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AERODYNAMIC AND ACOUSTIC EFFECTS OF ELIMINATING CORE SWIRL FROM A FULL SCALE 1.6 STAGE PRESSURE RATIO FAN (QF-5A)

Richard P. Woodward, Loren W. Acker,
and Edward G. Stakolich
Lewis Research Center
Cleveland, Ohio

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SUMMARY

Fan QF-5A was a version of fan QF-5 that involved modification of the core stator by adding a second stator element in tandem with the original stator to remove a 30°-core exit swirl in the original stage. The support struts were similarly adjusted for axial flow. These modifications were needed to correct problems caused by the impingement of the swirling flow exiting from the core stators on the axial support pylon of the NASA Quiet Fan facility. The problems were evidenced by reduced core mass flow, implying partial flow blockage by separation at the pylon and by localized damage to the sheet metal walls of the core flow passage at higher fan speeds. Acoustic results for the QF-5 fan suggested unusually high low frequency noise also was present at the higher fan speeds. The original QF-5 stage was designed for an engine application in which a core swirl was required as inflow to a succeeding core compressor stage.

The redesigned fan QF-5A did obtain the design bypass ratio with an increased core airflow and somewhat reduced bypass airflow. Acoustically, the redesigned stage showed a noise reduction compared to fan QF-5 at similar operating conditions. In particular, a significant broadband noise reduction was observed for the redesigned fan stage at frequencies below that of the blade passing tone, thus giving another indication of improved exhaust duct airflow. No structural problems were observed with the modified fan design.

E-9774

INTRODUCTION

Fan QF-5A is a 1.83 m (6-ft) rotor tip diameter, 1.6 bypass pressure ratio experimental fan stage with low noise characteristics which was tested at the NASA-Lewis Quiet Fan Facility. This fan stage is a modified version of fan QF-5 (ref. 1), which was manufactured under contract to NASA by the Pratt and Whitney Division of United Technologies Corporation. The QF-5 was designed for an engine application and had separate core and bypass flow streams downstream of the rotor with residual swirl in the core flow. In an engine application, this nonaxial outflow from the fan core stators is incorporated in the engine design to reduce the relative Mach number on the first stage compressor blades. This core exit swirl, about 30° with respect to the fan axis, impinged on the axial support pylon of the quiet fan facility with the result that core stream aerodynamic performance was reduced and structural damage occurred. Also, these effects were accompanied by an increase in the low frequency noise of the fan. Thus, Pratt and Whitney was contracted with to modify the fan stage to eliminate this residual swirl upstream of the facility support pylon. The modified stage was designated fan QF-5A.

This report compares selected results from the fan QF-5 and QF-5A tests. Radial total pressure profiles for the core exit airflow are included as an aid in understanding the aerodynamic performance changes associated with the fan stage modification. The acoustic results are presented in terms of selected sound pressure level spectra and sound power level spectra.

Before going into the detailed results for fan QF-5A, figure 1 is presented to show how fans QF-5A and QF-5 relate to other fans tested at the Lewis Quiet Fan Facility. Fans QF-5A (and QF-5) have the highest stage work coefficient (or blade loading) of any fans tested at this facility.

FAN STAGE

As previously mentioned, the original fan QF-5 stage (ref. 1) was designed for an engine application rather than for use in the Quiet Fan Facility. Thus, the fan QF-5 core flow left the core stator with a swirl angle of 30° with respect to the axial direction. Poor core flow aerodynamic performance at the Quiet Fan Facility, which has a large, axial support pylon in the fan duct, was evidenced by the core mass flow being substantially below design. Also, damage occurred to the sheet metal lining on the outer surface of the core flow passage at fan speeds greater than 85 percent of design. Figures 2 and 3 show how this problem was corrected by adding a core stator row downstream of the original core stator to return the flow to the axial direction; the flow splitter support strut was also realigned for axial flow. The facility support pylon, the leading edge of which is shown in figure 3, is a 20 percent thick symmetrical section which is common to all fans tested at the Quiet Fan Facility.

Fan QF-5 was designed for variable rotor-stator spacing, up to a maximum spacing of 2.3 mean rotor chords (ref. 1). Fan QF-5A was tested with only a 2.3 chord rotor-stator spacing. Likewise, the fan QF-5 results presented in this report are for the 2.3 chord spacing.

A variable-area plug nozzle was used on the core flow of fan QF-5, while a fixed plug nozzle, which was considered to have an equivalent area, was used on fan QF-5A. Both versions of fan QF-5 used fixed nozzles on the bypass flow ducts. The exact area used on the core nozzle of fan QF-5 was not available from previous records.

The fan QF-5A results presented in the report are for a core nozzle area of 0.23 m^2 (2.45 ft^2) and a bypass nozzle area of 1.01 m^2 (10.92 ft^2). The representative fan QF-5 configuration also had a bypass nozzle area of 1.01 m^2.

Table I presents selected design characteristics for fan QF-5A (and fan QF-5). Fan QF-5A had a design tip speed of 332.5 m/sec (1090 ft/sec) and a design bypass pressure ratio of 1.60. The design core stage pressure ratio was 1.45. The design bypass ratio for this fan was 5.40. As previously mentioned, fan QF-5A is relatively highly loaded.

Table II gives the physical characteristics of the fan QF-5A (and QF-5) blading. The bypass stator, original core stator, and new second core stator all have 88 blades. The rotor has 36 blades, resulting in cut-off of the fundamental tone due to rotor-stator interaction according to the theory of reference 2. That is, the fundamental blade passing tone due to rotor-stator interaction would not be expected to propagate to the far field. However, a significant fundamental blade passing tone was generated apparently due to rotor interaction with inflow disturbances. The existence of inflow distortion at the quiet fan facility was explored in reference 3. Also, reference 4 predicts that atmospheric turbulence may cause considerable tone noise generation during a static acoustic test.

Figure 4 is a photograph of the fan QF-5 (also fan QF-5A) rotor. Fans QF-5 and QF-5A were externally driven by a remote electric motor. The stage drive shaft is evident in this photograph.

Aerodynamic Instrumentation

The aerodynamic instrumentation was similar on fans QF-5 and QF-5A. Figure 5 is a cross-sectional sketch of the fan QF-5 stage showing the locations of the instrumentation stations. Further details of the instrumentation at these stations are available in figure 6.

The Quiet Fan Facility was designed primarily for acoustic investigations. Hence, the aerodynamic measurements are primarily to verify the fan operating conditions.

Core Nozzle Comparability

The variable core nozzle used on fan QF-5 may not compare directly in effective area with the fixed core nozzle of fan QF-5A. Cross-sections of these two nozzle configurations are shown in figure 7. Analysis of data from another fan stage tested at the Quiet Fan Facility with both nozzle configurations (ref. 5) suggests that the fixed-area nozzle is effectively more open, that is, has a higher flow coefficient than does the variable-area nozzle for the same measured area. These results were not available at the time of the QF-5A tests, however, their implications will be considered in the present analysis.

TEST FACILITY

The NASA-Lewis Quiet Fan Facility was designed for the acoustic testing of experimental full-size fan stages (up to 1.83 m, 6-ft. diam) with characteristics suitable for quiet turbofan engines. A typical fan stage is shown installed at the Quiet Fan Facility in figure 8. The test stages are remotely-driven by an electric motor and drive shaft. The wall of the wind tunnel drive building has acoustic wall treatment. This treatment was found to simulate a free field to within one decibel accuracy at frequencies above 400 hertz.

Far-field acoustic measurements are obtained with an array of microphones located at fan centerline elevation at a 30.5 m (100 ft) radius from 10° to 160° relative to the fan inlet axis (fig. 9). The entire test area is hard surfaced, resulting in noise reflections which add approximately 3 decibels to free field conditions.

DATA REDUCTION

Aerodynamic Data

The aerodynamic data were recorded through a pressure multiplexing valve, pressure transducer, and data acquisition network. All temperatures were recorded by the same network, which takes one scan of the aerodynamic pressures and temperatures in approximately 10 seconds. Several consecutive scans were made at each point, with the raw data samples arithmetically averaged and used to compute the desired flow parameters. The arithmetic averages of the computed parameters are presented in this report.

Isentropic flow conditions were assumed for these calculations. Performance parameters were corrected to standard day conditions of temperature of 15° C and an atmospheric pressure of 101,325 Pascals (760 mm of mercury).

The average inlet total temperature was determined from six iron-constantan thermocouples located at the bellmouth lip. The inlet Mach number and mass flow were calculated from static pressure data in the inlet duct.

The bypass mass flow was calculated from total and static pressure rake data at station 3 (fig. 5). These rakes also had iron-constantan thermocouples for temperature rise data. There was considerable question about the accuracy of the core stage measurements due to the location of the core rakes at measuring station 4, which is downstream of the facility support pylon. Hence, the core mass flows reported were calculated as the difference between the inlet total and bypass mass flows.

Acoustic Data

Data acquisition system. - Noise measurements were made with 1.3 centimeter (1/2 in.) diameter condenser microphones which had sensitivities of -60 decibels relative to 1 volt per 10^{-1} Pascal (1 μ bar). Frequency response of the system, as a whole, was flat from 50 hertz to 20 kilohertz. The acoustic data were reduced both on line through one-third-octave filters and recorded on magnetic tape for further analysis. Before each set of tests a pistonphone signal was impressed on each far-field microphone for an absolute calibration.

One-third-octave-band analysis. - The one-third-octave-band analyzer used for on-line data reduction used a 4-second averaging time and stepped sequentially through the angles from 10° to 160°. The 4-second averaging time was selected to accomodate all angles within a 100-second sample while preserving analyzer repeatability. Three 100-second samples were taken for each data point and averaged.

Results of one-third-octave-band sound pressure level (SPL) analysis yielded data at the ambient conditions of the test day at the microphone locations. The data were referred back to the sound source (i.e., the effect of atmospheric absorption was removed) by computing atmospheric absorption for the test conditions over the propagation path and adjusting the data accordingly. Atmospheric absorption was computed by using continuous frequency-dependent functions derived from reference 6. For the fan QF-5 and QF-5A results, which are fan noise dominated, the general shape of the measured spectrum was accounted for, and the one-third-octave-band attenuations were obtained by integrating the continuous absorption functions over each band (ref. 7).

Using data referenced to the source, calculations of atmospheric absorption for a standard day of 15° C and 70 percent relative humidity were made, and the data were so adjusted. All one-third-octave-band sound pressure level data reported herein are adjusted to standard-day conditions.

For power calculations the sound pressure levels were presumed to be axisymmetric and were integrated over an enclosing hemisphere. Implicit in this procedure was a perfectly reflective ground plane in the sense that acoustic intensity was doubled in the far field. No detailed spectral accounting was made for signal interference effects at the microphones because of ground reflections.

RESULTS AND DISCUSSION

Aerodynamic Performance

The aerodynamic performance of fans QF-5 and QF-5A is summarized in table III. The design bypass ratio (bypass-to-core mass flow ratio) is 5.40 (see table I). The bypass ratio results for fan QF-5A come close to this value.

It is not certain as to how the core nozzle geometry differences enter into this comparison of fans QF-5 and QF-5A. Reference 5 presents results for the variable-area nozzle and a fixed nozzle run on a different fan at the Quiet Fan Facility. The variable-area nozzle was shown to pass less flow (that is, appear more closed) than did the fixed-area nozzle for the same geometric nozzle exit area. Thus, one would expect the fan QF-5 (variable-area core nozzle) core flow to be reduced relative to that for fan QF-5A for the same measured core nozzle areas and otherwise similar operating conditions. However, the nonaxial core flow of fan QF-5 most certainly had a greater influence on reducing the mass flow than did the core nozzle geometries, although both considerations support the idea of lower core airflow for fan QF-5.

The bypass flow efficiency values are close to design for fan QF-5A if one assumes that a linear extrapolation of the efficiency results would yield an efficiency of about 0.88 at design fan speed. The design bypass efficiency is 0.87. Reliable efficiencies for fan QF-5 were unavailable.

The fan operating maps of bypass pressure ratio as a function of both the total and bypass corrected mass flows are presented in figure 10. As might be expected in view of the core modifications, there are considerable differences in the operating characteristics of the two fans. Fan QF-5A shows about the same bypass pressure ratio at 90 percent of design fan speed as does fan QF-5 at 85 percent design speed. However, fan QF-5A has a higher total mass flow, and lower bypass mass flow for this comparison. Acoustic results, given later in this report, will compare the 85 percent design speed results for fan QF-5 with the 85 and 90 percent speed results for fan QF-5A.

In general, from figure 10 it may be seen that the bypass pressure ratio at any fan speed was higher for fan QF-5. Fan QF-5A passed a greater portion of its flow through the core, indicating an improved flow condition in that region, and resulting in a bypass ratio close to design. It is expected that the improved core flow in fan QF-5A would relieve some of the flow that was previously diverted into the bypass region of the original design, resulting in a lower bypass pressure ratio and mass flow at similar fan speeds for fan QF-5A. This reasoning is consistent with the results of figure 10 for the bypass airflow.

It is unclear why fan QF-5A passed a slightly lower total mass flow than did fan QF-5 at similar fan speeds. Improved core flow with the same bypass nozzle would suggest a higher total mass flow for fan QF-5A.

Figure 11 shows the radial variation of total pressure in the core (station 4) for both fans operating at 85 percent of design speed. There is considerable rake-to-rake disagreement for the fan QF-5 results (fig. 11(a)). The improved core airflow of the redesigned fan QF-5A is evident from the well-behaved profiles of figure 11(b).

ACOUSTIC RESULTS

The acoustic results to be compared in this report are for fan QF-5 at 85 percent of design fan speed and fan QF-5A at 85 and 90 percent of design fan speed. The argument for selecting the points for comparison was made in the discussion of the fan map (fig. 10).
Appendix A of this report contains computer printouts of the acoustic results for fans QF-5 and QF-5A.

Sound power spectra for the inlet and aft quadrants are shown in figure 12. At frequencies greater than the blade passing frequency the two fans behaved similarly. On the other hand, it can be seen that the levels for the QF-5 fan are several decibels higher than those for the QF-5A fan in the spectral region below the blade passing tone. This difference was greater in the inlet data than in the aft data. In the aft quadrant the sound is mostly due to the jet noise which is about the same for the two fans and which tends to obscure the contribution of the poor core flow to the low frequency noise. This can be more clearly seen in the directivity data of figure 13, where the sound pressure level summed over the frequency range from 50 to 1000 hertz is plotted for the two fans. These data show that the increasing contribution of jet noise as the aft angles are approached is probably the cause of the reduction in the difference in aft sound power level between the two fan configurations. It seems clear that the core flow, due to its exit swirl, did interact with the rig pylon in fan QF-5 to produce the poor aerodynamic performance that was observed as well as generating extra low frequency noise and causing the structural failure of the sheet-metal ducting. Modification of the core stators and struts to better align the flow alleviated all these problems with the original fan design.

CONCLUDING REMARKS

Fan QF-5A was a modification of fan QF-5 which featured an additional core stator and adjusted support struts to turn the core exit flow from a 30° swirl to the axial direction. Aerodynamic results indicated a partial core flow blockage in the original fan which was considered to be due to the swirling core flow impinging on the large, axial fan support pylon. The flow-pylon interaction also generated extra low frequency noise and caused structural failure of the sheet metal ducting.

The original bypass nozzle area was duplicated on the modified fan QF-5A and aerodynamic results showed the bypass ratio to have essentially the design value. For the same fan speed, the original design showed a slightly higher inlet mass flow and bypass pressure ratio. While the higher bypass pressure ratio may be explained as a result of airflow being diverted from the core region, the higher inlet mass flow is an unexpected result.

The acoustic results showed only a small difference in tone levels between the two fan tests. The differences were within the uncertainties associated with choosing equivalent aerodynamic operating points (in terms of fan speed mass flow, and pressure ratio). However, the acoustic results did show decreased low-frequency broadband noise levels for the modified QF-5A fan which may relate to the elimination of nonaxial core flow and probably flow separation on the downstream support pylon. No structural failures were encountered with the modified core stators.

APPENDIX A

ACOUSTIC RESULTS

This appendix contains computor listings of the one-third-octave acoustic results for fan QF-5 (configuration 43) and QF-5A (configuration 411). Perceived noise results are presented for a 304.8 m (1000 ft) sideline.

NOISE OF OF 5 CONFIGURATION 43
ORIGINAL FAN, CONF. 43 2.3 ROTOR/STATOR SPACING
CORE NOZ. OPEN UNCERTAIN AREA . DESIGN BYPASS NOZ. 10.92 SQ. FT.

(A) 60 PERCENT SPEED, FAN PHYSICAL SPEED - 2138 RPM, FUNDAMENTAL BLADE PASSAGE FREQUENCY - 1282 HZ

DATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 70 PERCENT RELATIVE HUMIDITY
SPL RE .00002 N/SQ M PWL RE .1 PICOWATT

1/3-OCTAVE BAND SOUND PRESSURE LEVEL (SPL) 30.5-METER RADIUS

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	AVERAGE SPL	POWER LEVEL (PWL)
50	91.4	85.6	86.9	83.0	82.6	85.2	84.1	84.2	8[illegible].4	85.1	83.7	83.8	85.1	86.8	84.5	91.7	85.3	132.7
63	80.3	88.2	83.8	81.4	84.6	85.8	85.1	81.5	8[illegible].7	83.1	82.1	82.6	84.1	85.9	85.1	89.7	84.8	131.6
80	84.4	83.2	85.5	87.3	87.2	85.4	85.6	86.5	8[illegible].9	86.0	87.3	86.9	85.5	86.1	85.6	87.5	86.3	133.7
100	85.8	89.6	91.7	90.5	86.0	88.7	88.0	83.8	8[illegible].9	86.3	85.6	84.6	86.1	86.5	86.0	88.1	87.4	134.6
125	91.2	91.4	85.9	88.5	87.1	86.9	86.5	87.9	86.9	87.9	87.5	87.7	88.5	87.7	85.7	87.0	87.8	135.2
160	92.8	92.4	90.9	89.6	86.9	87.3	87.3	87.4	[illegible]	8[illegible].8	95.4	87.3	86.8	85.4	85.9	85.4	87.7	135.1
200	89.3	89.3	87.7	84.4	86.8	85.4	83.6	84.9	8[illegible].7	85.4	86.5	87.0	87.2	87.5	88.3	87.6	86.7	134.1
250	87.0	89.3	88.8	86.4	88.1	86.3	84.0	87.4	8[illegible].4	86.6	88.3	86.3	86.7	87.0	86.1	86.7	86.8	134.2
315	93.9	93.4	92.3	90.8	88.8	87.7	88.7	87.4	8[illegible].7	87.5	88.5	90.1	89.9	89.7	87.3	86.6	89.3	136.7
400	88.2	87.2	87.8	85.3	87.3	87.5	89.0	86.5	86.3	86.3	85.9	85.7	87.7	86.1	83.5	84.2	86.7	134.1
500	91.4	93.0	92.2	92.9	92.8	91.3	89.8	88.5	[illegible]	87.4	85.1	86.6	86.3	85.8	84.7	84.6	89.4	135.8
630	89.3	92.1	89.5	90.0	89.4	87.1	85.7	84.7	8[illegible].8	85.8	87.1	86.8	87.7	86.5	82.1	83.1	87.4	134.6
800	88.2	89.6	89.6	88.9	88.2	87.3	86.7	86.1	8[illegible].4	86.0	86.3	87.2	87.8	86.0	84.4	83.7	87.2	134.5
1000	88.5	88.5	90.7	88.4	88.2	87.6	86.1	85.7	[illegible]	87.4	88.4	87.5	89.7	87.1	84.5	83.9	88.0	135.4
1250	93.5	94.7	97.0	97.6	99.6	93.2	90.5	89.4	9[illegible].3	92.1	93.6	92.9	94.2	91.9	87.7	85.2	94.2	141.6
1600	88.0	88.7	90.4	89.2	88.7	86.2	84.5	85.6	[illegible]	88.2	89.5	89.9	90.2	89.2	84.9	82.2	88.3	135.7
2000	89.4	89.6	91.1	90.2	88.2	86.9	84.8	86.3	[illegible]	90.8	91.8	91.4	91.6	89.9	85.1	82.4	89.7	137.2
2500	92.3	94.2	93.3	93.5	92.8	90.5	90.5	91.5	[illegible]	96.8	96.5	99.7	100.5	94.8	91.3	87.0	95.8	143.2
3150	90.2	91.4	92.2	90.9	90.6	87.6	86.0	88.5	[illegible]	91.9	97.0	9[illegible].4	93.7	89.7	86.5	83.2	91.3	133.7
4000	93.4	94.9	97.6	95.1	94.4	90.4	86.5	88.0	9[illegible]	97.2	98.1	98.9	96.[illegible]	90.7	87.4	83.4	93.8	141.2
5000	89.4	91.4	94.4	95.3	92.1	89.3	87.1	84.1	8[illegible]	97.1	93.0	93.5	94.6	89.5	85.0	80.6	92.4	139.6
6300	88.0	89.1	91.7	92.5	90.2	87.3	82.1	84.4	8[illegible]	89.0	90.3	90.1	92.2	84.5	84.1	80.5	90.4	137.8
8000	85.6	88.6	90.9	90.2	89.4	86.3	80.4	81.4	8[illegible]	87.1	85.6	89.6	90.2	81.6	77.3	77.2	89.7	137.1
10000	82.5	85.0	87.7	87.2	86.4	83.5	76.7	77.5	8[illegible]	87.0	84.5	85.7	87.2	82.0	79.5	74.5	87.3	134.7
12500	80.9	84.0	86.4	84.5	84.2	81.9	74.1	75.3	7[illegible]	81.5	82.7	84.3	85.4	87.5	77.0	71.9	86.8	134.2
16000	79.3	81.3	82.6	81.5	79.8	79.2	69.7	70.7	7[illegible]	77.0	79.3	79.0	79.8	75.8	73.3	67.5	84.8	132.0
20000	77.3	77.1	78.6	79.3	77.0	72.7	65.1	67.1	6[illegible]	72.6	74.4	75.0	75.4	71.6	69.4	62.9	83.5	130.9
OVERALL	104.0	104.8	105.6	105.0	104.7	102.0	100.4	100.4	10[illegible]	107.1	107.6	108.9	105.7	102.3	99.3	99.6	103.9	151.3

SIDELINE PERCEIVED NOISE LEVELS

DISTANCE	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
304.8 METERS	66.8	77.4	83.6	86.7	89.2	88.1	88.1	89.2	90.6	92.0	92.5	93.2	92.3	85.9	79.2	71.3

NOISE OF OF 5 CONFIGURATION 43

ORIGINAL FAN, CONF. 43 2.3 ROTOR/STATOR SPACING

CORE NOZ. OPEN UNCERTAIN AREA , DESIGN BYPASS NOZ. 10.92 SQ. FT.

(B) 70 PERCENT SPEED, FAN PHYSICAL SPEED - 2494 RPM, FUNDAMENTAL BLADE PASSAGE FREQUENCY - 1496 HZ

DATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 70 PERCENT RELATIVE HUMIDITY

SPL RE .00002 N/SQ M PWL RE .1 PICOWATT

FREQUENCY	ANGLE, DEG																AVERAGE SPL	POWER LEVEL (PWL)
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160		
1/3-OCTAVE BAND SOUND PRESSURE LEVEL (SPL) ON 30.5-METER RADIUS																		
50	96.1	90.6	90.6	86.8	86.2	80.4	89.7	89.7	89.2	88.3	87.5	87.8	89.2	90.0	89.3	91.7	89.2	136.6
63	90.5	91.7	65.1	84.2	89.1	90.6	88.1	85.7	86.7	87.9	86.9	87.3	88.6	89.2	89.4	91.7	88.3	135.7
80	86.7	82.0	95.9	89.1	88.8	87.9	87.5	87.5	88.9	87.5	89.8	89.4	89.2	89.4	89.9	90.8	88.6	136.0
100	89.6	92.2	90.1	89.3	89.7	91.5	88.9	87.9	90.7	89.6	89.9	90.1	91.0	91.5	91.6	91.0	90.3	137.7
125	91.9	90.9	89.6	91.4	88.8	88.4	87.9	89.1	89.6	88.6	89.6	90.2	90.5	90.7	91.2	89.7	89.7	137.1
160	91.7	94.5	99.1	93.3	91.5	92.3	91.8	92.0	90.8	89.8	89.8	89.5	90.3	89.6	90.8	87.6	92.1	139.5
200	90.8	92.6	91.5	87.7	89.9	89.9	87.9	89.9	90.7	90.4	90.8	90.1	91.8	91.8	91.5	88.6	90.4	137.8
250	91.4	92.8	91.5	90.6	91.1	91.1	91.8	92.4	91.1	91.3	91.2	90.6	90.1	90.8	90.2	87.0	91.2	138.6
315	94.5	94.6	92.1	94.3	91.6	92.7	92.3	91.1	90.4	91.5	92.0	92.9	93.9	94.0	92.6	92.1	92.5	139.9
400	91.2	91.2	91.1	89.9	91.3	91.2	92.7	91.1	91.4	91.4	91.3	90.2	93.2	92.1	89.7	88.9	91.5	138.9
500	94.1	95.7	93.9	96.3	96.7	95.2	94.1	93.2	93.8	92.3	90.4	90.5	90.2	90.5	89.3	89.3	93.3	140.7
630	92.1	96.1	93.3	94.5	94.5	92.2	90.4	89.5	89.8	90.4	92.2	90.7	91.9	90.8	87.4	88.9	91.9	139.3
800	91.0	93.3	92.8	93.4	92.3	91.6	91.0	90.9	90.5	91.3	90.6	91.2	91.5	89.8	89.0	89.7	91.4	138.8
1000	90.9	92.1	94.6	92.5	92.0	91.6	90.8	90.8	90.5	92.0	92.7	92.8	92.6	89.8	87.5	88.3	91.8	139.2
1250	91.6	92.0	94.7	94.5	93.3	90.0	89.6	88.8	91.2	93.0	92.0	91.8	93.4	89.3	87.5	87.5	92.0	139.4
1600	96.9	97.4	99.7	101.2	101.5	97.2	93.9	94.9	95.7	97.0	97.5	98.9	98.9	92.5	90.7	91.7	97.9	145.3
2000	91.1	92.3	93.3	93.4	93.1	91.1	88.9	90.8	93.3	94.4	94.6	94.1	94.4	90.1	88.3	87.6	93.0	140.4
2500	91.7	93.2	93.4	93.9	93.4	91.4	90.2	92.4	95.0	96.2	96.2	96.4	95.5	91.0	88.5	87.5	94.4	141.8
3150	95.2	96.7	97.4	96.9	98.6	95.6	93.1	95.7	97.1	98.6	99.7	103.2	101.2	96.4	93.2	90.9	98.9	146.3
4000	93.4	95.8	97.3	97.6	96.3	93.6	90.7	92.7	95.1	96.8	96.3	98.9	98.4	92.7	90.4	88.2	96.6	144.0
5000	93.3	95.2	97.0	96.7	95.5	93.7	88.5	89.5	94.3	95.5	97.8	97.6	97.0	92.5	88.5	85.8	96.1	143.5
6300	91.7	93.1	95.5	96.6	97.0	93.2	87.5	90.1	91.9	93.5	95.1	94.7	94.6	90.1	87.5	86.0	95.1	142.5
8000	89.6	92.6	94.7	93.4	95.4	92.8	86.9	87.2	91.1	92.6	93.8	94.3	93.1	89.6	86.3	83.1	94.5	141.9
10000	86.7	89.0	91.9	91.0	92.2	89.7	83.2	83.2	87.3	88.7	90.5	90.5	90.4	86.4	83.2	80.0	92.2	139.6
12500	85.0	88.5	90.7	88.7	90.7	88.5	80.6	80.9	85.3	87.3	88.0	89.3	88.8	85.5	81.3	77.8	92.0	139.4
16000	83.6	85.9	87.0	85.7	86.0	85.0	76.0	76.5	81.9	83.1	84.9	85.1	83.8	80.6	77.5	73.8	90.0	137.4
20000	81.5	81.5	83.4	84.2	83.9	79.3	72.6	73.1	76.6	76.5	80.4	81.1	79.7	76.7	73.2	69.2	89.1	136.5
OVERALL	106.4	107.5	108.4	108.2	108.4	106.3	104.4	104.8	106.1	107.0	107.8	108.7	108.3	105.2	103.6	103.0	107.6	155.0
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
304.8 METERS	68.6	80.7	87.3	91.2	93.6	92.6	91.7	93.6	95.1	96.0	96.1	96.6	94.1	87.9	81.9	75.6		

NOISE 6 OF 5 CONFIGURATION 43
ORIGINAL FAN, CONF. 43 — 1.3 ROTOR/STATOR SPACING
CORE 40%, OPEN UNCERTAIN AREA, DESIGN BYPASS NOZ. 10.92 SQ. FT.

(C) 80 PERCENT SPEED, FAN PHYSICAL SPEED - 2850 RPM, FUNDAMENTAL BLADE PASSAGE FREQUENCY - 1710 HZ

DATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 70 PERCENT RELATIVE HUMIDITY
SPL RE .00002 N/SQ M   PWL RE .1 PICOWATT

1/3-OCTAVE BAND SOUND PRESSURE LEVEL (SPL) ON 30.5-METER RADIUS

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	AVERAGE SPL	POWER LEVEL (PWL)
50	100.3	92.8	93.4	88.7	87.3	92.6	96.1	95.2	91.0	97.6	93.[illegible]	92.8	94.0	94.7	94.1	95.8	93.8	141.2
63	91.8	93.3	86.5	86.6	91.3	94.1	90.2	87.8	8[illegible].8	91.2	90.2	89.9	97.8	94.1	95.3	96.6	91.7	139.1
80	89.1	82.5	87.5	91.0	90.9	91.1	90.5	89.6	91.2	90.9	91.7	92.8	93.6	94.3	95.8	95.8	91.9	139.3
100	88.8	89.9	91.9	90.4	90.2	93.2	91.7	89.0	91.4	92.7	92.6	93.2	94.7	95.3	96.0	96.0	92.9	140.3
125	92.2	90.6	91.9	93.0	88.6	90.7	90.0	91.0	91.7	91.9	92.0	97.7	95.2	95.7	96.0	96.7	97.6	140.0
160	97.5	99.8	102.0	96.8	94.6	95.5	95.0	93.1	91.6	92.8	92.3	93.1	94.0	94.8	95.3	92.6	95.4	142.8
200	94.3	95.4	94.0	91.8	93.8	94.5	91.5	92.5	92.9	94.0	93.7	94.0	95.7	96.2	96.5	93.3	94.0	141.4
250	93.2	94.5	93.3	93.6	95.0	96.0	94.7	95.1	96.1	94.3	95.0	94.0	93.3	94.7	94.1	91.8	94.7	142.2
315	96.8	96.2	95.5	97.8	94.9	96.5	95.3	94.4	95.5	96.1	96.0	97.5	98.0	97.7	96.0	95.5	96.3	143.7
400	94.8	92.7	94.2	93.5	95.1	95.5	96.5	95.3	95.3	95.8	95.7	95.3	98.3	96.5	94.5	93.8	95.7	143.1
500	96.1	97.7	96.7	99.1	100.0	97.0	97.7	97.2	95.6	97.8	98.8	94.6	94.8	97.5	94.8	94.1	97.2	144.8
630	95.5	98.3	95.9	98.0	97.9	96.1	93.7	97.4	94.5	94.6	95.4	94.9	96.4	95.5	93.4	94.1	95.7	143.1
800	93.2	94.5	96.0	97.4	97.2	96.6	96.1	94.5	94.5	94.8	94.4	94.8	94.9	93.3	93.5	93.0	95.4	142.8
1000	93.3	94.5	97.5	97.1	97.7	96.6	95.8	93.9	94.5	95.9	95.8	96.6	96.2	93.9	92.1	93.4	95.9	143.3
1250	91.8	97.0	95.5	95.9	95.2	93.4	93.0	91.9	94.4	95.2	94.2	95.0	95.5	92.4	90.9	90.5	94.3	141.7
1600	99.6	103.3	104.4	105.9	105.8	103.9	99.6	98.6	102.6	101.4	102.1	99.9	100.4	95.6	94.1	93.6	102.2	149.6
2000	95.1	95.9	98.4	100.1	99.7	97.6	95.4	95.6	97.6	98.8	99.1	97.1	97.9	96.1	97.8	91.8	98.1	145.5
2500	92.0	93.5	94.7	95.5	95.5	94.9	93.9	95.1	98.1	98.9	98.6	98.1	96.9	97.9	91.1	90.2	96.7	144.1
3150	95.8	97.6	100.3	100.1	101.0	99.8	98.3	100.1	102.8	104.5	105.1	105.8	104.0	99.3	96.1	94.6	102.8	150.2
4000	94.0	96.0	97.5	97.6	98.6	97.8	95.9	97.3	100.4	107.1	107.9	103.9	102.8	99.3	96.3	93.8	101.0	148.4
5000	95.9	98.0	99.4	100.1	98.0	98.7	93.4	94.0	99.7	100.9	101.7	101.7	99.9	95.2	92.2	89.4	100.0	147.4
6300	93.5	95.5	97.9	98.8	97.8	96.0	93.2	95.1	97.6	99.4	99.5	100.4	100.4	95.4	93.6	91.6	99.4	146.8
8000	91.6	94.2	97.3	96.6	97.0	95.1	92.7	97.8	96.7	95.8	98.8	97.8	98.8	97.2	97.9	89.2	98.8	146.2
10000	88.7	90.8	94.0	93.5	94.0	92.7	88.5	88.6	97.7	95.0	96.5	96.2	95.3	90.8	88.3	85.0	96.7	144.1
12500	87.0	90.7	93.4	91.7	92.3	91.7	85.9	87.0	91.6	97.8	94.3	95.4	94.7	90.4	87.0	83.7	96.8	144.2
16000	85.3	87.8	89.8	89.1	89.1	88.4	81.9	83.3	88.9	97.4	92.0	91.5	90.8	87.6	84.3	79.7	93.4	142.8
20000	83.2	83.5	86.5	87.9	86.4	83.7	79.4	79.9	84.0	86.7	88.4	86.7	87.4	83.6	80.2	75.7	94.8	142.2
OVERALL	108.8	109.5	111.3	111.7	111.6	110.7	108.7	108.7	110.9	111.8	112.1	112.4	111.9	109.4	105.2	107.4	111.7	159.1

SIDELINE PERCEIVED NOISE LEVELS

DISTANCE	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
304.8 METERS	71.1	82.9	90.0	95.1	97.3	97.8	96.4	97.6	100.0	101.0	100.6	98.8	97.3	91.6	85.9	79.5

ORIGINAL PAGE IS OF POOR QUALITY

NOISE OF OF 5 CONFIGURATION 43
ORIGINAL FAN, CONF. 43 2.3 ROTOR/STATOR SPACING
CORE NOZ. OPEN UNCERTAIN AREA , DESIGN BYPASS NOZ. 10.92 SQ. FT.

(D) 85 PERCENT SPEED, FAN PHYSICAL SPEED - 3028 RPM, FUNDAMENTAL BLADE PASSAGE FREQUENCY - 1816 HZ

DATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 70 PERCENT RELATIVE HUMIDITY
SPL RE .00002 N/SQ M PWL RE .1 PICOWATT

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	AVERAGE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVEL (SPL) ON 30.5-METER RADIUS																	
50	102.8	94.7	95.8	89.6	88.9	96.8	99.5	97.9	94.6	95.7	96.9	96.5	95.5	96.5	96.2	97.0	96.5	143.9
63	92.9	94.0	86.7	86.8	92.6	94.0	91.7	89.6	91.3	92.0	91.6	92.4	94.3	96.3	97.3	97.9	93.1	140.5
80	91.1	85.1	88.6	91.5	92.7	92.5	92.1	92.3	93.6	92.6	94.6	94.7	94.9	96.9	97.4	97.9	93.9	141.3
100	88.6	90.9	92.9	93.0	91.4	97.7	91.9	91.0	93.7	94.5	94.8	94.2	96.3	97.8	98.2	98.2	94.5	141.9
125	93.6	93.1	92.9	93.7	91.0	91.3	91.1	92.1	92.3	97.6	94.9	95.4	96.4	97.3	98.4	96.6	94.3	141.7
160	100.3	102.4	103.9	98.6	96.6	97.3	96.1	94.9	93.8	93.9	94.3	95.3	95.6	96.1	97.4	94.1	97.2	144.6
200	96.9	98.6	97.6	94.2	95.8	96.3	93.4	94.6	94.9	95.7	95.9	96.3	98.0	99.0	98.5	95.9	96.2	143.6
250	95.5	96.3	95.5	96.1	97.0	96.6	95.3	97.2	96.2	99.3	97.2	95.5	95.6	96.6	97.2	94.5	96.5	143.9
315	97.9	97.5	97.1	99.5	96.3	96.9	97.2	97.1	97.4	97.7	98.4	99.3	99.8	99.3	97.5	97.1	98.0	145.4
400	93.7	94.6	96.3	94.5	96.3	97.2	98.2	96.7	96.7	97.0	98.3	97.2	99.7	97.9	95.4	94.7	97.2	144.6
500	96.7	99.6	98.6	99.5	100.7	99.7	99.0	98.9	96.2	97.7	96.6	97.0	96.9	97.6	96.5	95.5	98.3	145.7
630	96.3	99.5	98.4	99.4	98.2	96.3	96.1	95.1	95.5	96.3	97.9	96.6	98.1	98.1	95.6	95.6	97.2	144.6
800	93.8	96.0	98.9	99.4	91.6	98.2	97.8	96.9	95.8	96.3	96.9	97.2	97.0	95.4	95.8	94.7	97.3	144.7
1000	94.6	96.0	99.5	97.8	97.3	97.5	97.4	95.5	95.9	97.0	98.7	98.7	98.3	95.8	94.5	95.0	97.4	144.8
1250	92.8	93.8	97.9	97.8	97.1	95.0	95.1	94.0	95.5	96.5	96.8	96.6	97.3	97.8	92.8	92.1	96.1	143.5
1600	96.4	99.2	102.7	104.4	105.6	102.4	99.4	97.2	100.4	99.0	99.9	99.2	99.0	95.5	93.7	93.2	100.8	148.2
2000	100.6	104.6	107.4	109.7	110.9	107.6	102.9	100.9	104.9	103.4	103.3	102.1	102.1	98.9	96.4	94.9	105.6	153.0
2500	93.0	94.6	96.3	96.6	96.6	96.3	95.6	97.3	99.5	99.6	100.7	99.2	98.0	94.3	92.8	91.6	98.1	145.5
3150	94.6	96.7	98.2	98.2	99.2	98.1	97.7	100.1	100.9	102.4	104.6	104.7	102.2	97.1	95.1	94.2	101.5	148.9
4000	97.5	100.4	102.7	102.1	103.4	101.5	99.7	101.4	102.5	104.7	108.5	108.2	107.2	102.4	98.9	96.9	105.1	152.5
5000	95.1	96.4	97.9	99.1	97.4	97.6	94.8	95.9	100.6	100.9	103.6	102.4	100.9	96.4	93.1	91.1	100.6	148.0
6300	93.5	94.3	96.3	96.7	96.5	96.0	94.2	97.0	98.8	99.8	102.0	101.7	99.7	94.9	92.9	91.5	99.9	147.3
8000	92.2	95.1	97.2	95.9	97.6	96.6	94.1	94.9	98.7	100.2	102.3	104.1	102.3	97.8	94.2	91.4	101.5	146.9
10000	88.8	91.4	93.6	93.1	94.6	93.8	90.9	91.4	95.8	97.3	100.9	99.1	98.1	93.7	90.8	88.4	99.2	146.6
12500	87.2	90.3	92.3	90.6	92.3	92.1	88.2	89.0	93.3	95.5	97.6	98.2	96.3	92.1	88.5	84.9	98.5	145.9
16000	85.0	87.7	89.3	88.7	88.8	89.0	84.0	85.6	90.8	92.1	96.7	94.8	92.6	88.6	86.0	81.1	97.6	145.0
20000	82.3	83.3	85.6	86.9	86.4	84.1	80.6	82.5	86.1	88.6	92.8	92.6	89.3	85.6	81.6	77.3	97.1	144.5
OVERALL	110.2	111.6	113.2	113.6	114.5	112.7	110.7	110.7	112.2	112.6	114.7	114.4	113.6	111.2	110.0	109.0	113.6	161.0

DISTANCE	SIDELINE PERCEIVED NOISE LEVELS															
304.8 METERS	72.3	85.9	93.6	96.2	101.3	100.8	99.0	98.0	101.4	101.0	102.6	101.0	98.6	92.9	87.8	81.1

NOISE OF OF 5A CONFIGURATION 411
MODIFIED FAN QF-5A, CONF. 411 2.3 ROTOR/STATOR SPACING
SMALL CORE NOZ. 2.45 SQ. FT. , LARGE BYPASS NOZ. 10.92 SQ. FT.

RDG 60 PERCENT SPEED, FAN PHYSICAL SPEED - 2176 RPM, FUNDAMENTAL BLADE PASSAGE FREQUENCY - 1305 HZ

DATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 70 PERCENT RELATIVE HUMIDITY
SPL RE .00002 N/SQ M PWL RE .1 PICOWATT

1/3-OCTAVE BAND SOUND PRESSURE LEVEL (SPL) ON 30.5-METER RADIUS

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	AVERAGE SPL	POWER LEVEL (PWL)
50	72.1	69.4	70.3	70.6	69.8	70.8	71.4	71.1	71.6	72.8	73.9	74.7	75.1	76.4	78.8	78.6	73.6	121.0
63	70.8	72.1	69.9	69.3	69.1	69.6	70.4	70.3	71.3	71.6	72.4	74.4	75.7	77.4	79.1	80.6	73.7	121.1
80	72.8	74.0	70.8	70.0	70.5	69.5	70.6	71.8	71.5	73.6	75.6	76.9	78.8	79.8	82.0	82.5	75.9	123.7
100	77.7	77.5	76.0	76.7	75.8	75.3	77.2	76.5	76.3	78.5	79.8	80.3	81.8	83.0	84.7	83.7	79.6	127.0
125	83.2	84.7	84.2	82.3	81.5	81.8	81.0	81.0	80.0	81.2	82.8	82.6	84.2	83.3	84.5	84.2	82.5	129.5
160	86.8	85.8	84.5	84.0	83.5	82.3	83.1	82.3	80.6	80.4	79.8	81.2	81.3	80.6	81.1	81.5	82.3	129.7
200	86.5	84.8	83.3	81.3	81.0	79.2	79.0	79.2	77.3	77.2	78.3	78.8	80.5	81.2	82.0	81.4	80.4	127.8
250	83.2	84.5	82.2	80.7	79.0	77.7	77.7	77.4	77.0	80.4	81.9	82.5	83.4	83.7	83.4	82.4	81.2	128.6
315	86.2	86.4	86.0	85.4	83.2	80.0	79.7	80.4	80.2	81.2	82.4	82.6	82.9	82.9	83.5	82.8	82.7	130.1
400	85.9	85.7	85.4	83.9	82.1	81.1	80.6	80.1	79.4	81.1	81.9	81.9	82.9	83.2	82.2	81.1	82.3	129.7
500	87.8	87.5	86.0	86.1	85.1	83.6	81.8	80.6	80.3	80.8	82.1	82.6	83.3	[illegible]	81.8	80.2	82.4	130.8
630	88.3	88.2	86.3	85.3	84.2	82.3	81.3	81.2	80.7	81.5	82.5	83.4	84.2	84.2	81.2	80.5	83.5	130.9
800	88.1	89.3	87.6	86.4	84.6	83.6	82.1	81.9	[illegible]	83.1	84.3	84.7	85.8	85.3	83.4	83.3	84.7	132.1
1000	87.6	88.8	87.9	87.4	86.6	83.9	83.3	83.4	81.4	84.8	85.8	86.0	86.6	85.4	83.7	83.6	85.7	133.1
1250	94.5	95.6	95.1	95.6	96.1	93.0	89.3	90.0	91.3	91.5	91.6	91.1	92.3	91.0	86.8	86.0	92.7	140.1
1600	90.0	91.1	91.8	90.0	89.0	86.3	84.9	86.0	[illegible]	88.8	89.6	89.1	90.5	89.1	84.5	84.5	88.7	136.1
2000	90.2	91.5	92.7	90.5	89.0	86.5	85.3	87.5	89.0	91.0	92.2	90.9	91.8	88.8	85.3	84.7	90.1	137.5
2500	93.4	95.3	95.8	94.4	92.6	90.8	89.3	91.8	93.4	95.9	97.6	100.4	100.6	94.6	91.6	92.0	96.2	143.6
3150	92.0	94.2	95.2	92.9	91.2	88.0	86.2	85.0	90.9	92.7	93.7	94.4	94.8	90.5	86.9	86.9	92.6	140.0
4000	94.4	98.7	101.1	98.7	94.5	90.6	87.2	88.0	90.5	92.0	95.1	93.7	95.7	91.0	87.7	85.8	95.1	142.5
5000	89.0	92.8	94.6	93.9	93.3	89.5	83.8	86.8	87.6	90.1	93.3	92.7	93.8	89.6	85.3	84.2	92.3	139.7
6300	88.1	91.3	92.7	92.1	89.9	86.4	82.1	84.7	87.1	88.4	90.9	90.6	93.4	90.1	84.5	82.3	91.0	138.4
8000	86.3	90.0	91.0	90.2	88.3	85.9	80.0	83.0	84.2	86.7	88.3	90.0	90.5	86.7	82.2	80.6	89.7	137.1
10000	83.3	86.6	87.1	87.5	84.8	83.6	76.9	79.6	81.3	83.4	85.3	85.8	88.3	84.1	78.3	76.8	87.6	135.0
12500	81.6	85.4	83.3	86.0	81.6	80.1	74.6	76.1	79.3	80.1	83.3	83.1	85.1	81.6	75.9	74.8	86.3	133.7
16000	76.4	79.4	78.8	80.1	77.4	74.2	69.5	70.2	72.4	73.7	77.0	77.1	78.7	76.1	71.4	69.0	82.4	129.8
20000	72.0	73.2	72.4	74.4	71.0	68.4	62.2	63.7	65.7	67.9	69.5	71.0	72.4	70.4	65.9	62.6	78.9	126.3
OVERALL	102.7	104.8	105.7	104.3	102.6	99.8	97.2	98.7	101.0	101.7	103.4	104.2	105.1	101.3	98.5	99.0	103.1	150.4

SIDELINE PERCEIVED NOISE LEVELS

DISTANCE	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
304.8 METERS	63.6	76.6	83.3	85.9	86.8	86.3	85.6	88.0	89.4	91.2	92.1	[illegible]	91.4	84.7	78.4	72.0

ORIGINAL PAGE IS OF POOR QUALITY

NOISE OF OF 5A CONFIGURATION 411
MODIFIED FAN QF-5A, CONF. 411 2.3 ROTOR/STATOR SPACING
SMALL CORE NOZ. 2.45 SQ. FT. , LARGE BYPASS NOZ. 10.92 SQ. FT.

888 70 PERCENT SPEED, FAN PHYSICAL SPEED - 2519 RPM, FUNDAMENTAL BLADE PASSAGE FREQUENCY - 1523 HZ

DATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 70 PERCENT RELATIVE HUMIDITY
SPL RE .00002 N/SQ M PWL RE .1 PICOWATT

1/3-OCTAVE BAND SOUND PRESSURE LEVEL (SPL) ON 30.5-METER RADIUS

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	AVERAGE SPL	POWER LEVEL (PWL)
50	76.5	72.3	74.6	75.3	76.0	77.0	75.5	77.3	76.6	78.3	78.1	78.7	80.1	81.6	83.8	85.2	78.8	126.2
63	72.3	74.5	73.0	73.0	72.6	73.6	73.6	74.5	76.0	77.1	77.8	78.1	81.1	83.3	84.6	85.8	78.7	126.1
80	74.9	75.0	73.7	73.8	74.7	74.5	75.7	74.7	75.5	78.3	80.2	81.1	83.7	85.8	88.0	88.6	81.1	128.5
100	78.5	78.0	78.1	77.1	76.3	78.1	78.0	79.0	80.8	82.5	83.8	84.6	86.8	88.8	90.3	90.0	84.0	131.4
125	85.9	86.3	85.3	84.6	84.6	83.8	84.3	83.8	83.6	84.4	85.3	86.7	87.3	88.4	89.8	89.2	85.8	133.2
160	88.6	87.6	88.5	86.6	84.6	85.6	85.8	84.3	84.[illegible]	84.1	84.1	84.7	85.0	86.0	86.1	87.4	85.7	133.1
200	92.1	90.8	89.1	87.5	86.3	85.3	83.6	83.5	82.5	81.8	83.1	83.4	85.6	87.1	87.6	86.3	85.7	133.1
250	86.2	87.0	84.9	83.4	81.7	81.9	81.0	82.0	83.2	84.7	85.2	86.1	87.4	88.9	88.5	86.3	85.1	132.5
315	87.5	88.9	87.4	86.7	84.4	83.5	83.7	84.7	84.8	84.7	85.2	86.3	87.5	88.7	88.4	87.4	86.1	133.5
400	88.3	88.1	87.0	86.0	85.1	84.6	84.0	83.6	83.6	85.0	85.6	86.4	88.0	88.5	88.1	86.0	86.1	133.5
500	89.3	90.4	88.7	[illegible].1	87.4	86.4	85.3	84.4	84.2	85.1	85.4	86.5	87.4	87.8	86.9	86.0	86.8	134.2
630	89.9	91.6	89.6	85.3	88.6	86.9	85.6	84.9	85.1	85.8	86.1	86.9	88.4	87.8	86.1	86.0	87.4	134.8
800	91.0	92.7	90.2	90.0	88.[illegible]	87.8	86.5	86.2	86.0	86.8	88.0	88.4	89.7	89.5	88.0	87.6	88.5	135.9
1000	89.5	90.1	90.8	90.7	89.2	87.5	87.5	86.9	87.2	88.3	88.8	89.1	90.0	89.1	87.0	86.4	88.8	136.2
1250	90.7	92.4	92.4	92.2	91.2	88.9	87.4	87.7	89.1	90.1	90.7	90.5	91.6	89.2	87.2	86.8	90.3	137.7
1600	96.0	100.0	100.4	101.7	102.9	99.5	95.2	94.2	95.9	96.2	96.7	96.8	97.7	93.9	91.2	91.1	98.1	145.5
2000	91.7	93.4	94.2	93.4	92.7	90.7	89.1	90.8	93.1	93.9	94.8	94.0	94.1	90.8	88.8	88.5	93.0	140.4
2500	92.3	95.0	94.4	94.1	93.6	91.3	90.1	92.8	94.1	96.1	96.6	97.7	97.0	91.5	89.0	89.2	94.9	142.3
3150	96.4	98.7	99.7	99.2	99.7	96.7	94.0	95.0	97.2	99.0	101.4	107.8	107.7	97.2	94.0	95.1	102.1	149.5
4000	93.8	96.6	98.7	96.8	94.3	92.1	89.5	91.1	93.6	95.3	98.8	98.2	99.0	97.6	90.1	87.7	96.3	143.7
5000	94.3	97.8	99.0	97.3	96.8	93.0	88.5	90.8	92.1	94.6	97.8	97.2	97.0	92.1	89.0	87.9	96.3	143.7
6300	91.5	96.7	93.0	97.9	97.3	93.8	88.7	89.4	92.4	93.5	96.2	95.7	97.2	92.8	88.4	85.8	96.3	143.7
8000	89.3	93.7	95.0	95.2	95.2	92.4	85.6	86.0	89.3	91.2	93.0	94.8	94.7	90.5	85.8	85.0	94.6	142.0
10000	86.8	91.2	90.8	92.7	91.0	90.0	83.2	84.6	86.5	89.0	90.3	91.1	92.3	87.8	82.3	81.1	92.6	140.0
12500	85.1	89.9	87.1	91.2	88.8	86.8	80.6	81.6	84.7	85.6	88.7	89.2	90.0	85.3	80.2	78.9	91.7	139.1
16000	80.3	84.3	84.0	85.6	84.5	81.1	75.0	75.1	78.0	79.3	83.0	83.7	83.8	80.7	75.7	73.4	88.1	135.5
20000	75.2	78.3	76.8	80.3	78.6	75.3	68.6	69.1	71.3	73.7	75.8	77.4	77.3	74.5	70.5	66.7	84.7	132.1
OVERALL	104.7	107.4	107.8	107.6	107.6	104.5	101.7	102.3	104.0	105.4	107.3	110.0	110.2	104.3	102.4	102.1	107.3	154.7

SIDELINE PERCEIVED NOISE LEVELS

DISTANCE	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
304.8 METERS	85.9	80.4	86.2	90.0	92.7	91.1	89.9	91.4	93.3	94.5	95.7	98.3	96.6	87.4	81.3	74.9

NOISE OF QCSEE CONFIGURATION 411
MODIFIED FAN QF-5A, CONF. 411 2.3 ROTOR/STATOR SPACING
SMALL CORE NOZ. 2.45 SQ. FT. , LARGE BYPASS NOZ. 10.42 SQ. FT.

888 80 PERCENT SPEED, FAN PHYSICAL SPEED - 2931 RPM, FUNDAMENTAL BLADE PASSAGE FREQUENCY - 1740 HZ

DATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 70 PERCENT RELATIVE HUMIDITY
SPL RE .00002 N/SQ M PWL RE .1 PICOWATT

1/3-OCTAVE BAND SOUND PRESSURE LEVEL (SPL) ON 30.5-METER RADIUS

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	AVERAGE SPL	POWER LEVEL (PWL)
50	86.7	83.6	81.1	86.6	81.9	82.7	80.6	81.4	80.4	81.2	84.0	83.5	84.7	85.7	88.9	87.8	84.1	131.5
63	75.4	77.4	75.9	76.7	76.9	77.6	79.1	77.4	78.6	79.7	[illegible]	82.6	85.4	87.2	89.4	90.1	82.7	130.4
80	76.9	77.4	75.4	74.9	75.4	76.4	77.1	77.8	78.1	81.4	83.4	85.9	88.3	90.1	92.1	93.3	85.2	132.6
100	82.6	80.2	80.6	82.2	80.6	81.1	82.4	82.9	84.2	86.2	87.4	89.7	91.1	92.9	94.4	94.8	88.2	135.6
125	86.9	85.2	85.7	85.2	84.7	85.2	85.2	86.7	86.7	87.7	88.9	90.0	91.7	92.4	93.4	92.9	88.7	136.1
160	90.8	90.4	91.8	89.1	88.9	88.6	88.1	87.1	86.9	87.1	87.6	88.7	89.1	90.4	90.4	91.3	88.9	136.3
200	95.8	95.1	91.3	90.1	90.3	88.1	87.0	86.1	85.0	85.5	87.0	88.4	90.1	91.6	92.1	91.0	89.5	136.9
250	90.4	90.2	88.2	86.6	85.2	85.2	84.9	85.2	86.9	87.6	88.4	90.2	90.7	91.6	91.7	90.0	88.5	135.9
315	87.6	88.6	88.3	87.5	87.5	88.1	87.5	88.1	87.8	89.1	89.0	90.4	91.5	90.3	91.6	89.9	89.2	136.6
400	90.2	90.1	89.4	89.4	88.9	88.9	87.4	87.4	87.9	89.2	90.2	90.8	91.9	93.7	93.1	91.4	90.2	137.6
500	89.7	92.1	91.1	90.9	91.4	89.9	88.2	89.1	88.6	91.1	91.1	91.2	91.4	93.1	91.2	90.1	90.7	138.1
630	92.9	94.9	93.4	93.7	93.4	92.6	90.7	89.4	89.4	90.6	91.1	91.3	92.1	91.9	91.6	91.1	91.9	139.1
800	92.9	95.8	93.8	94.4	94.1	94.1	91.3	92.0	90.3	91.1	92.1	92.5	93.6	93.1	91.6	91.7	92.9	140.3
1000	91.8	94.8	94.3	95.1	94.9	93.6	92.6	91.9	91.6	91.8	93.1	93.5	93.4	92.6	91.1	90.6	93.2	140.6
1250	91.4	93.4	93.7	93.9	93.7	92.2	91.2	91.6	92.2	92.7	94.0	94.0	94.0	91.4	90.5	90.3	93.0	140.4
1600	98.6	102.4	105.9	105.8	105.4	101.9	100.4	100.1	100.3	99.9	99.9	98.4	99.3	95.4	94.8	95.2	101.7	149.1
2000	96.6	99.6	102.9	102.9	102.2	99.7	97.4	98.2	98.7	99.2	99.4	98.3	98.1	94.6	94.4	94.0	99.7	147.1
2500	92.9	95.7	96.7	95.7	95.9	94.9	93.7	96.4	97.2	98.9	99.2	98.7	97.6	93.1	91.6	91.5	97.1	144.5
3150	97.7	99.6	102.1	101.3	100.8	98.5	98.0	100.0	100.1	104.6	107.5	104.7	106.1	99.0	96.6	96.2	103.3	150.7
4000	96.0	98.5	100.6	99.5	98.6	96.6	95.8	97.5	98.7	107.1	105.8	103.2	104.5	99.8	96.6	94.9	101.8	149.2
5000	94.2	98.5	99.2	98.9	98.4	96.4	92.9	95.7	95.9	99.2	102.4	100.6	99.4	94.4	92.2	91.4	99.3	146.7
6300	93.2	97.6	98.9	98.1	98.3	94.8	92.8	94.6	96.9	98.6	101.1	100.1	101.1	95.8	93.3	91.2	99.5	146.9
8000	91.0	95.5	97.2	96.5	96.5	94.5	91.0	93.2	94.7	96.7	99.5	99.5	99.4	95.5	92.7	90.7	98.7	146.1
10000	87.9	92.2	93.0	94.1	92.4	92.1	88.6	90.2	91.7	94.4	96.7	95.7	96.1	91.9	86.8	86.2	96.5	143.9
12500	86.1	91.1	89.7	92.6	90.3	89.4	86.6	87.4	89.9	91.9	95.0	94.2	94.2	90.1	85.1	84.2	95.9	143.3
16000	81.7	85.7	85.9	87.5	86.5	84.3	80.8	81.5	84.3	86.5	90.2	89.4	89.3	85.2	82.0	79.8	92.9	140.3
20000	76.5	79.6	80.1	82.5	81.0	78.8	74.8	76.0	77.8	81.5	84.1	83.8	84.0	80.8	76.8	73.0	90.0	137.4
OVERALL	106.7	109.4	111.2	110.9	110.5	108.2	106.5	107.6	108.1	110.3	112.7	111.0	111.7	107.9	106.6	106.0	110.7	158.1

SIDELINE PERCEIVED NOISE LEVELS

DISTANCE																	
304.8	METERS	68.3	82.8	90.5	93.8	95.8	94.9	94.5	96.[illegible]	96.8	99.5	101.0	98.1	97.2	90.2	84.9	78.9

NOISE OF CF 5A CONFIGURATION 411
MODIFIED FAN CF-5A, CONF. 411 2.3 ROTOR/STATOR SPACING
SMALL CORE NOZ. 2.45 SQ. FT. , LARGE BYPASS NOZ. 10.92 SQ. FT.

888 85 PERCENT SPEED, FAN PHYSICAL SPEED - 3083 RPM, FUNDAMENTAL BLADE PASSAGE FREQUENCY - 1849 HZ

DATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 70 PERCENT RELATIVE HUMIDITY
SPL RE .00002 N/SQ M PWL RE .1 PICOWATT

1/3-OCTAVE BAND SOUND PRESSURE LEVEL (SPL) ON 30.5-METER RADIUS

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	AVERAGE SPL	POWER LEVEL (PWL)
50	83.5	80.5	80.2	82.9	78.7	84.4	81.9	85.2	83.4	84.5	84.4	85.6	87.5	88.5	90.5	92.7	85.7	133.1
63	77.4	78.8	78.6	78.3	77.9	78.4	79.6	79.4	79.8	81.3	82.6	84.7	87.3	89.4	91.9	93.3	85.0	132.4
80	79.7	79.2	76.4	77.1	76.7	77.7	77.6	79.1	80.7	83.1	85.2	87.3	90.2	92.6	94.4	95.8	87.3	134.7
100	85.1	81.9	82.2	82.2	80.4	82.1	82.7	84.2	85.4	87.4	89.1	91.0	93.6	95.4	96.7	97.1	90.2	137.6
125	86.6	85.6	87.1	87.0	85.8	86.5	86.1	87.5	86.3	89.8	91.3	91.7	93.6	94.3	95.8	95.7	90.7	138.1
160	91.6	92.7	93.2	91.1	90.6	89.4	89.7	88.6	88.4	88.9	88.7	90.2	90.7	92.4	92.9	94.0	90.6	138.0
200	98.4	97.6	94.1	91.4	91.9	89.9	88.4	87.4	86.1	86.9	88.2	89.7	92.2	94.1	94.4	93.4	91.5	138.9
250	93.3	93.0	90.0	88.1	87.5	87.1	86.6	88.1	86.6	89.5	90.1	91.4	92.8	94.0	94.0	93.0	90.5	137.9
315	88.5	89.6	89.5	89.1	89.5	89.5	89.5	90.0	89.5	90.0	90.5	92.0	93.1	94.3	93.5	91.8	90.9	138.3
400	90.7	91.0	90.5	90.5	89.7	89.4	89.5	89.5	90.2	90.4	91.4	92.6	94.2	96.4	94.7	93.1	91.9	139.3
500	91.0	92.8	92.0	91.2	91.2	90.7	90.5	89.7	89.5	90.5	91.5	92.3	93.8	94.5	94.0	92.1	91.8	139.2
630	95.1	96.2	93.7	93.2	93.2	92.7	91.4	90.7	90.9	91.7	92.7	93.3	94.4	94.6	93.9	92.8	93.1	140.5
800	93.9	95.4	96.9	97.6	96.0	95.6	94.9	94.1	92.1	93.1	94.3	95.9	95.4	94.9	93.4	94.0	95.2	142.6
1000	93.1	95.7	96.7	97.6	96.7	94.6	94.4	94.2	93.2	94.1	95.4	96.2	96.2	94.6	92.9	93.[illegible]	95.3	142.7
1250	92.6	94.3	94.8	95.4	95.4	94.8	93.4	93.8	94.6	95.3	96.8	96.9	96.8	93.9	93.4	92.8	95.3	142.7
1600	94.3	96.8	99.5	100.5	100.7	98.5	96.3	97.0	98.8	96.6	99.0	98.2	98.6	94.6	94.5	93.7	98.4	145.8
2000	99.4	102.7	105.4	104.2	107.7	105.2	102.2	107.7	104.7	103.7	103.7	101.8	101.6	96.6	97.7	97.0	104.3	151.7
2500	93.2	96.0	97.0	96.4	97.0	96.0	95.2	98.4	99.7	100.4	100.9	100.0	98.9	94.9	93.9	93.8	98.6	146.0
3150	95.1	97.8	98.9	98.4	98.4	97.6	96.9	99.1	101.4	102.4	103.9	103.4	102.3	96.9	95.6	94.8	101.1	148.5
4000	97.6	100.7	102.9	101.9	101.7	100.2	98.9	99.2	102.7	103.2	107.7	106.3	106.9	101.2	99.9	98.0	104.2	151.6
5000	93.7	96.1	96.7	97.7	97.6	96.4	94.1	96.9	98.4	100.6	102.9	102.2	100.6	96.1	93.4	92.8	100.0	147.4
6300	93.2	96.1	96.6	97.4	96.9	95.6	94.1	96.2	99.2	100.1	102.1	101.4	101.8	97.4	93.9	92.0	100.3	147.7
8000	92.0	96.2	96.9	97.4	97.5	96.7	93.5	96.0	97.5	99.5	107.1	103.9	103.9	99.5	95.2	93.7	101.7	149.1
10000	88.2	91.6	92.0	94.1	93.2	93.2	90.6	92.7	94.6	96.6	101.1	99.2	99.4	95.6	90.7	89.7	99.3	146.7
12500	85.9	90.1	87.7	92.5	89.9	90.0	88.2	89.5	93.1	94.0	97.5	96.4	97.0	92.4	87.7	86.2	97.8	145.2
16000	80.9	84.2	84.1	87.6	86.4	85.1	83.0	83.9	87.2	88.7	93.2	92.3	91.9	88.2	83.9	81.7	95.0	142.4
20000	75.8	78.3	78.0	81.8	80.5	79.8	77.0	78.3	81.5	83.7	87.8	87.7	87.2	83.4	78.9	75.2	92.6	140.0
OVERALL	107.3	109.5	110.7	111.8	111.4	109.7	107.9	108.9	110.8	111.3	113.4	112.9	112.9	109.7	108.6	108.0	112.0	159.4

SIDELINE PERCEIVED NOISE LEVELS

DISTANCE	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
304.8 METERS	69.5	83.3	90.7	95.8	97.6	97.6	96.6	97.9	99.7	99.5	100.8	98.9	97.3	91.6	87.3	80.9

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NOISE OF OF **5A** CONFIGURATION 411

MODIFIED FAN QF-5A, CONF. 411 2.3 ROTOR/STATOR SPACING

SMALL CORE NOZ. 2.45 SQ. FT. , LARGE BYPASS NOZ. 10.92 SQ. FT.

600 90 PERCENT SPEED, FAN PHYSICAL SPEED - 3264 RPM, FUNDAMENTAL BLADE PASSAGE FREQUENCY - 1958 HZ

DATA ADJUSTED TO STANDARD DAY OF 15 DEGREES C, 70 PERCENT RELATIVE HUMIDITY

SPL RE .00002 N/SQ M PWL RE .1 PICOWATT

1/3-OCTAVE BAND SOUND PRESSURE LEVEL (SPL) ON 30.5-METER RADIUS

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	AVERAGE SPL	POWER LEVEL (PWL)
50	84.9	80.2	83.9	83.2	84.0	84.7	84.2	86.9	85.5	86.7	86.0	86.5	88.0	90.2	92.7	94.6	87.4	134.8
63	79.7	80.5	80.7	80.3	80.3	81.3	81.0	82.5	82.2	83.5	85.5	86.3	88.8	91.3	94.0	95.7	87.1	134.5
80	80.6	79.6	78.6	79.1	79.2	79.6	79.4	81.1	82.4	84.9	87.4	89.5	92.2	94.4	96.9	98.3	89.5	136.9
100	86.2	85.4	87.2	87.7	84.7	85.7	85.0	86.7	88.2	89.7	91.2	93.8	95.7	97.0	99.4	99.4	92.6	140.0
125	87.9	86.9	89.4	87.5	86.5	87.4	87.7	88.9	87.4	90.5	91.9	93.4	95.2	96.2	98.0	97.2	92.7	139.6
160	93.9	94.6	95.1	92.1	92.4	91.1	91.2	89.7	87.9	90.2	90.7	92.3	93.2	94.2	95.6	95.4	92.4	139.8
200	104.1	99.9	98.1	93.7	94.1	91.9	89.9	89.4	85.6	89.4	92.1	92.2	93.7	96.7	97.1	96.6	94.4	141.2
250	98.9	96.1	94.7	90.9	91.1	89.7	89.4	90.8	90.4	91.3	92.8	93.5	95.1	96.2	96.6	95.1	93.2	140.6
315	91.1	91.1	90.6	89.8	90.6	90.3	90.4	91.4	91.3	91.[illegible]	91.9	93.7	95.1	95.4	95.6	94.1	92.4	139.6
400	91.3	91.5	91.3	90.8	90.3	91.3	91.6	91.1	91.1	92.3	93.1	94.7	96.5	97.8	96.3	94.4	93.5	140.9
500	93.0	94.2	93.0	92.2	92.3	91.8	91.0	91.2	9[illegible].5	92.7	93.0	94.8	95.[illegible]	95.5	96.[illegible]	94.1	[illegible]	[illegible]
630	97.1	97.6	94.7	95.1	94.4	94.7	92.9	92.7	9[illegible].7	93.7	94.6	95.5	96.6	96.7	96.9	95.3	95.0	142.4
800	97.0	99.5	100.0	98.7	98.5	100.0	96.7	98.3	9[illegible]	95.3	96.8	98.3	98.0	96.7	97.3	96.9	97.9	145.3
1000	95.1	99.0	99.5	98.5	97.8	98.3	96.5	97.0	95.5	96.3	97.5	99.2	98.3	96.6	96.1	96.0	97.8	145.0
1250	93.7	95.5	96.7	96.9	96.7	95.9	95.4	95.9	96.0	97.2	98.7	99.5	98.4	95.5	95.4	94.8	97.1	144.5
1600	94.9	97.1	98.4	98.4	98.7	97.4	96.7	97.1	98.9	99.1	100.2	99.8	99.6	95.7	95.6	94.9	98.5	145.9
2000	103.9	105.2	108.9	110.0	109.5	107.5	103.2	103.4	10[illegible].5	106.0	105.0	103.5	102.5	100.2	99.9	99.4	106.2	153.6
2500	94.4	96.5	98.0	99.4	98.5	98.0	97.5	100.4	101.4	102.7	107.9	102.1	100.2	96.7	95.4	95.6	100.5	147.9
3150	94.6	97.3	98.8	98.5	98.3	98.5	99.0	101.3	103.3	104.1	105.1	104.9	103.0	99.0	96.5	96.4	102.4	149.8
4000	98.5	100.5	103.5	103.5	101.9	101.7	99.2	101.0	103.5	106.2	108.9	108.8	109.7	101.0	99.9	97.9	105.9	153.3
5000	92.3	94.5	95.8	97.0	97.0	97.1	96.0	98.8	100.3	102.5	104.8	103.8	101.6	97.8	95.3	94.2	101.4	148.8
6300	94.3	96.3	97.8	99.5	98.7	97.5	96.8	98.7	101.0	102.2	103.7	103.1	102.2	98.3	95.0	93.4	101.9	149.3
8000	92.1	94.1	95.7	97.2	96.7	96.8	95.1	97.4	99.3	101.6	107.6	104.6	102.9	99.0	98.9	93.6	102.1	149.5
10000	88.2	90.7	91.4	94.2	92.7	94.3	92.7	94.5	97.4	99.7	102.0	100.7	100.2	96.9	92.0	91.2	100.7	148.1
12500	86.6	89.2	87.5	93.0	89.7	91.0	90.9	91.7	95.4	96.9	99.4	99.0	98.7	94.4	89.9	88.6	99.8	147.2
16000	81.0	83.3	83.2	87.5	85.9	85.7	85.5	86.2	91.0	97.0	94.7	94.6	92.9	89.4	85.0	83.1	96.7	144.1
20000	75.8	77.3	77.1	82.1	80.1	80.3	80.1	81.2	84.3	87.9	89.5	90.4	88.6	84.6	80.7	76.7	94.7	142.1
OVERALL	110.2	110.8	112.6	113.0	112.5	111.5	109.3	110.6	111.9	117.5	114.9	114.9	114.4	111.0	110.4	109.9	113.6	161.0

SIDELINE PERCEIVED NOISE LEVELS

DISTANCE	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160
304.8 METERS	73.7	85.2	93.2	97.2	99.2	99.5	97.9	99.3	101.4	101.6	102.3	101.1	99.4	93.1	89.0	83.1

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6. Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity. Aerospace Recommended Practice 866A, 1977, SAE.

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TABLE I. - DESIGN CHARACTERISTICS OF

QF-5A AND QF-5 FAN

Corrected flow, kg/sec (lb/sec)	385.9 (850)
Corrected fan speed, rpm	3630
Corrected tip speed, m/sec (ft/sec)	332.5 (1090)
Bypass pressure ratio	1.60
Core pressure ratio	1.45
Predicted bypass efficiency	0.870
Predicted core efficiency	0.872
Bypass ratio	5.40

TABLE II. - PHYSICAL CHARACTERISTICS OF QF-5A AND QF-5 FAN

Blade parameter	Rotor	Fan stator	Core stator	New core stator QF-5A fan
Number	36	88	88	88
Chord, m (in.):				
Hub	0.17 (6.65)	0.10 (4.0)	0.08 (3.0)	0.05 (1.88)
Midspan	.19 (7.65)	.10 (4.0)	.08 (3.0)	.05 (1.88)
Tip	.21 (8.12)	.10 (4.0)	.08 (3.0)	.05 (1.88)
Aspect ratio:				
Hub	2.65	2.74	1.12	1.83
Tip	2.17	2.74	1.12	1.83
Solidity:				
Hub	2.36	2.35	2.35	1.46
Tip	1.38	1.63	1.95	1.24

TABLE III. - AERODYNAMIC PERFORMANCE

Config-uration	Percent design speed	Corrected total mass flow		Bypass flow				Core flow			Bypass ratio	Bypass exit velocity		Corrected thrust	
				Corrected mass flow		Pressure ratio	Efficiency	Corrected[a] mass flow		Pressure ratio					
		kg/sec	lbm/sec	kg/sec	lbm/sec			kg/sec	lbm/sec			m/sec	ft/sec	N	lbf
Fan QF-5	60	231	510	207	456	1.198	N.A.	24	54	1.126	8.44	147	481	32272	7255
	70	271	597	241	532	1.275	N.A.	29	65	1.173	8.18	170	559	44309	9961
	80	313	691	279	614	1.374	N.A.	35	77	1.263	7.97	193	634	58975	13258
	85	335	738	298	656	1.431	N.A.	37	82	1.268	8.00	205	673	67328	15136
Fan QF-5A	60	229	505	195	431	1.182	0.960	34	74	1.124	5.82	144	474	30337	6820
	70	269	593	228	503	1.252	.944	41	90	1.170	5.59	168	552	41591	9350
	80	307	677	261	576	1.337	.922	46	101	1.227	5.70	191	627	54789	12317
	85	327	720	278	612	1.386	.914	49	108	1.257	5.67	203	665	62039	13947
	90	345	761	294	648	1.436	.901	51	113	1.293	5.73	210	688	69521	15629

[a]Corrected core flow calculated as difference between inlet and bypass airflows.

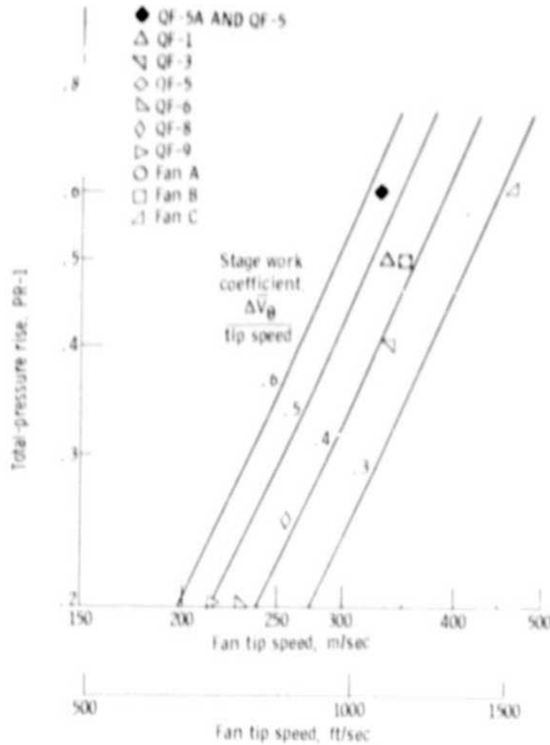


Figure 1. - Matrix of fan design parameters.

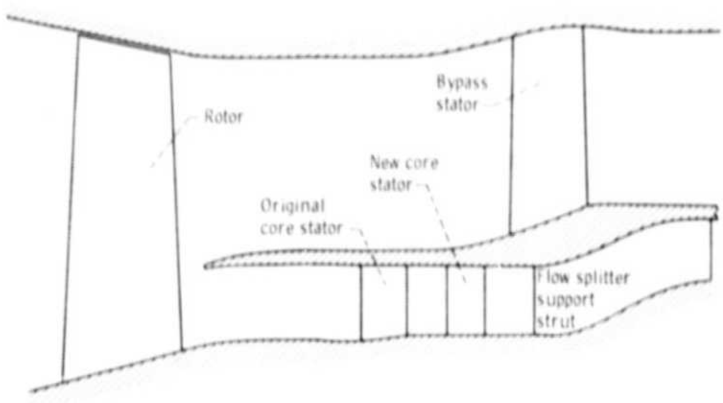
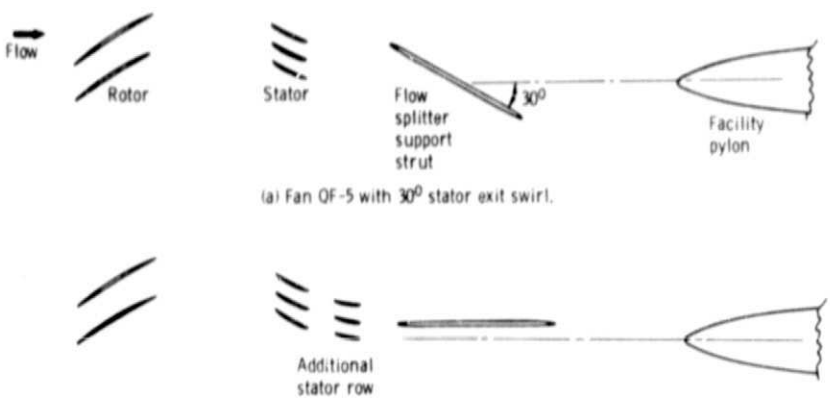


Figure 2. - Stage cross-section showing new core stator of fan QF-5A.



(a) Fan QF-5 with 30° stator exit swirl.

(b) Fan QF-5A showing additional stator to restore flow to axial direction and realignment of flow splitter support struts.

Figure 3. - Blade and support structure locations on unwrapped core flow surface (view toward hub).

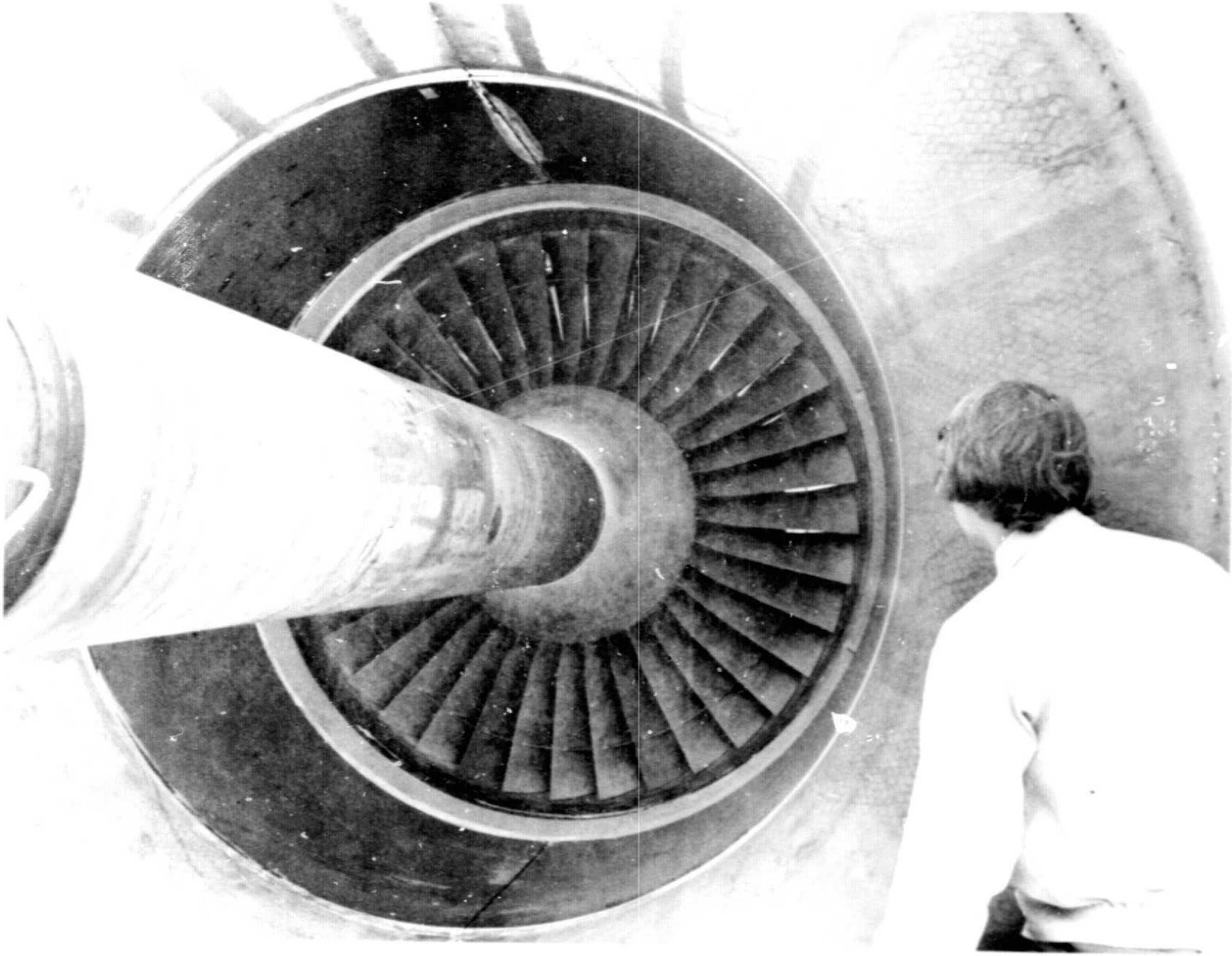


Figure 4. - Inlet view of fan QF-5 rotor.

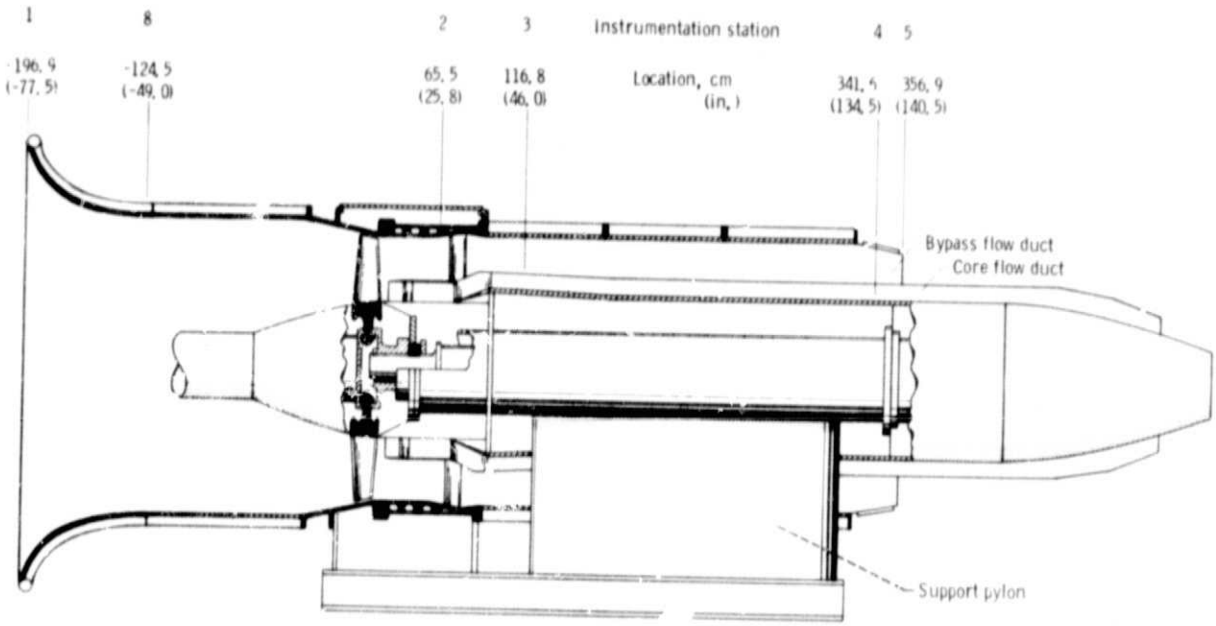


Figure 5. - Fan QF-5 stage cross-section.

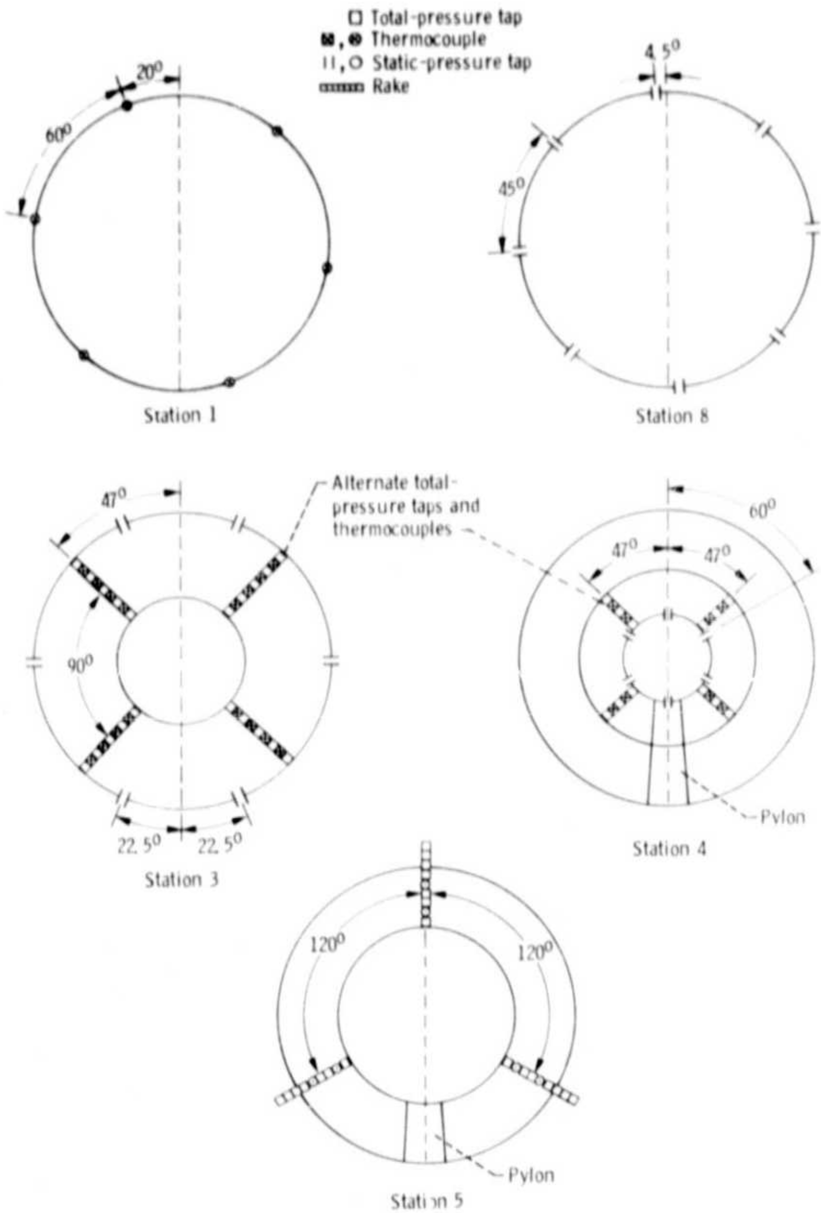
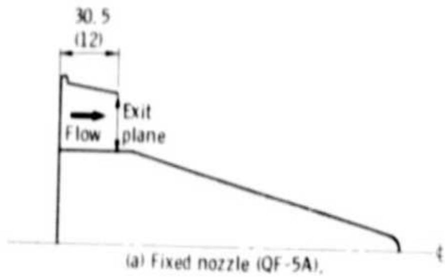
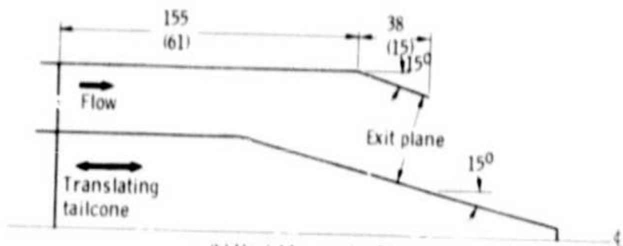


Figure 6. - Radial locations of fan aerodynamic instrumentation at numbered axial stations (ref. fig. 5) sketch not to scale.



(a) Fixed nozzle (QF-5A).



(b) Variable nozzle (QF-5).

Figure 7. - Comparison of core exhaust nozzles used on fans QF-5 and QF-5A. (All dimensions are in cm (in.).)

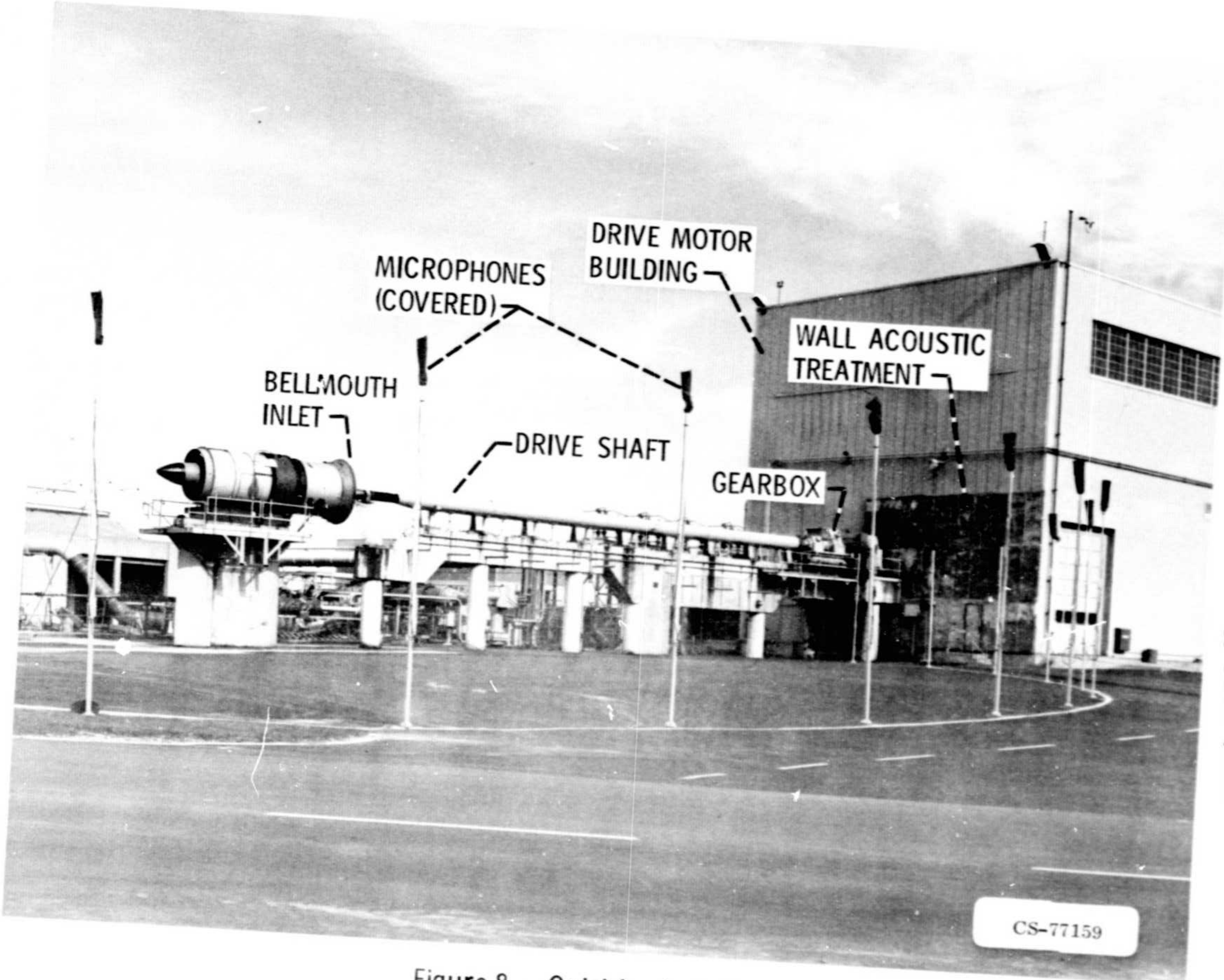


Figure 8. - Quiet fan test site.

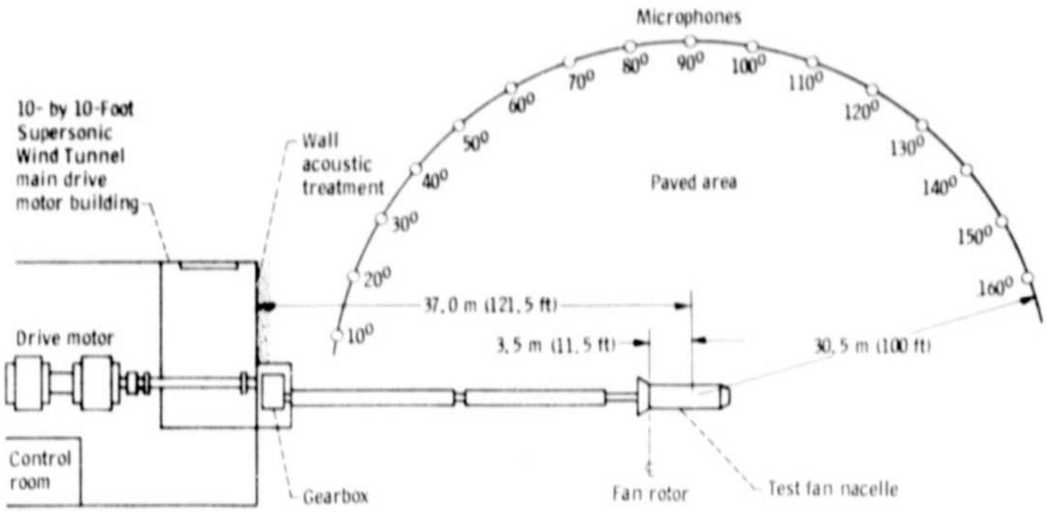


Figure 9. - Plan view of quiet fan facility.

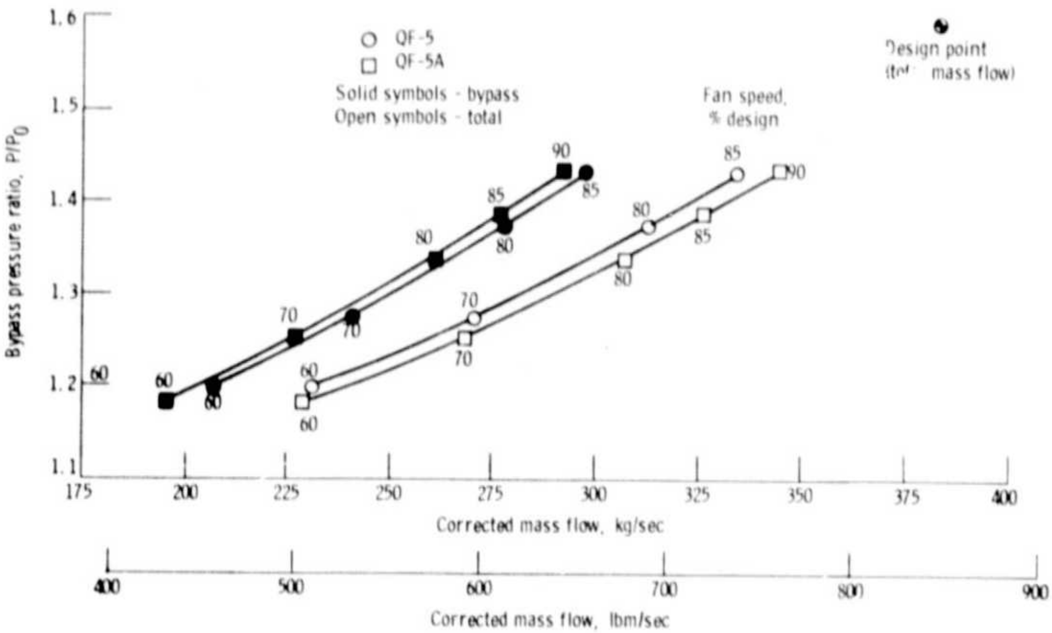


Figure 10. - Fan operating map.

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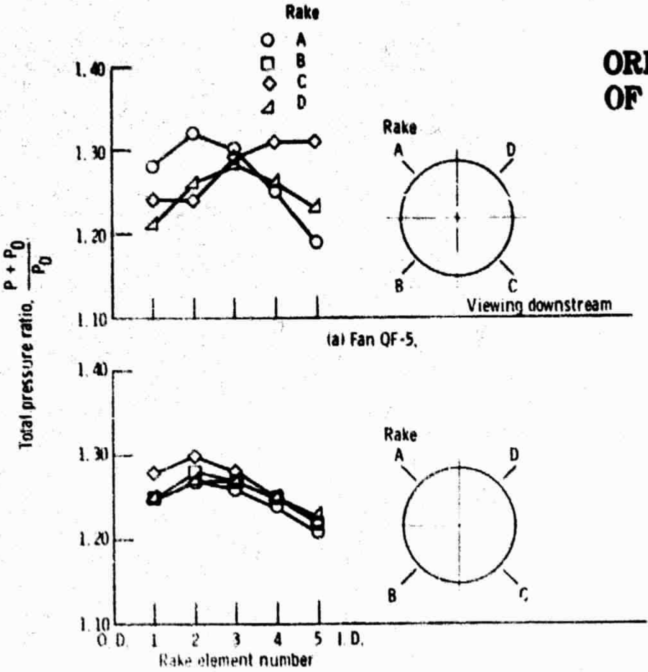
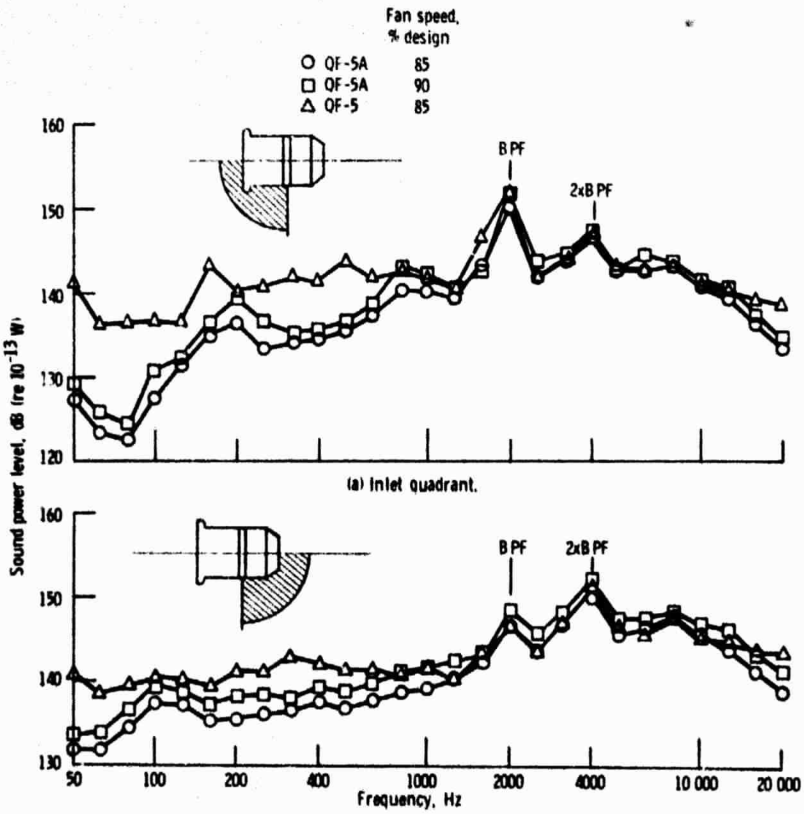


(a) Fan QF-5.

(b) Fan QF-5A.

Figure 11. - Core stator total pressure distribution (station 4) 85 percent design fan speed.



(a) Inlet quadrant.

(b) Aft quadrant.

Figure 12. - Sound power level spectra.

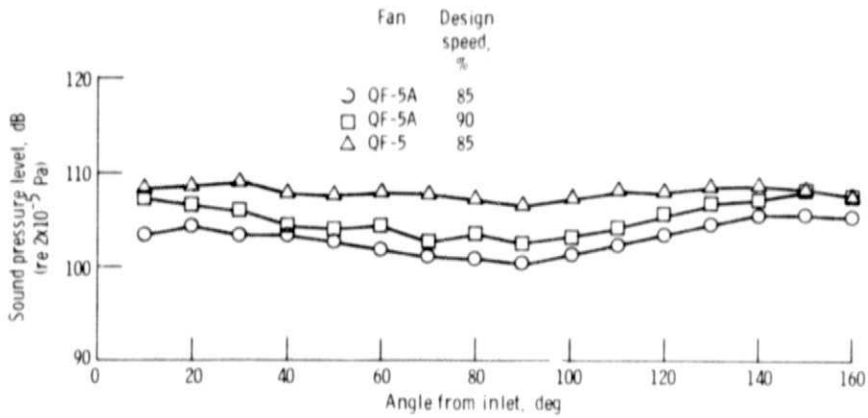


Figure 13. - Sound pressure level (50 to 1000 Hz) directivity.