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RESULTS OF ACOUSTICAL SURVEY OF SA-2 LAUNCH

By

Wade D. Dorland and Richard N. Tedrick

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GEORGE C. MARSHALL SPACE FLIGHT CENTER

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ABSTRACT

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A comprehensive program of sound measurements was made for the launch of Saturn Vehicle, SA-2, on April 25, 1962. Some 50 measurements were made at the launch pad, within the launch complex, and at ranges up to 20 miles to obtain an evaluation of the noise environments produced during the launch. The measurements were made with facilities of both Test Division and the Launch Operations Directorate of MSFC thereby utilizing the unique capabilities of both organizations to allow sufficient redundancy and diversity of data to adequately describe the characteristics of the noise.

The data obtained from the measurements made by Test Division, which is presented herein, is processed to show the variations of the sound levels in relation to both time and frequency during the launch. While the vehicle was restrained on the launch pedestal, sound pressure levels (SPL's) of 145 to 150 decibels (db) were measured on the pedestal and at a 150-ft radius from the vehicle. Levels in the underground utility rooms were in the range of 110 to 116 db. On the complex, beyond the pad, levels of 120 to 145 db were found during the restrained phase of the flight, but after liftoff, the levels reached a maximum, in the range of 134 to 144 db, when the lobe of most intense radiation passed over the individual measurement sites.

The frequency spectra for measurements on the 600-ft radius from pad center generally peaked between 125 and 500 cps, and the peak was below 100 cps for the measurements on the 1200-ft radius. The "on pad" directivity pattern of the sound propagation was a maximum between 70 and 90 degrees from either deflected exhaust, but the directivity during the launch was found to have its maximum 50 to 70 degrees from the exhaust (also vehicle) center line.

author

Complete processing of the measurements for the noise source characteristics revealed that the acoustic efficiency was approximately a 0.4 percentage, and that 20 to 40 megawatts of acoustic power was generated, mostly in the frequency range below 50 cps.

In general, the measured values of the characteristics of the sound during the launch were within the uncertainties of techniques presently employed for estimating noise environments; thus a basis for higher confidence in both estimation methods and measurement techniques used in evaluations of noise environments is now available.

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TEST DIVISION

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UNUSUAL TERMS

SOUND-FIELD - A region containing sound waves.

NEAR-FIELD - The part of the sound field in the immediate vicinity of the sound source. In general practice near field environments are found to be non-linear and dimensions are not large compared to the dimensions of the noise source. Thus the relative dimensions of the noise source cannot be considered to approximate a point. In this report the near field is somewhat arbitrarily considered to exist within 50 feet of the vehicle.

FAR-FIELD - That part of the sound field where the sound waves are propagated as if in a free sound field and where the wave front approximates a plane wave. Also the region is sufficiently far removed from the source such that it can be assumed that all the energy originates at a point and is radiated according to classical laws of physics. For purposes of reference, the acoustic far-field is arbitrarily divided into two subregions: the mid-field which is between 50 and 1500 feet from the source where free field conditions and inverse square law radiation are most likely to occur, and the far-field which is beyond 1500 feet where atmospheric heterogeneities and other diffusion effects have a considerable effect on measurement values.

NOISE FLOOR - The minimum RMS sound pressure level which can be measured due to background acoustic noise or internal electrical noise in the measurement system. In this report noise floors are analyzed in octave bands and the values are indicated by an X on the center frequency of the individual octave bands. Where the X is omitted, this indicates the value of the noise floor was less than the minimum value of SPL which can be plotted on the graph.

OCTAVE - A bandwidth in the frequency spectrum where the upper frequency limit is twice the lower frequency, usually identified by the center frequency.

ONE-THIRD OCTAVE - A band width of frequency where the upper frequency limit is 1.26 times the lower frequency, usually identified by the center frequency. The contigious bandwidths are arranged according to American Standard Preferred Frequencies for Acoustical Measurements, S1.6-1960.

RANGE TIME - The time in seconds after the beginning of the second during which liftoff of the vehicle occurred.

SOUND PRESSURE LEVEL (SPL) - The sound pressure level, in decibels, of an RMS sound pressure is 20 times the logarithm to the base 10 of the ratio of this pressure to a reference pressure of 0.0002 microbar.

POWER LEVEL (PWL) - The power level, in decibels, of an acoustic power is 10 times the logarithm to the base 10 of the ratio of the power to a reference power of 10^{-13} watts.

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SUMMARY

A comprehensive program of sound measurements was made for the launch of Saturn Vehicle, SA-2, on April 25, 1962. Some 50 measurements were made at the launch pad, within the launch complex, and at ranges up to 20 miles to obtain an evaluation of the noise environments produced during the launch. The measurements were made with facilities of both Test Division and the Launch Operations Directorate of MSFC thereby utilizing the unique capablities of both organizations to allow sufficient redundancy and diversity of data to adequately describe the characteristics of the noise.

The data obtained from the measurements made by Test Division, which is presented herein, is processed to show the variations of the sound levels in relation to both time and frequency during the launch. While the vehicle was restrained on the launch pedestal, sound pressure levels (SPL's) of 145 to 150 decibels (db) were measured on the pedestal and at a 150-ft radius from the vehicle. Levels in the underground utility rooms were in the range of 110 to 116 db. On the complex, beyond the pad, levels of 120 to 145 db were found during the restrained phase of the flight, but after liftoff, the levels reached a maximum, in the range of 134 to 144 db, when the lobe of most intense radiation passed over the individual measurement sites.

The frequency spectra for measurements on the 600-ft radius from pad center generally peaked between 125 and 500 cps, and the peak was below 100 cps for the measurements on the 1200-ft radius. The "on pad" directivity pattern of the sound propagation was a maximum between 70 and 90 degrees from either deflected exhaust, but the directivity during the launch was found to have its maximum 50 to 70 degrees from the exhaust (also vehicle) center line.

Complete processing of the measurements for the noise source characteristics revealed that the acoustic efficiency was approximately 0.4 percentage, and that 20 to 40 megawatts of acoustic power was generated, mostly in the frequency range below 50 cps.

In general, the measured values of the characteristics of the sound during the launch were within the uncertainties of techniques presently employed for estimating noise environments; thus a basis for higher confidence in both estimation methods and measurement techniques used in evaluations of noise environments is now available.

SECTION I. INTRODUCTION

As a part of the combined interagency Saturn Environmental Measurement Program, acoustic measurements were taken during the launch of Saturn flight vehicle, SA-2. Many of these measurements were taken with facilities of Test Division and were instituted to evaluate the characteristics of the launch environments, both within the launch complex and at long ranges. Accordingly, the data was processed to show the environments at particular locations and also to give generalized parameters of the characteristics of Saturn noise.

Results of these measurements are reasonably consistent with data obtained from the acoustical survey of SA-1 launch, and allows improved evaluation of the actual noise environments. Further, the empirical information now available concerning Saturn noise considerably reduces the uncertainties in procedures for estimating acoustic environmental values during test and launch operations of high-thrust rocket boosters.

SECTION II. PRESENTATION OF DATA

A. GENERAL

The measurements were made using standard techniques of acoustic instrumentation as discussed in References 1, 2, and 3. The locations of the microphones are listed in Table I. To convert the measurement recordings to useful data, they were processed to obtain the rms sound pressure level as a function of time and as a function of frequency in both octave and 1/3-octave band widths. The evaluation of the rms sound levels versus frequency was usually performed using averaging times 3 to 5 seconds long, and the limits of the averaging times in terms of range time is also presented in Table I.

The sound from a Saturn launch as a function of time is characterized by two distinct conditions. Between ignition of the engines and liftoff of the vehicle, the sound levels are relatively stable; thus, the data samples can be processed using an averaging time of approximately 3 seconds, which is long enough to allow a processing accuracy of $\pm$ 1 to 2 db for all octave bandwidths and the 1/3-octave bandwidths above 50 cps. The data obtained during this time, referred to as "on pad" conditions, while not as accurate as static test data, still allows a reasonably valid measure of the noise characteristics.

To obtain an equally valid evaluation of the noise characteristics of the Saturn after liftoff, a data sample was taken shortly after the liftoff time mark from those measurements which showed a stable interval of data during this time phase. These spectra referred to as "launch" data were averaged together and presented as spectrum levels and are the best available measure of the frequency distribution of the Saturn noise source in free-field conditions.

By correlating the missile position during the launch with the time history of the measured overall sound levels, the directivity pattern of the noise source was calculated with the technique discribed in detail in the SA-1 launch report (Ref. 1).

For "quick-look" purposes, the over-all levels of the measurements are presented in Table II, and the over-all characteristics of the noise source are given in Table III.

B. NEAR-FIELD ENVIRONMENTS

These measurement locations, as indicated on FIG. 1, were the same as utilized on the launch of SA-1, and methods for reducing the data were also repeated. The over-all time-history records and frequency spectrum plots for these measurements are shown in FIG. 2 through 7.

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C. MID-FIELD ENVIRONMENTS

The measurements were located as shown in FIG. 8 with the objective of measuring the "on-pad" conditions in a manner similar to static test evaluations. As will be discussed later, the results of

SA-1 measurements had shown certain inconsistencies in the data which could possibly have been due to the fact that the measurements were taken at various vertical elevations. To reduce these inconsistencies, the microphones were placed 6 ft above the pad level (termed "pad level" results) on the 600-ft radius and at 150 ft and 300 ft. Results of these measurements are presented in FIG. 9 through 31. The positions on the 1200-ft radius and at the 300-ft radius, Az 182°, 600-ft radius, Az 162° and Az 198°, had microphones positioned 6 ft above the grade level at each position. The data obtained from these microphones is referred to as "grade level" results. In general, the data from the SA-2 measurements was much more consistent than that from the SA-1 launch. It should be noted that the positions only 10° off the deflected exhaust centerline were subject to extreme turbulence during the launch operation and and very little valid data was obtained from these measurements.

Measurements were also made inside and outside the control blockhouse in complex 34 to evaluate the noise levels inside during the launch and to check the acoustic energy loss through the blockhouse walls. The data from these measurements is presented in FIG. 32, 33, and 34.

D. FAR-FIELD ENVIRONMENT

To investigate the variation of over-all sound pressure levels as a function of range from the source and meteorological conditions over the acoustic ray path, ten data collection points were established. As shown in FIG. 35, these points were chosen to fall along three azimuths running through the major population centers of Brevard County. Each station was equipped with a sound level meter, tape recorder, and radio timing receiver. The acoustic time histories as they were recorded are shown in FIG. 36 through 41 plotted against an arbitrary time scale based upon range timing. Zero seconds occurred at liftoff. Ignition occurred approximately two seconds earlier.

By utilizing the meteorological data from the launch-time rawinsonde release from Cape Canaveral and the surface weather measurements taken on Pad 34, acoustic velocity profiles have been calculated for each measurement azimuth. However, no significant focal conditions toward the far-field measuring points were noted, even though the levels were somewhat higher than during the launch of Saturn SA-1. The sound pressure levels fall off much as would be anticipated from classical acoustic propagation theory (including excess attenuation). No appreciable attenuation in excess of the inverse square law could be seen. This differs completely from the static test data (Ref. 4) where 4 db per mile appears to be standard. The maximum over-all SPL's measured at each far-field monitoring point are listed in Table II along with those from SA-1. Because of the directivity of the moving noise source, these levels cannot be considered to have originated at either the same time or trajectory position.

E. NOISE SOURCE CHARACTERISTICS

By processing the data from the individual measurements, certain derived, or generalized, results can be obtained which describe the noise source. By comparing these derived results, a convenient means for evaluating different noise sources is available. Therefore, the SA-2 data has been averaged and processed to show the power spectra, directivity patterns of the over-all noise radiation, spectrum level curve, and acoustic efficiency, which shows the percentage of kinetic jet stream power converted to acoustic power. This information is presented in Table III and in FIG. 44, 45, and 46, along with partial results of the Saturn static test survey and the SA-1 survey.

F. DIFFUSE FIELD EFFECTS

The results of sound measurements taken during the SA-1 launch indicated that certain discrepancies in the data had occurred which may have resulted from reflections and diffusions of the sound waves generated by the rocket exhausts. Because all the microphones used in the SA-1 survey were located 6 ft above the grade level at each mike location, the character of the terrain caused the mikes to be positioned at a variable elevation with respect to the pad surface. The microphones at 150 ft, angular coordinate (A.C.) 50° and 600 ft, A.C. 90° were both mounted 6 ft above the pad surface, but all others were lower, with the result that some pickups were slightly above the pad surface, and others were as much as 4 ft, below the pad surface. Also, sound levels sensed by the microphones at 300 ft, A.C. 50°, 600 ft, A.C. 30°, and 600 ft, A.C. 70° could be misleading because the sound waves at these locations might be diffused by large solid objects or reflecting surfaces which could cause local reflections or refractions.

To obtain a better estimate of the magnitude of these effects all measurements within 1000 ft of the launch pad center line were mounted 6 ft above the pad elevation for the SA-2 measurements. In addition the mikes located 6 ft above grade level at the previously mentioned positions were also used. The results of the measurements made at the two elevations at each of these three locations are presented in FIG. 47 and 48.

The plots show differences in the spectra in each case, but no consistent difference in the spectra are present in all the plots. Hence, it is likely that diffusion occurred at all three locations, but the local geometry at each position was slightly different thus causing the lack of consistency in the results. However, the over-all SPL's of the measurements on the 600-ft radius, as tabulated in Table II are much more consistent than the SA-1 results. Based on these

evaluations, it can be concluded that the SA-2 measurements allow a better evaluation of the sound fields present in LC-34 during the launch, and it can be recommended that all measurements within 600 ft of the pad center line be made at an elevation 6 ft above pad level for future launch surveys.

SECTION III. CONCLUSION

The acoustic data obtained from this survey is reasonably consistent with predicted environments and the results of the SA-2 launch. This data is particularly valuable in allowing improved evaluation of the actual noise environments and generalized characteristics of the Saturn vehicle as a moving noise source. Also sufficient redundancy of data is available to allow a high measure of confidence in the system for acquiring and reducing data used in surveys of Saturn static tests and launches.

TABLE I. TABULATION OF ACOUSTIC MEASUREMENT INFORMATION

MEASUREMENT LOCATION	SPECTRUM PLOT (Figure No.)	SAMPLE TIME (In Range Time In Seconds)	REMARKS
Near Field			
1. STA. 860, Umbilical Pole, High Range	None	None	
2. STA. 860, Umbilical Pole, Low Range	4	On Pad: T-2.5 to T+2 Launch: T+3.5 to T+5	
3. STA. 167, Umbilical Pole,	5	On Pad: T-1.5 to T+2	
4. Large Utility Room	6	On Pad: T-1 to T+2.5	
5. Small Utility Room	7	On Pad: T-1 to T+2.5	
6. "B" Platform, Umbilical Base	None		No Valid Data
Mid Field			
7. 150 Ft Az 82°, A.C. -50°	None		No Valid Data
8. 300 Ft Az 82°, A.C. -50°	None		No Valid Data
9. 600 Ft Az 82°, A.C. -50°	16	On Pad: T-1 to T+2.5 Launch: T+5 to T+9	
10. 600 Ft Az 102°, A.C. -30°	17	On Pad: T-1 to T+2.5 Launch: T+6 to T+10	
11. 600 Ft Az 122°, A.C. -10°	None		No Valid Data

TABLE I. CONT'D

MEASUREMENT LOCATION	SPECTRUM PLOT (Figure No.)	SAMPLE TIME (In Range Time In Seconds)	REMARKS
12. 1200 Ft Az 122°, A.C. -10°	28	Launch: T+7.5 to T+11	
13. 600 Ft AZ 142°, A.C. +10°	None		No Valid Data
14. 1200 Ft Az 142°, A. C. +10°	None		No Valid Data
15. 600 Ft Az 162°, A. C. +30°	18	On Pad: T-1 to T+2.5	
16. 600 Ft Az 162°, A.C. +30°	26	On Pad: T-1 to T+2.5	Grade Level
17. 150 Ft Az 182°, A.C. +50°	14	On Pad: T-1 to T+1	
18. 300 Ft Az 182°, A.C. +50°	15	On Pad: T-1 to T+2.5	
19. 300 Ft Az 182°, A.C. +50°	25	On Pad: T-1 to T+2 Launch: T+6 to T+9	Grade Level
20. 600 Ft Az 182°, A.C. +50°	19	On Pad: T-1 to T+2.5 Launch: T+6.5 to T+10	
21. 1200 Ft Az 162°, A.C. +30°	29	On Pad: T-0 to T+3 Launch: T+7 to T+10.5	Grade Level
22. 1200 Ft Az 182°, A.C. +50°	30	On Pad: T-0 to T+3.5 Launch: T+8 to T+11.5	Grade Level
23. 600 Ft Az 198°, A.C. +70°	20	On Pad: T-1 to T+2.5 Launch: T+5 to T+8.5	

TABLE I. CONT'D

MEASUREMENT LOCATION	SPECTRUM PLOT (Figure No.)	SAMPLE TIME (In Range Time In Seconds)	REMARKS
24. 600 Ft Az 198°, A.C. +70°	27	On Pad: T-1 to T+2.5 Launch: T+5 to T+8.5	Grade Level
25. 1200 Ft Az 198°, A. C. +70°	31	On Pad: T-0.5 to T+3 Launch: T+9 to T+12.5	Grade Level
26. 600 Ft Az 222°, A.C. +90°	21	On Pad: T-1 to T+2.5	
27. 600 Ft Az 242°, A.C. +110°	22	On Pad: T-1 to T+2.5 Launch: T+6.5 to T+8	
28. 600 Ft Az 262°, A.C. +130°	23	On Pad: T-1.5 to T+1.5 Launch: T+5 to T+7.5	
29. 600 Ft Az 282°, A.C. +150°	24	On Pad: T-1.5 to T+1.5 Launch: T+6 to T+9.5	
30. 600 Ft Az 302°, A.C. -170°	None		No Valid Data
31. Outside Blockhouse	33	On Pad: T-0.5 to T+3 Launch: T+8 to T+11.5	
32. Inside Blockhouse	34	On Pad: T+1 to T+3 Launch: T+10 to T+11	

TABLE II.
OVER-ALL ACOUSTIC LEVELS RESULTING FROM SATURN LAUNCHES

MICROPHONE LOCATION	OVER-ALL SOUND PRESSURE LEVELS DB (Re: 0.0002 Microbar)			
	ON PAD		LAUNCH MAXIMUM	
VEHICLE ENVIRONMENTAL MEASUREMENTS	SA-1	SA-2	SA-1	SA-2
Sta. 860, Umbilical Pole	147	145		
Sta. 167, Umbilical Pole	154	149		
GSE ENVIRONMENTAL MEASUREMENTS				
Small Utility Room	114	112		
Large Utility Room	119	116		
Outside Control Building		113.5	138	
Inside Control Building				114.5
MID-FIELD MEASUREMENTS FOR EVALUATION OF NOISE CHARACTERISTICS				
(Following Measurements were made in a plane 6 Ft above pad level)				
150 Ft Az 182°, A.C. +50°	153	150		
300 Ft Az 182°, A.C. +50°		142.5		
600 Ft Az 82°, A.C. -50°		141		137
600 Ft Az 102°, A.C. -30°		132		140
600 Ft Az 162°, A.C. +30°		129.5		
600 Ft Az 182°, A.C. +50°		134		142.5
600 Ft Az 198°, A.C. +70°		140		144
600 Ft Az 222°, A.C. +90°	141	139.5		
600 Ft Az 242°, A.C. +110°	143	143		141
600 Ft Az 262°, A.C. +130°		141		141
600 Ft Az 282°, A.C. +150°		133		140.5
(The following measurements were made at the elevation 6 Ft above grade level at the microphone location.)				
300 Ft Az 182°, A.C. +50°		138		132.5
600 Ft Az 162°, A.C. +30°	129	133		
600 Ft Az 198°, A.C. +70°	130	138.5		144
1200 Ft Az 122°, A.C. -10°				134
1200 Ft Az 162°, A.C. +30°	122	121	131	135
1200 Ft Az 182°, A.C. +50°	129	126	138	136.5
1200 Ft Az 198°, A.C. +70°	130	127	135	136.5

TABLE II. CONT'D

FAR FIELD Monitoring Station	MEASUREMENTS Range In Feet	ON PAD		LAUNCH MAXIMUM	
		SA-1	SA-2	SA-1	SA-2
A	86,750			94	100
B	33,800			102	109
C	5,000			122	126
D	14,780			122	122
E	51,750			102	107
F	72,300			93	103
G	79,600			86	100
H	29,600				121
I	71,250				102
J	54,300			105	105

TABLE III. COMPARISON OF NOISE SOURCE PARAMETERS

PARAMETERS	STATIC TEST[1]	ON PAD[2]		LAUNCH[3]	
		SA-1	SA-2	SA-1	SA-2
OA PWL (600-ft radius)[4]	205.5	202.5	203.0	204.5	205.5
OA PWL (1200-ft radius)[4]				204.0	206.0
Acoustic Power Generated (from measurement results) in megawatts	35	18	21	28	40
Acoustic Efficiency In Percent	0.5%	0.3%	0.3%	0.4%	0.5%
Space Average SPL in db (600-ft radius)[5]	142.0	139.0	139.5	138.0	139.0
Space Average SPL in db (1200-ft radius)[5]				131.5	133.5
Nominal Thrust in Kilopounds	1,300	1,300	1,300	1,300	1,300

NOTES:
1. Average of static tests SAT-04, -05, -06, and -08 (Reference 2)
2. For range time: T-2 to T+1 seconds
3. For first 25 seconds of flight
4. In decibels where db = 10 log (power/10^{-13} watts)
5. In decibels where db = 20 log (pressure/0.0002 microbar)
6. On-pad wind; 2.6 M/sec from Az 70°
7. Speed of sound on pad (due to temperature): 1136 ft/sec

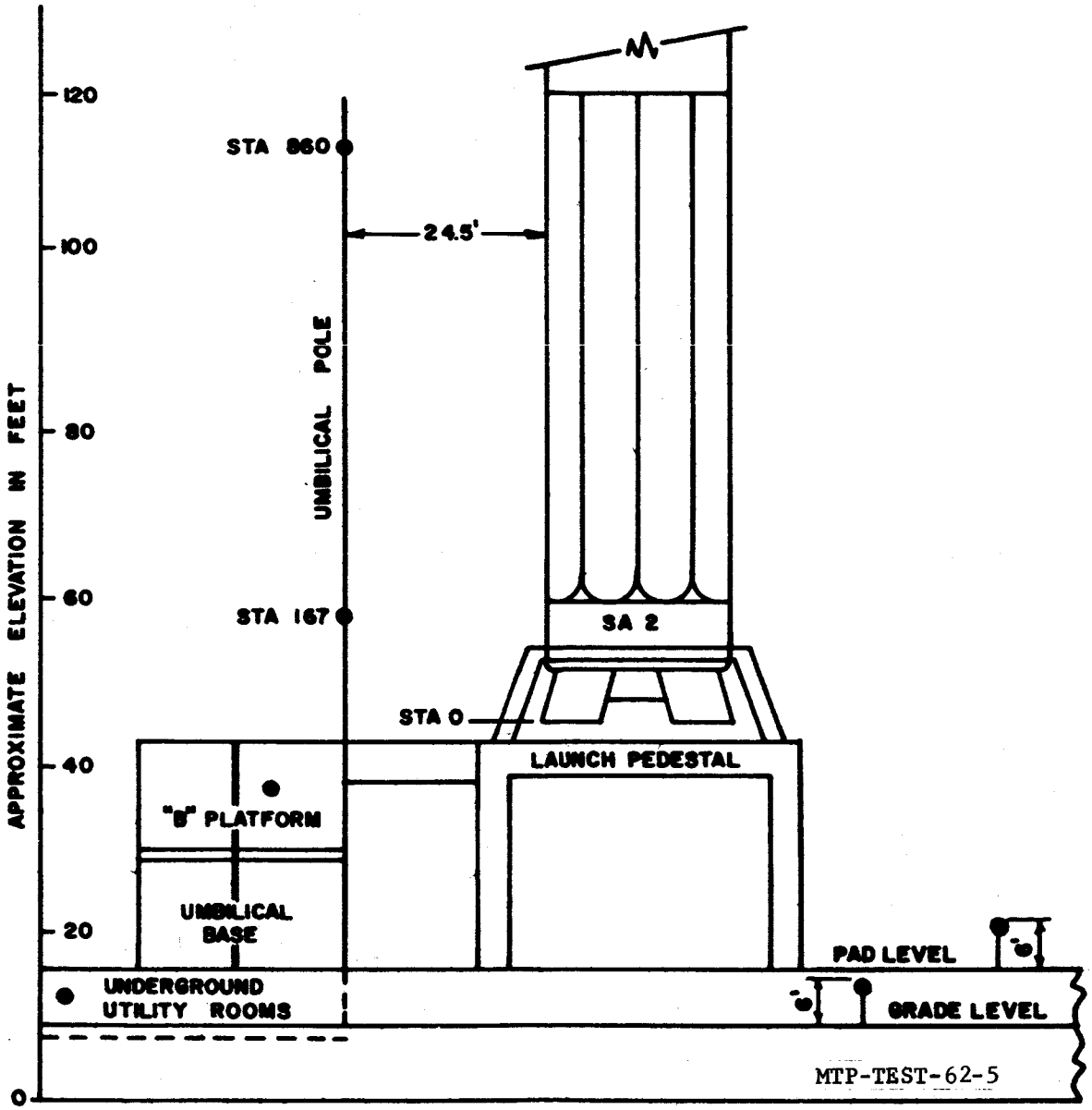

FIGURE 1. SKETCH OF PAD-34 SHOWING RELATIVE LOCATIONS OF MICROPHONES.

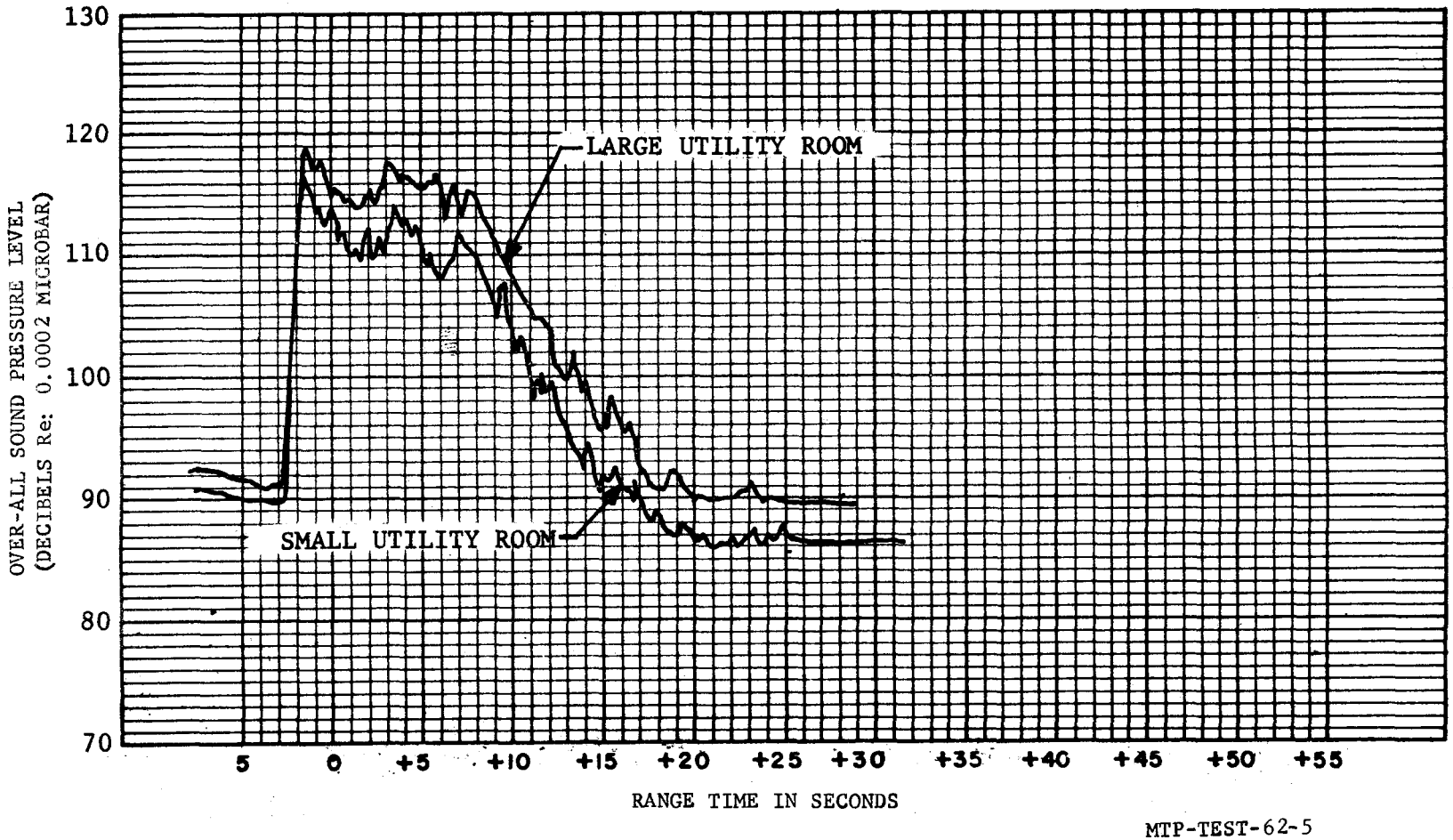

FIGURE 2. OVER-ALL TIME-HISTORY OF THE UNDERGROUND UTILITY ROOM MEASUREMENTS.

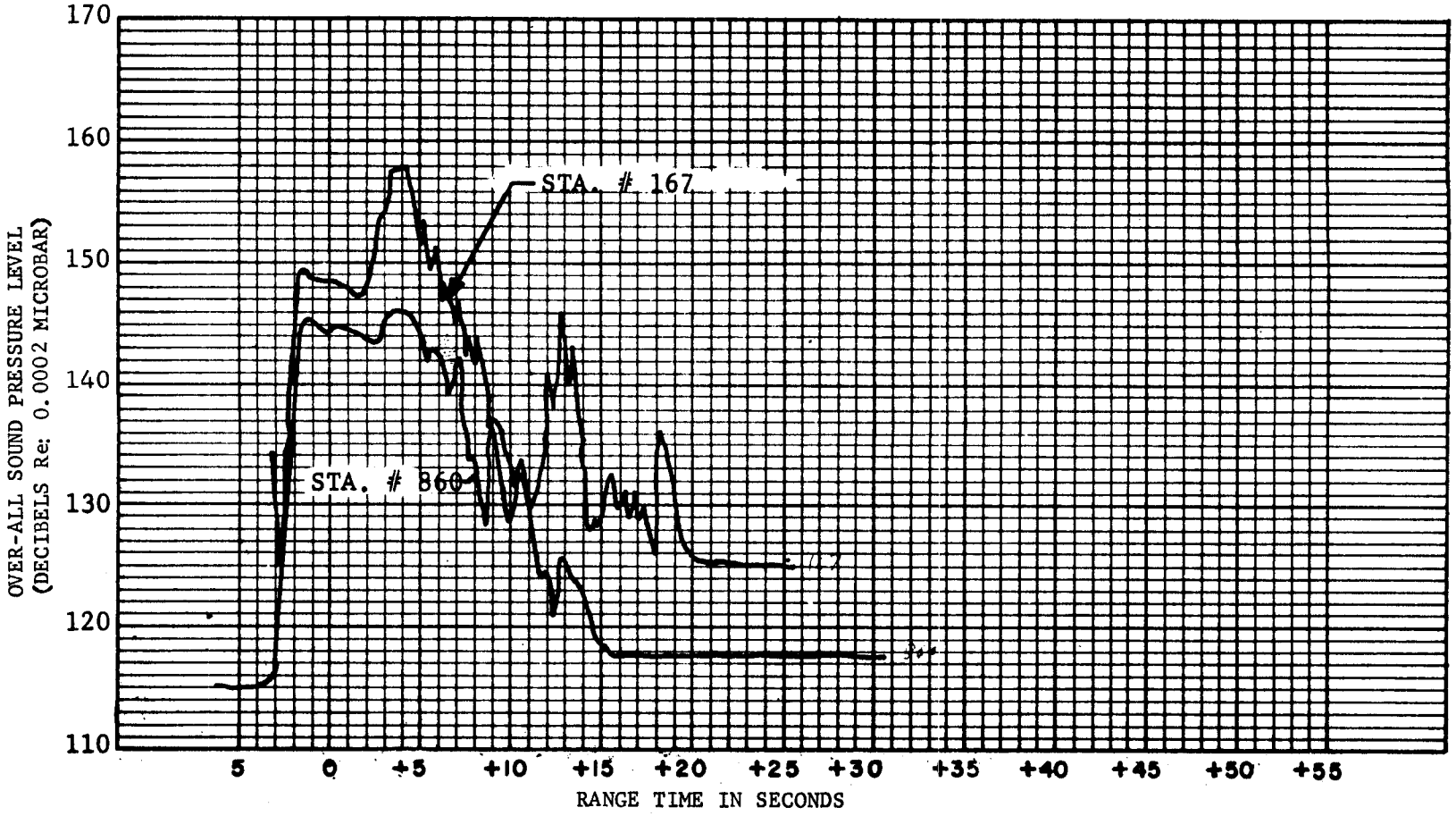

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FIGURE 3. OVER-ALL TIME-HISTORY OF THE UMBILICAL POLE MEASUREMENTS

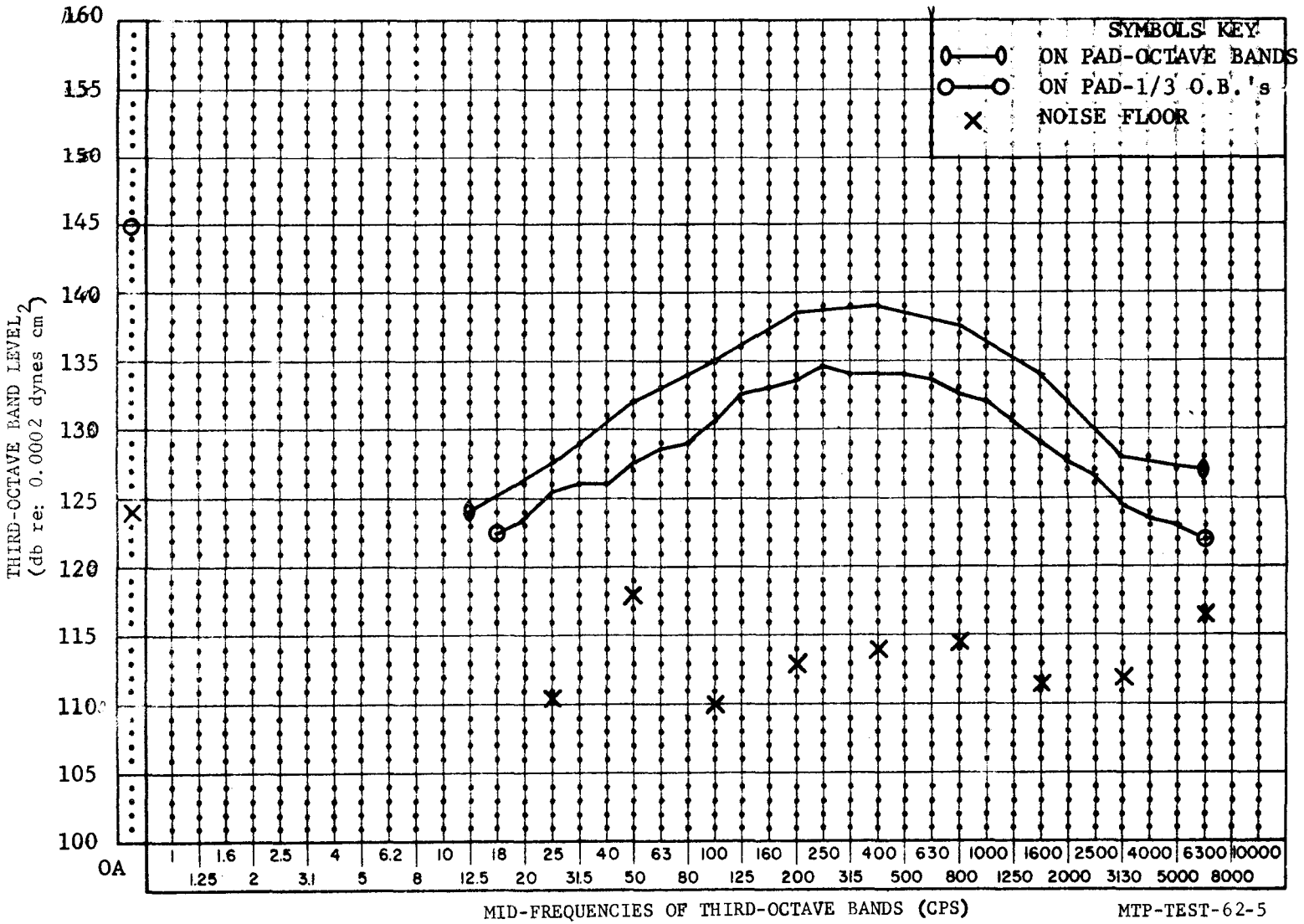

FIGURE 4. RMS SPECTRA, STA. 860, UMBILICAL POLE

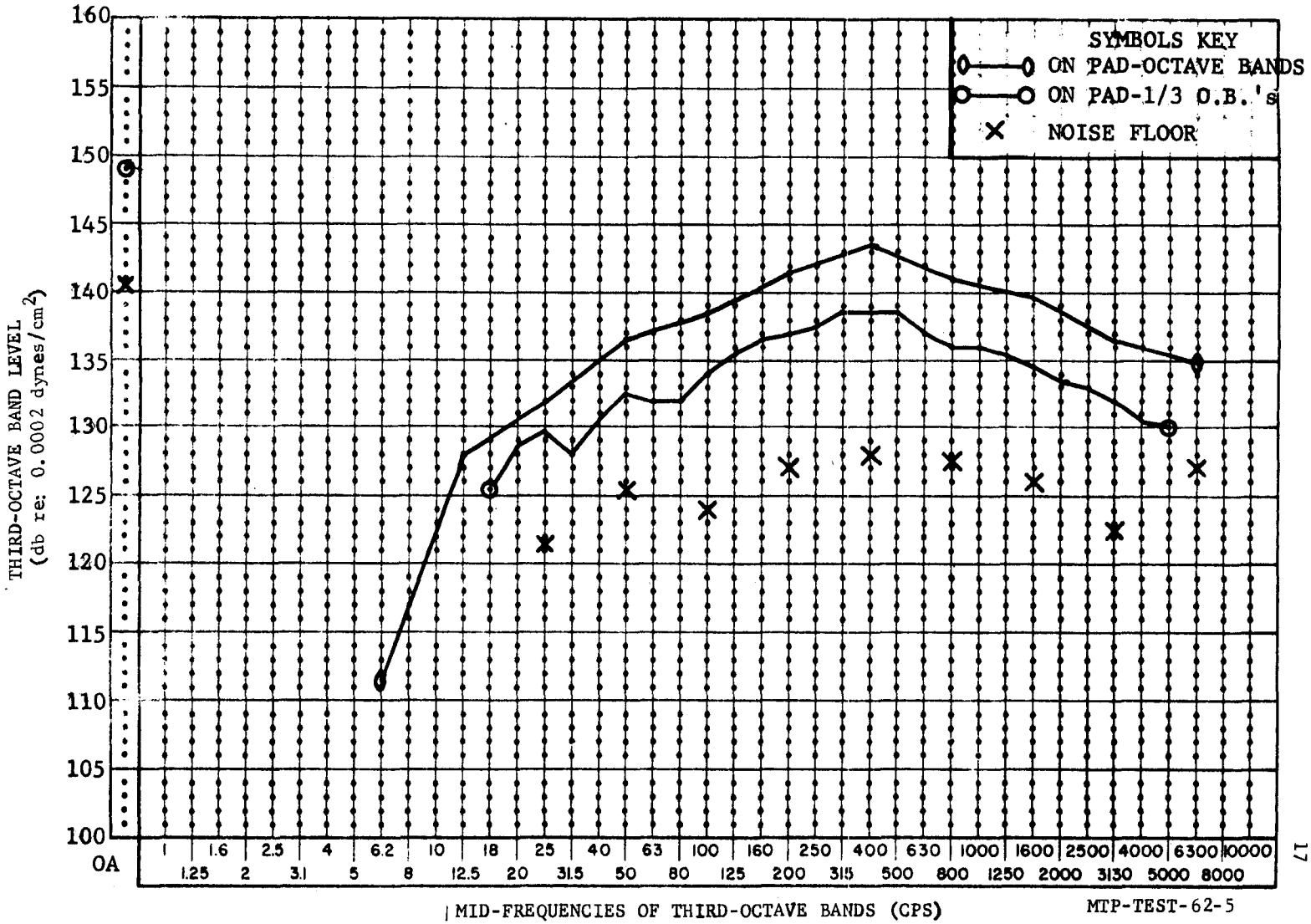

FIGURE 5. RMS SPECTRA, STA 167, UMBILICAL POLE

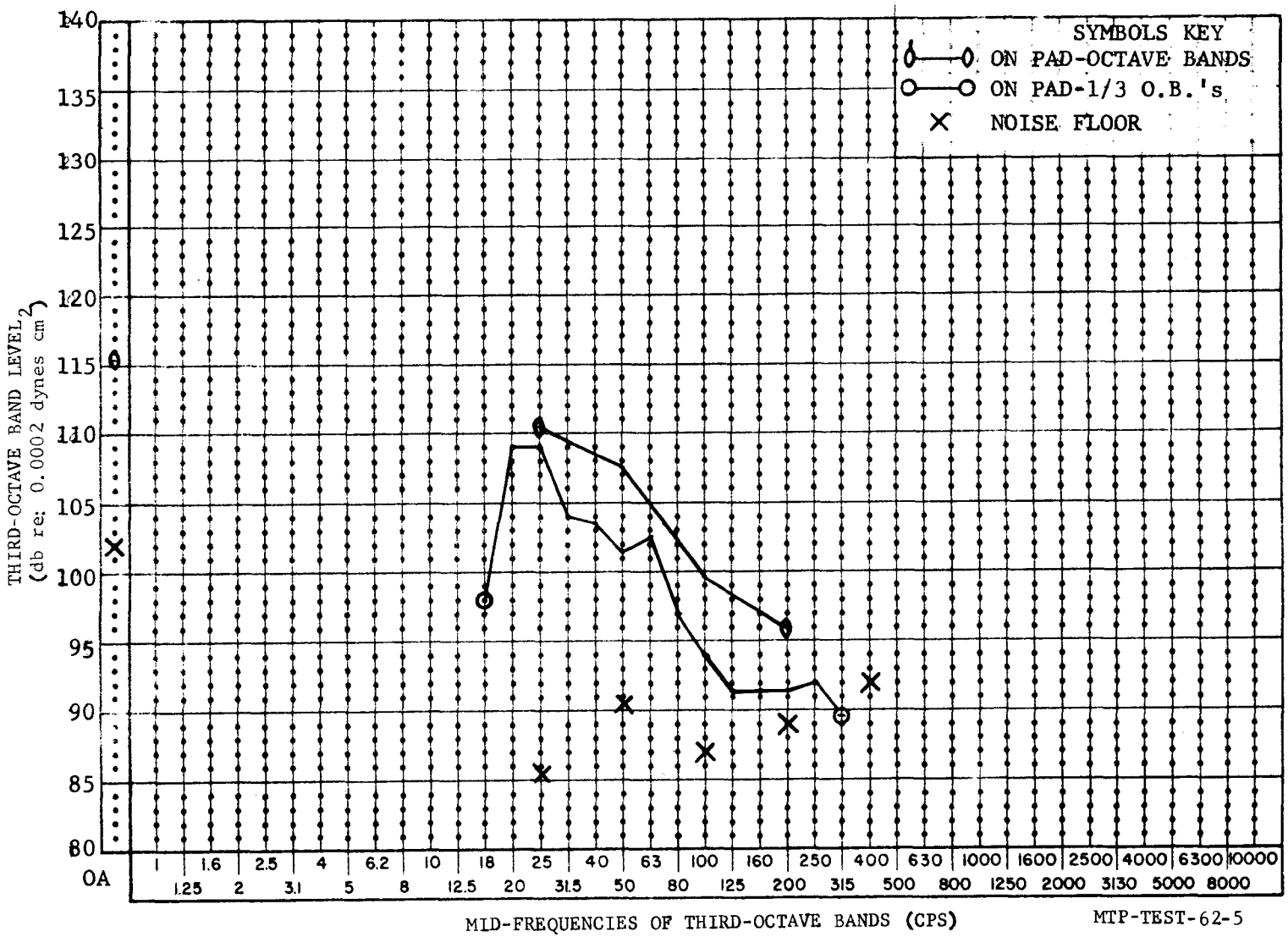

FIGURE 6. RMS SPECTRA, LARGE UTILITY ROOM

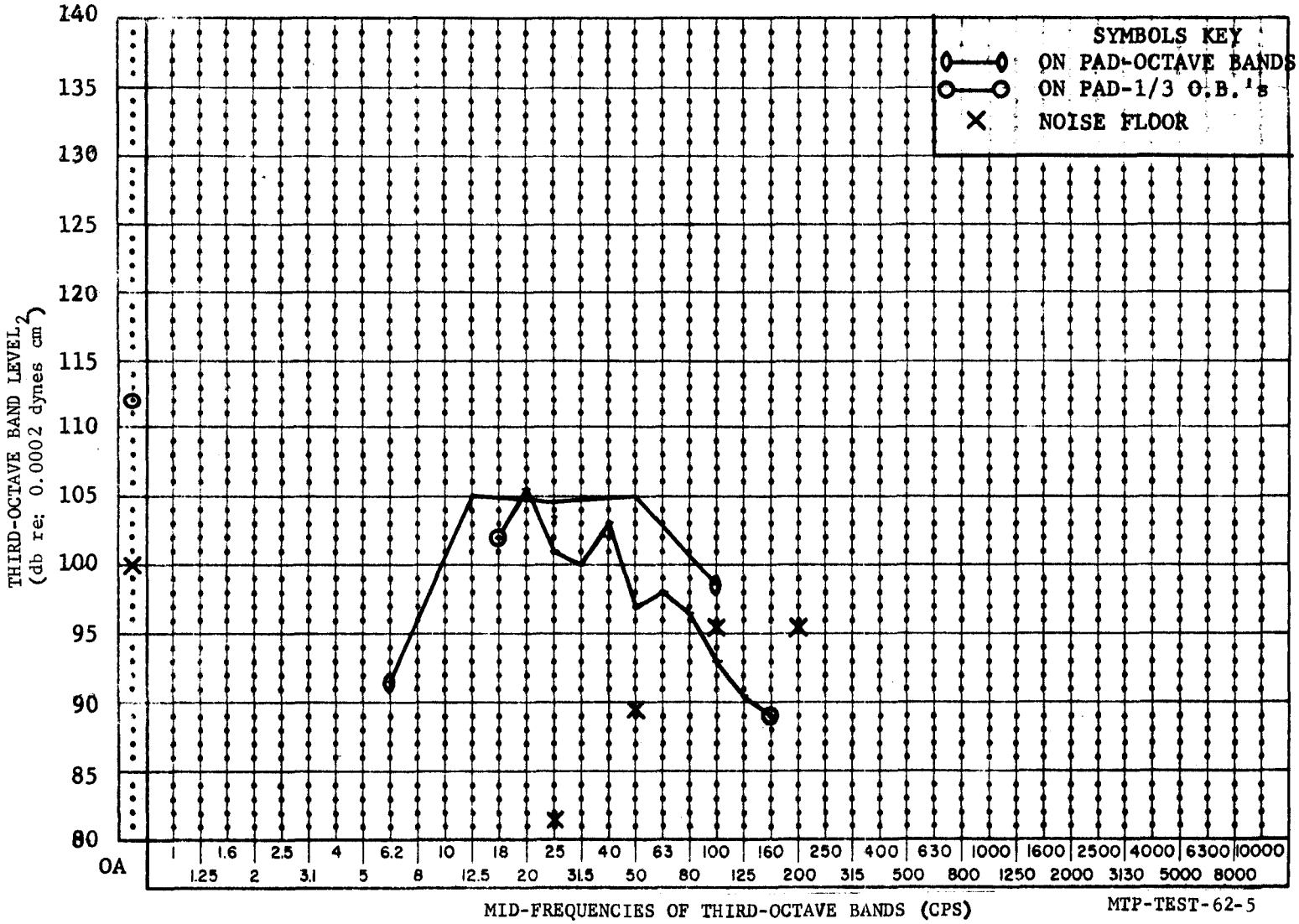

FIGURE 7. RMS SPECTRA, SMALL UTILITY ROOM

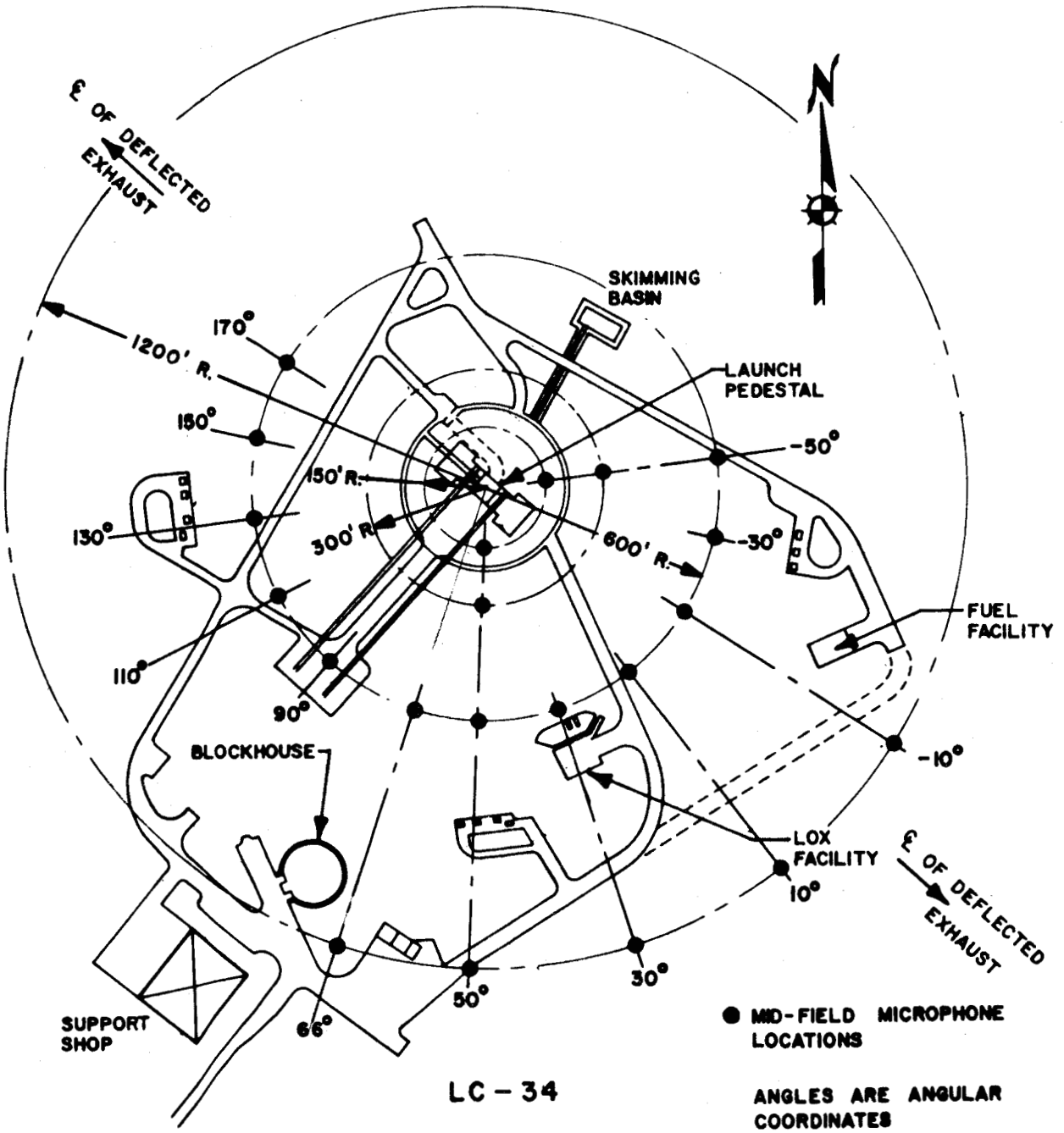

FIGURE 8. MIDFIELD MICROPHONE LOCATIONS FOR SA-2 LAUNCH ACOUSTIC SURVEY

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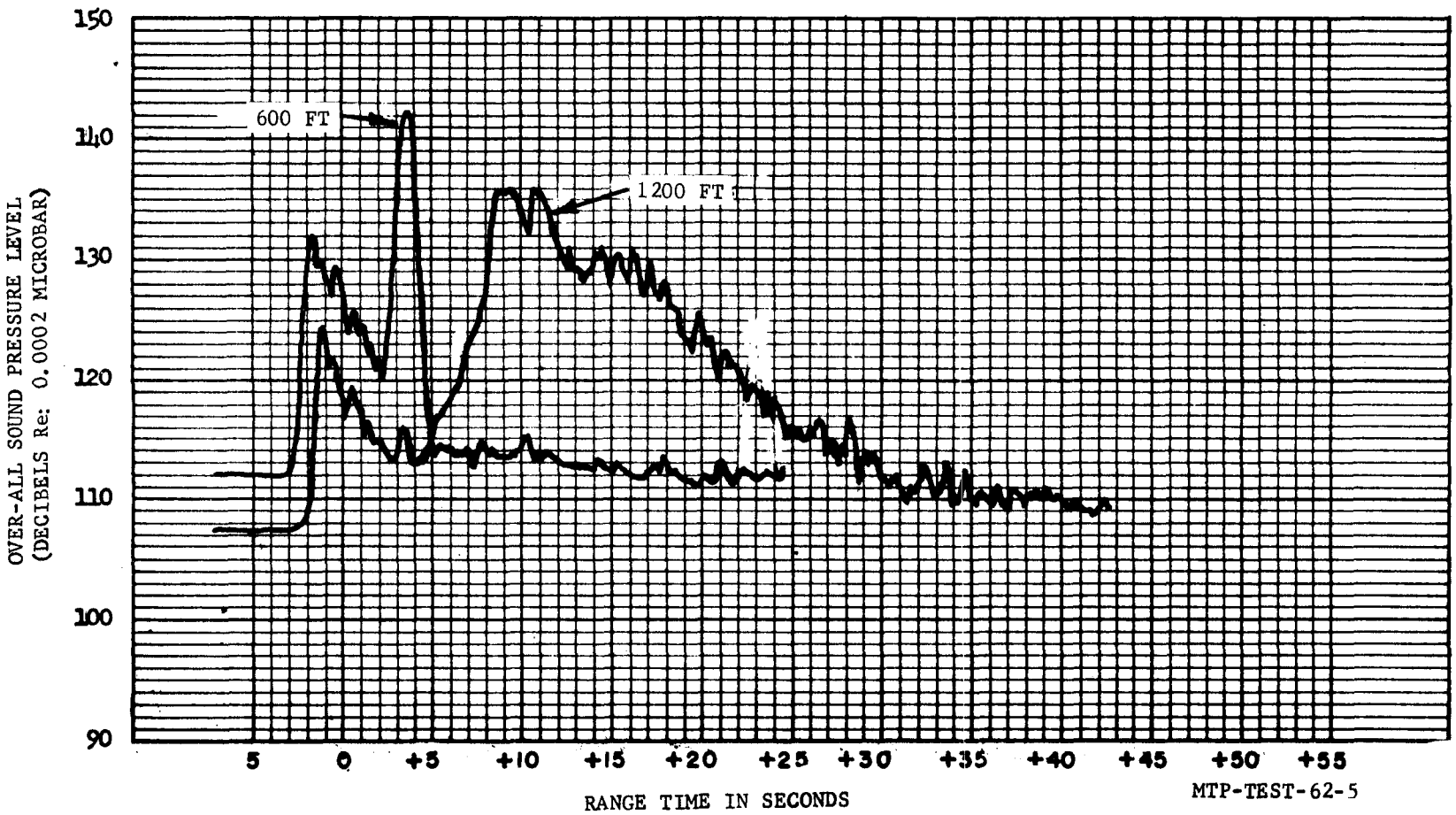

FIGURE 9. OVER-ALL TIME HISTORIES OF MEASUREMENTS AT -10° ANGULAR COORDINATE (AZ 122°)

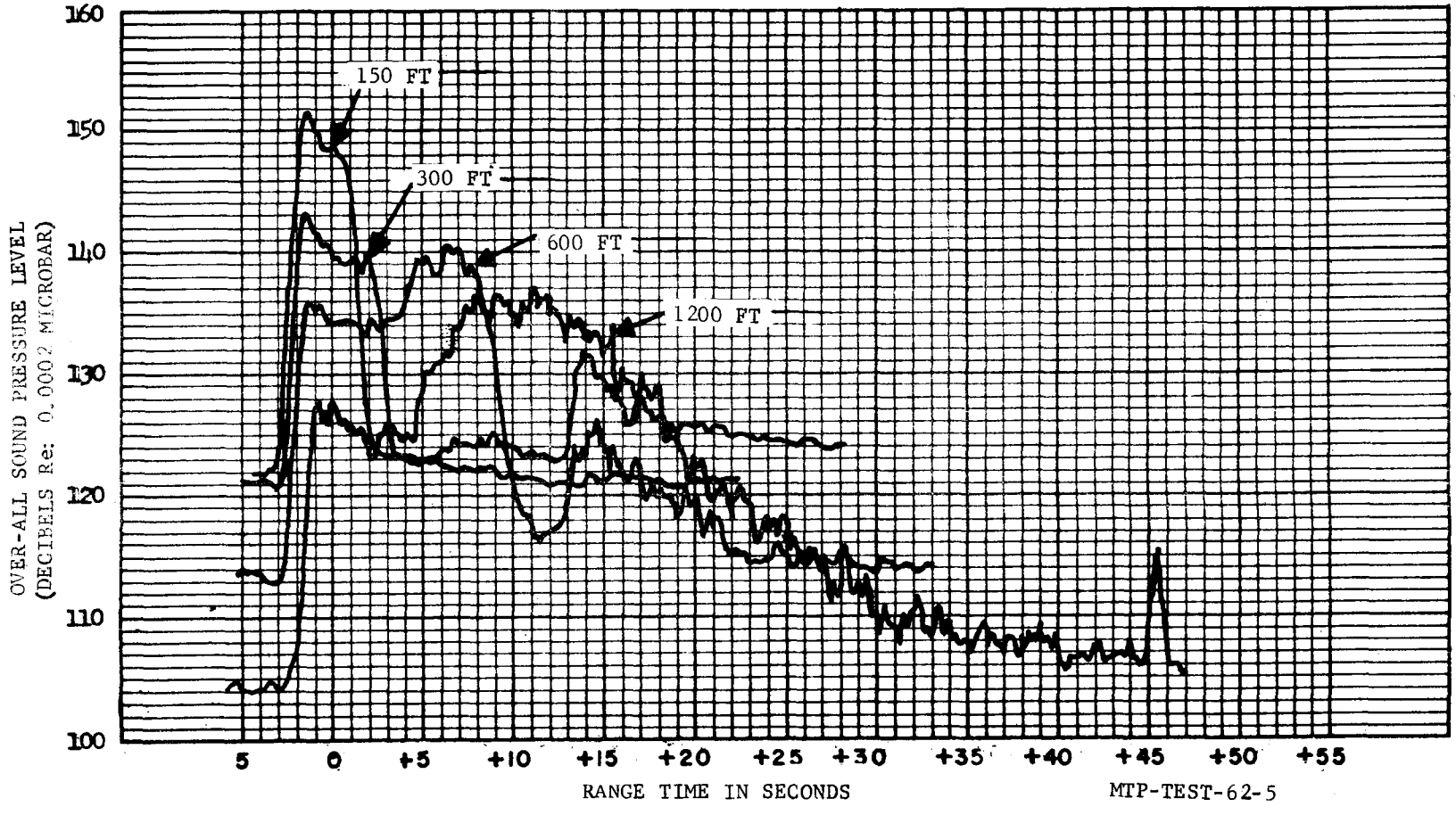

FIGURE 10. OVER-ALL TIME-HISTORIES OF MEASUREMENTS ALONG 182° AZIMUTH

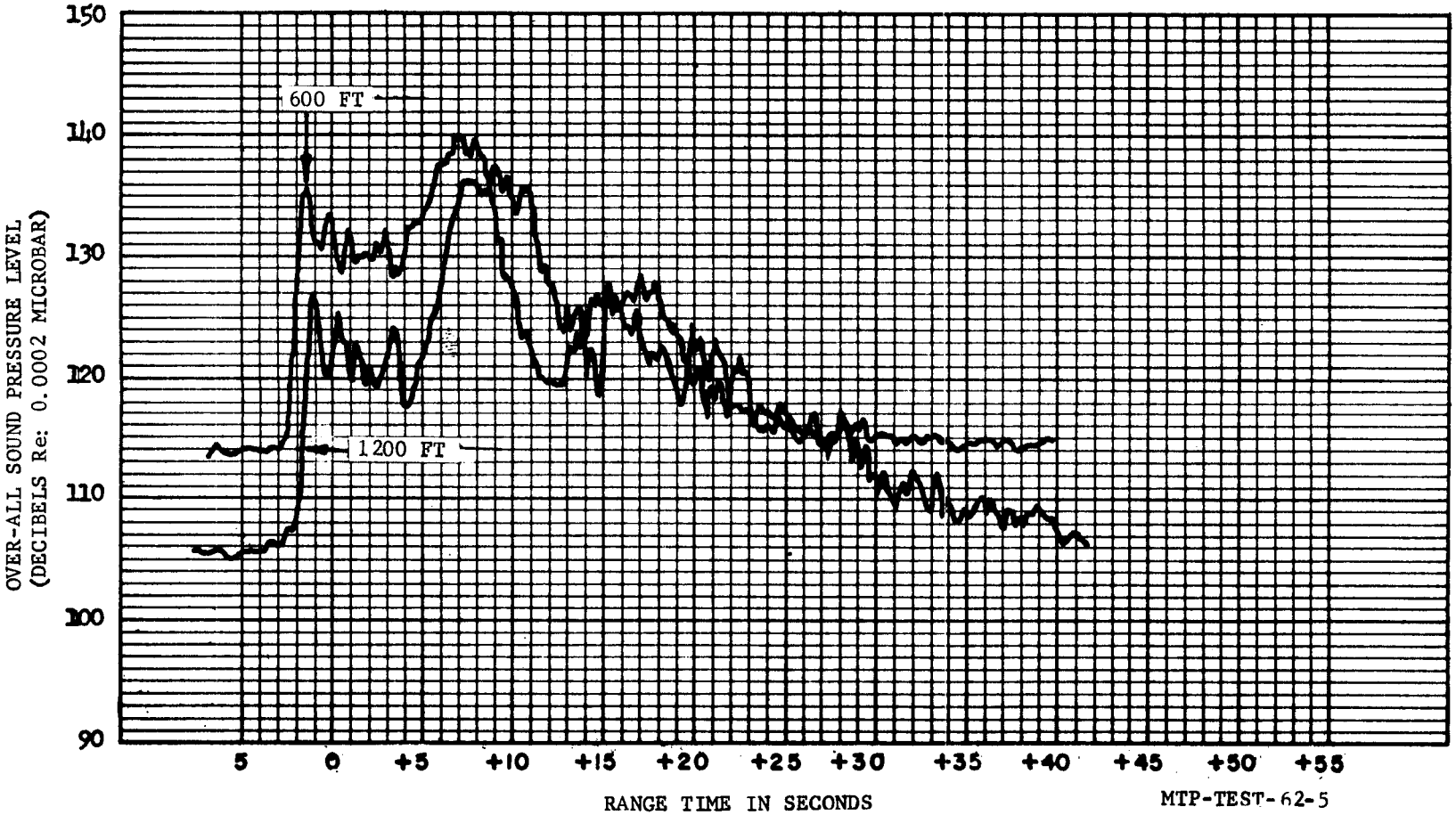

FIGURE 11. OVER-ALL TIME HISTORIES OF MEASUREMENTS AT +30° ANGULAR COORDINATE (AZ 162°)

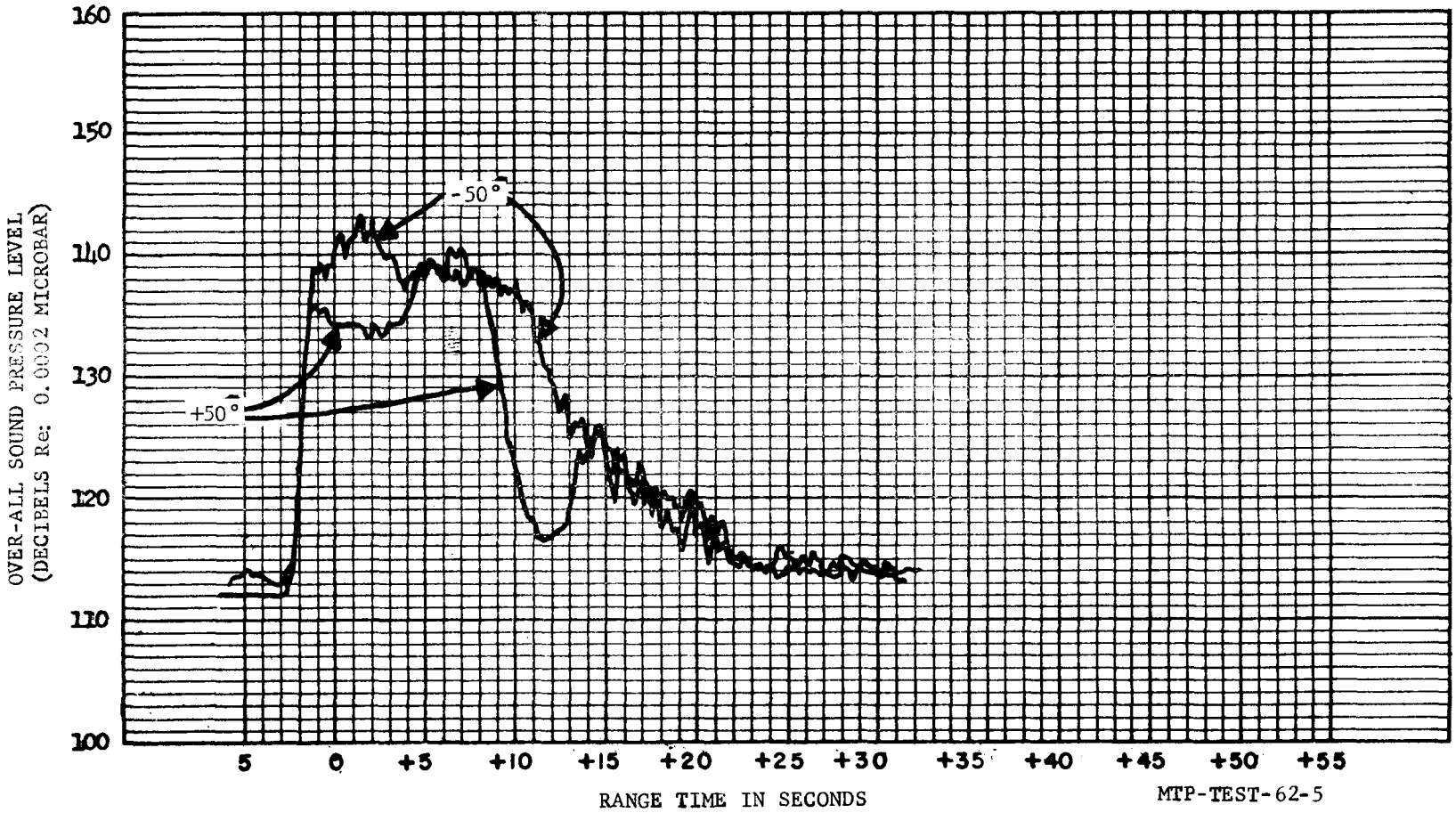

FIGURE 12. OVER-ALL TIME HISTORIES OF MEASUREMENTS 50° ON EACH SIDE OF SOUTH EXHAUST PATH AZ OF -50° MEASUREMENT AT 82°, AZ OF +50° AT 182°

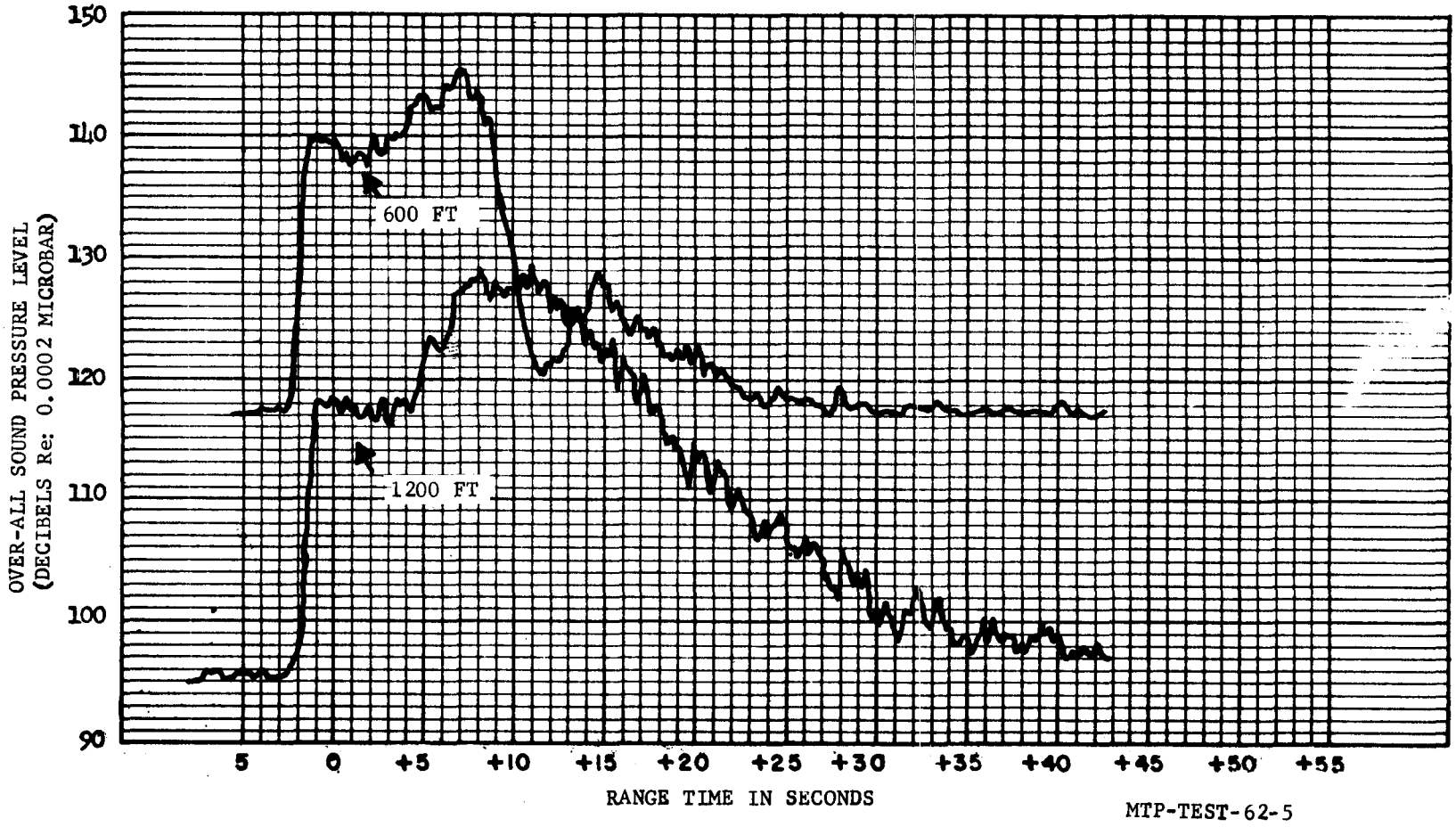

FIGURE 13. OVER-ALL TIME HISTORIES OF MEASUREMENTS AT +70° ANGULAR COORDINATE (AZ 198°)

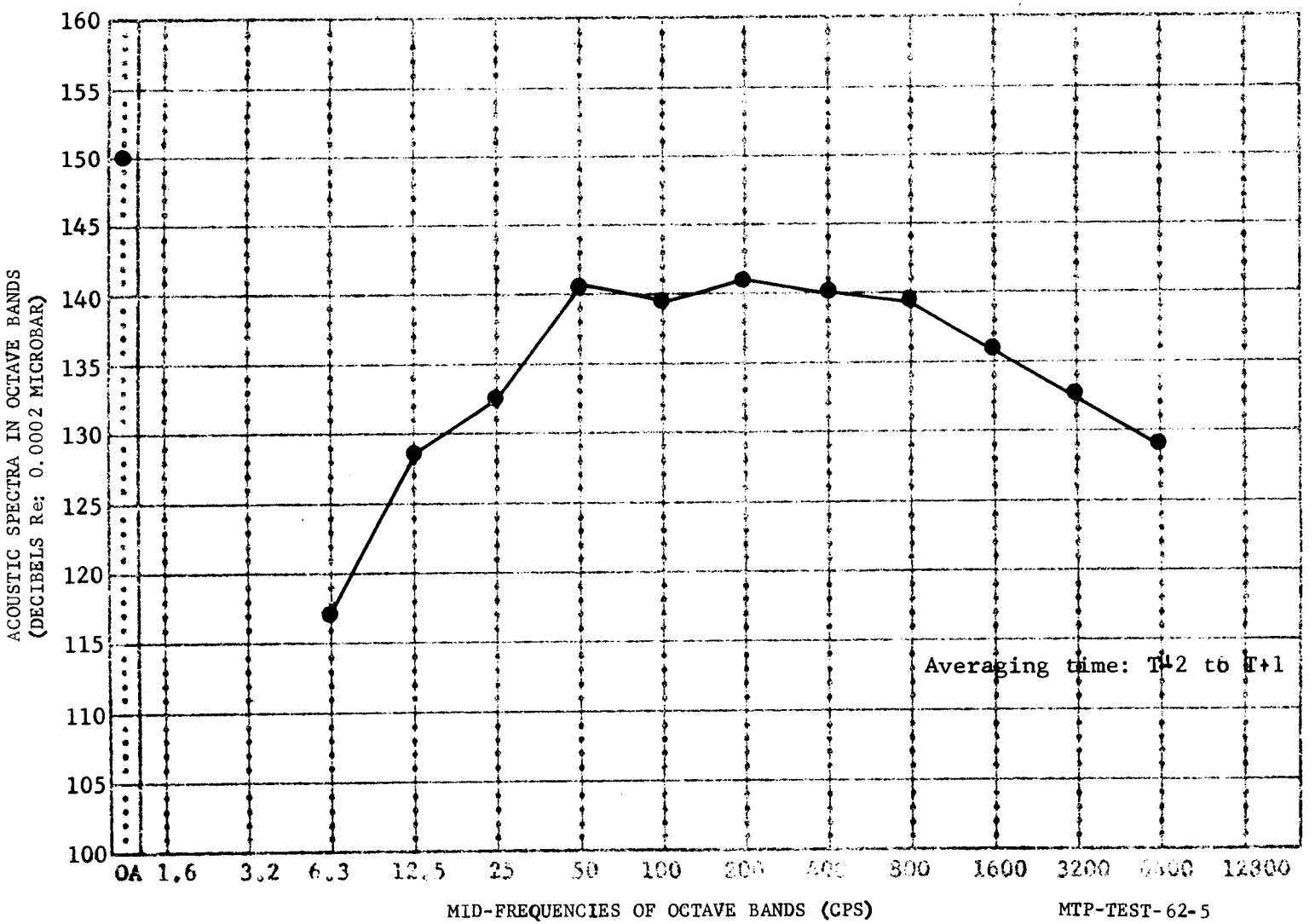

FIGURE 14. RMS SPECTRA, 150 Ft., AZ 182°, A.C. +50°

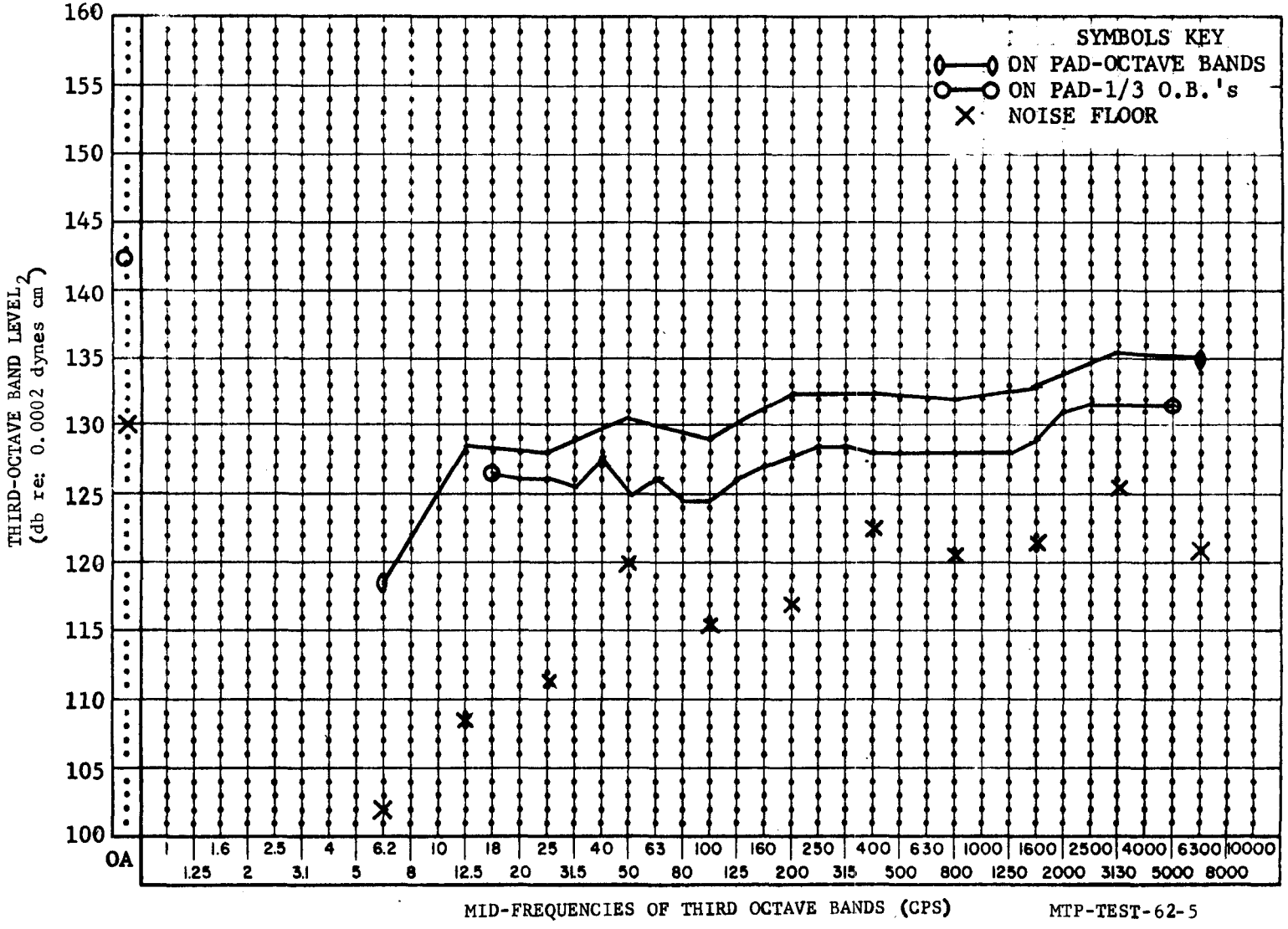

FIGURE 15. RMS SPECTRA, 300 Ft, AZ 182°, A.C. +50°

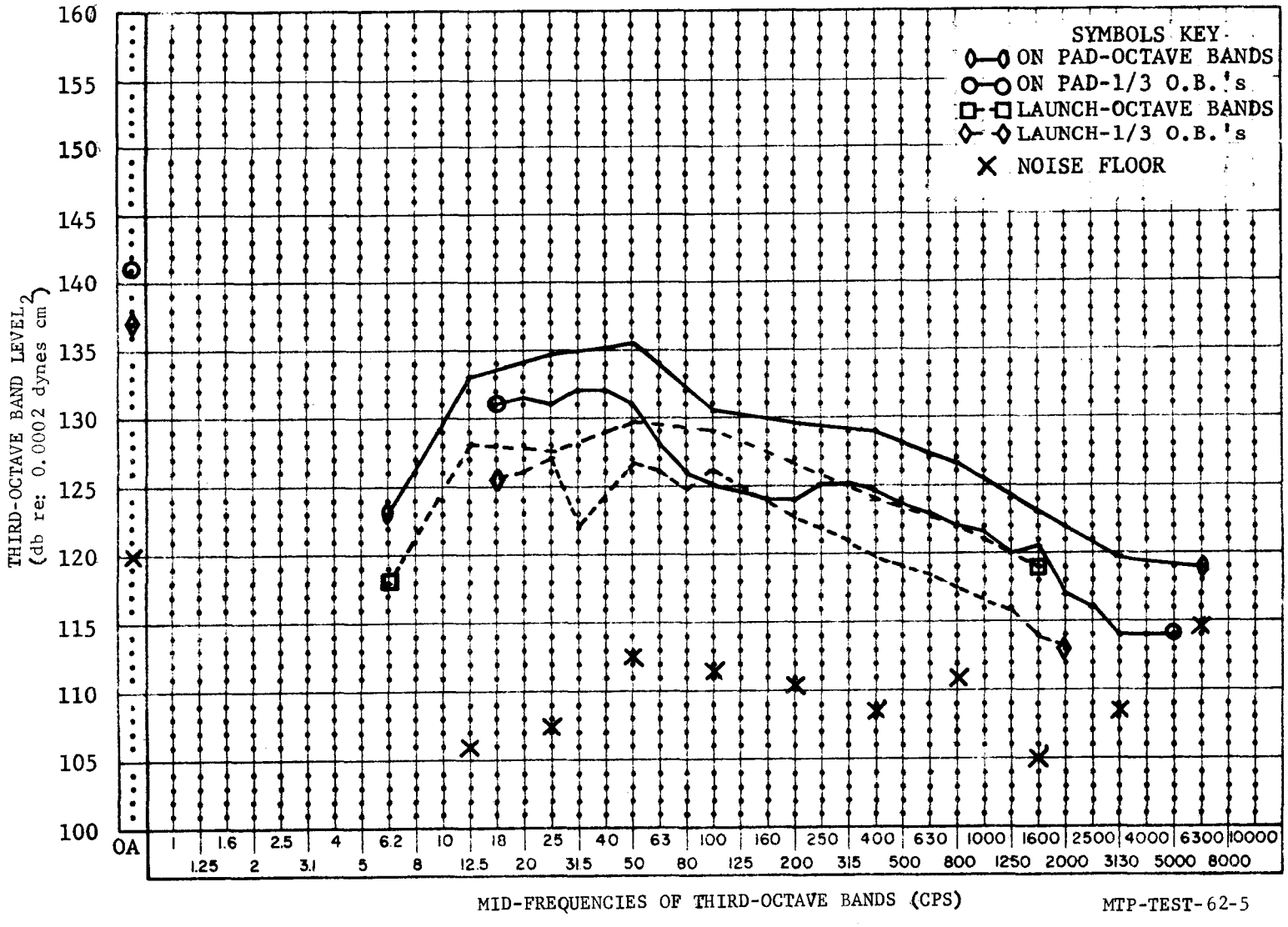

FIGURE 16. RMS SPECTRA, 600 Ft, AZ 82°, A.C. -50°

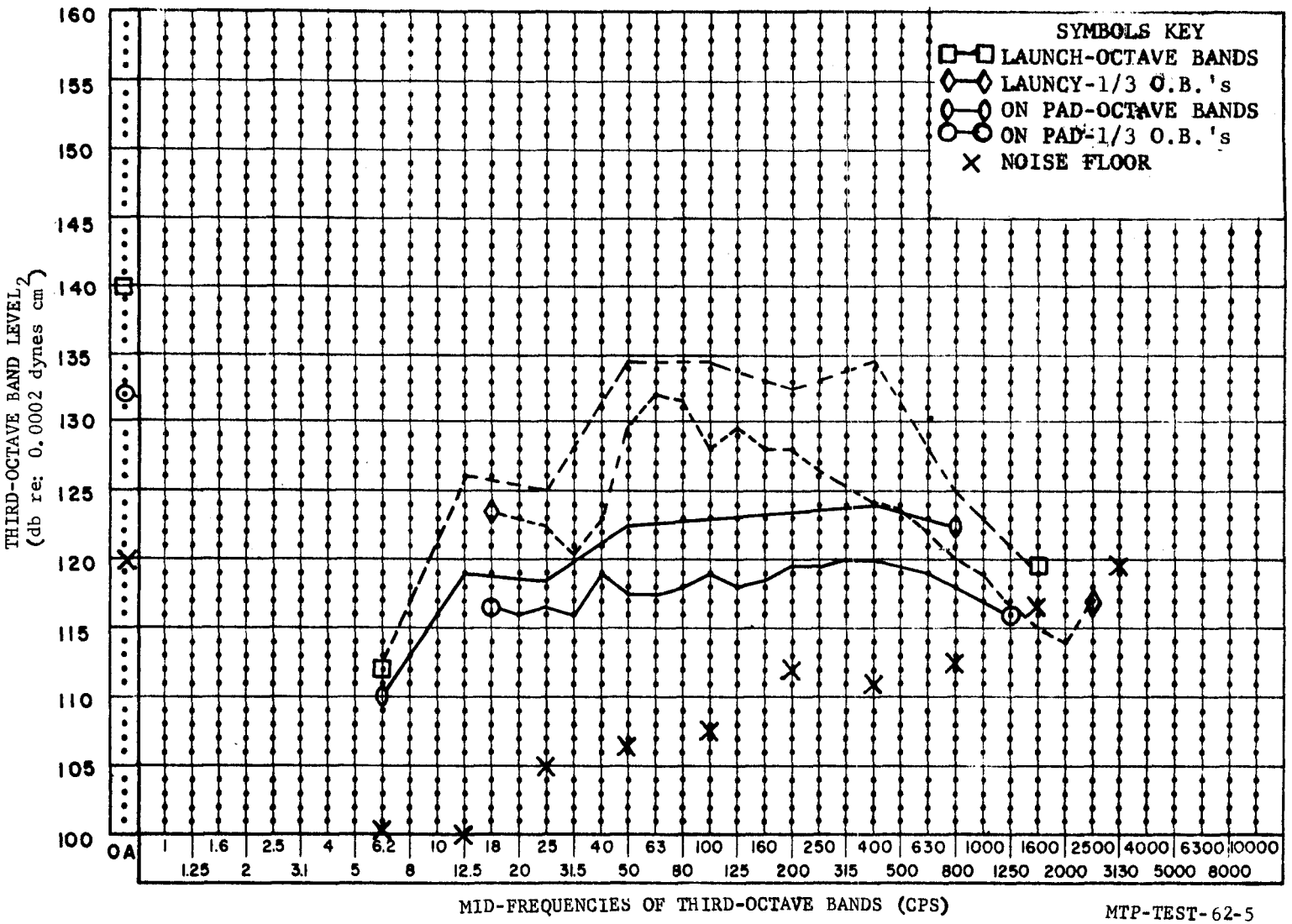

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FIGURE 17. RMS SPECTRA, 600 Ft, AZ 102°, A.C. -30°

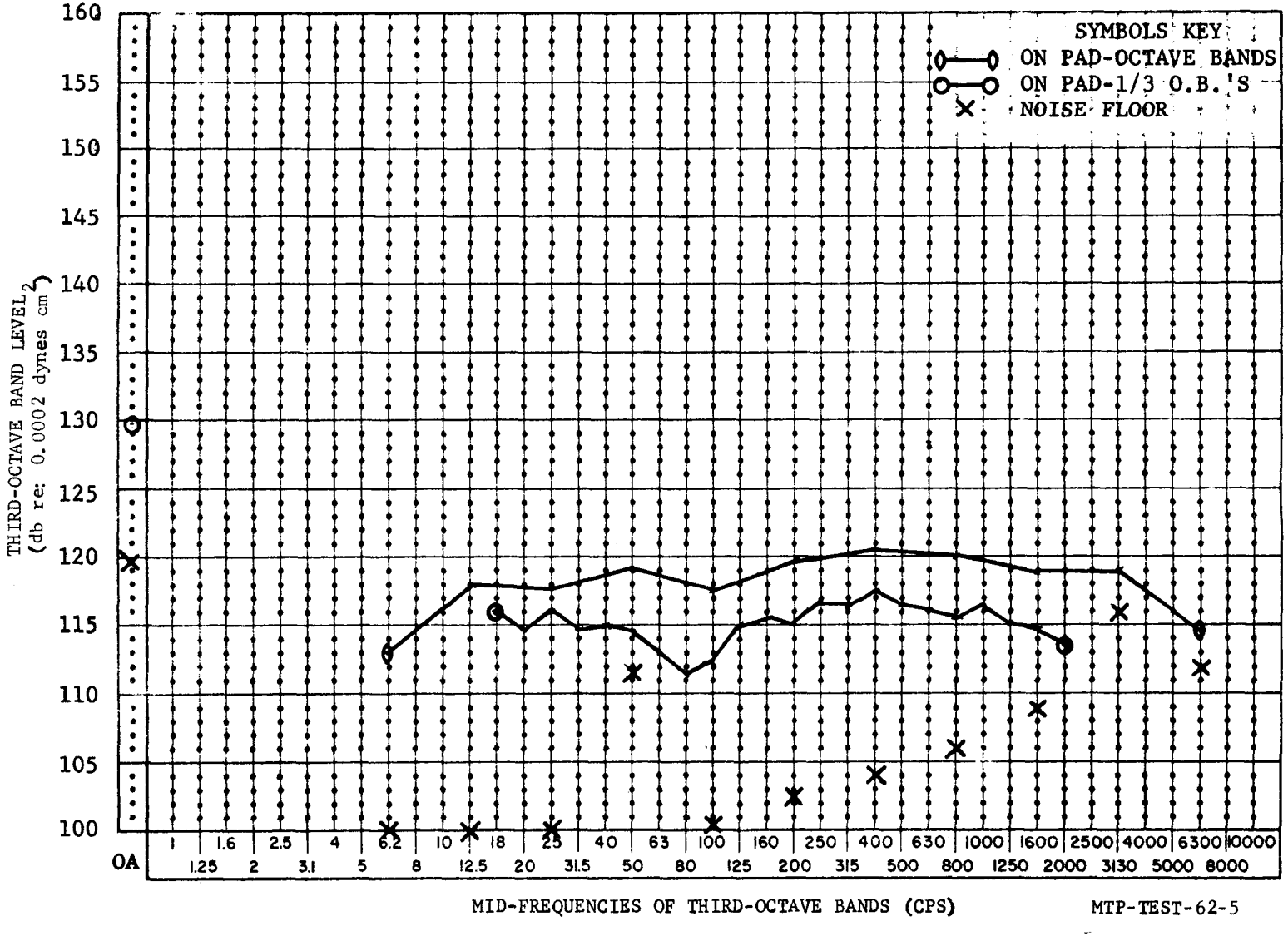

FIGURE 18. RMS SPECTRA, 600 Ft, AZ 162°, A.C. +30°

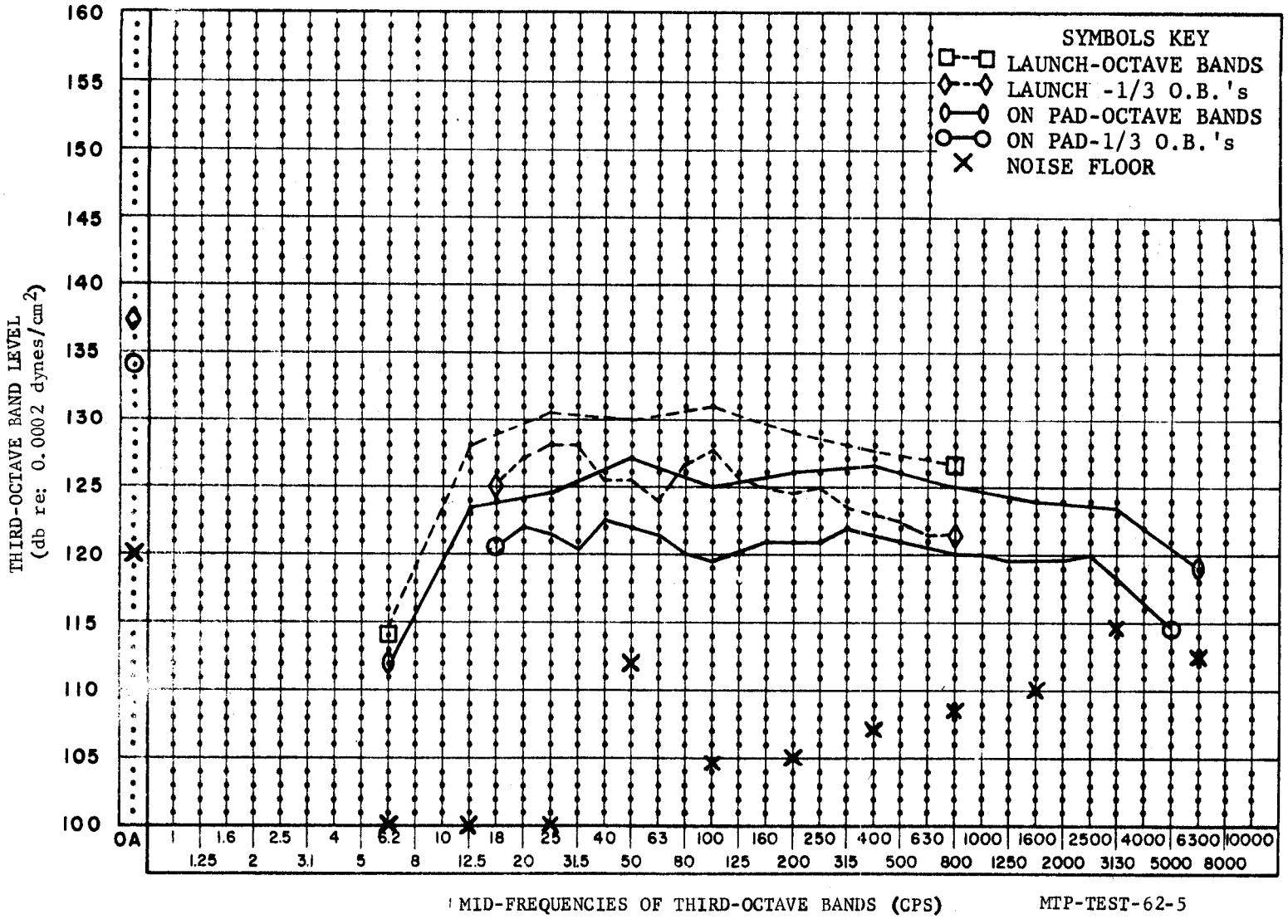

FIGURE 19. RMS SPECTRA, 600 Ft, AZ 183°, A.C. +50°

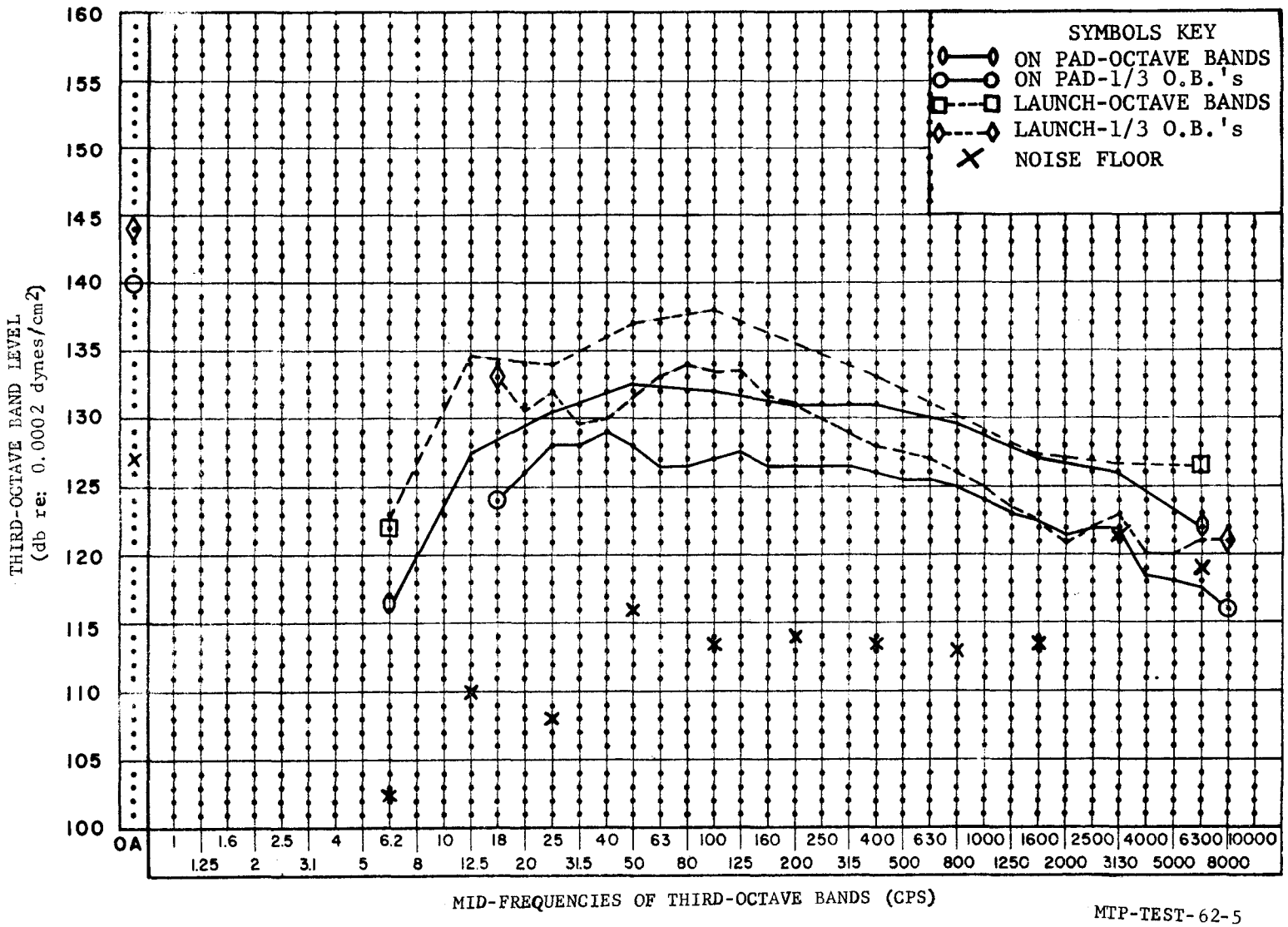

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FIGURE 20. RMS SPECTRA, 600 Ft, AZ 198°, A.C. +70°

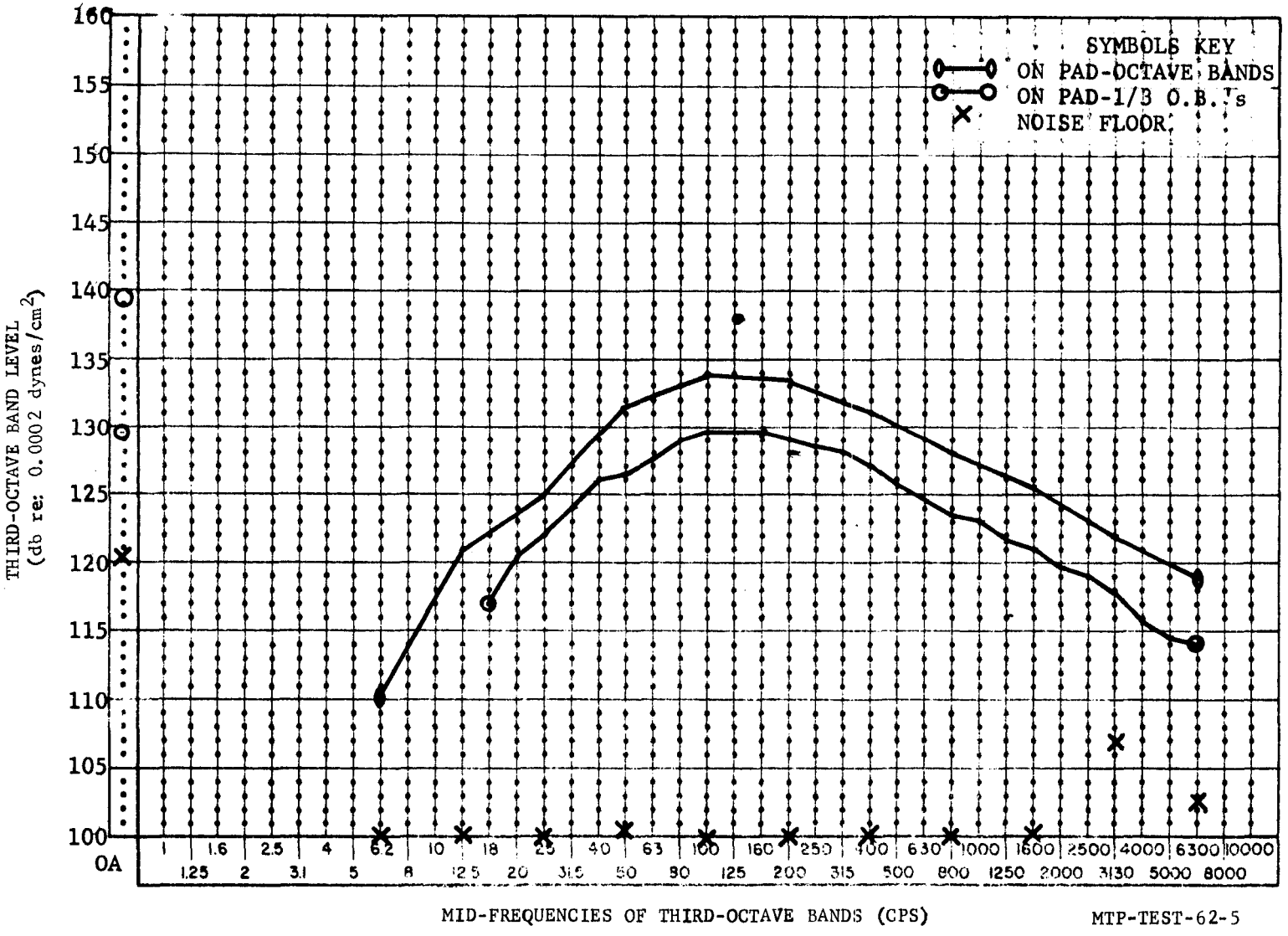

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FIGURE 21. RMS SPECTRA, 600 Ft, AZ 222°, A. C. +90°

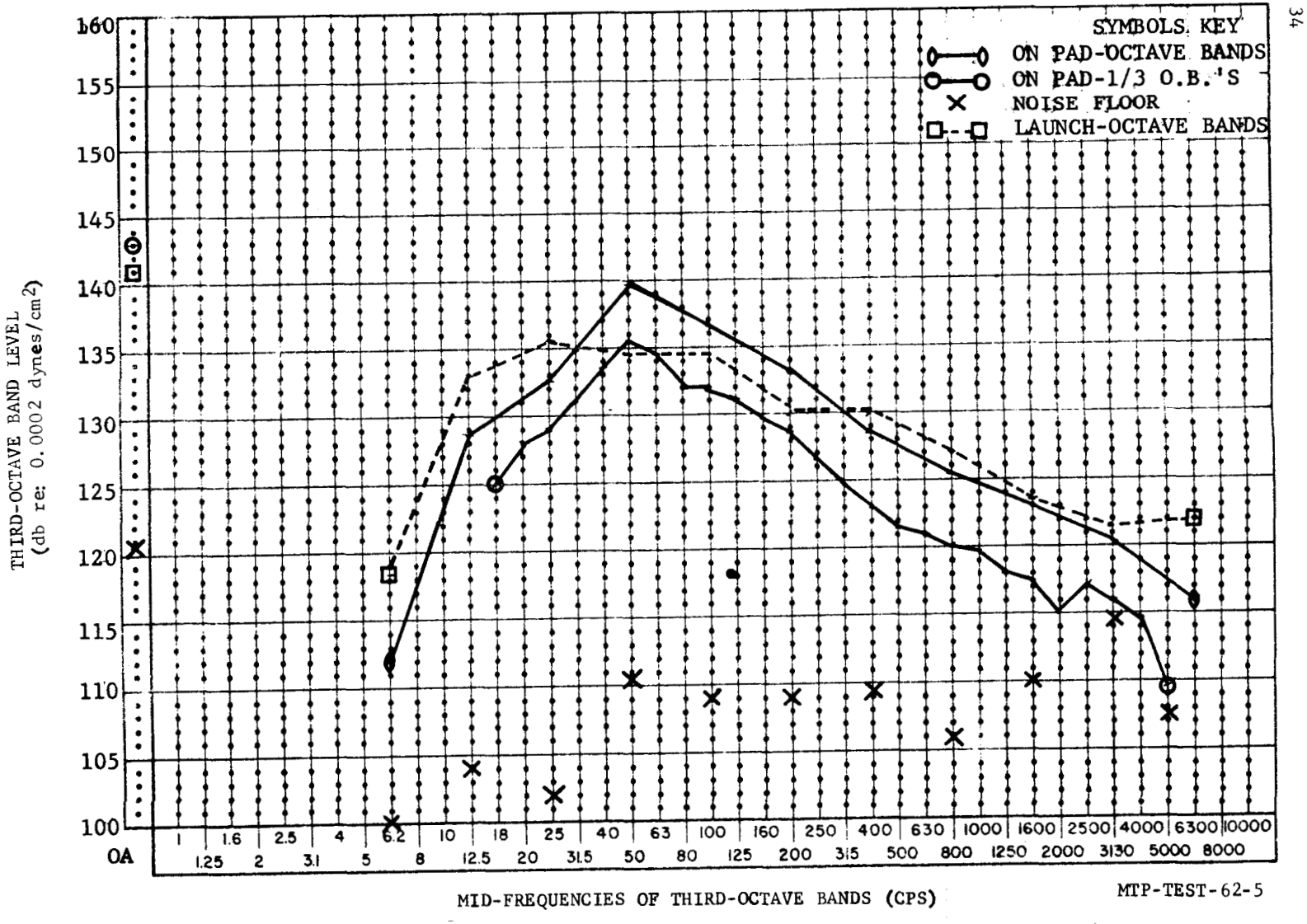

FIGURE 22. RMS SPECTRA, 600 Ft, AZ 242°, A.C. +110°

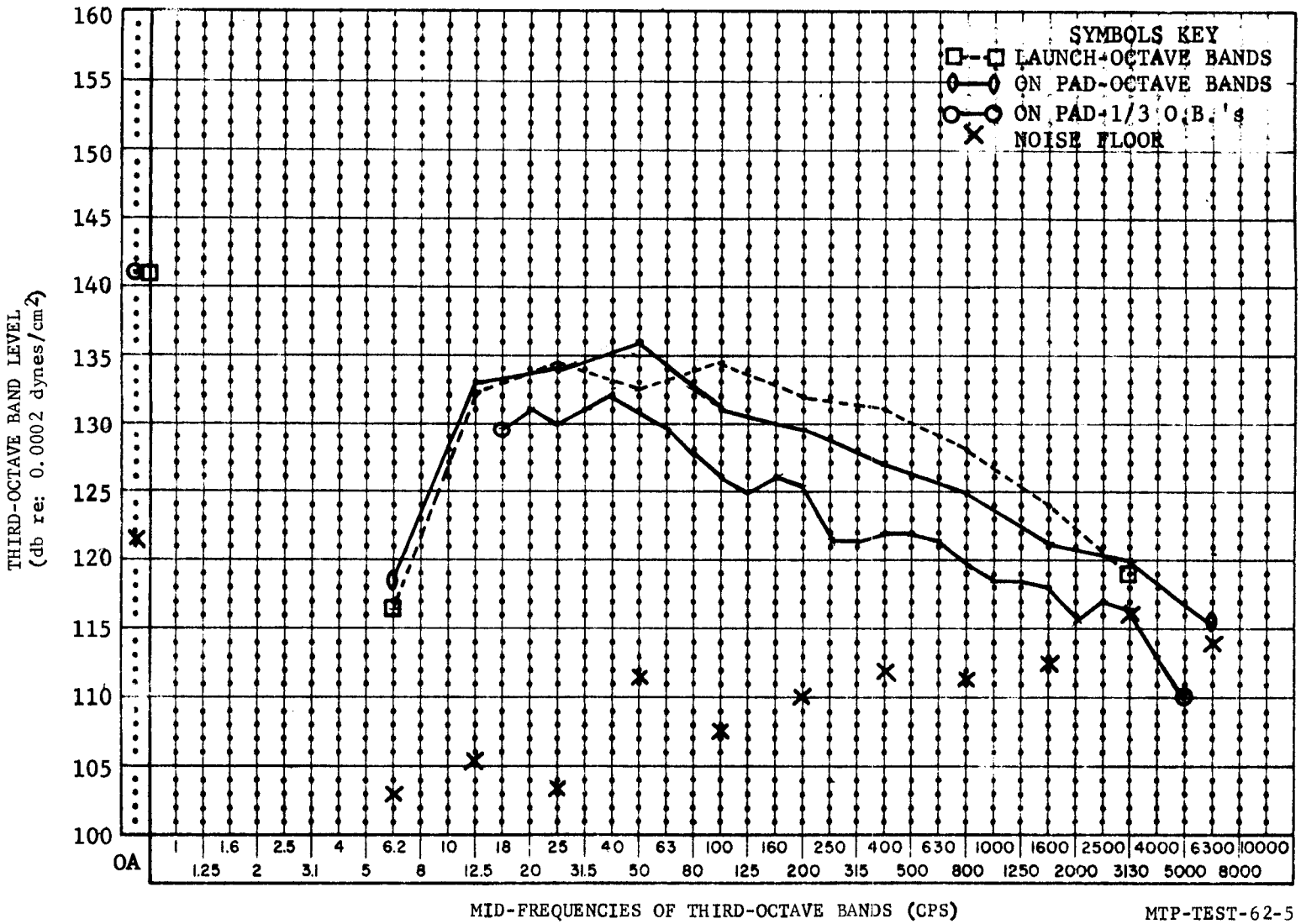

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FIGURE 23. RMS SPECTRA, 600 Ft, AZ 262°, A. C. +130°

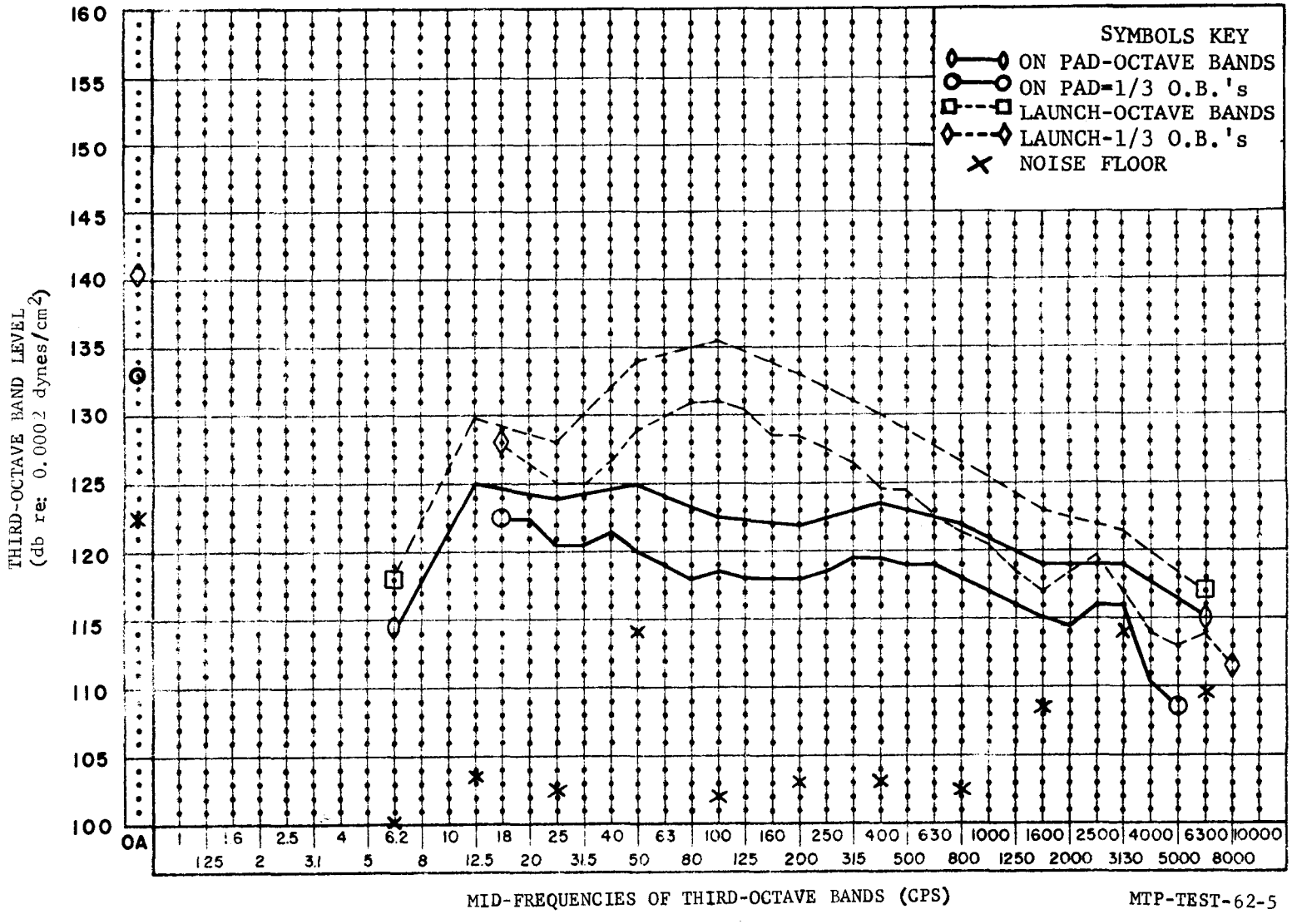

FIGURE 24. RMS SPECTRA, 600 Ft, AZ 282°, A.C. +150°

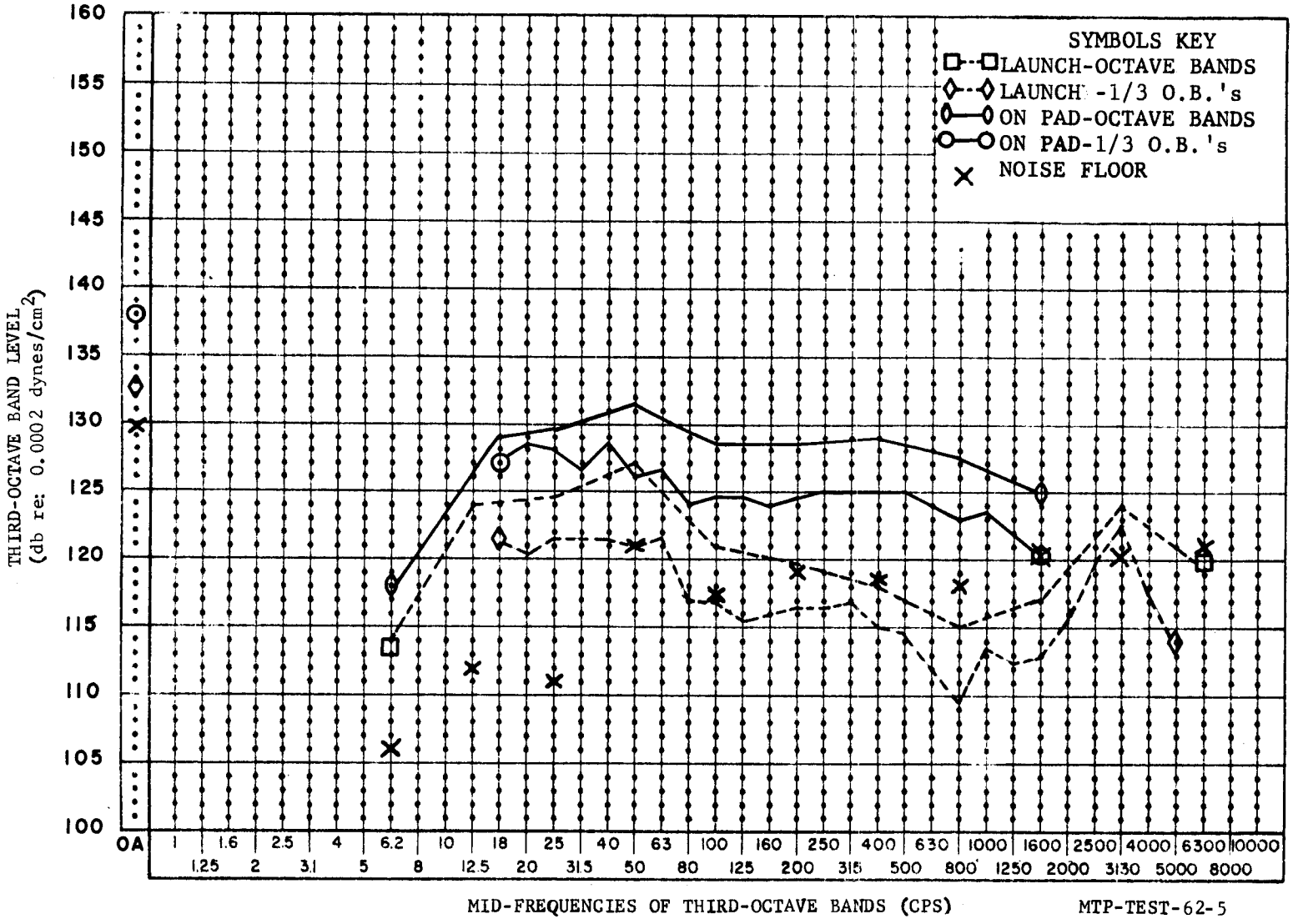

FIGURE 25. RMS SPECTRA, 300 Ft, AZ 182°, A.C. +50°. (GRADE LEVEL)

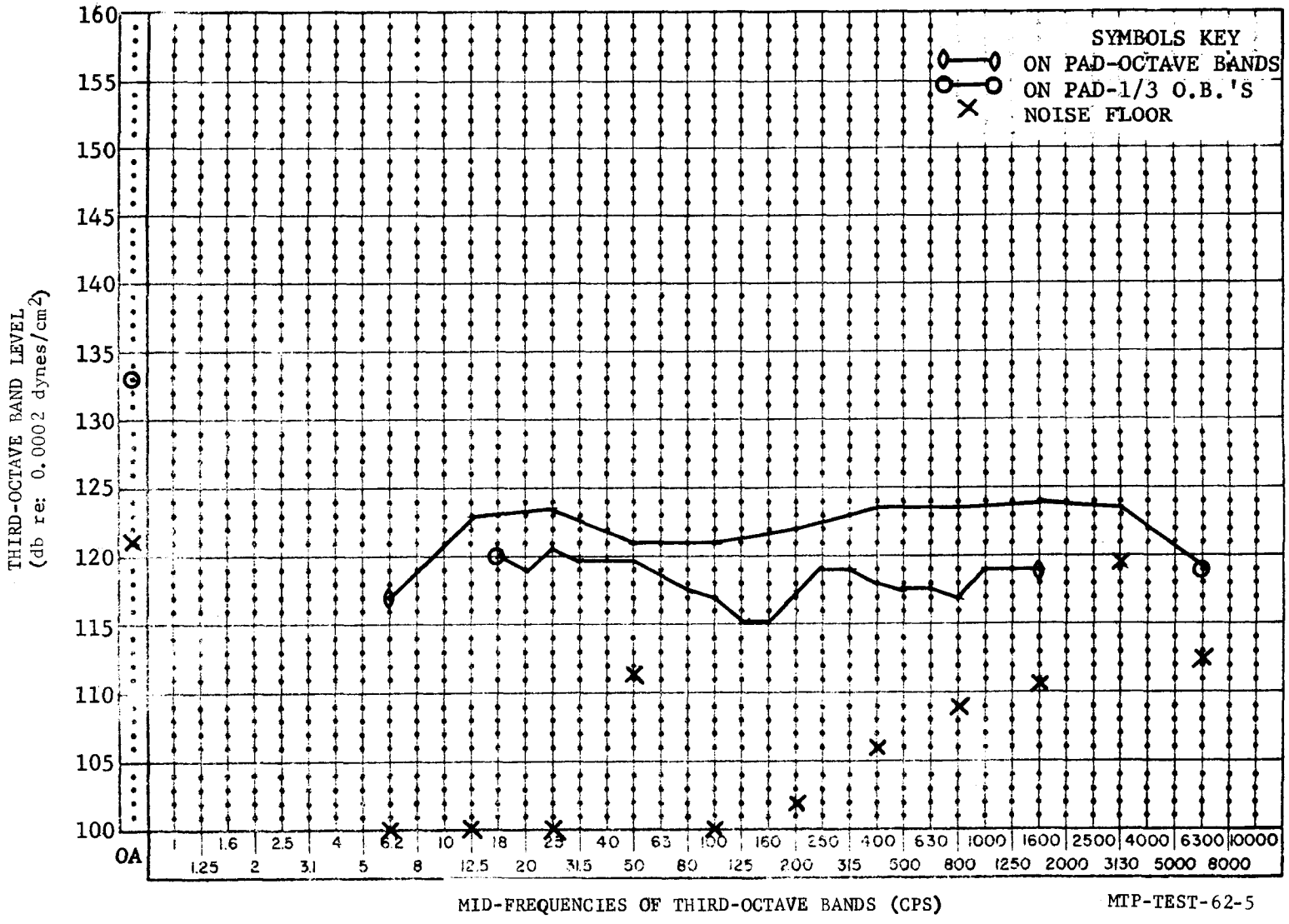

FIGURE 26. RMS SPECTRA, 600 Ft, AZ 162°, A.C. +30° (GRADE LEVEL)

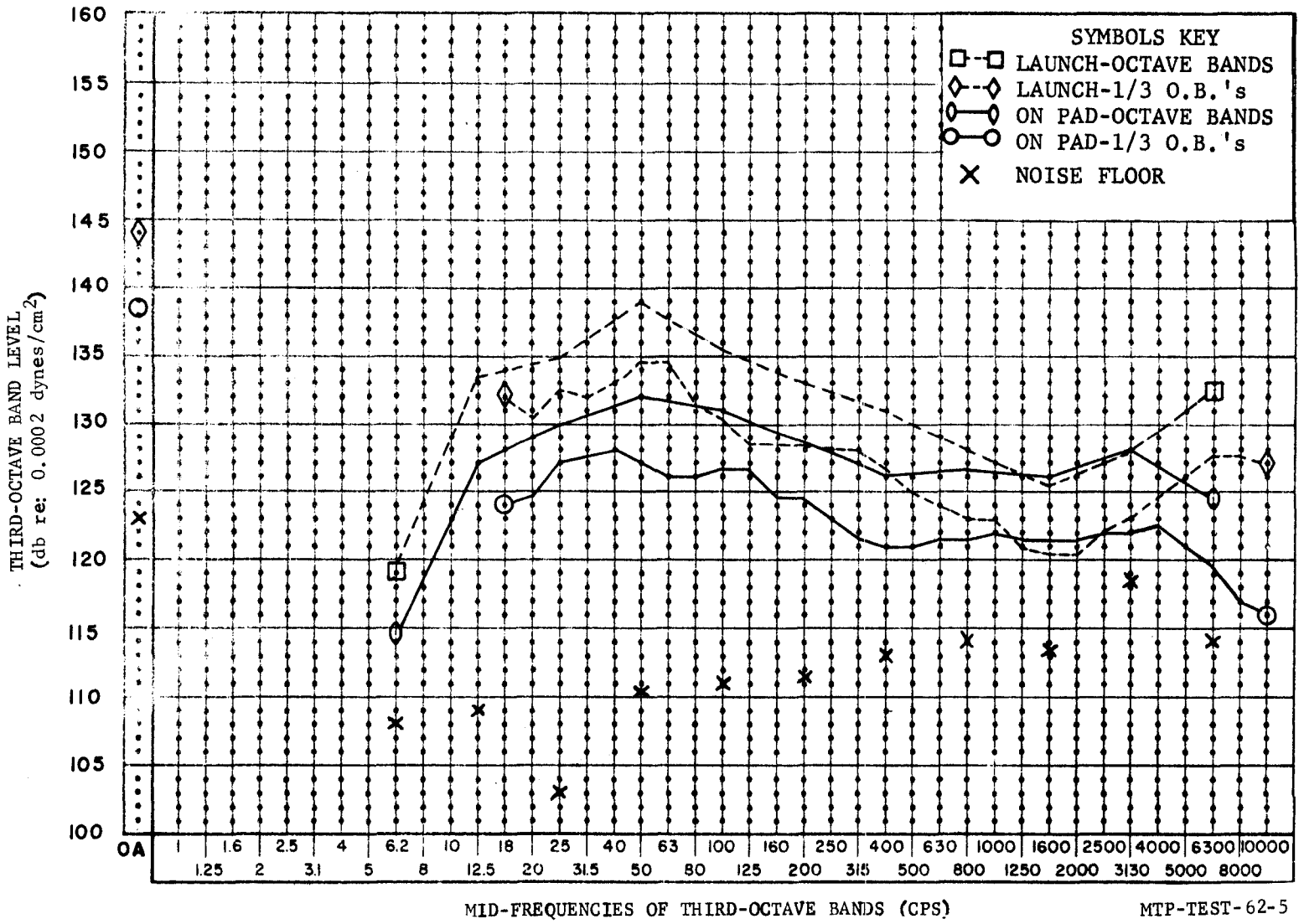

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FIGURE 27. RMS SPECTRA, 600 Ft, AZ 198°, A.C. +70° (GRADE LEVEL)

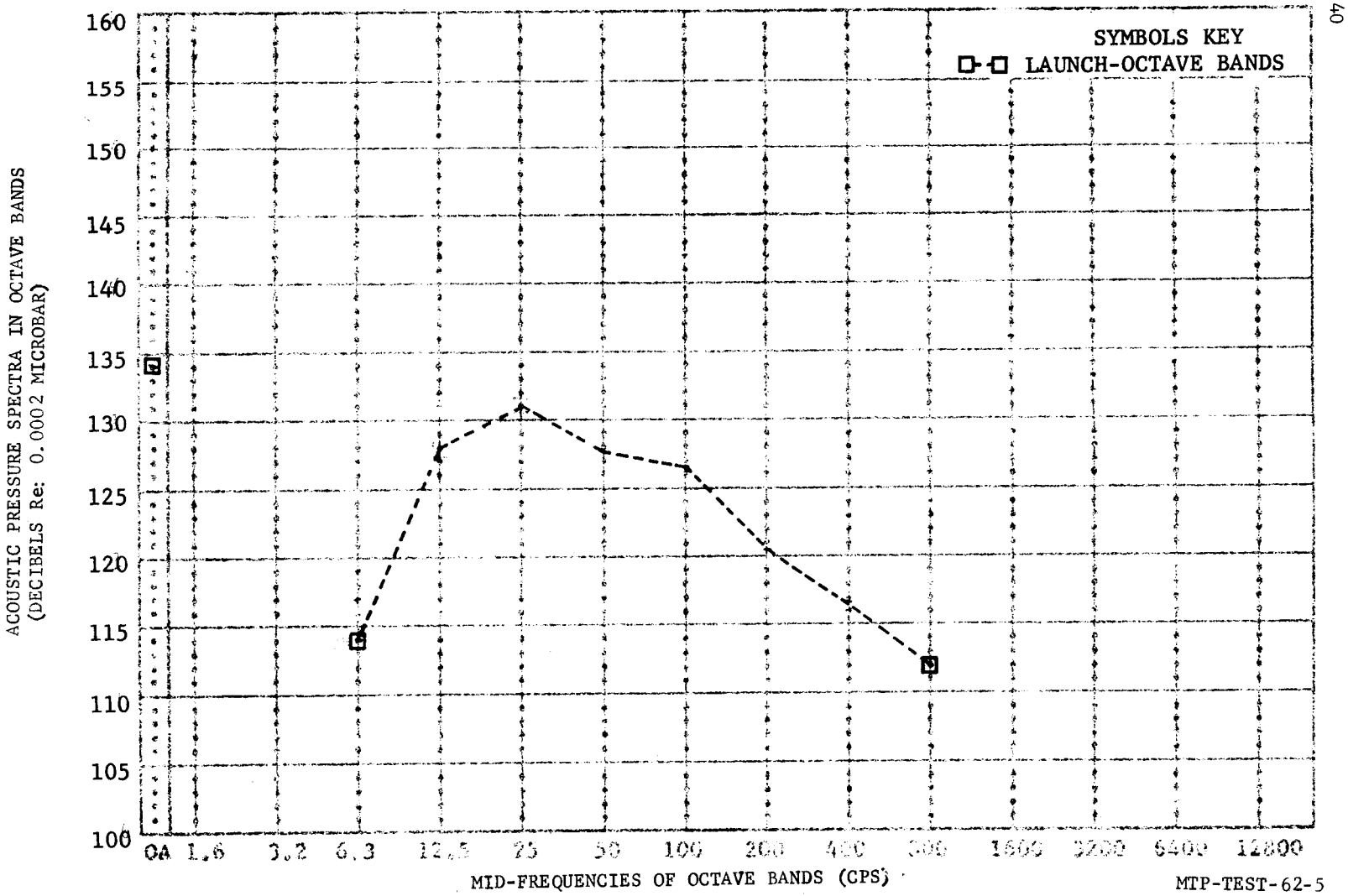

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FIGURE 28. RMS SPECTRA, 1200 Ft, AZ 122°, A.C. -10° (GRADE LEVEL)

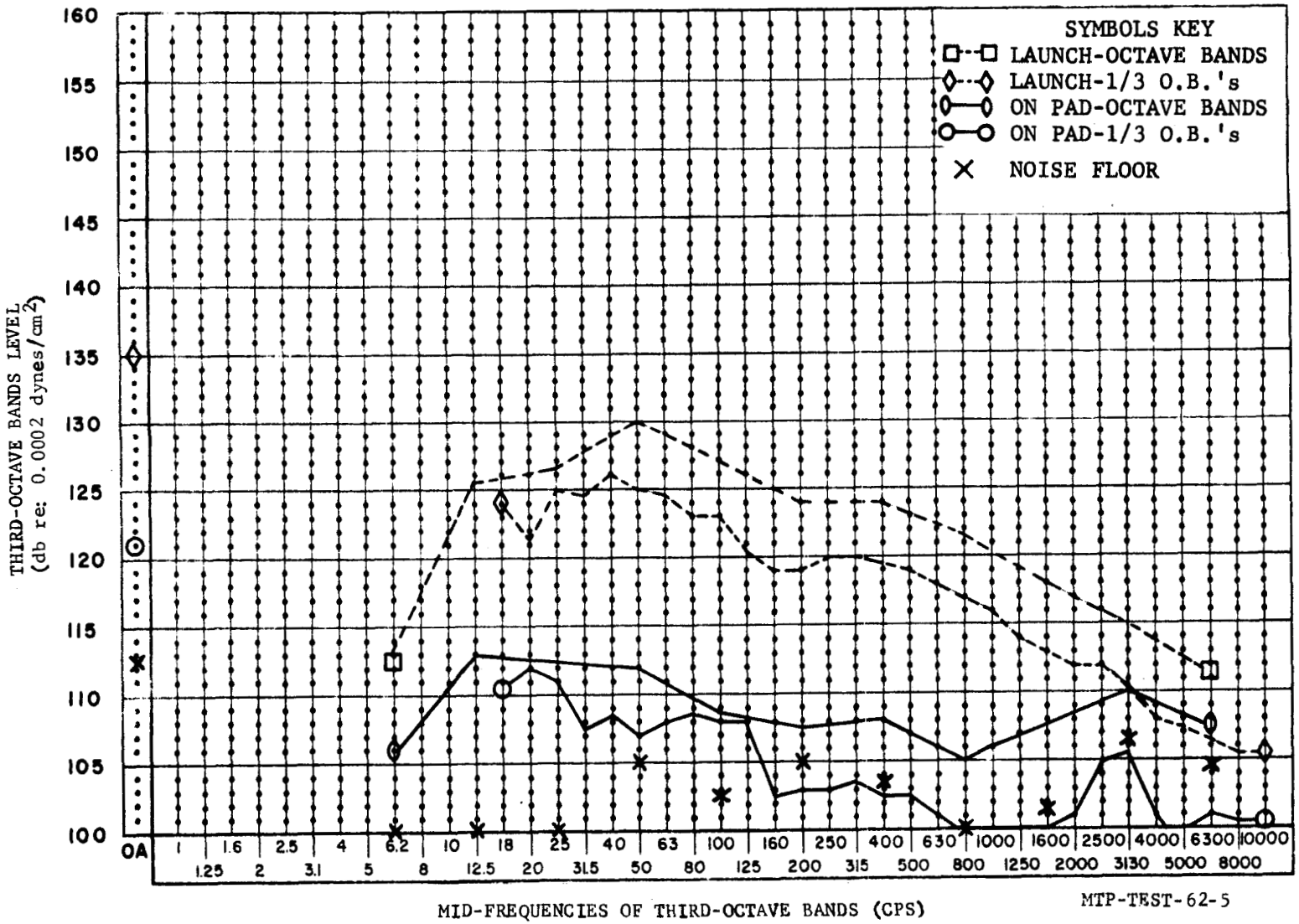

FIGURE 29. RMS SPECTRA, 1200 Ft, AZ 162°, A.C. +30° (GRADE LEVEL)

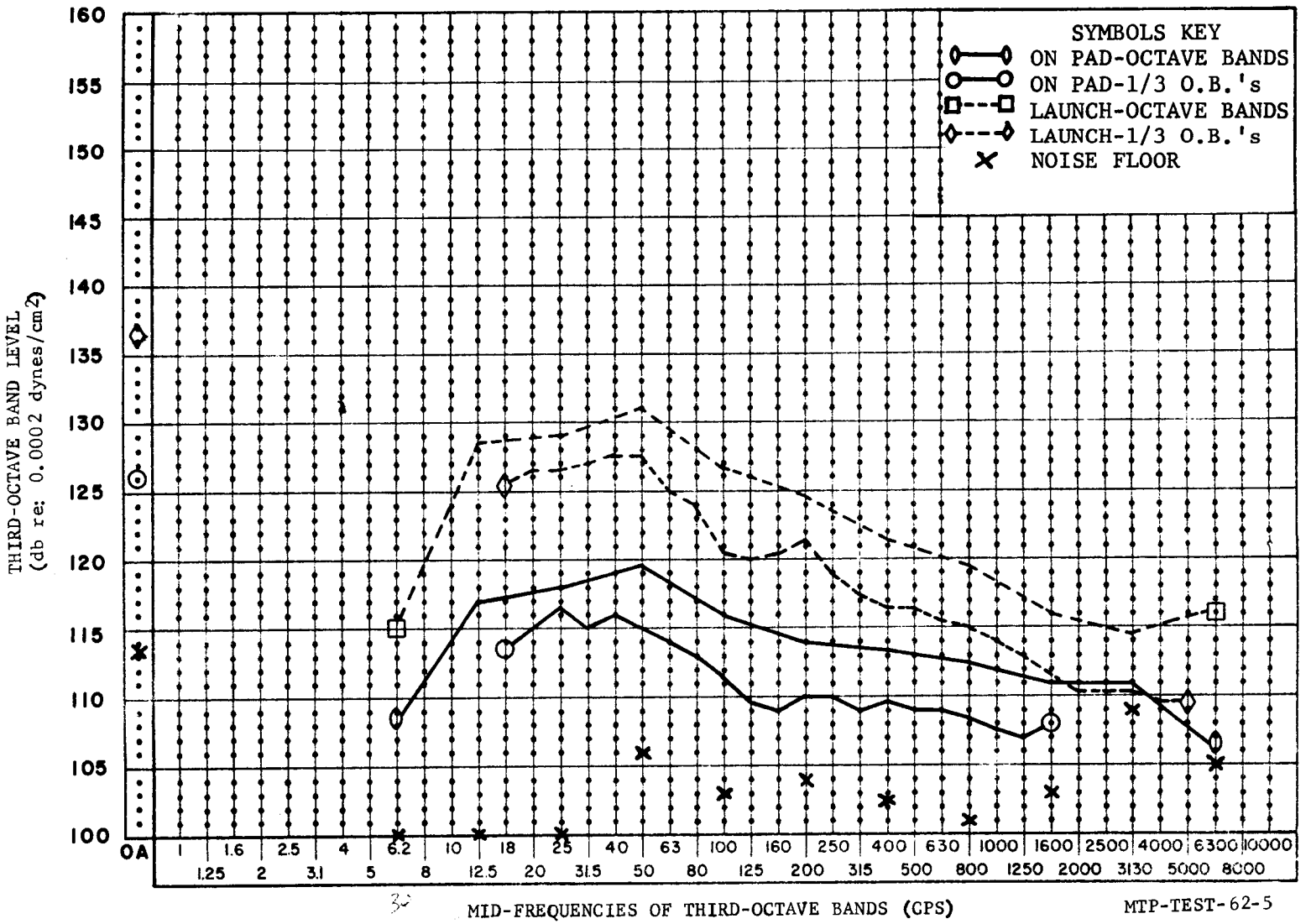

FIGURE 30. RMS SPECTRA, 1200 Ft, AZ 182°, A.C. +50° (GRADE LEVEL)

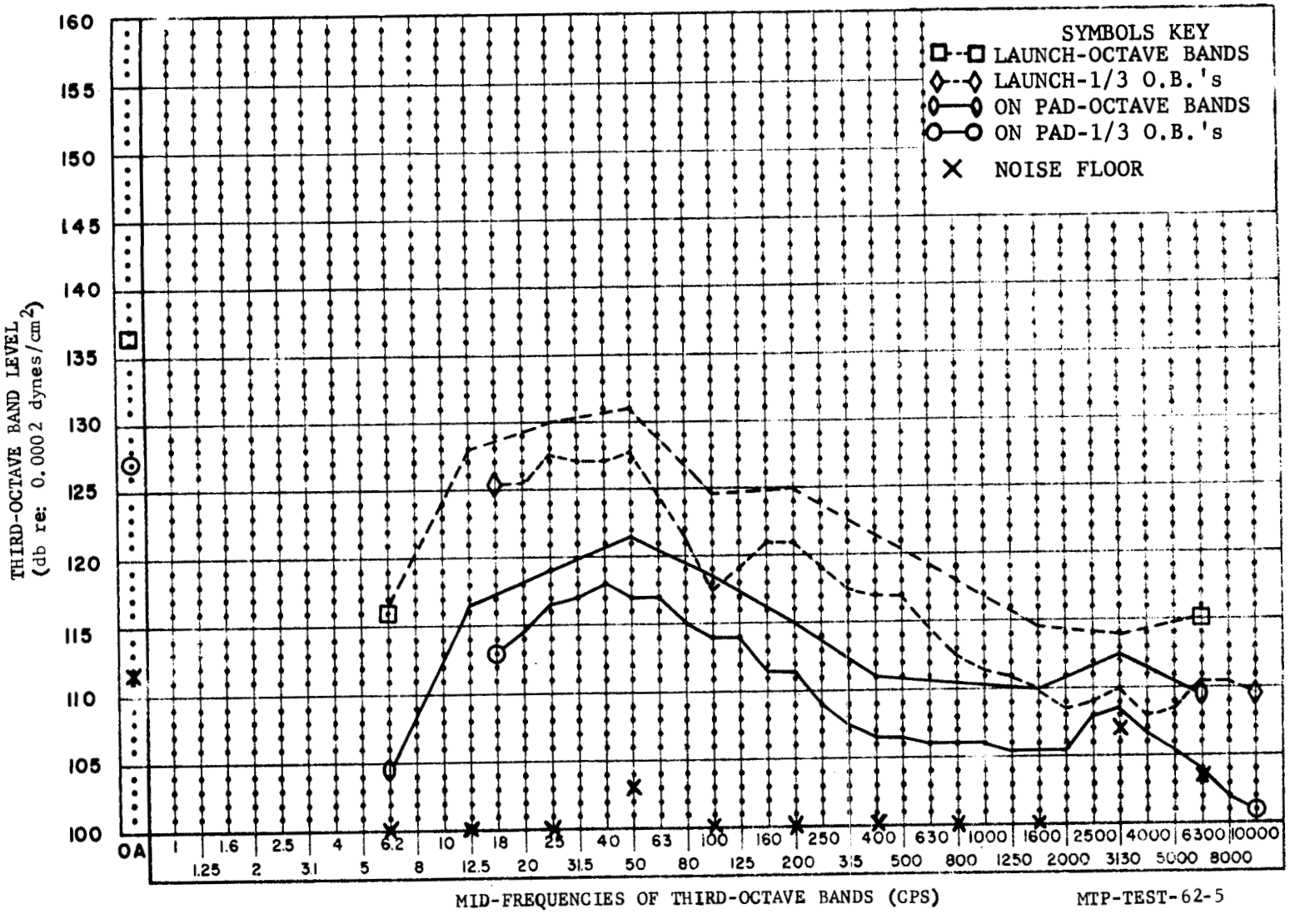

FIGURE 31. RMS SPECTRA, 1200 Ft, AZ 198°, A.C. +70° (GRADE LEVEL)

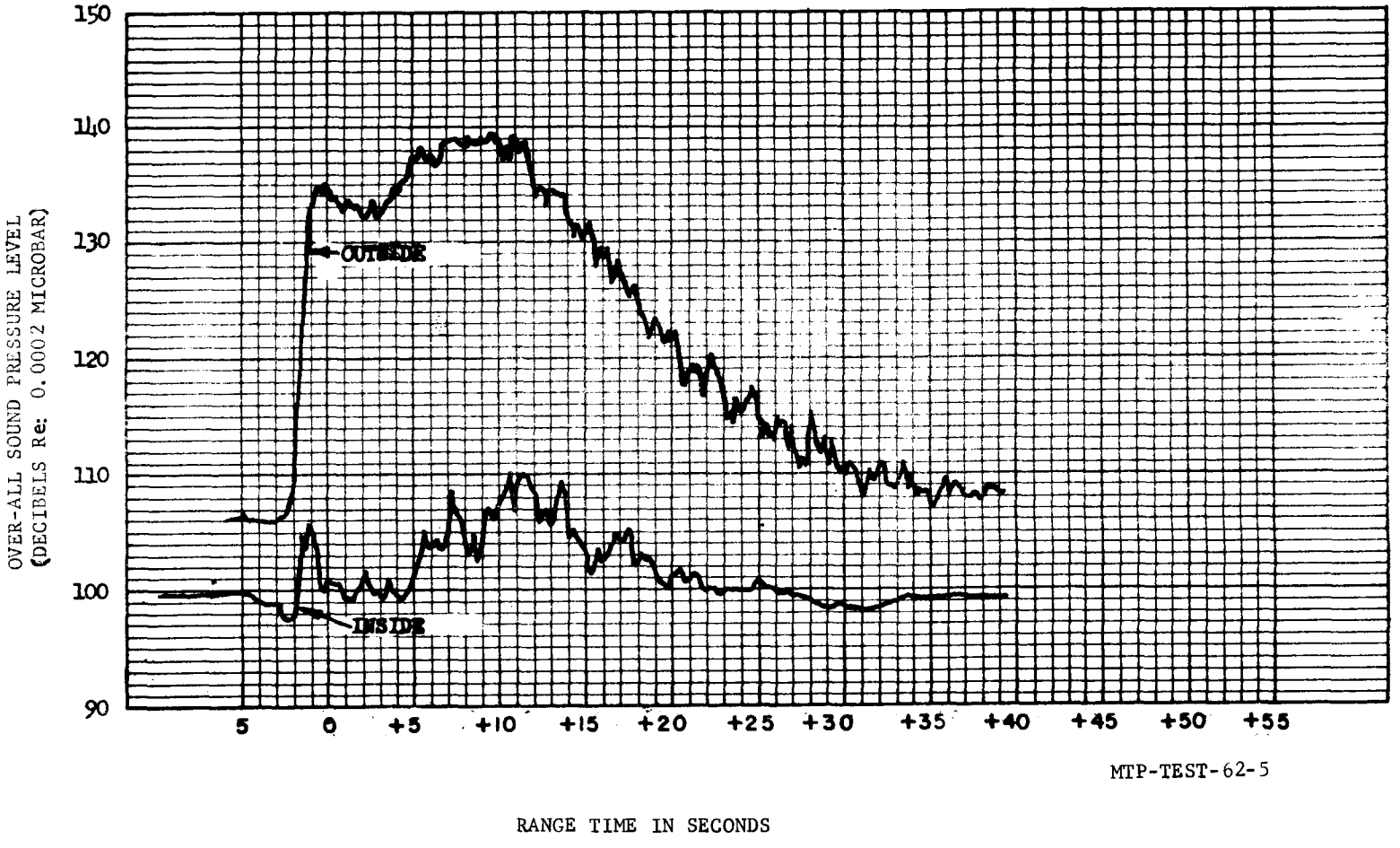

FIGURE 32. OVER-ALL TIME HISTORIES OF MEASUREMENTS AT LC-34 CONTROL BUILDING (AZ 202°)

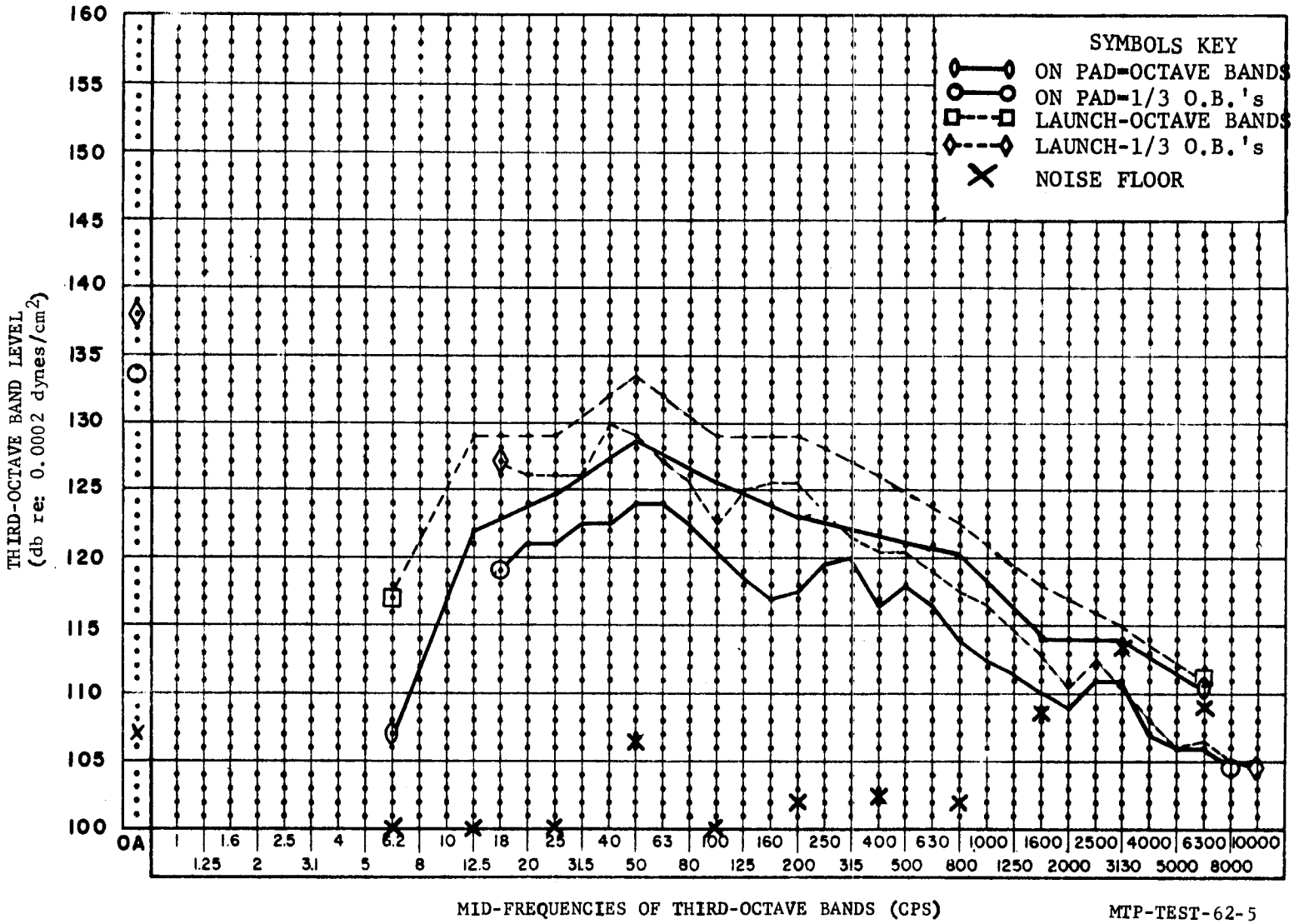

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FIGURE 33. RMS SPECTRA, OUTSIDE BLOCKHOUSE

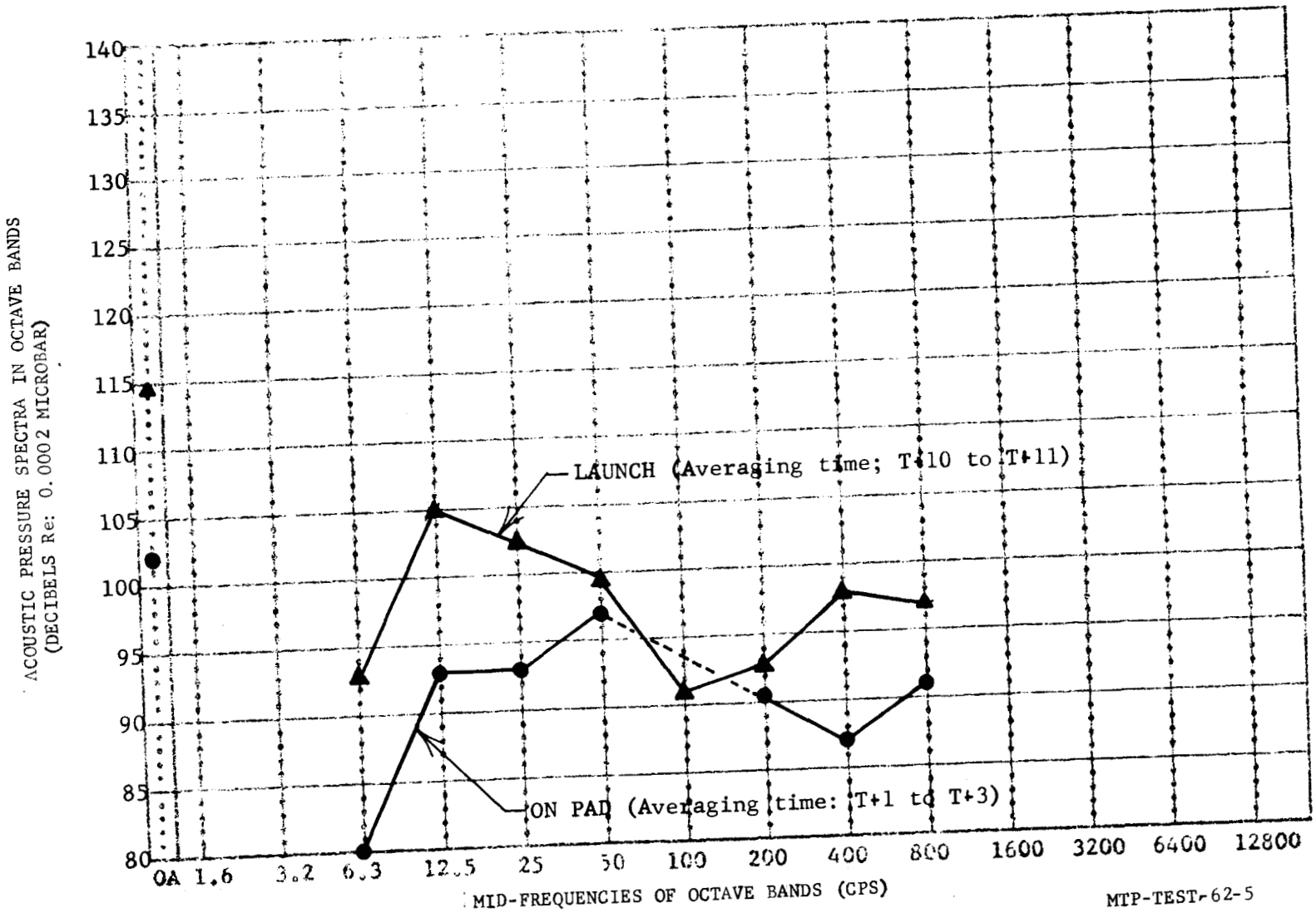

FIGURE 34. RMS SPECTRA, INSIDE BLOCKHOUSE

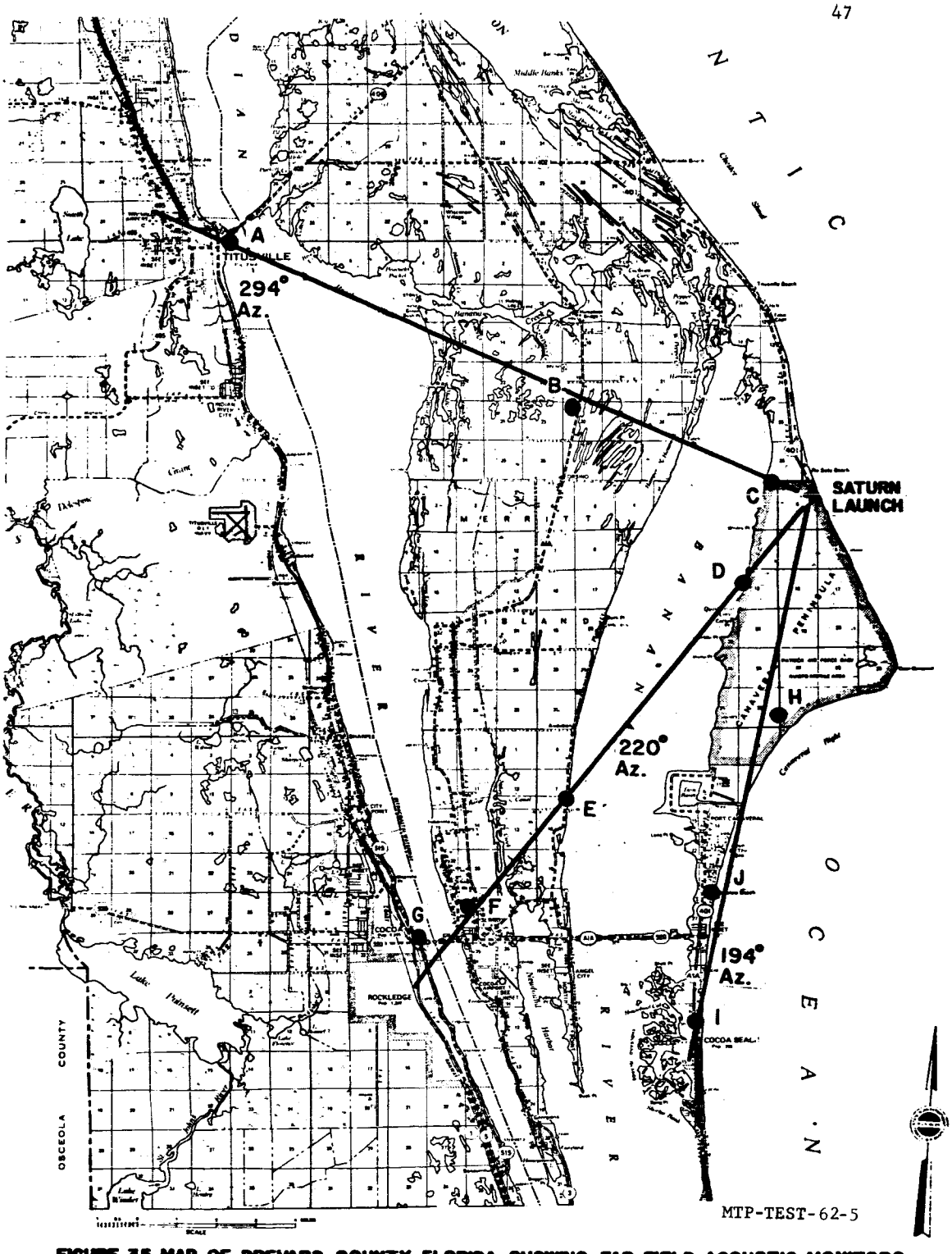

FIGURE 35, MAP OF BREVARD COUNTY, FLORIDA, SHOWING FAR-FIELD ACOUSTIC MONITORS

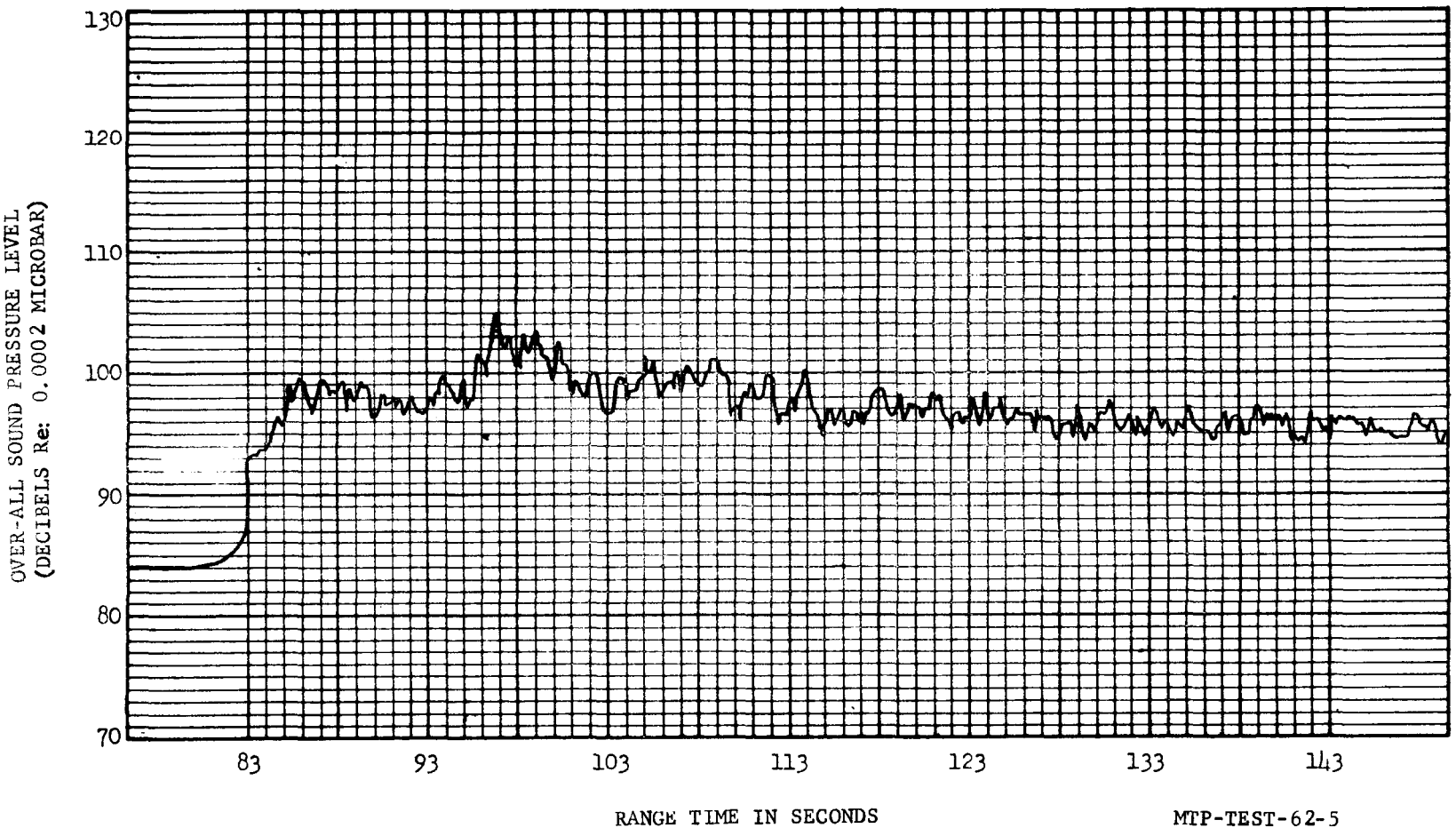

FIGURE 36. OVER-ALL TIME-HISTORY OF THE SATURN

54,300 FEET RNAGE, 194° AZIMUTH

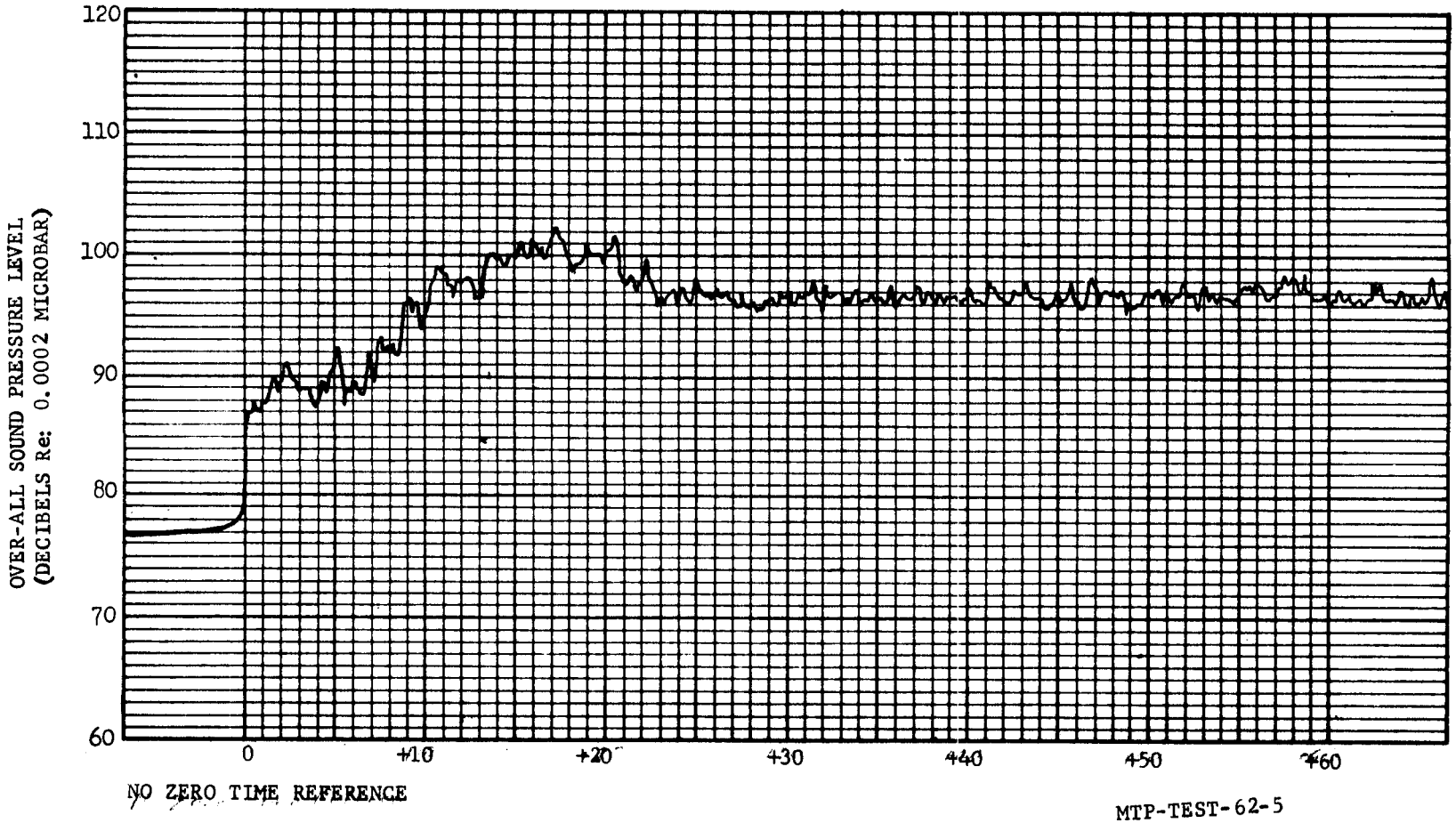

FIGURE 37. OVER-ALL TIME-HISTORY OF THE SATURN
71,250 FEET RANGE, 194° AZIMUTH

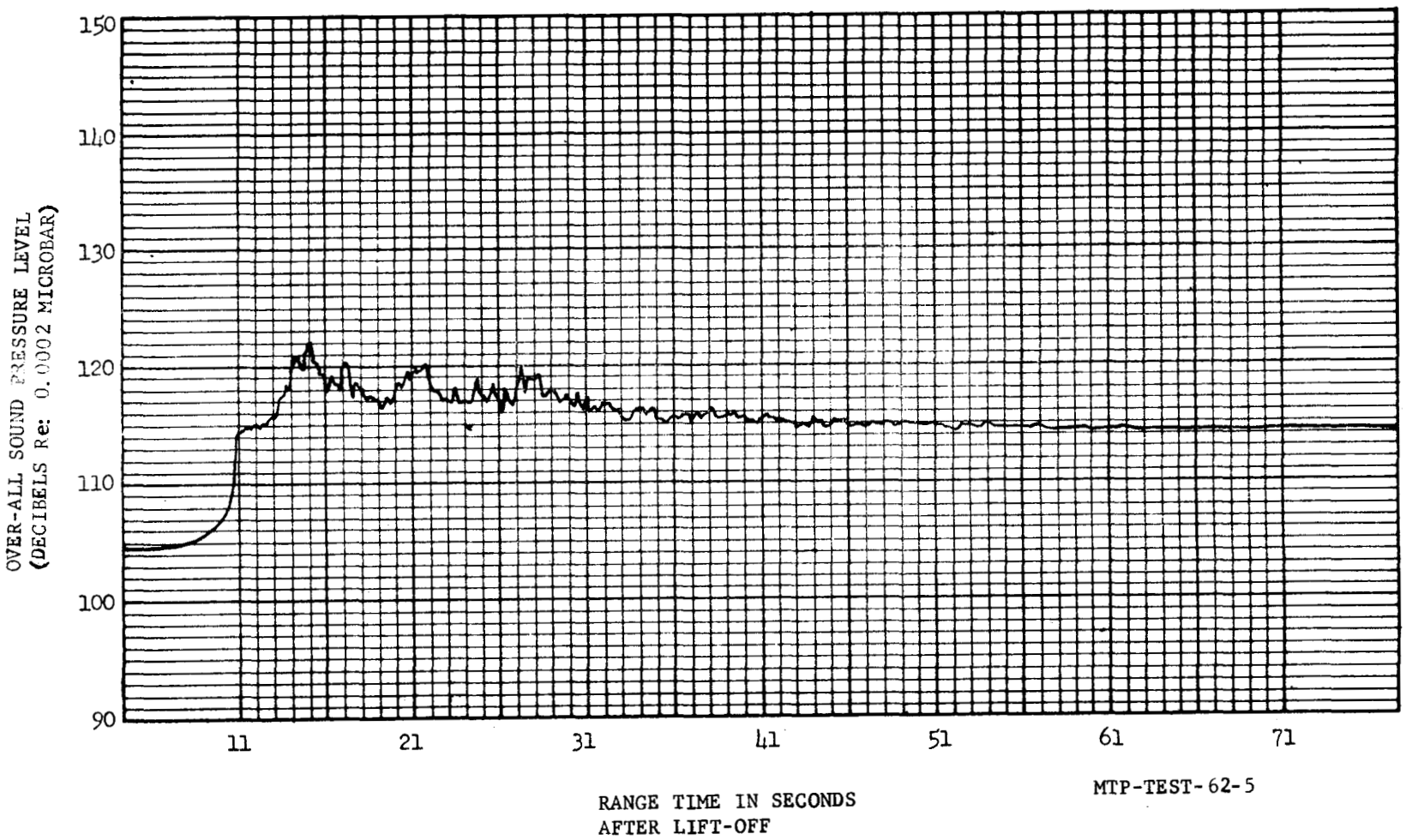

FIGURE 38. OVER-ALL TIME-HISTORY OF THE SATURN.

14,780 FEET RANGE, 220° AZIMUTH

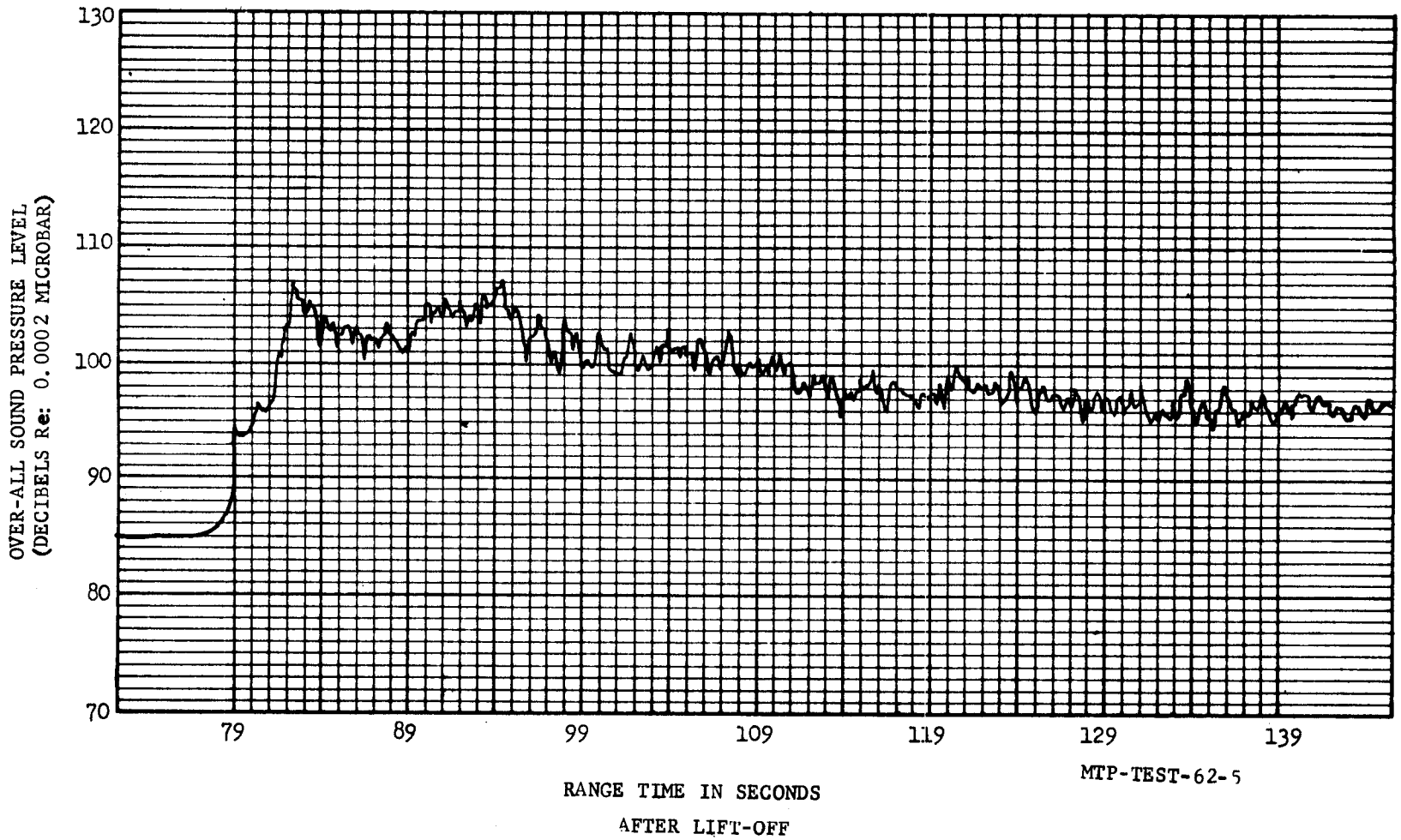

FIGURE 39. OVER-ALL TIME-HISTORY OF THE SATURN.

51,750 FEET RANGE, 220° AZIMUTH

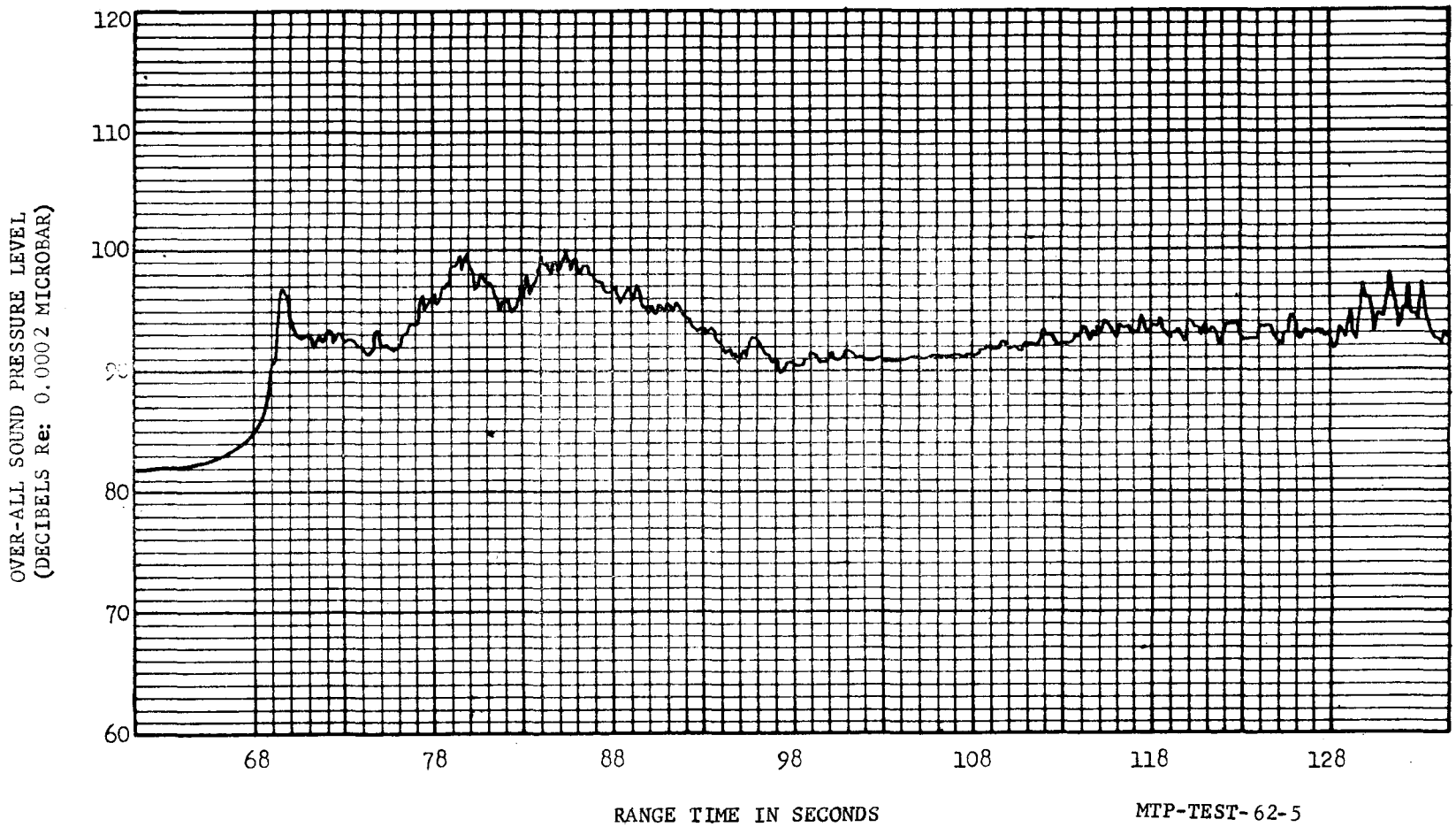

FIGURE 40. OVER-ALL TIME-HISTORY OF THE SATURN.

79,600 FEET RANGE, 220° AZIMUTH

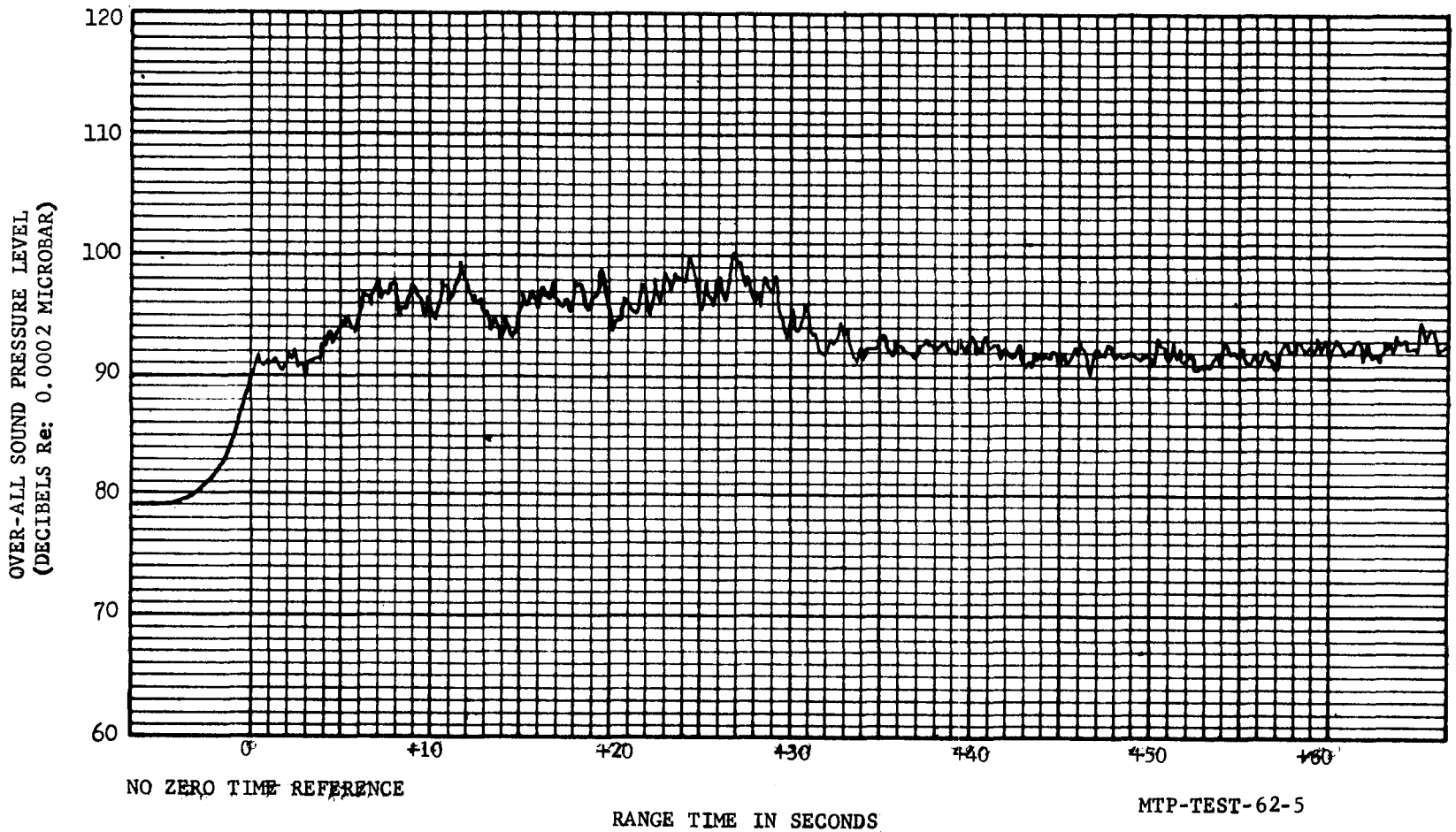

FIGURE 41. OVER-ALL TIME-HISTORY OF THE SATURN.

86,750 FEET RANGE, 294° AZIMUTH

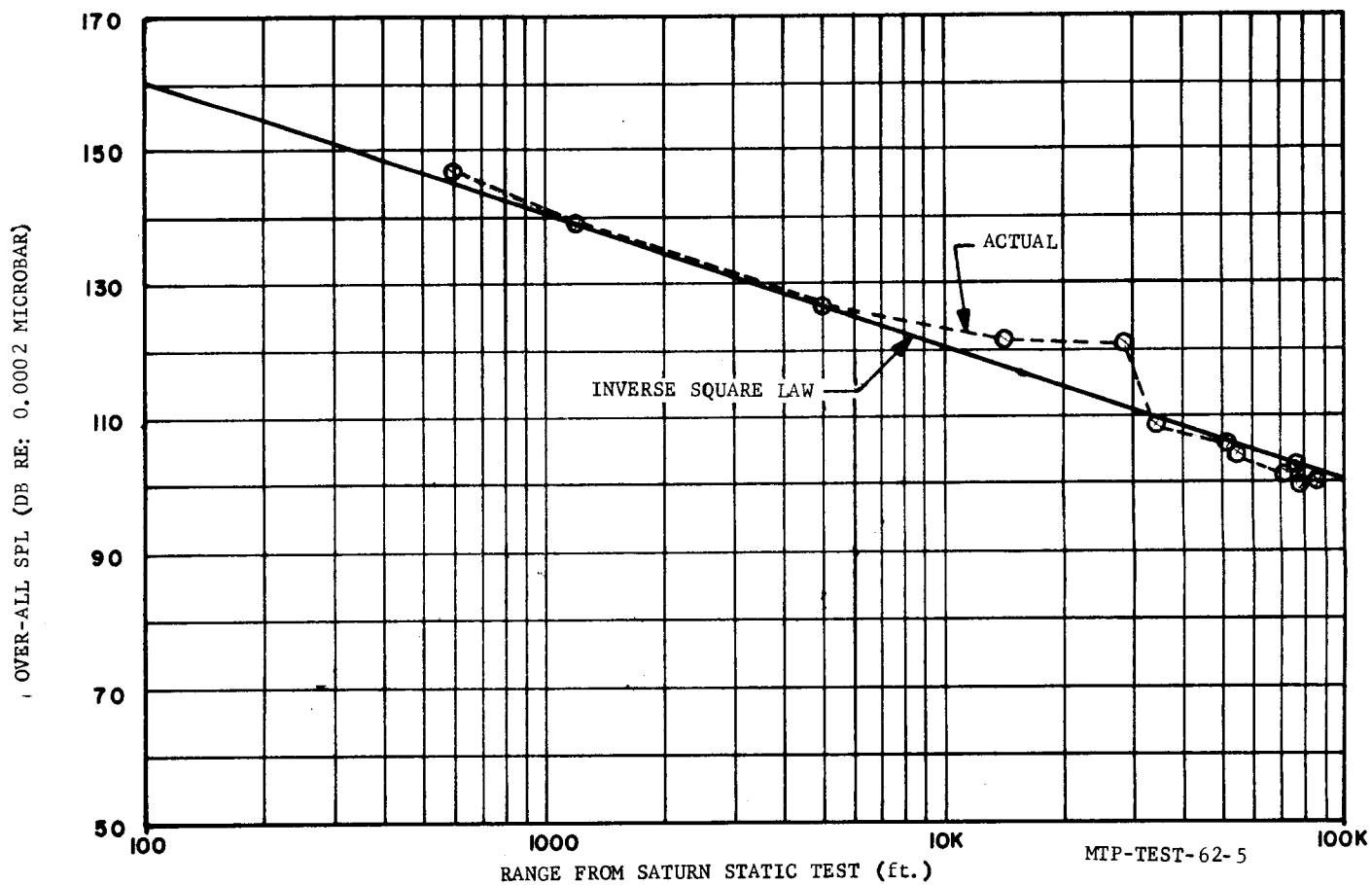

FIGURE 42. OVER-ALL SOUND PRESSURE LEVELS AT VARIOUS RANGES FROM SATURN LAUNCH SA-2.

SATURN SA-2 LAUNCH
ACOUSTIC PROFILE

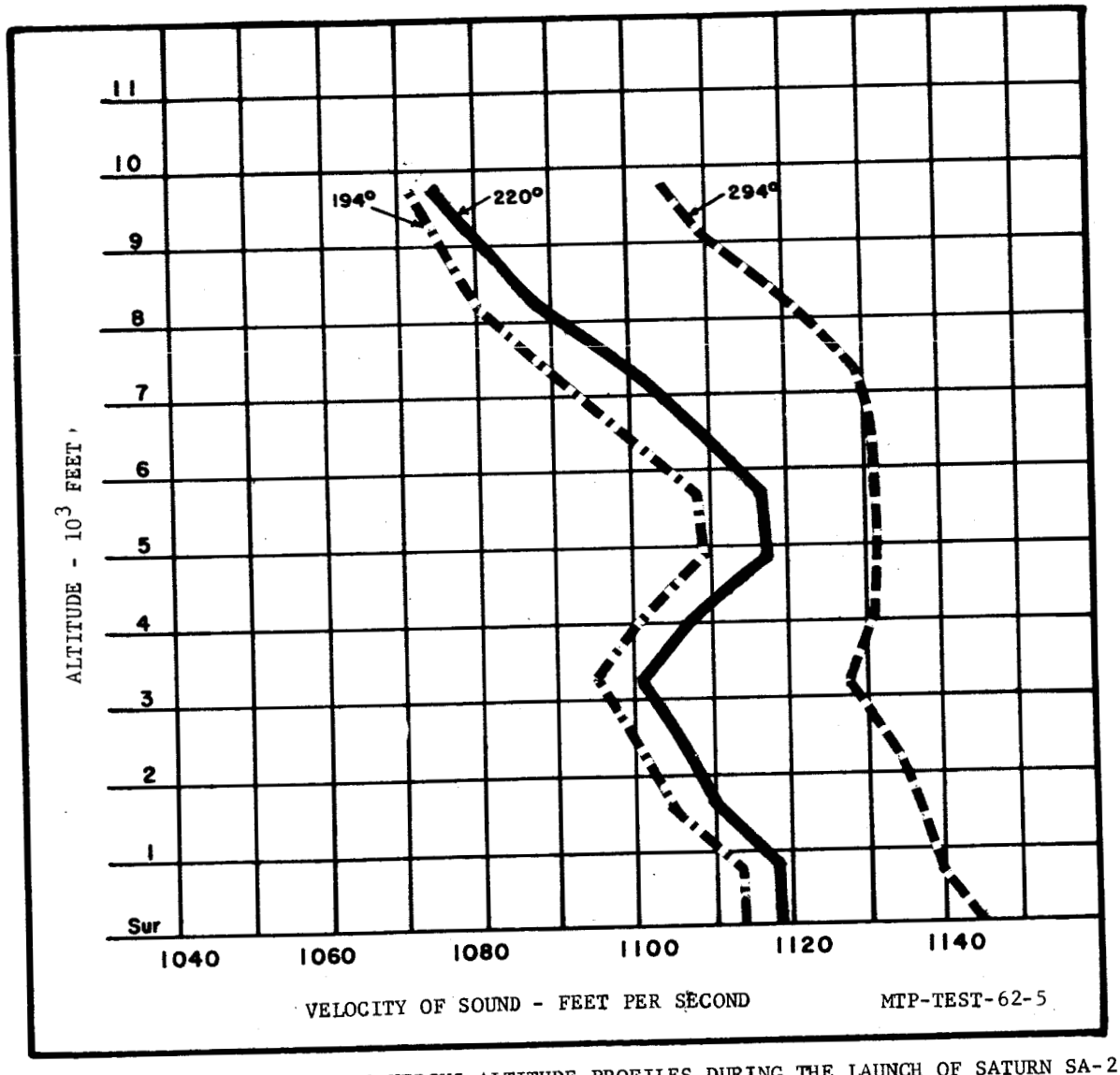

FIGURE 43. VELOCITY OF SOUND VERSUS ALTITUDE PROFILES DURING THE LAUNCH OF SATURN SA-2

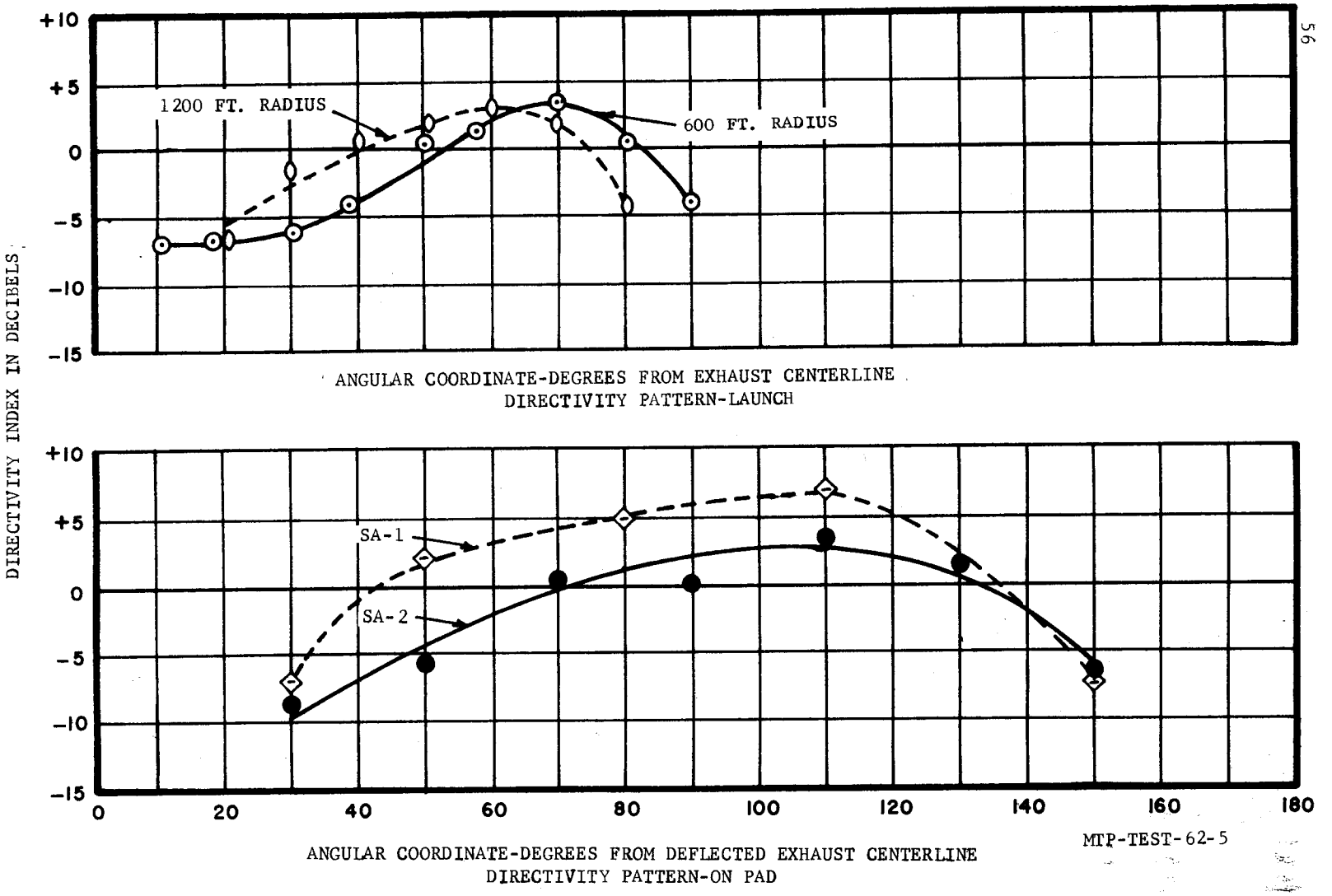

FIGURE 44. SATURN DIRECTIVITY PATTERNS FOR SA-2 LAUNCH

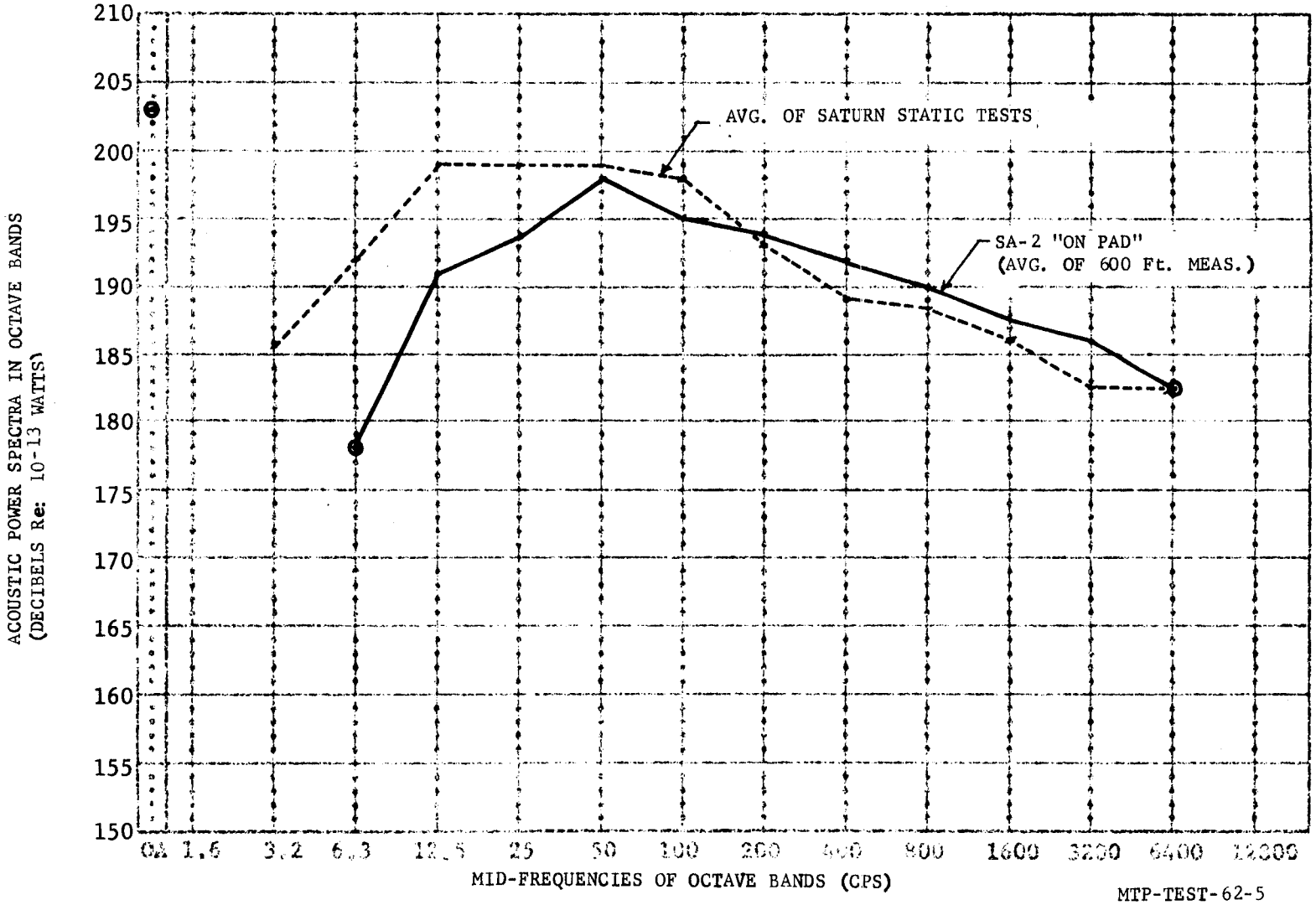

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FIGURE 45. SATURN ACOUSTIC POWER SPECTRA

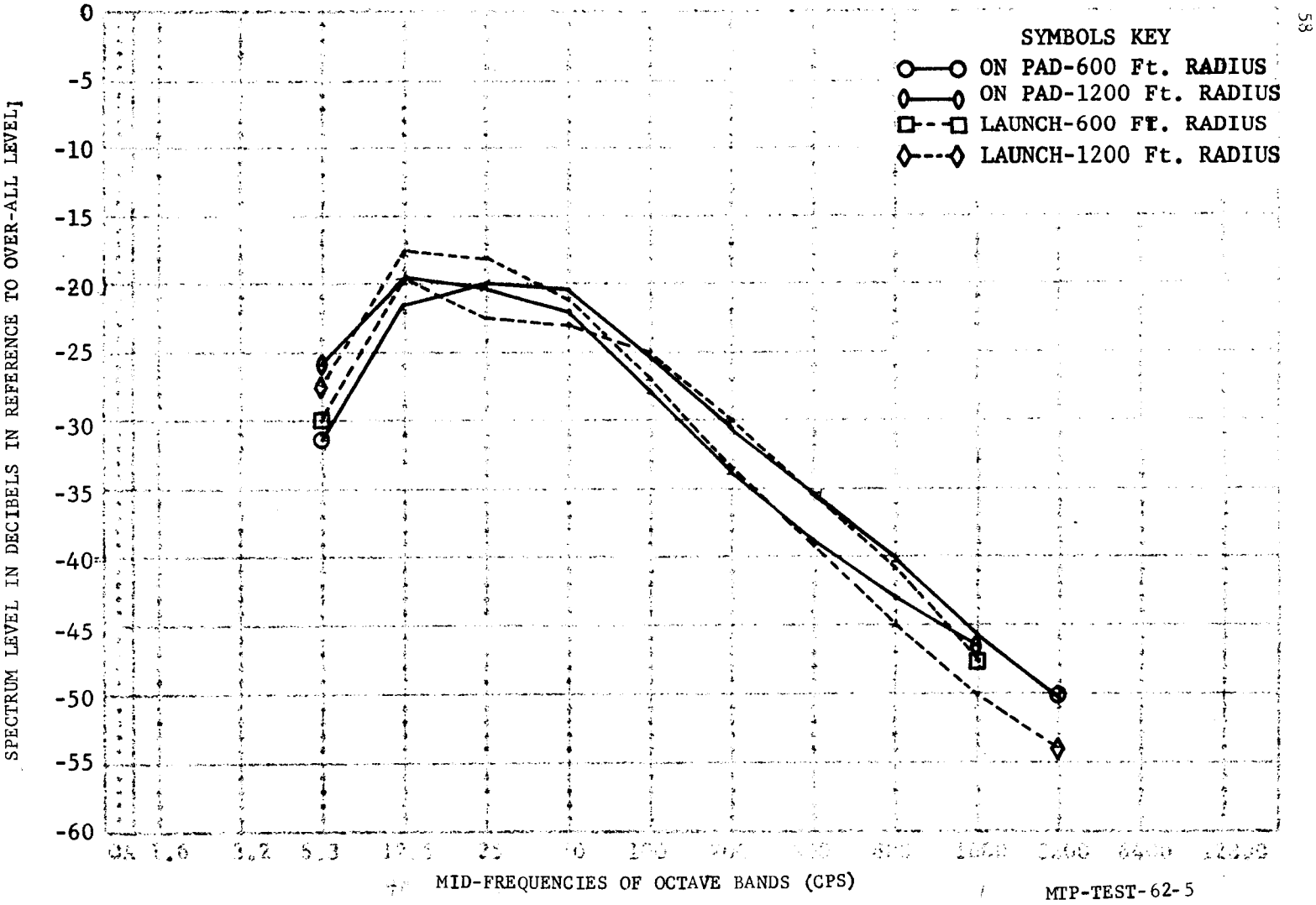

FIGURE 46. SATURN SPECTRUM LEVEL CHARACTERISTICS

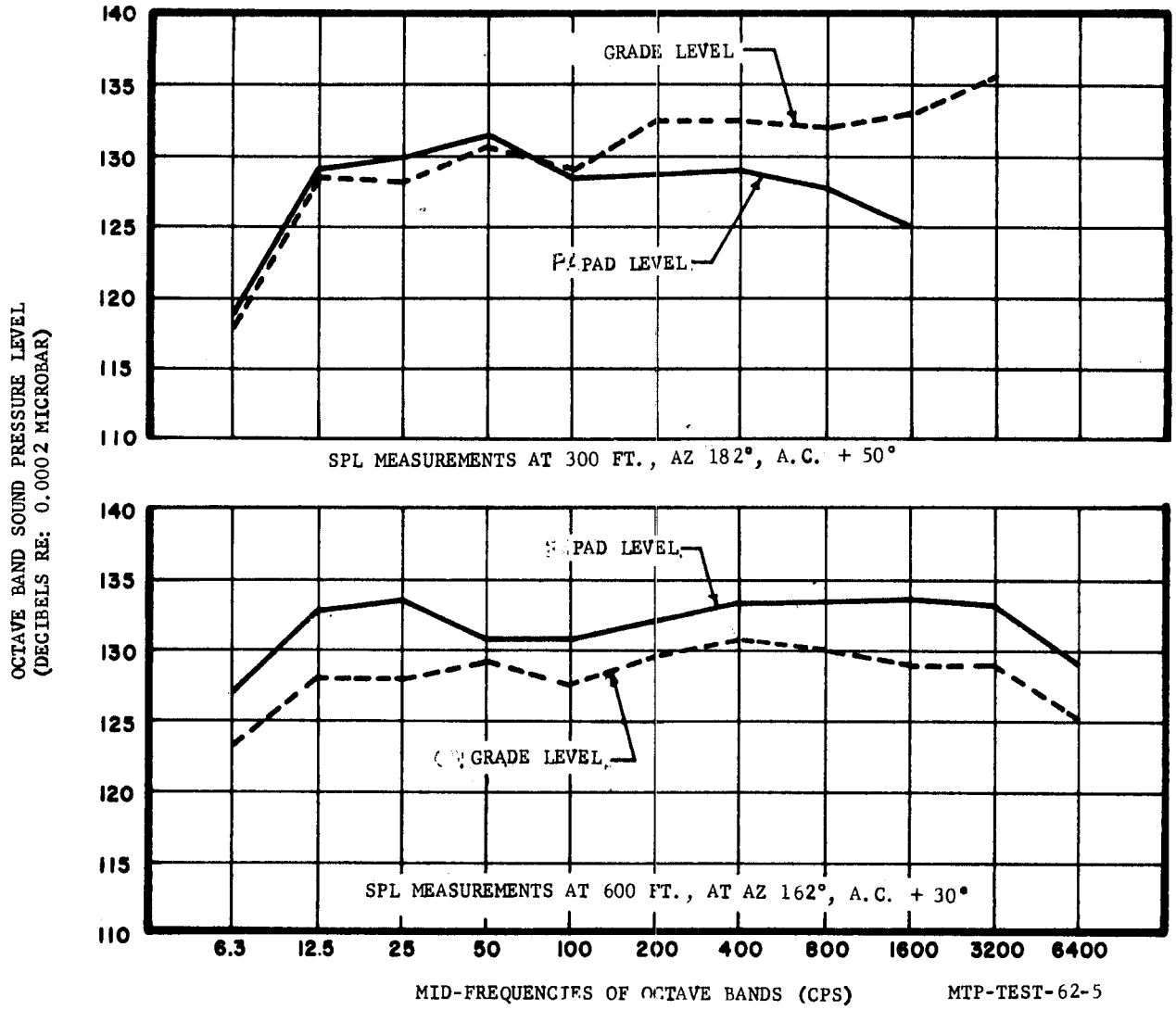

FIGURE 47. COMPARISON OF GRADE LEVEL AND PAD LEVEL SPECTRA DURING ON PAD TIME PHASE

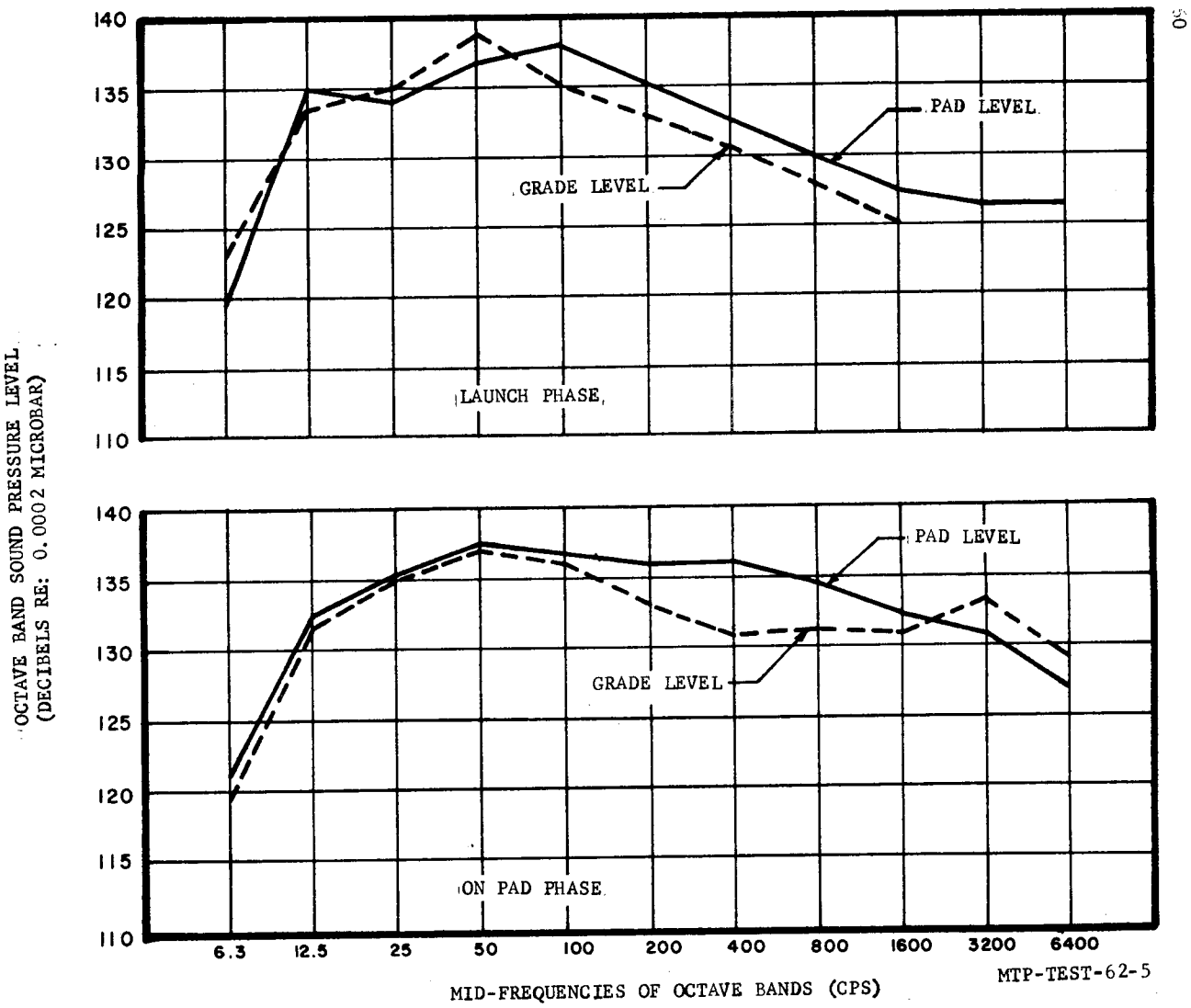

FIGURE 48. COMPARISON OF GRADE LEVEL AND PAD LEVEL SPECTRA AT MICROPHONE LOCATION 600 Ft, AZ 198°, A.C. +70°.

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1. Dorland, W. D. and Tedrick, R. N. "Results of Acoustical Survey of SA-1 Launch," MTP-TEST-62-2, March 27, 1962.

2. Dorland, W. D., "Far-Field Noise Characteristics of Saturn Static Tests," NASA TN D-611, August 1961.

3. Coleman, D. J., Jr., "Results of NASA-LOD Sound Pressure Level Measurements During SA-2 Launch," MTP-LOD-62-9, May 21, 1962.

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APPROVAL MTP-TEST-62-

RESULTS OF ACOUSTIC SURVEY OF SA-1 LAUNCH

by

Wade D. Dorland and Richard N. Tedrick

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

C. C. THORNTON
Chief, Special Projects Unit
Components Instrumentation Section
Measuring & Instrumentation Branch

KARL L. HEIMBURG
Director, Test Division

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