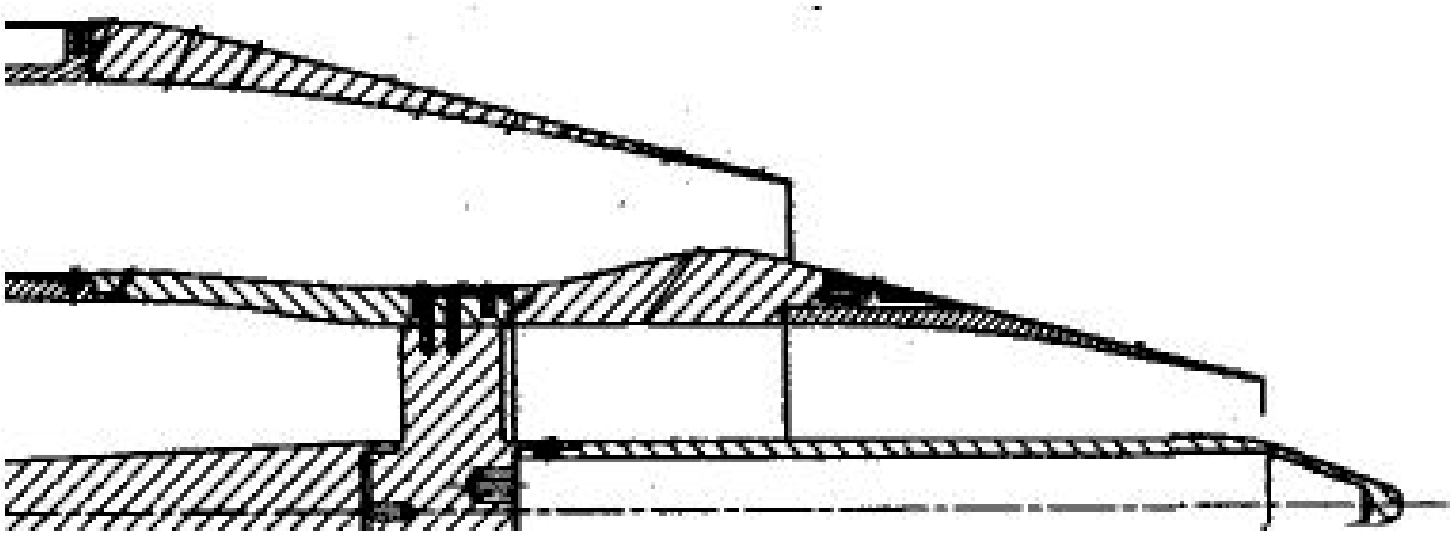


Fig B-6. Cross-section of Model #6 Baseline (6BB) with Modified Plug for AEC's Tongue Mixer Nozzle

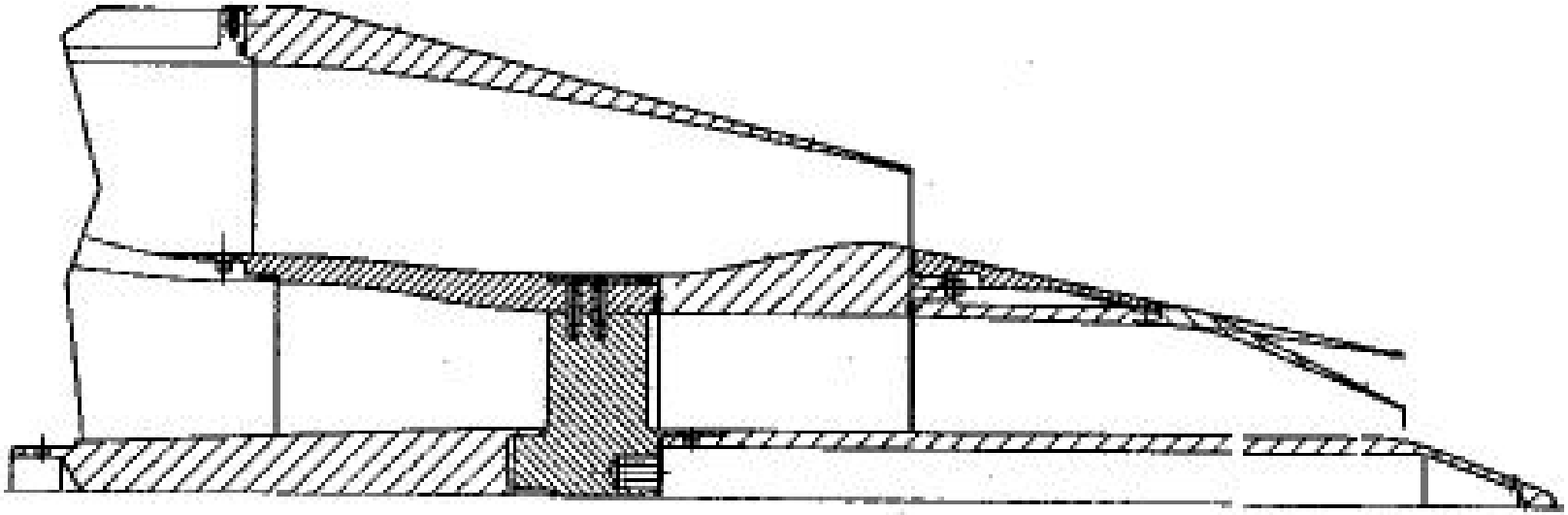
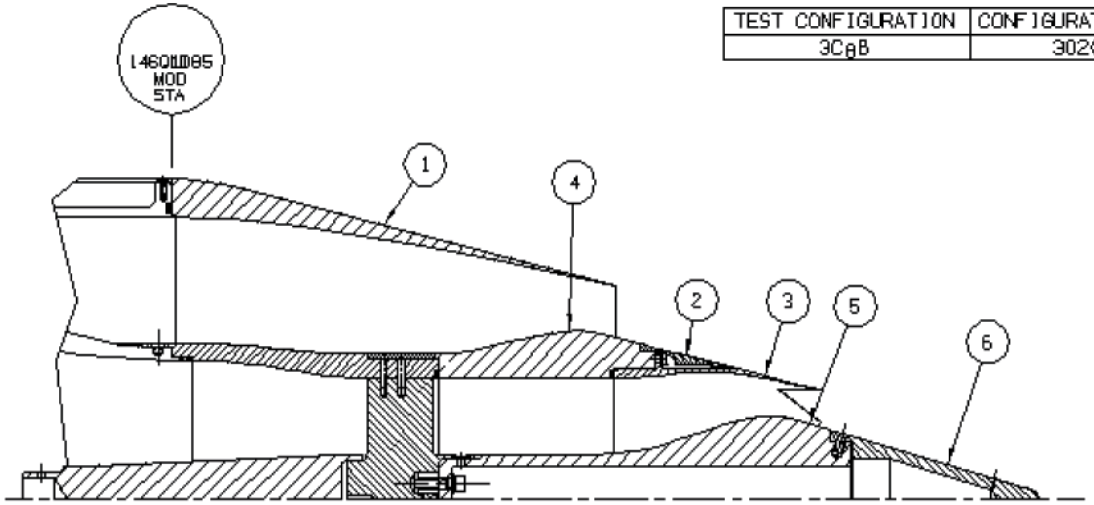


Fig B-7. Cross-section of AEC's Tongue Mixer Nozzle with Modified Plug Installed in Model#6 Configuration. (6TmB)



TEST CONFIGURATION	CONFIGURATION CODE
3C8B	302000

QTY	ITEM	PART NO	DESCRIPTION	SPECIFICATION
1	6	2078-411	TAIL CONE	CONFIG. #3
1	5	2078-402	TAIL CONE ADAPTER	CONFIG. #3
1	4	2078-404	CORE NOZZLE FORWARD SECTION - CONFIG. #2 & #3	
1	3	2078-423	CORE NOZZLE 96	CONFIG. #3
1	2	2078-605	CORE NOZZLE COVER RING CONFIG. #2 & #3	
1	1	2078-001	FAN NOZZLE CONFIG. #2 THRU #5	

LIST OF MATERIALS

1. SEE DRAWING 2078-419 FOR ITEMS NOT SHOWN ON THIS DRAWING

NOTE:

DRILLED HOLE TOLERANCE
.0 - .125 DIA. +.004 -.001
.126 - .250 DIA. +.006 -.001
.251 - .500 DIA. +.006 -.001
.501 - .750 DIA. +.006 -.001
.751 - 1.000 DIA +.010 -.001

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE
DECIMALS .XX±.005 .XXX±.010 .XX±.050
FRACTIONS ±1/16 MACHINED ANGLES ±1/2°
THREADS PER FED STD H28 NAME DRAWING NO ON PART
MACHINED SURFACE ROUGHNESS 125

MATERIAL SEE L/N
FINISH -

L/N -
NHA -
GAD NO -
JOB NO L06-2078-1660652

SIGNATURES		DAY-MO-YR
DRAWN	WMW	15JAN97
CHK	WMW	17JAN97
ENGR	RLW	26JAN97
RLSE	-	-
MFTLN		
PART NO.	-	
TYPE/TITLE	-	

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359 EAST FILLMORE AVENUE, ST. PAUL, MINNESOTA 55107 • USA

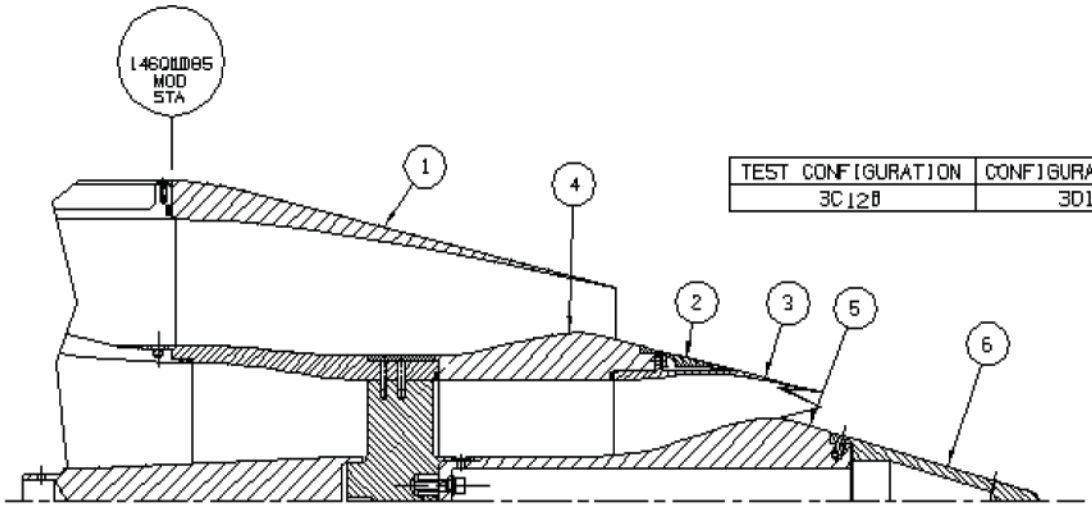
FluiDyne AEROTEST GROUP
13525 SCHMIDT LAKE RD. PLYMOUTH, MINNESOTA 55

DWG TITLE
BASE FAN/8 CHEV. CORE
MODEL 3 NOZZLE ASSEMBLY
GE HIGH BYPASS RATIO
EXHAUST NOZZLE MODEL

FACILITY DWT NO -

SIZE D | DWG NO 54933 | DWG NO 2078-631 | REV -
SCALE 1/2 | SHEET -

Figure B-8. Cross-section of an Eight (8) Neutral-Chevrons Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3C8B).



TEST CONFIGURATION	CONFIGURATION CODE
3C12B	3D100D

QTY	ITEM	PART NO	DESCRIPTION	SPECIFICATION
1	6	2078-411	TAIL CONE	CONFIG. #3
1	5	2078-402	TAIL CONE ADAPTER	CONFIG. #3
1	4	2078-404	CORE NOZZLE FORWARD SECTION - CONFIG. #2 & #3	
1	3	2078-422	CORE NOZZLE 96i	CONFIG. #3
1	2	2078-605	CORE NOZZLE COVER RING CONFIG. #2 & #3	
1	1	2078-001	FAN NOZZLE CONFIG. #2 THRU #5	

LIST OF MATERIALS

1. SEE DRAWING 2078-419 FOR ITEMS NOT SHOWN ON THIS DRAWING

NOTE:

DRILLED HOLE TOLERANCE

.0 - .125 DIA.	+.004 -.001
.126 - .250 DIA.	+.006 -.001
.251 - .500 DIA.	+.008 -.001
.501 - .750 DIA.	+.009 -.001
.751 - 1.000 DIA	+.010 -.001

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE

DECIMALS .XX±.005 .XXX±.010 .XXX±.050

FRACTIONS ±1/16 MACHINED ANGLES ±1/2°

THREADS PER FED STD H28 NAME DRAWING NO ON PART

MACHINED SURFACE ROUGHNESS 125

MATERIAL SEE L/N

FINISH -

L/O -

RIN -

PROJ PARTS -

NHA -

CAD NO -

JOB NO L06-2078-1660652

SIGNATURES		DAY-MO-YR
DRAWN	WMW	15JAN97
CHK	WMW	17JAN97
ENGR	WMW	28JAN97
RLSE	-	-
MFTLN		
PART NO.	-	
TYPE/TITLE	-	

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FluiDyne AEROTEST GROUP
13525 BONANZA LAKE RD, PLYMOUTH, MINNESOTA 55

DWG TITLE
BASE FAN/12 CHEV. CORE
MODEL 3 NOZZLE ASSEMBLY
GE HIGH BYPASS RATIO
EXHAUST NOZZLE MODEL

FACILITY DWG NO -

SIZE D | DWG NO 54933 | DWG NO 2078-630 | REV -

FT DWG NO - | SCALE 1/2 | SHEET -

Figure B-9. Cross-section of a Twelve (12) Neutral-Chevrons Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3C12B).

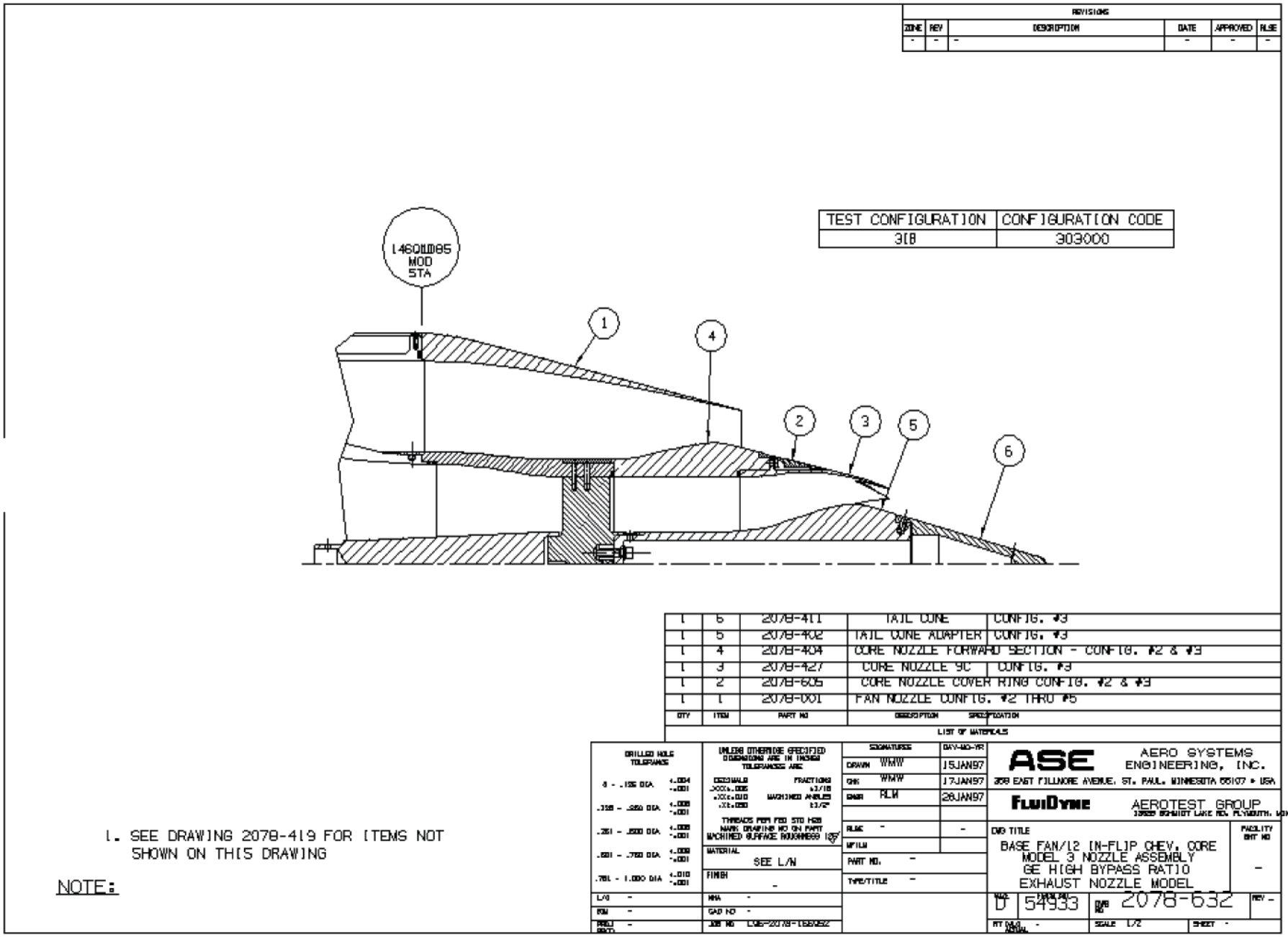
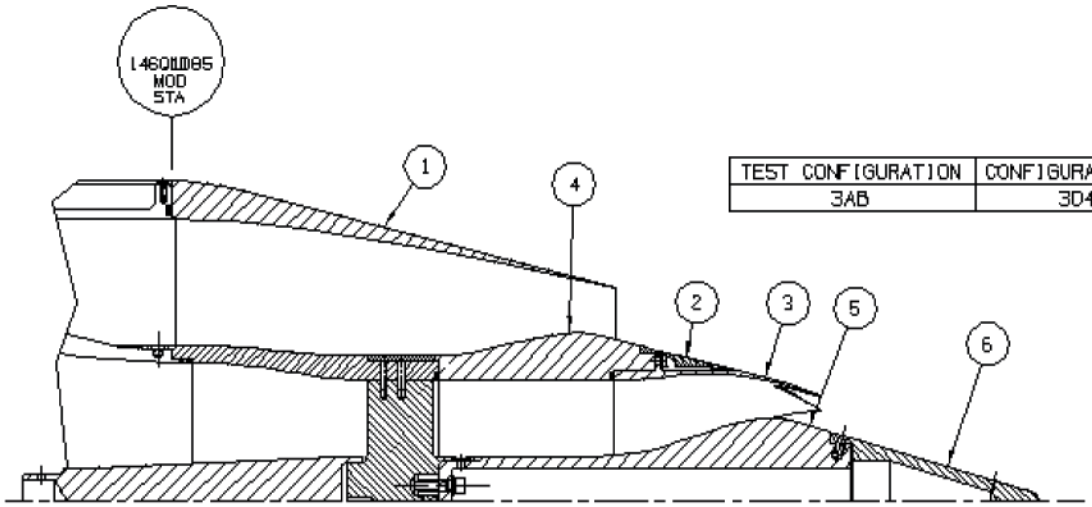


Figure B-10. Cross-section of a Twelve (12) Inward-Facing-Chevrons Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3IB).



TEST CONFIGURATION	CONFIGURATION CODE
3AB	3D400D

QTY	ITEM	PART NO	DESCRIPTION	SPECIFICATION
1	6	2078-411	TAIL CONE	CONFIG. #3
1	5	2078-402	TAIL CONE ADAPTER	CONFIG. #3
1	4	2078-404	CORE NOZZLE FORWARD SECTION - CONFIG. #2 & #3	
1	3	2078-429	CORE NOZZLE 90	CONFIG. #3
1	2	2078-605	CORE NOZZLE COVER RING CONFIG. #2 & #3	
1	1	2078-001	FAN NOZZLE CONFIG. #2 THRU #5	

LIST OF MATERIALS

1. SEE DRAWING 2078-419 FOR ITEMS NOT SHOWN ON THIS DRAWING

NOTE:

DRILLED HOLE TOLERANCE

0 - .125 DIA.	+.004 -.001
.126 - .250 DIA.	+.006 -.001
.251 - .500 DIA.	+.006 -.001
.501 - .750 DIA.	+.008 -.001
.751 - 1.000 DIA	+.010 -.001

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE

DECIMALS .XX±.005 .XXX±.010 .XXX±.050 FRACTIONS ±1/16 MACHINED ANGLES ±1/2°

THREADS PER FED STD H28 NAME DRAWING NO ON PART MACHINED SURFACE ROUGHNESS 125

MATERIAL SEE L/N

FINISH -

L/O	-
RW	-
PROJ DRTG	-
NHA	-
CAD NO	-
JOB NO	L06-2078-1660652

SIGNATURES		DAY-MO-YR
DRAWN	WMW	15JAN97
CHK	WMW	17JAN97
ENGR	RLW	28JAN97
RLSE	-	-
MFTLW		
PART NO.	-	
TYPE/TITLE	-	

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FluiDyne AEROTEST GROUP
13525 BONANZA LAKE RD. PLYMOUTH, MINNESOTA 55

DWG TITLE
BASE FAN/12 ALT FLIP CHEV. CORE
MODEL 3 NOZZLE ASSEMBLY
GE HIGH BYPASS RATIO
EXHAUST NOZZLE MODEL

FACILITY DWT NO -

SIZE D | DWG NO 54933 | DWG NO 2078-616 | REV -

FT DWG NO - | SCALE 1/2 | SHEET -

REVISIONS					
ZONE	REV	DESCRIPTION	DATE	APPROVED	RLSE
-	-	-	-	-	-

Figure B-11. Cross-section of a Twelve (12) Alternating Inward-Outward Chevrons Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3AB).

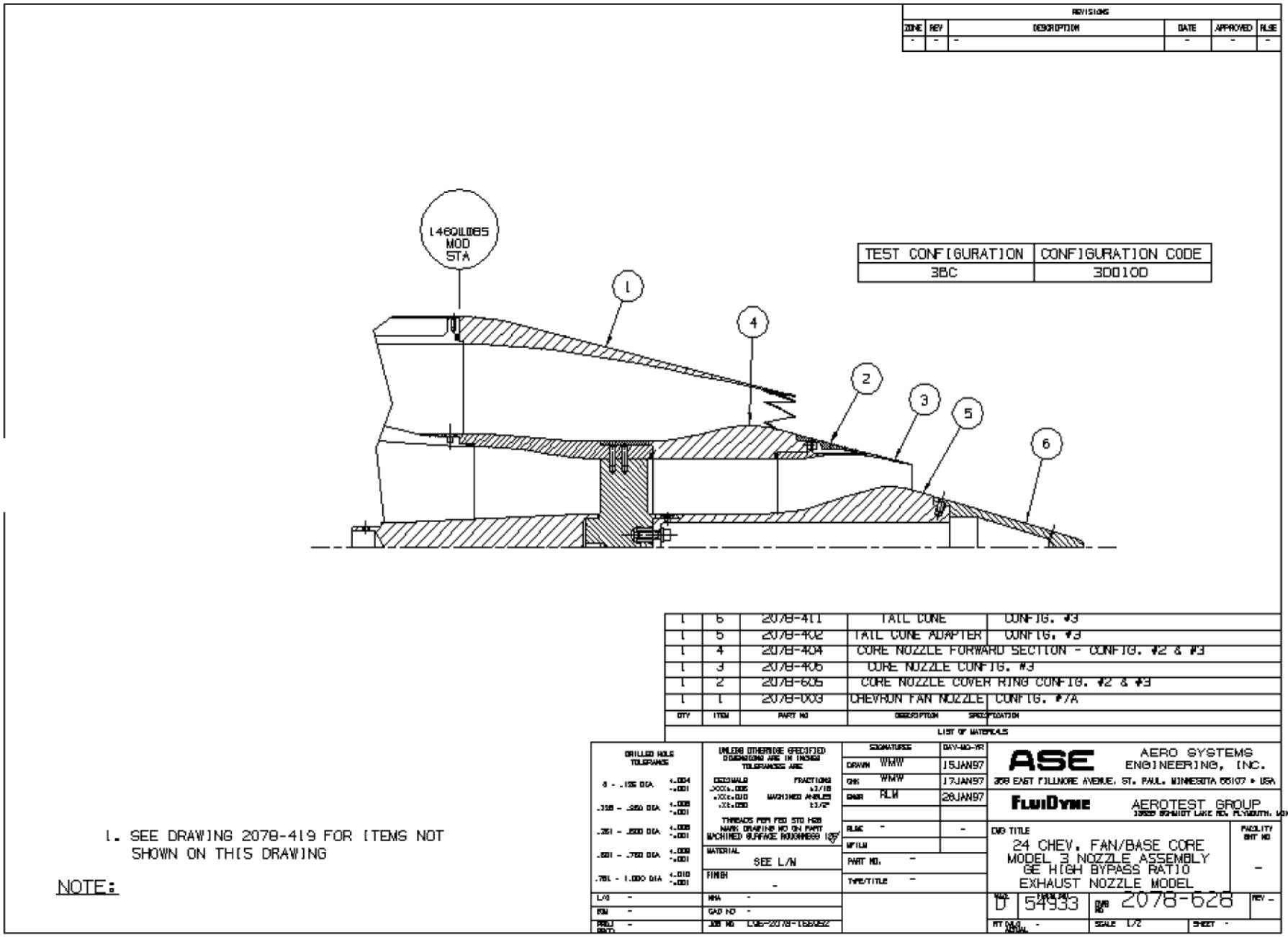


Figure B-12. Cross-section of a Twenty Four (24) Neutral-Chevrons Fan Nozzle Combined with Model 3 Baseline Fan Nozzle (3BC).

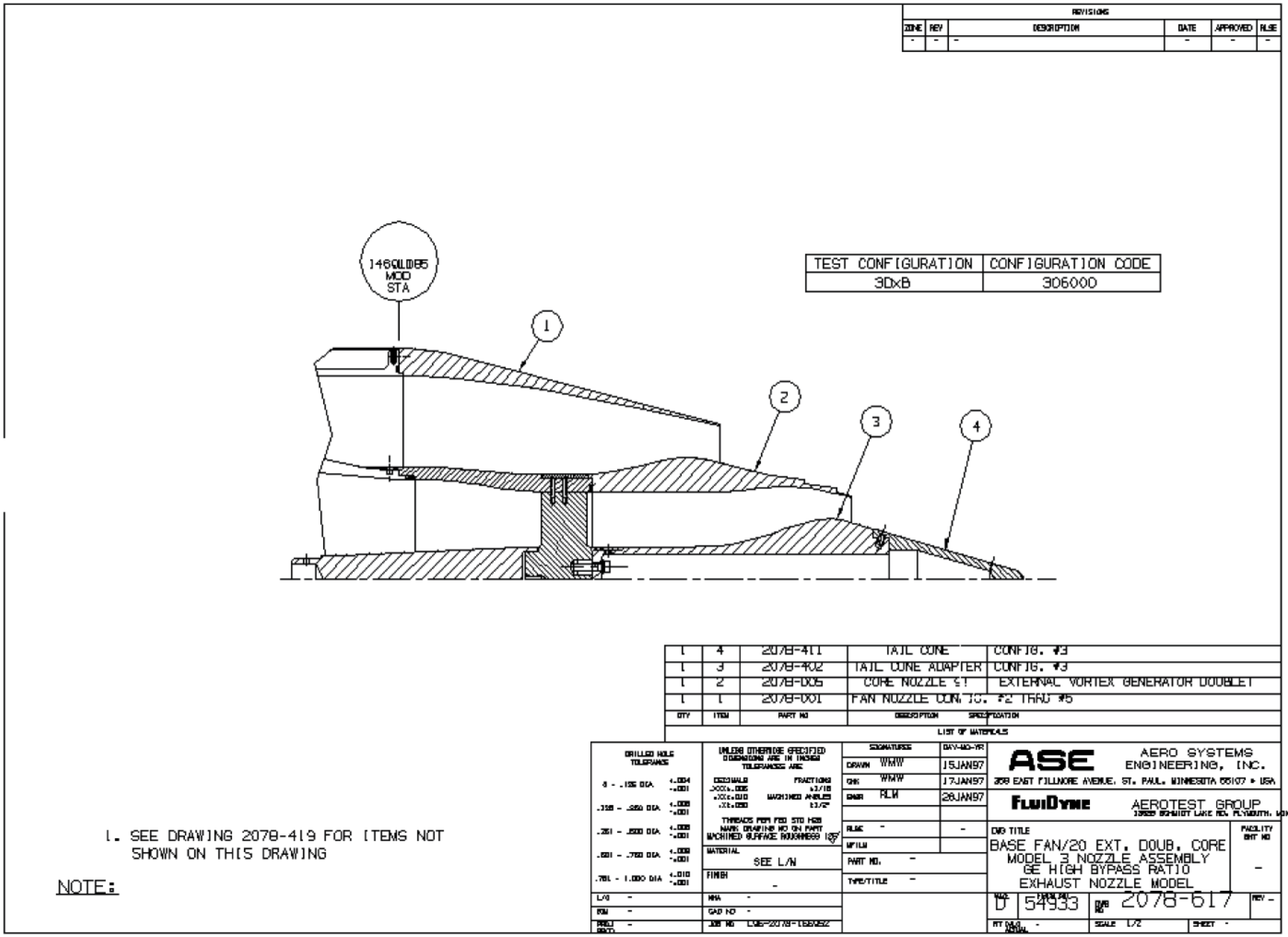


Figure B-13. Cross-section of a 20 External Vortex Generator Doublets Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3DxB).

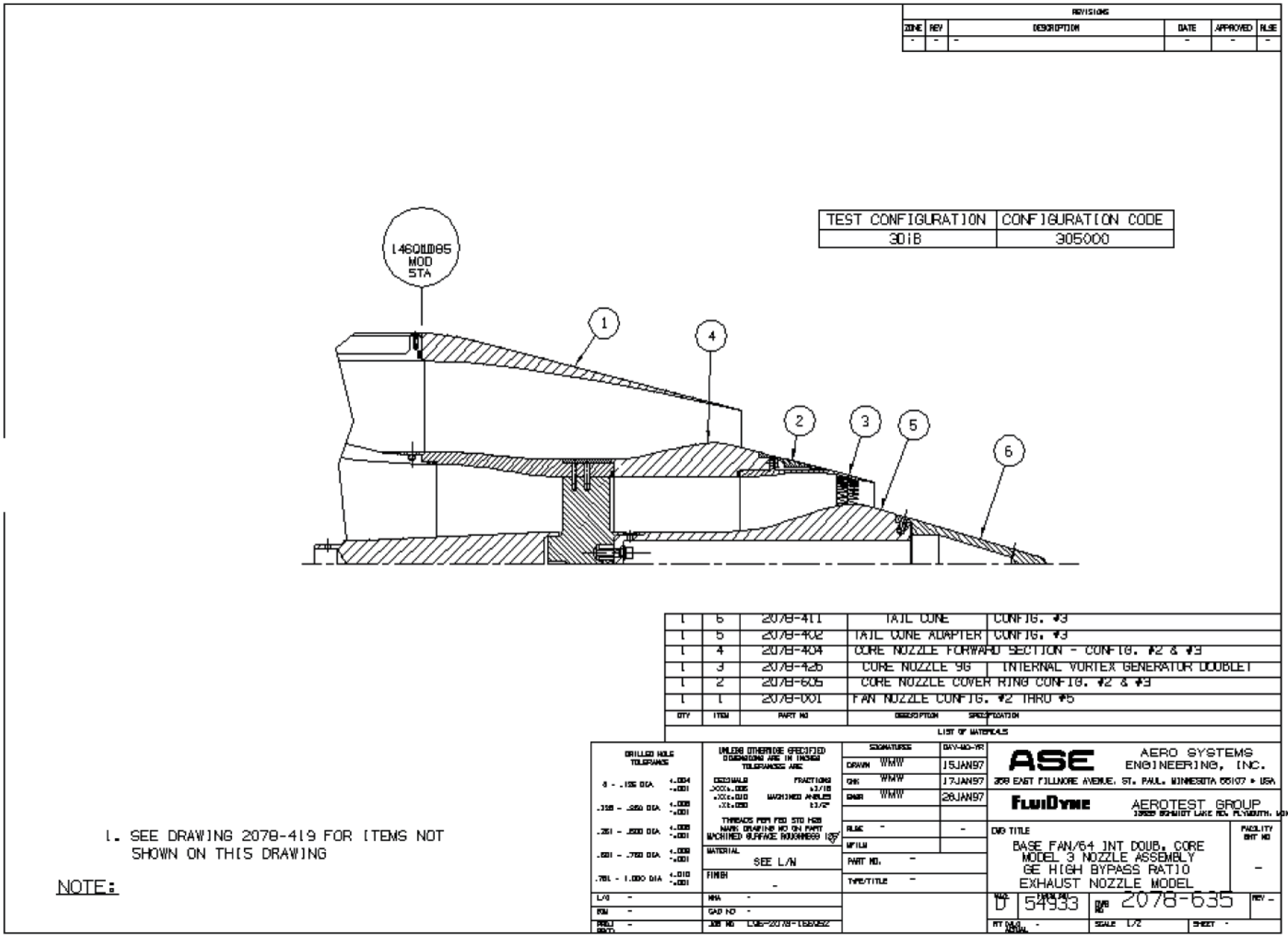


Figure B-14. Cross-section of a 64 Internal Vortex Generator Doublets Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3DiB).

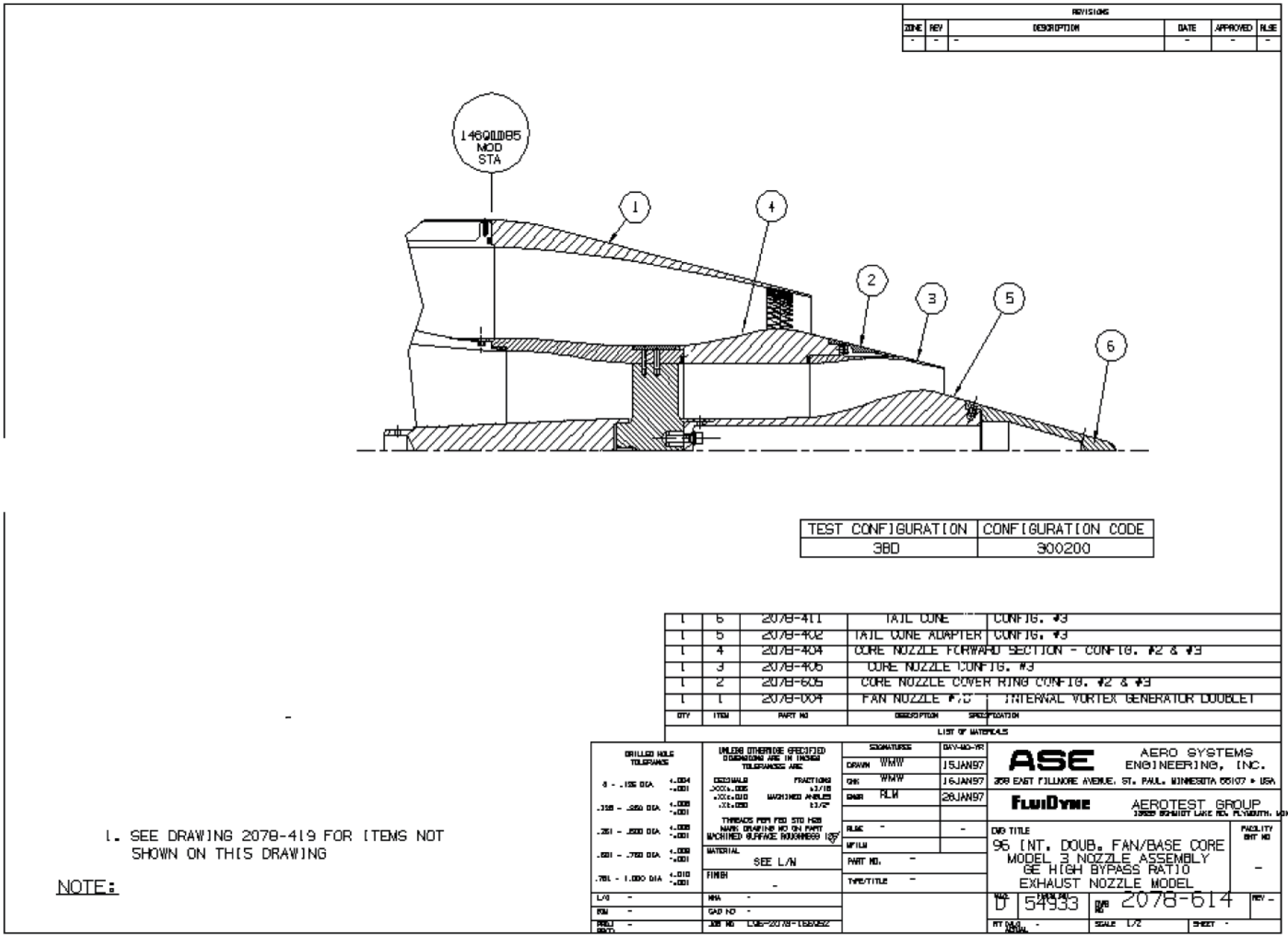


Figure B-15. Cross-section of a 96 Internal Vortex Generator Doublets Fan Nozzle, Combined with Model 3 Baseline Core Nozzle (3BDi).

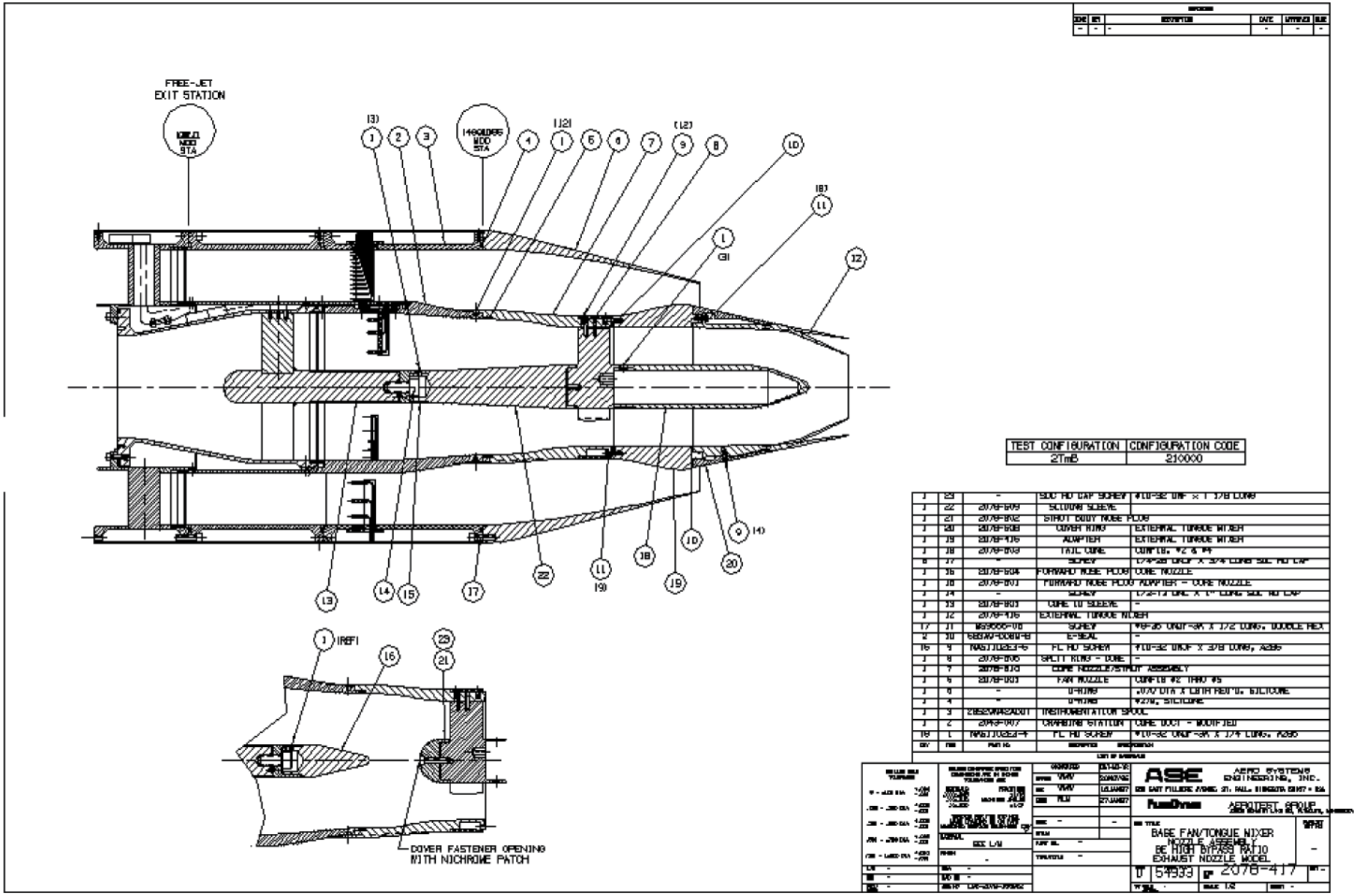


Figure B-16. Cross-section of AEC's Tongue Mixer Core Nozzle with Model 2 Baseline Fan Nozzle (2TmB)

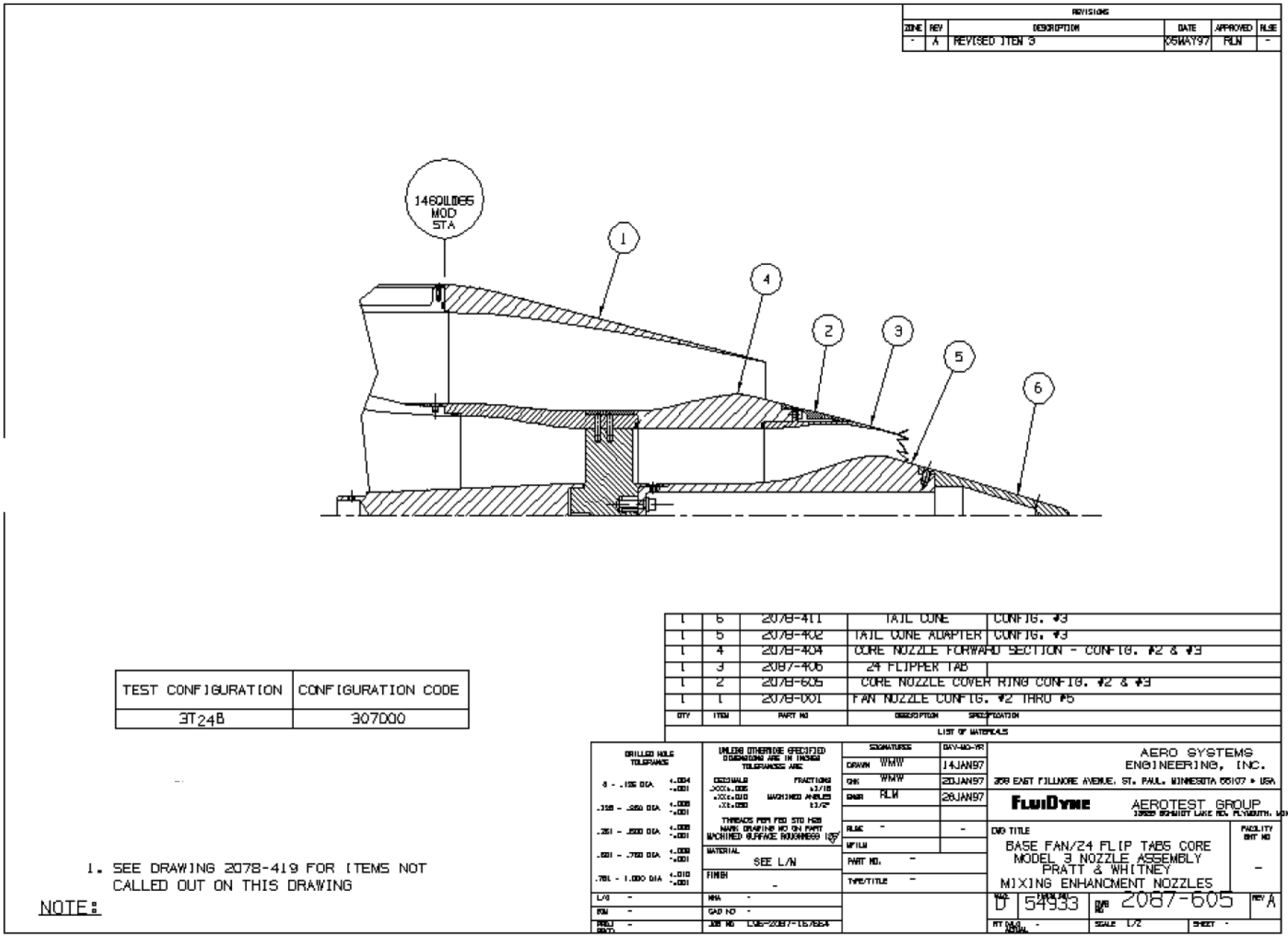
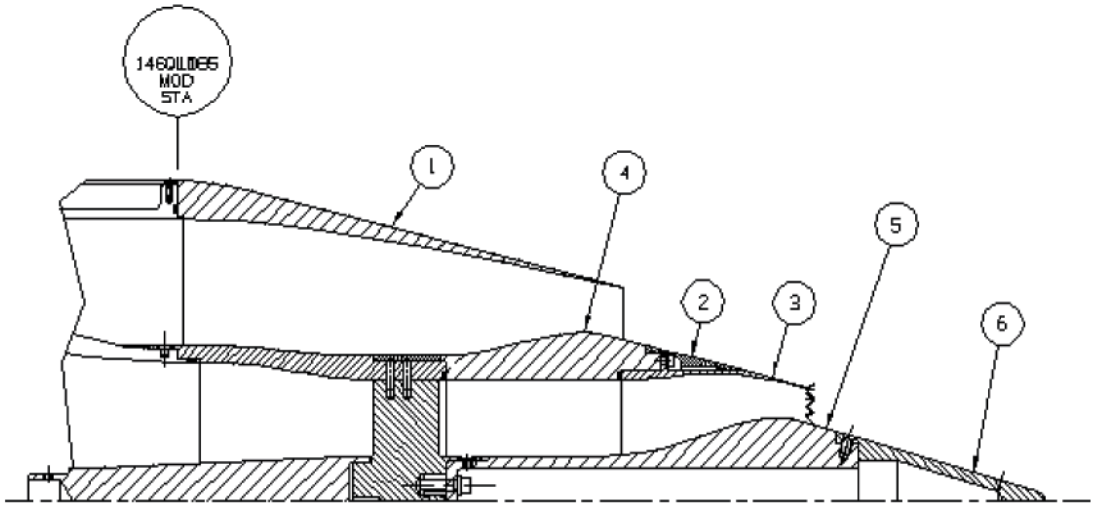


Figure B-17. Cross-section of a Twenty Four (24) Flipper-Tabbed Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3T24B).



REVISIONS					
ZONE	REV	DESCRIPTION	DATE	APPROVED	RLSE
-	A	REVISED ITEM 3	25APR97	RLW	-

QTY	ITEM	PART NO	DESCRIPTION	SPECIFICATION
1	6	2078-411	TAIL CONE	CONFIG. #3
1	5	2078-402	TAIL CONE ADAPTER	CONFIG. #3
1	4	2078-404	CORE NOZZLE FORWARD SECTION - CONFIG. #2 & #3	
(A) 1	3	2087-406	48 FLIPPER TAB	
1	2	2078-605	CORE NOZZLE COVER RING CONFIG. #2 & #3	
1	1	2078-001	FAN NOZZLE CONFIG. #2 THRU #5	

LIST OF MATERIALS

TEST CONFIGURATION	CONFIGURATION CODE
3T48B	308000

1. SEE DRAWING 2078-419 FOR ITEMS NOT CALLED OUT ON THIS DRAWING

NOTE:

DRILLED HOLE TOLERANCE
.8 - .125 DIA. +.004 -.001
.138 - .250 DIA. +.006 -.001
.251 - .500 DIA. +.006 -.001
.501 - .750 DIA. +.006 -.001
.751 - 1.000 DIA +.010 -.001

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE
DECIMALS .XX±.005 .XXX±.010 .XXX±.050
FRACTIONS ±1/16
MACHINED ANGLES ±1/2°
THREADS PER FED STD H28
MARK DRAWING NO ON PART
MACHINED SURFACE ROUGHNESS 125

MATERIAL SEE L/N
FINISH -

L/N -
RN -
PROJ DRTG -
NHA -
CAD NO -
JOB NO L06-2087-16/664

SIGNATURES		DAY-MO-YR
DRAWN	WMW	14JAN97
CHK	WMW	20JAN97
ENGR	RLW	26JAN97
RLSE	-	-
MFTLN		
PART NO.	-	
TYPE/TITLE	-	

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359 EAST FILLMORE AVENUE, ST. PAUL, MINNESOTA 55107 • USA

FluiDyne AEROTEST GROUP
13525 SCHMIDT LAKE RD., PLYMOUTH, MINNESOTA 55

DWG TITLE
BASE FAN/48 FLIP TABS CORE MODEL 3 NOZZLE ASSEMBLY PRATT & WHITNEY MIXING ENHANCMENT NOZZLES

FACILITY DWG NO -

SIZE D | DWG NO 54933 | DWG NO 2087-608 | REV A
FT DWG NO -
SCALE 1/2 | SHEET -

Figure B-18. Cross-section of a Forty Eight (48) Flipper-Tabbed Core Nozzle Combined with Model 3 Baseline Fan Nozzle (3T48B).

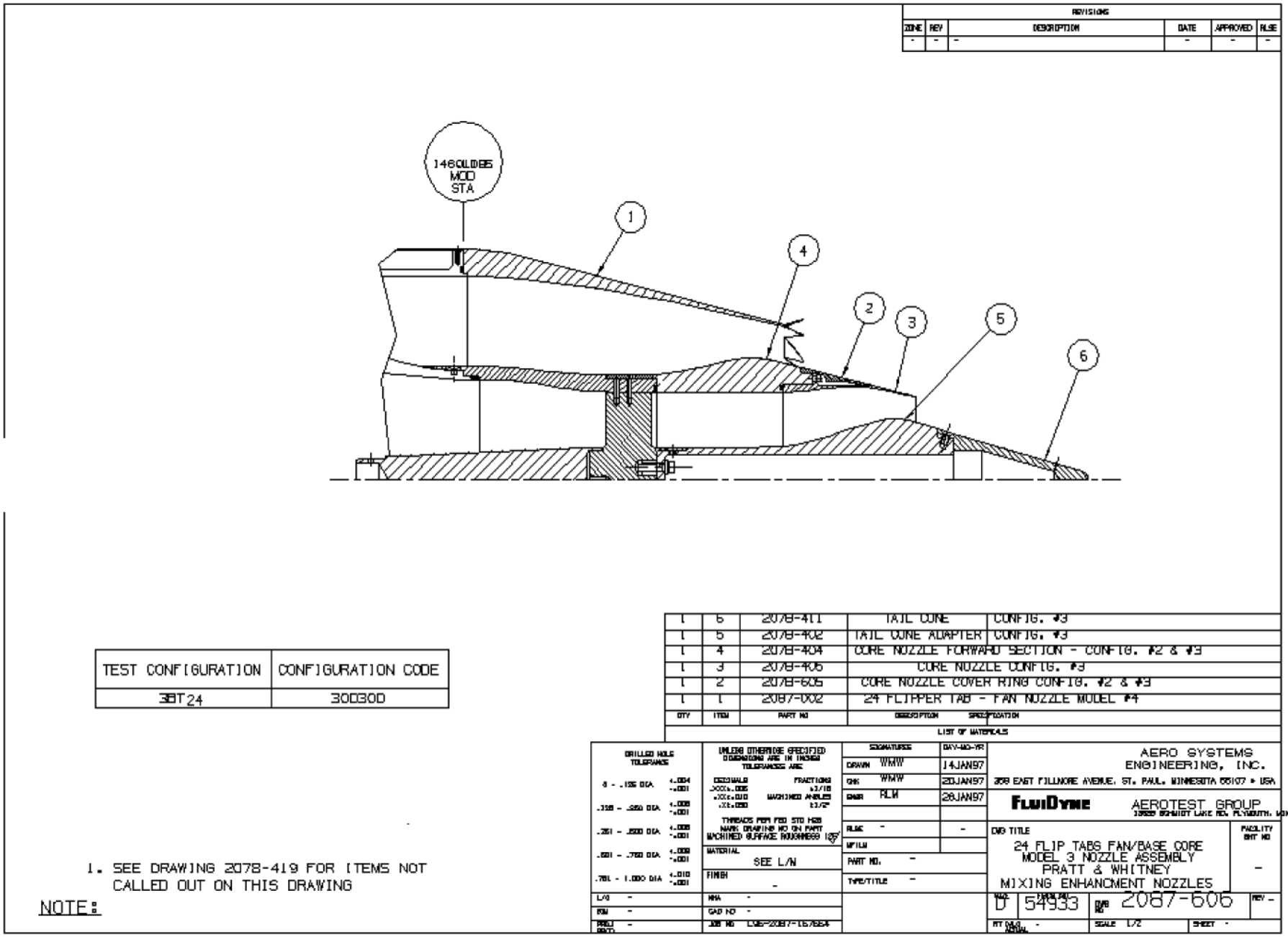


Figure B-19. Cross-section of a Twenty Four (24) Flipper-Tabbed Fan Nozzle Combined with Model 3 Baseline Core Nozzle (3BT24).

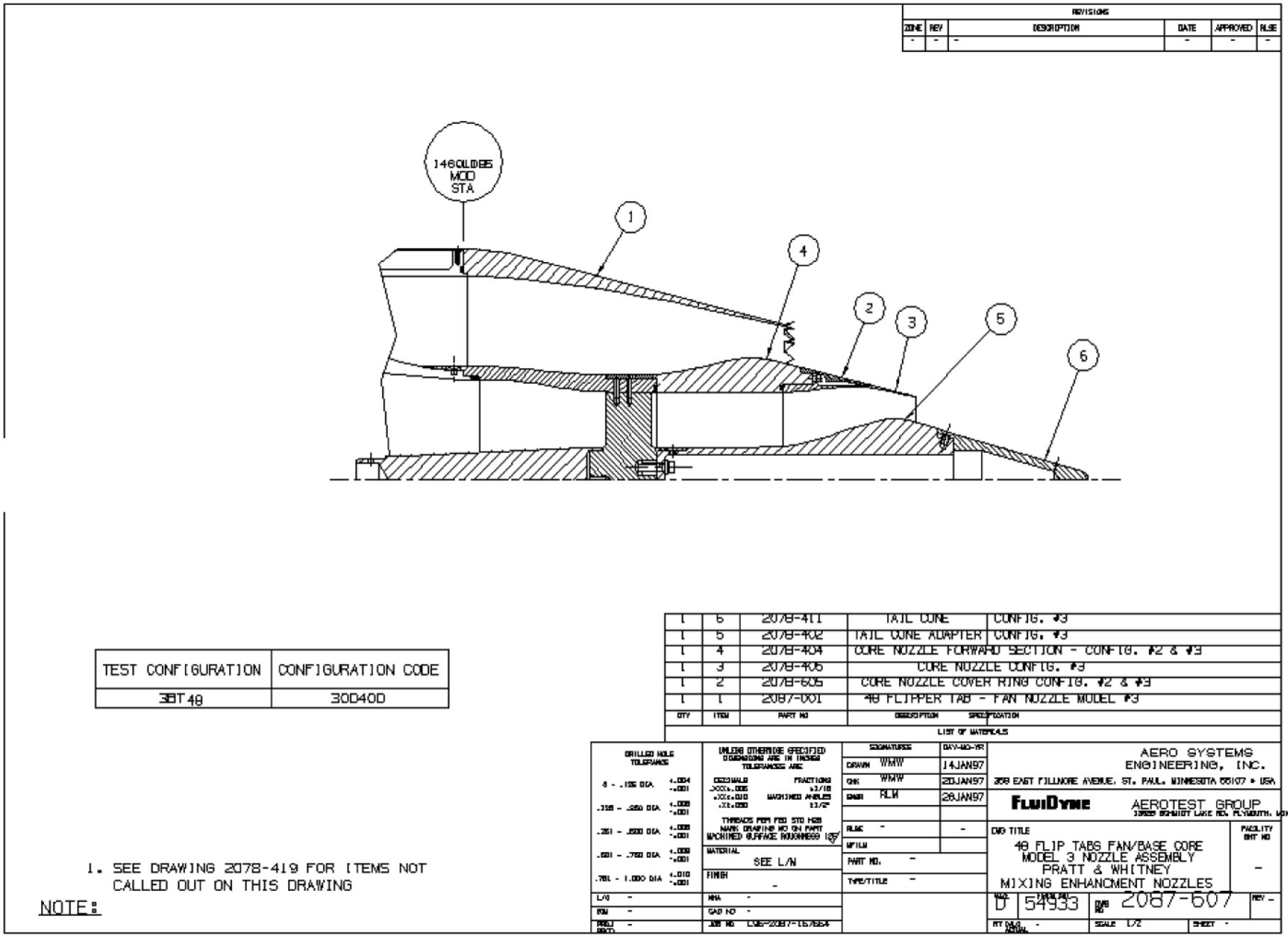


Figure B-20. Cross-section of a Forty Eight (48) Flipper-Tabbed Fan Nozzle Combined with Model 3 Baseline Core Nozzle (3BT48).

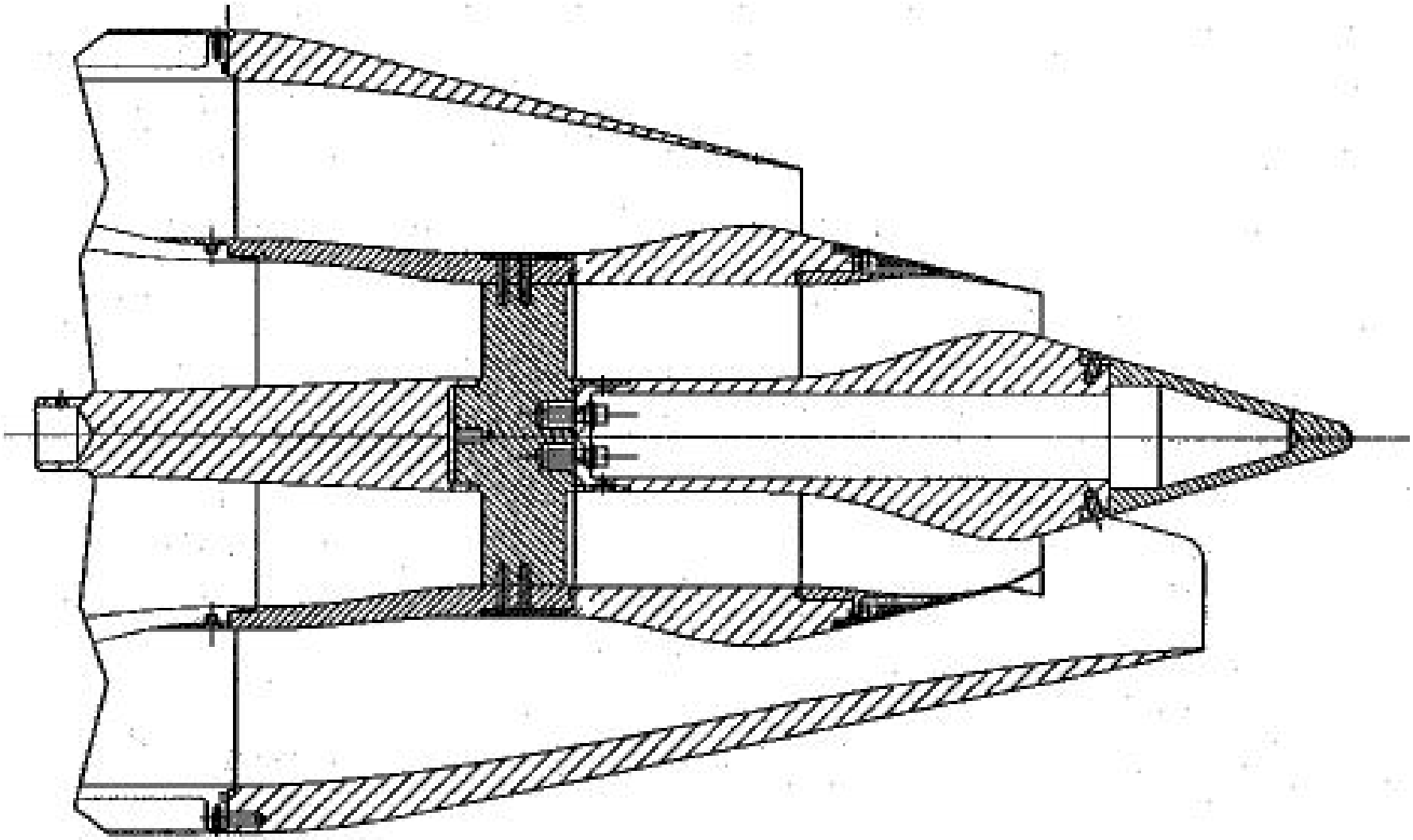


Figure B-21. Cross-section of a Scarfed Fan Nozzle combined with Model 3 Baseline Core Nozzle (3BS). (Top)

Figure B-22. Cross-section of a Scarfed Fan Nozzle combined with the Core Half-Mixer Nozzle (3HmS). (Bottom)

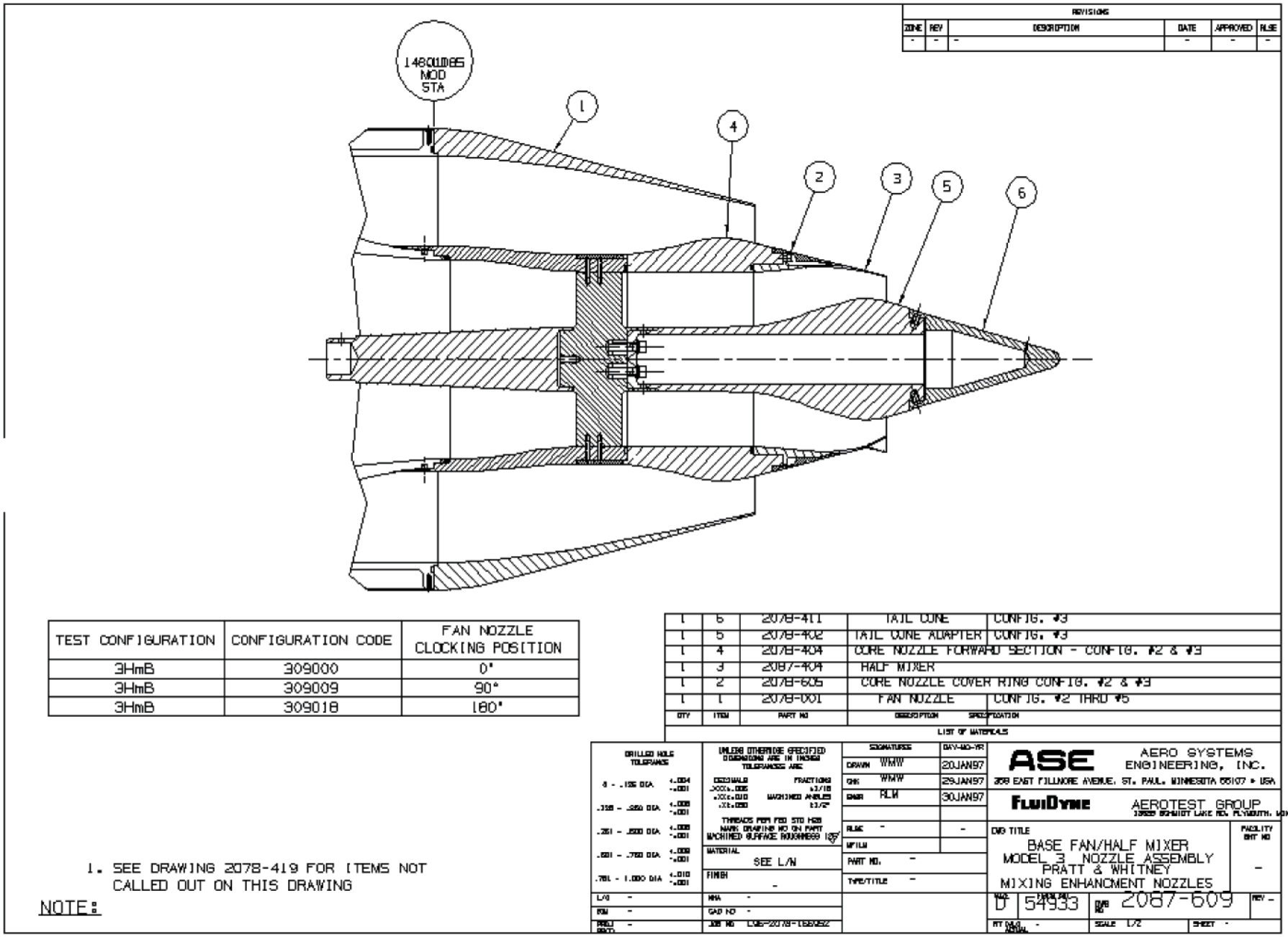


Figure B-23. Cross-section of a Half-Mixer Core Nozzle with Model 3 Baseline Fan Nozzle (3HmB).

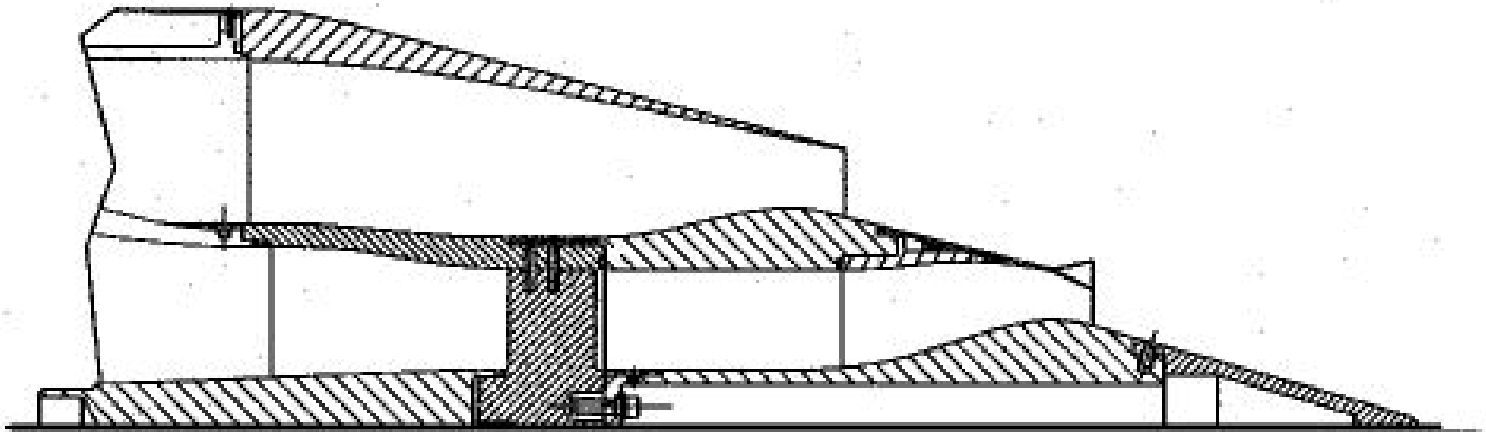


Fig B-24 Cross-section of the Full-Mixer Core Nozzle with Model 3 Baseline Fan Nozzle (3FmB).

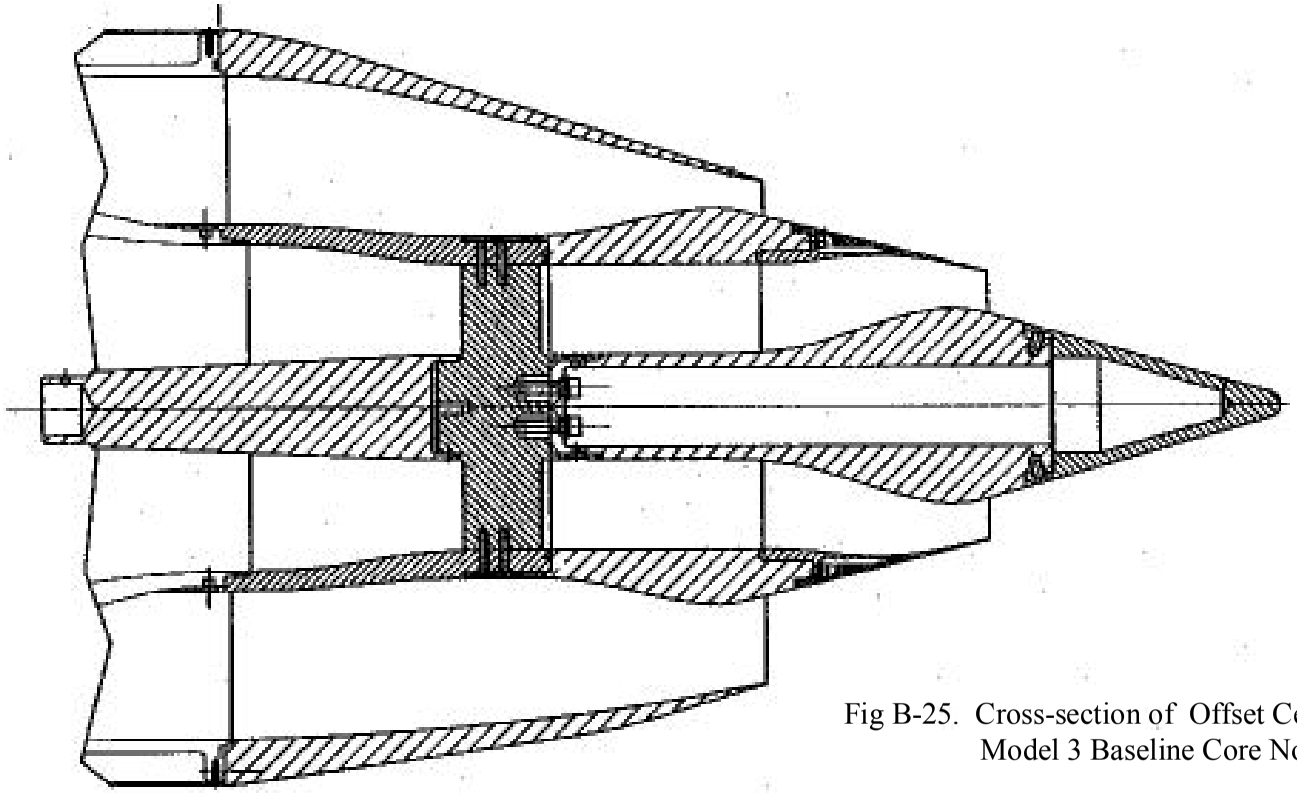


Fig B-25. Cross-section of Offset Centerline Fan Nozzle with Model 3 Baseline Core Nozzle (3BOmax)

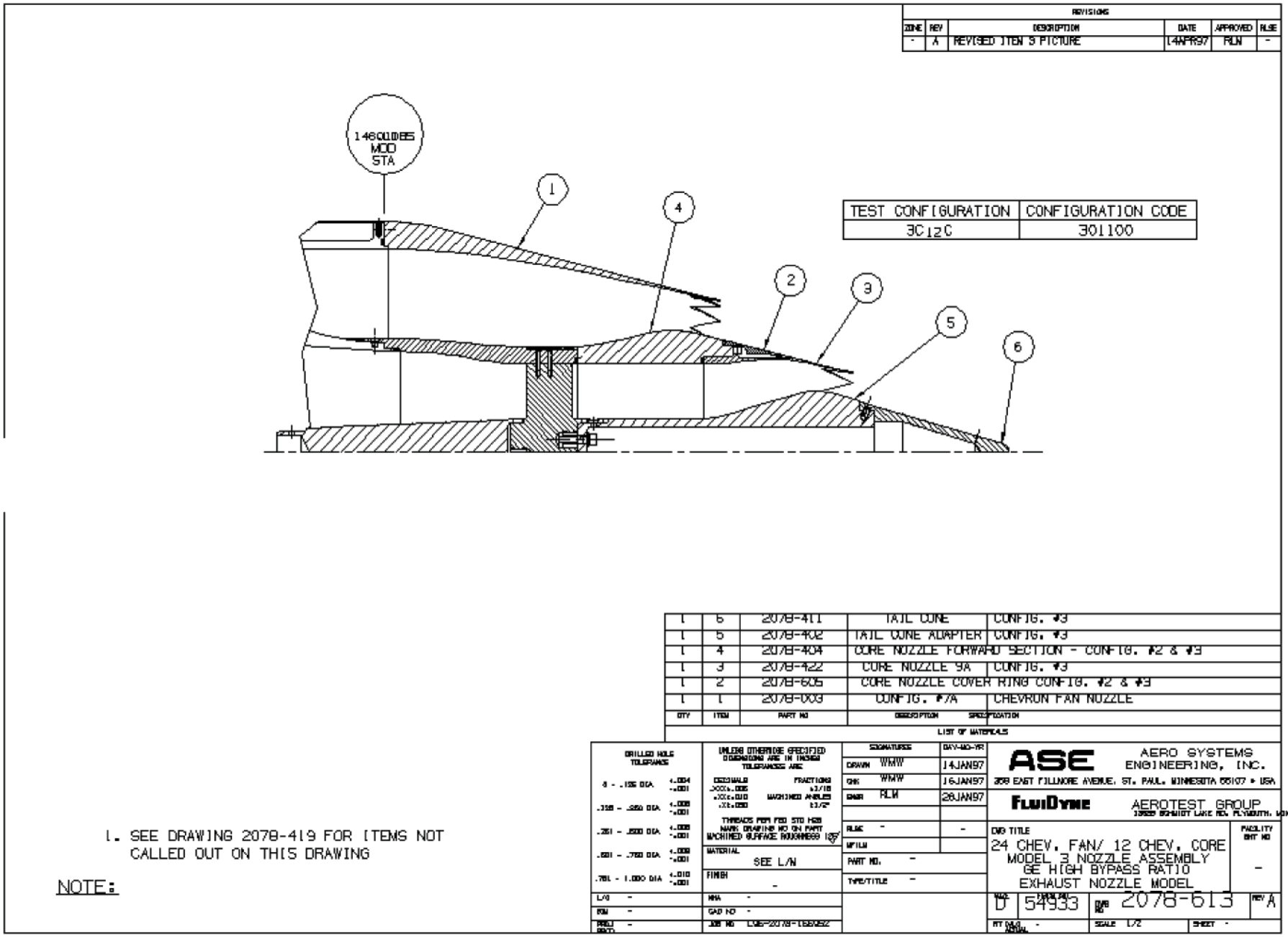


Figure B-26. Cross-section of the Combination Nozzle Configuration (3C12C), 12-Neutral-Chevrons Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

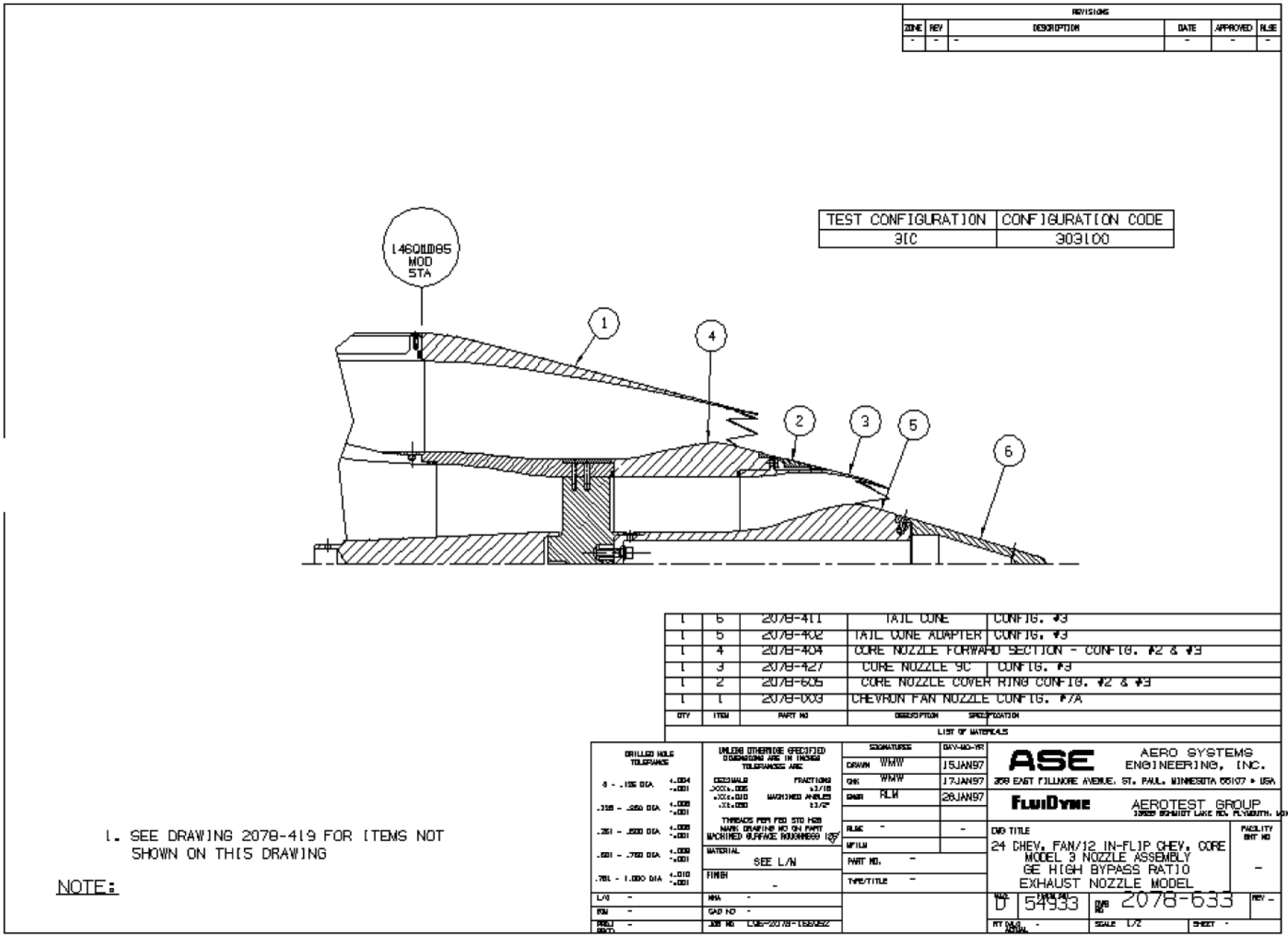
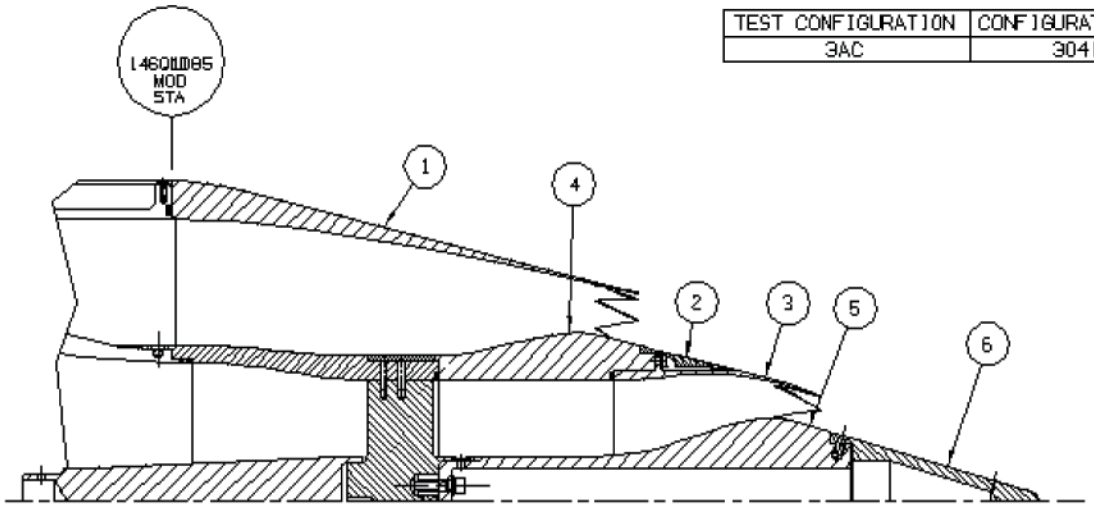


Figure B-27. Cross-section of the Combination Nozzle Configuration (3IC), 12-Inward-Facing-Chevrons Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.



TEST CONFIGURATION	CONFIGURATION CODE
3AC	304100

QTY	ITEM	PART NO	DESCRIPTION	SPECIFICATION
1	6	2078-411	TAIL CONE	CONFIG. #3
1	5	2078-402	TAIL CONE ADAPTER	CONFIG. #3
1	4	2078-404	CORE NOZZLE FORWARD SECTION - CONFIG. #2 & #3	
1	3	2078-429	CORE NOZZLE 90	CONFIG. #3
1	2	2078-605	CORE NOZZLE COVER RING CONFIG. #2 & #3	
1	1	2078-003	CHEVRON FAN NOZZLE CONFIG. #7A	

LIST OF MATERIALS

1. SEE DRAWING 2078-419 FOR ITEMS NOT SHOWN ON THIS DRAWING

NOTE:

DRILLED HOLE TOLERANCE
.0 - .125 DIA. +.004 -.001
.126 - .250 DIA. +.006 -.001
.251 - .500 DIA. +.006 -.001
.501 - .750 DIA. +.008 -.001
.751 - 1.000 DIA +.010 -.001

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE
DECIMALS .XX±.005 .XXX±.010 .XXX±.050
FRACTIONS ±1/16 MACHINED ANGLES ±1/2°
THREADS PER FED STD H28 NAME DRAWING NO ON PART
MACHINED SURFACE ROUGHNESS 125

MATERIAL SEE L/N
FINISH -

L/O -
RIN -
PROJ DRTG -
NHA -
GAD NO -
JOB NO L06-2078-1660652

SIGNATURES		DAY-MO-YR
DRAWN	WMW	15JAN97
CHK	WMW	17JAN97
ENGR	RLW	28JAN97
RLSE	-	-
MFTLN		
PART NO.	-	
TYPE/TITLE	-	

ASE AERO SYSTEMS ENGINEERING, INC.
359 EAST FILLMORE AVENUE, ST. PAUL, MINNESOTA 55107 • USA

FluiDyne AEROTEST GROUP
13525 SCHMIDT LAKE RD. PLYMOUTH, MINNESOTA 55

DWG TITLE
24 CHEV. FAN/12 ALT-FLIP CHEV. CORE
MODEL 3 NOZZLE ASSEMBLY
GE HIGH BYPASS RATIO
EXHAUST NOZZLE MODEL

FACILITY DWG NO -

SIZE D | DWG NO 54933 | DWG NO 2078-634 | REV -
RT DWG NO -
SCALE 1/2 | SHEET -

Figure B-28. Cross-section of the Combination Nozzle Configuration (3AC), 12-Alternating Inward-Outward-Facing-Chevrons Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

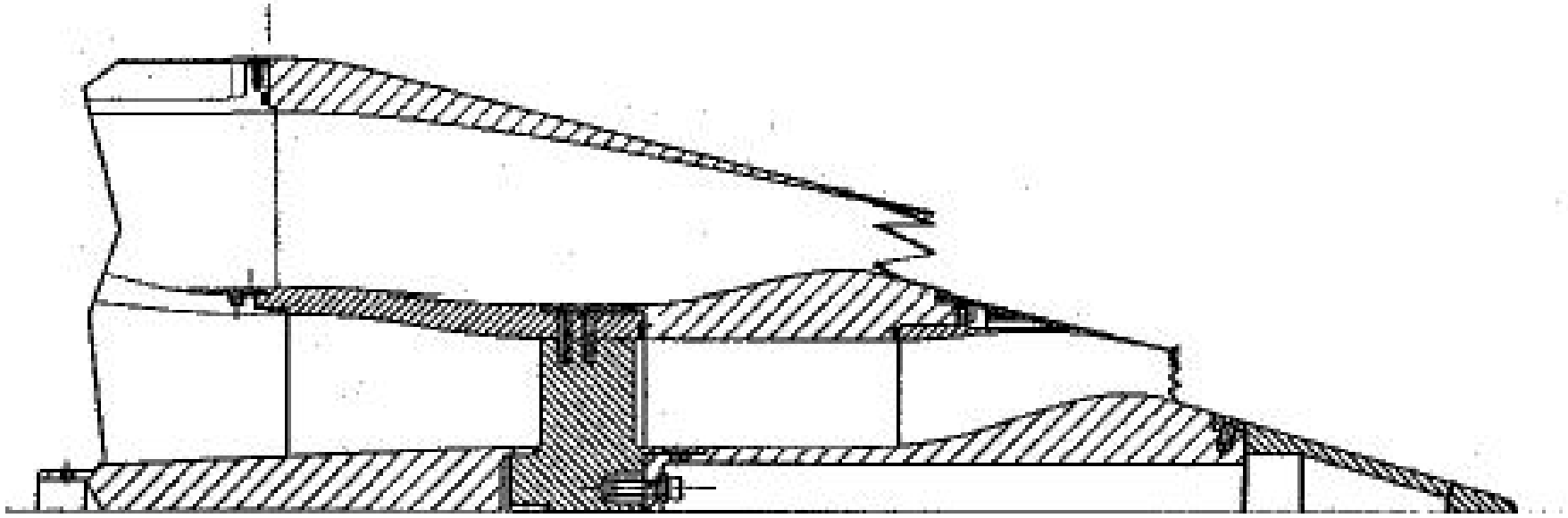


Figure B-29. Cross-section of the Combination Nozzle Configuration (3T48C), 48-Flipper-Tabbed Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

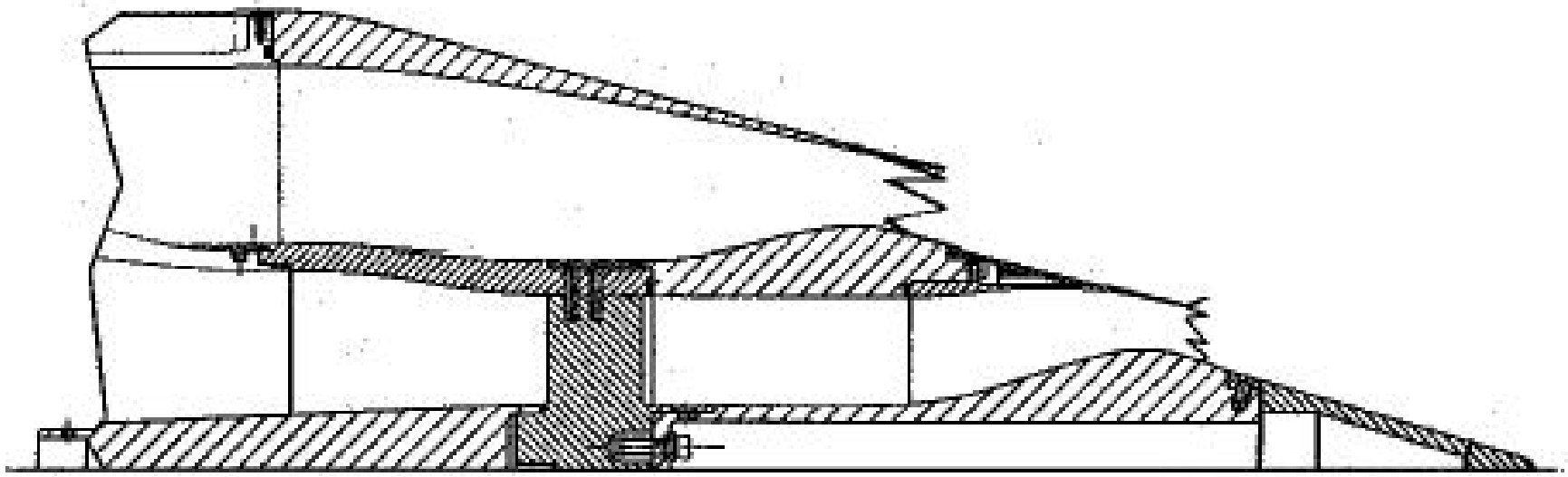


Figure B-30. Cross-section of the Combination Nozzle Configuration (3T24C), 24-Flipper-Tabbed Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

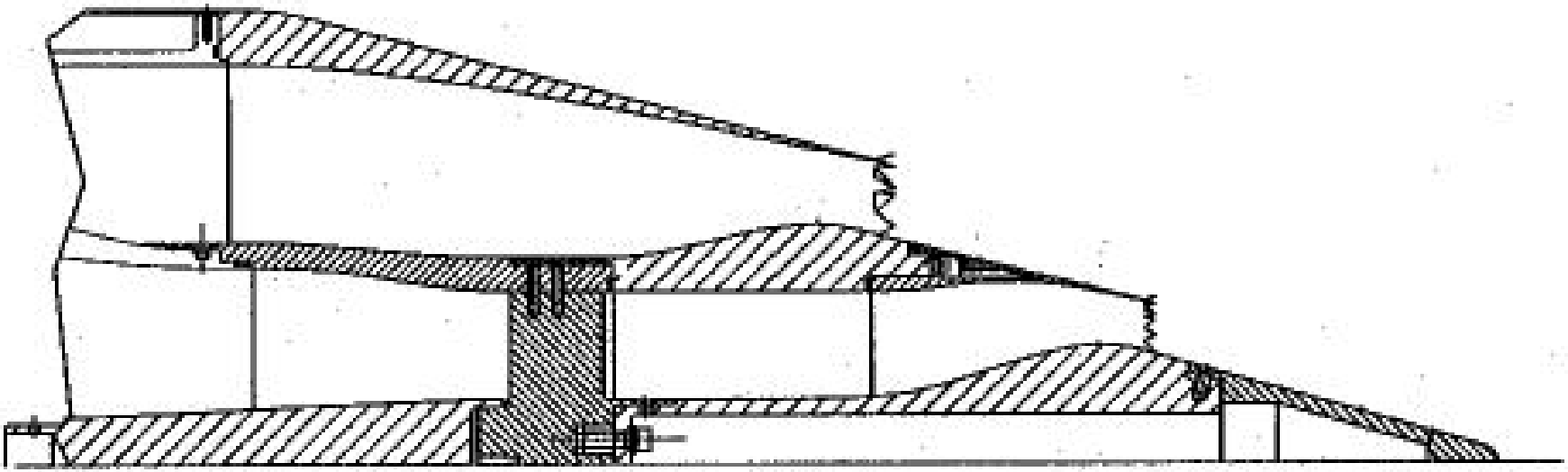


Figure B-31. Cross-section of the Combination Nozzle Configuration (3T48T48), 48-Flipper-Tabbed Core Nozzle with 48-Flipper-Tabbed Fan Nozzle.

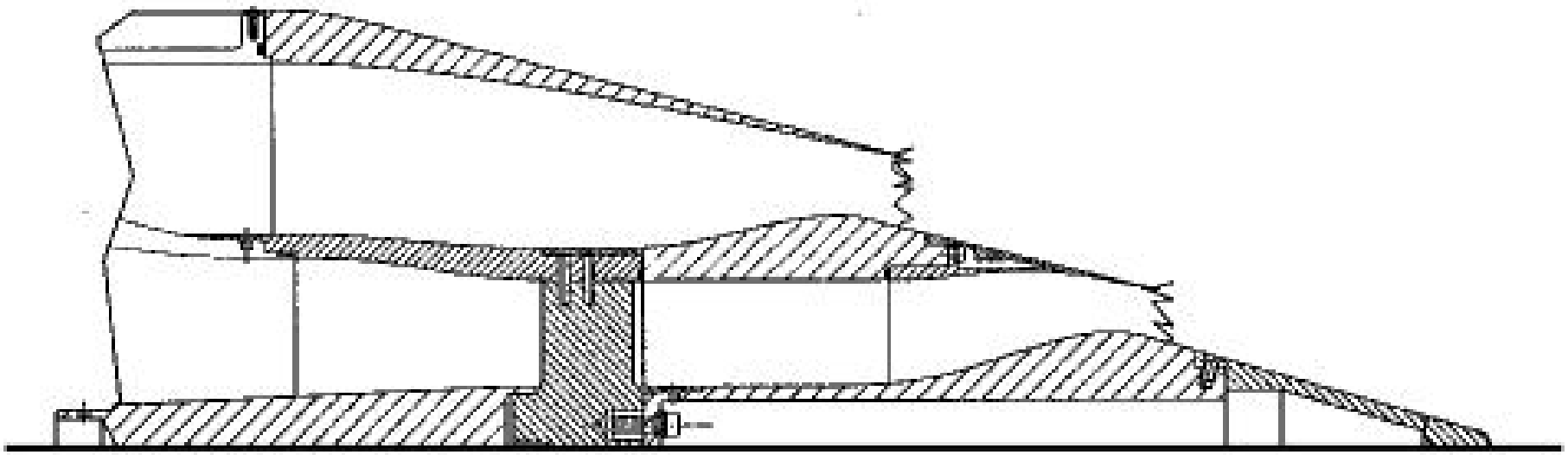


Figure B-32. Cross-section of the Combination Nozzle Configuration (3T24T48), 24-Flipper-Tabbed Core Nozzle with 48-Flipper-Tabbed Fan Nozzle.

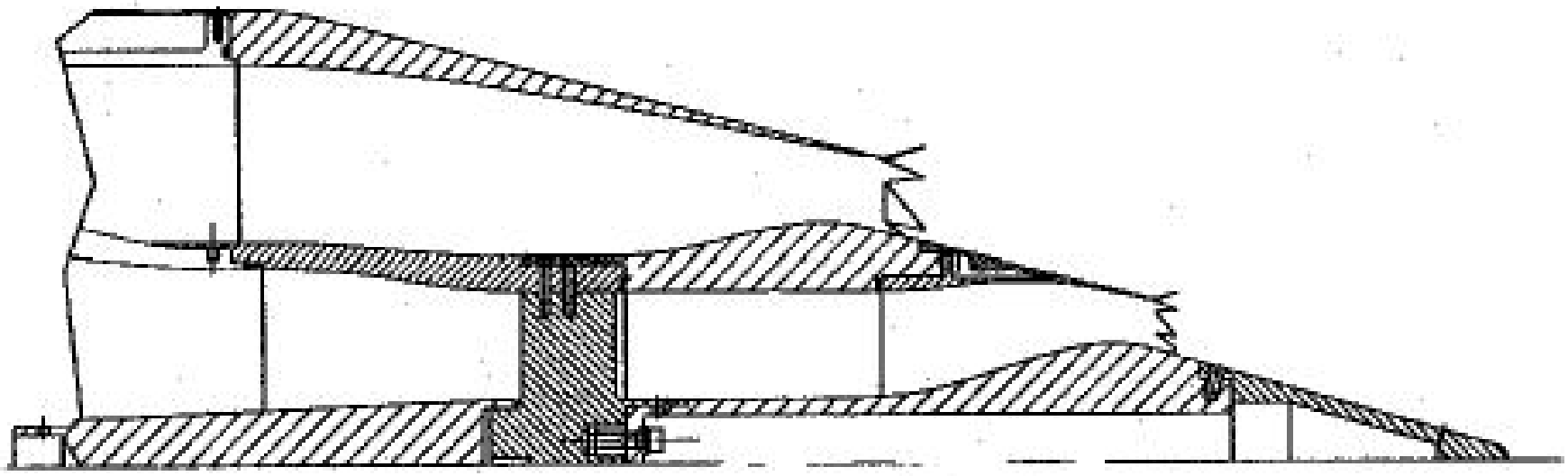


Figure B-33. Cross-section of the Combination Nozzle Configuration (3T24T24), 24-Flipper-Tabbed Core Nozzle with 24-Flipper-Tabbed Fan Nozzle.

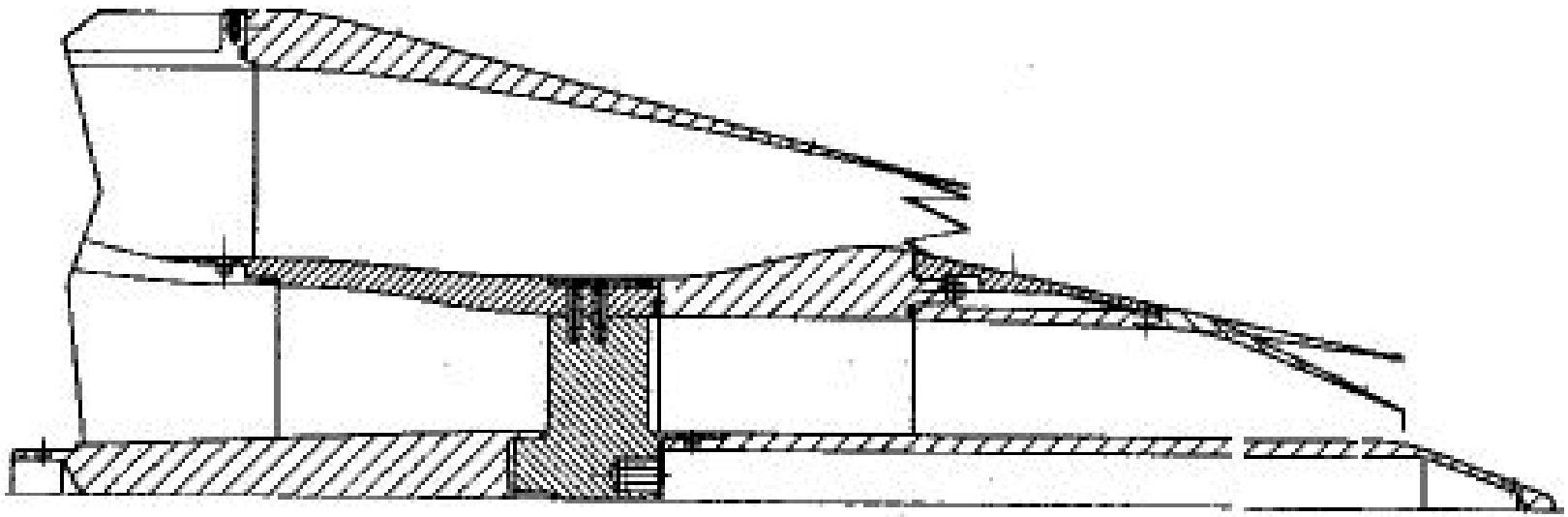


Figure B-34. Cross-section of the Combination Nozzle Configuration (6TmC), Tongue-Mixer Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

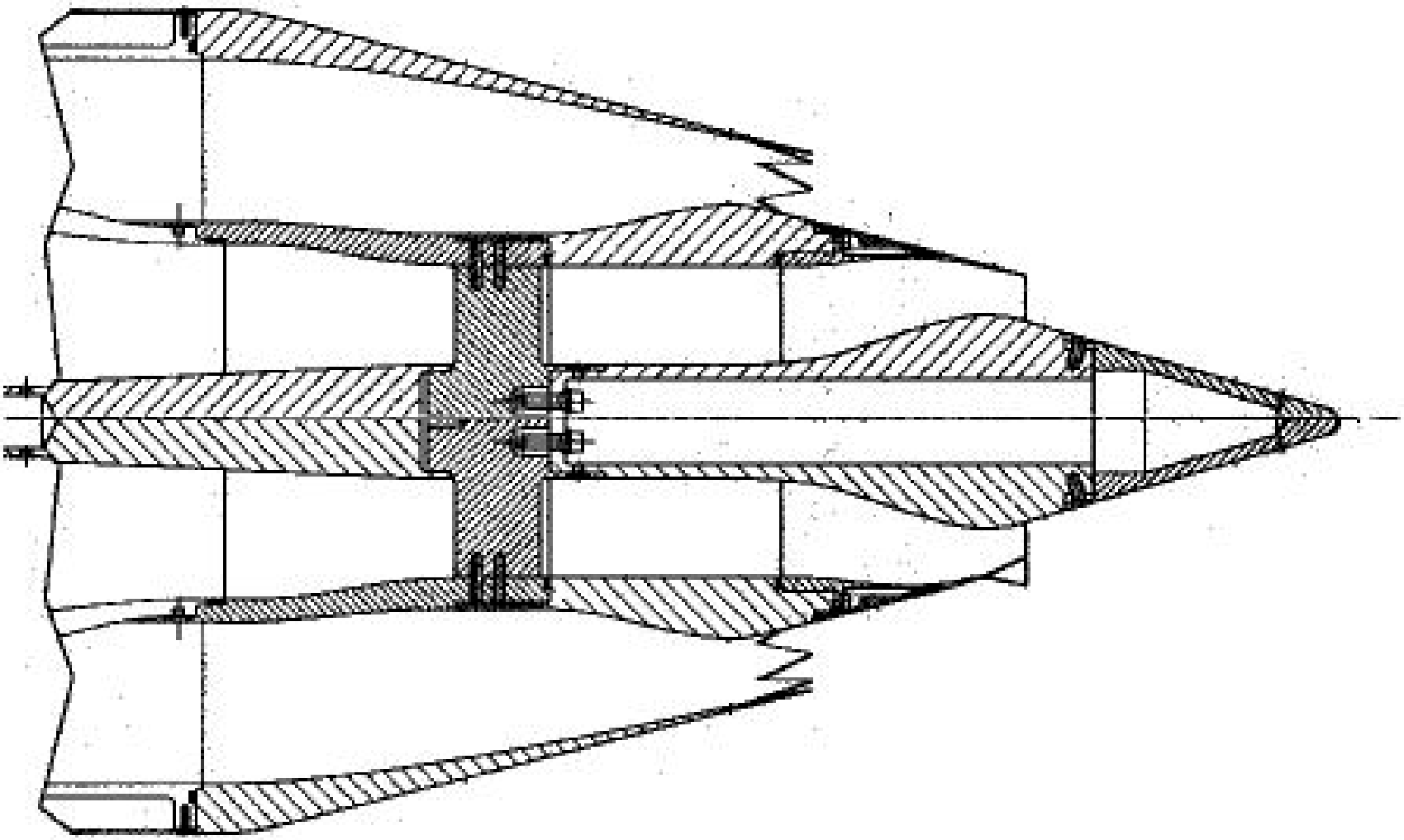


Figure B-35. Cross-section of the Combination Nozzle Configuration (3HmC), Half-Mixer Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

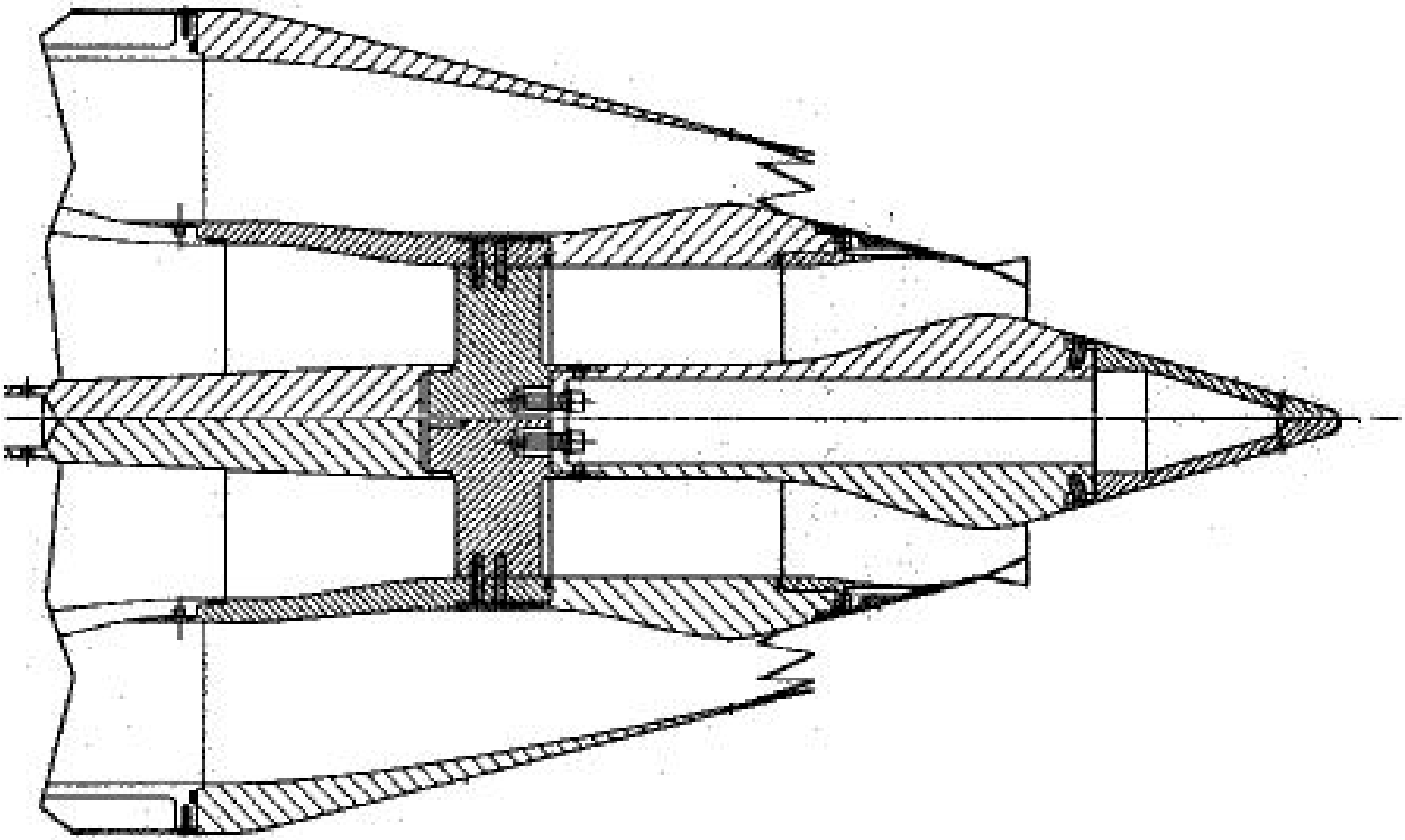


Figure B-36. Cross-section of the Combination Nozzle Configuration (3FmC), Full-Mixer Core Nozzle with 24-Neutral-Chevrons Fan Nozzle.

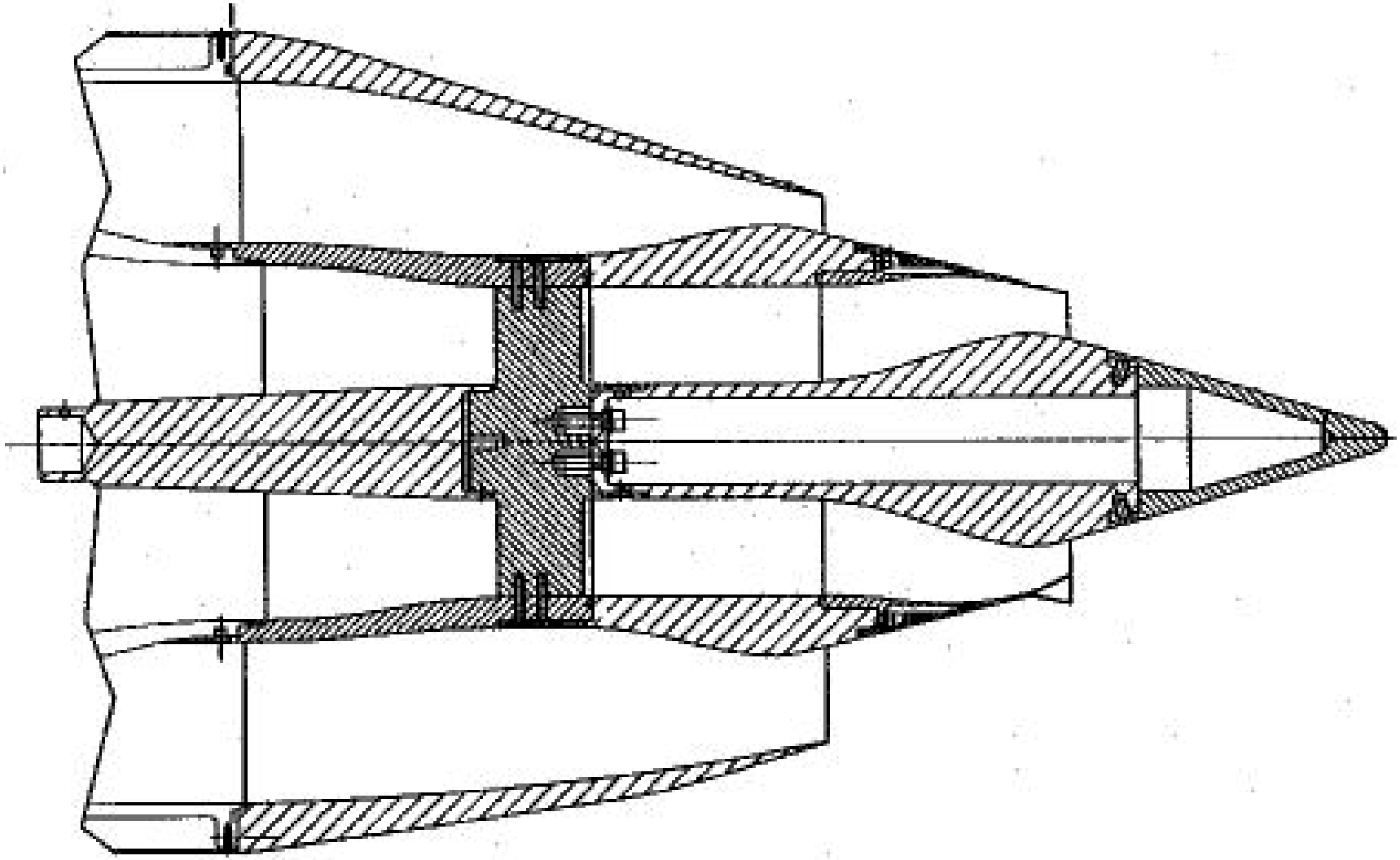


Figure B-37. Cross-section of the Combination Nozzle Configuration (3HmOmax), Half-Mixer Core Nozzle with Offset Centerline Fan Nozzle.

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13. ABSTRACT ***(Maximum 200 words)***
NASA's model-scale nozzle noise tests show that it is possible to achieve a 3 EPNdB jet noise reduction with inward-facing chevrons and flipper-tabs installed on the primary nozzle and fan nozzle chevrons. These chevrons and tabs are simple devices and are easy to be incorporated into existing short duct separate-flow nonmixed nozzle exhaust systems. However, these devices are expected to cause some small amount of thrust loss relative to the axisymmetric baseline nozzle system. Thus, it is important to have these devices further tested in a calibrated nozzle performance test facility to quantify the thrust performances of these devices. The choice of chevrons or tabs for jet noise suppression would most likely be based on the results of thrust loss performance tests to be conducted by Aero System Engineering (ASE) Inc. It is anticipated that the most promising concepts identified from this program will be validated in full scale engine tests at both Pratt & Whitney and Allied-Signal, under funding from NASA's Engine Validation of Noise Reduction Concepts (EVNRC) programs. This will bring the technology readiness level to the point where the jet noise suppression concepts could be incorporated with high confidence into either new or existing turbofan engines having short-duct, separate-flow nacelles.

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