

RTD-TDR-63-4139
Vol I

FOREWORD

The research work in this report was performed by the IIT Research Institute, Chicago, Illinois, for the Aerospace Dynamics Branch, Vehicle Dynamics Division, AF Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, under Contract AF33-(657)-8231. This research is part of a continuing effort to provide rational and reliable dynamic load design criteria for flight vehicles and is part of the Research and Technology Division, Air Force Systems Command's exploratory development program. The Department of Defense Program Element Number is 6.24.05.33.4, "Aircraft Flight Dynamics". This work was performed under Project No. 1367 "Structural Design Criteria", Task No. 136701, "Design Criteria for Ground-Induced Dynamic Loads". Walter P. Dunn and later Bernard H. Groomes, of the Vehicle Dynamics Division, AF Flight Dynamics Laboratory, were the Project Engineers. The research was conducted from March 1962 to October 1963.

IIT Research Institute personnel who contributed to the program are C. E. Gebhart, Dr. E. E. Hahn, Dr. E. Saleme, R. E. Wheeler, and W. J. Wheeler.

Contrails

RTD-RTD-TDR-63-4139
Vol I

ABSTRACT

The purpose of this research program was to collect all available measured prepared surface profile and power spectral data, to ascertain the reliability of these data, to establish from these data design criteria for vehicles operating on prepared surfaces, and to demonstrate the applicability of these design criteria.

All of the known power spectral density and profile data sets which have been compiled in the United States and in the countries of the North Atlantic Treaty Organization are described. Power spectral density curves are given for those data sets which do not appear in United States Government Agency documents. The procedures used for calculation of these power spectral densities are examined and recommendations as to which power spectral have been accurately computed are made. Design criteria for vehicles operating on prepared surfaces (runways, taxiways or ramps) are established in the form of power spectral densities and discrete bumps.

In Volume II, both deterministic and statistical analyses are used to determine the responses of a five-degree-of-freedom vehicle to some of these criteria.

PUBLICATION REVIEW

This report has been reviewed and is approved.


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RTD-TDR-63-4139

TABLE OF CONTENTS
VOLUME ONE

<u>Section</u>		<u>Page</u>
I.	INTRODUCTION	1-1
II.	DATA COLLECTION AND HANDLING	1-3
III.	COMPUTATION OF POWER SPECTRAL DENSITIES	1-7
	1. The Computer Program	1-7
	2. The Validity of Spectral Density Estimates	1-9
	(a) basic definitions	1-9
	(b) spectral density estimates	1-10
	(c) prefiltering	1-12
	(d) windows, lags, and aliasing	1-16
	(e) evaluation of estimate	1-16
IV.	DEVELOPMENT OF DESIGN CRITERIA	1-18
	1. Power Spectra Criteria	1-18
	2. Discrete Bump Criteria	1-34
	3. Limitations and Areas of Application of Criteria	1-34
	REFERENCES	1-43
APPENDIXES		
I.	GENERATION OF PROFILES FROM POWER SPECTRA	1-45
II.	POWER SPECTRAL DENSITIES	1-53
III.	DISCRETE BUMP MEASUREMENTS	1-149
IV.	PROFILE RECORD BOOK	1-165

RTD-TDR-63-4139

LIST OF ILLUSTRATIONS
VOLUME ONE

<u>Figure</u>		<u>Page</u>
1-1	Sample Data Card	1-6
1-2	Comparison of Technique for Removing Power at Zero Frequency (Runway 41)	1-13
1-3	Comparison of Technique for Removing Power at Zero Frequency (Runway 39)	1-14
1-4	Profile of Runway 41	1-15
1-5	Profile of Runway 39	1-15
1-6	Comparison of Spectra Computed Using Hamming and Hanning Windows: Data Set 39	1-17
1-7	Comparison of Spectra Computed Using 40 Lags Versus 120 Lags: Data Set 39	1-17
1-8	Power Spectral Density Roughness Classification Diagram	1-22
1-9	Distributions for N, D', and Q'; All Non ASD Data	1-23
1-10	Distributions for N, D, and Q; All ASD Data	1-24
1-11	Distributions for N, D, and Q; ASD Runways	1-25
1-12	Distributions for N, D, and Q; ASD Runways Longer than 8,000 ft	1-26
1-13	Distributions for N, D, and Q; ASD Runways Shorter than 8,000 ft	1-27
1-14	Distributions for N, D, and Q; ASD Taxiways	1-28
1-15	Distributions for N, D, and Q; ASD Ramps	1-29
1-16	Power Spectral Density Criteria; All Non-ASD Data	1-30
1-17	Power Spectral Density Criteria; All ASD Data	1-31
1-18	Power Spectral Density Criteria; ASD Runways	1-31
1-19	Power Spectral Density Criteria; ASD Runways Longer than 8,000 ft	1-32
1-20	Power Spectral Density Criteria; ASD Runways Shorter than 8,000 ft	1-32
1-21	Power Spectral Density Criteria; ASD Taxiways	1-33
1-22	Power Spectral Density Criteria; ASD Ramps	1-33

RTD-TDR-63-4139

LIST OF ILLUSTRATIONS (Cont.)

<u>Figure</u>		<u>Page</u>
1-23	Distribution of Bump Length	1-35
1-24	Distribution of Bump Height/Bump Length	1-35
1-25	Distribution of Dip Length	1-36
1-26	Distribution of Dip Height/Dip Length	1-36
1-27	Distribution of Angular Deviation from 180 deg	1-37

RTD-TDR-63-4139

LIST OF TABLES
VOLUME ONE

<u>Table</u>		<u>Page</u>
1-1	Orgnizations Contacted in Data Search	1-4
1-2	IBM Card Format	1-5
1-3	Spectral Density Classification	1-19
1-4	Statistics for Spectral Density	1-20
1-5	Power Spectral Density Criteria	1-21
1-6	Distribution of Bumps by Height and Length	1-38
1-7	Distribution of Dips by Depth and Length	1-39
1-8	Typical Characteristics of Aircrafts	1-40

LIST OF SYMBOLS

a_0, a_1	dimensionless	Constants Describing Spectral Window
C	ft^2	Autocovariance
C_0	ft^2	Autocovariance with Lag 0
C_μ	ft^2	Autocovariance with Lag μ
C_p	ft^2	Autocovariance with Lag p
C_r	ft^2	Autocovariance with Lag r
C_z	ft^2	Autocovariance of $Z(t)$
D	dimensionless	Lag Window
D, D'	dimensionless	Parameters Specifying PSD Curve Position
\bar{D}, \bar{D}'	dimensionless	Mean Values of D and D'
f	cps	Frequency
f_0	cps	Frequency
f_n	cps	Natural Frequency
G	dimensionless	Lag Window
h	ft	Bump Height or Dip Depth
I_T	$ft^2 / (rad/ft)$	Periodogram
K	dimensionless	Index Denoting Mass Position
L	ft	Bump or Dip Length
\bar{L}	ft	Mean Value of L
M	dimensionless	Maximum Lag
N	dimensionless	Parameters Specifying PSD Curve Position
\bar{N}	dimensionless	Mean Value of N
P	$ft^2 / (rad/ft)$	Power Spectral Density

LIST OF SYMBOLS (Cont.)

P_1	$\text{ft}^2 / (\text{rad}/\text{ft})$	Power Spectral Density
\bar{P}_1	$\text{ft}^2 / (\text{rad}/\text{ft})$	Power Spectral Density
P_z	$\text{ft}^2 / (\text{rad}/\text{ft})$	Power Spectral Density of z
p	dimensionless	Index Denoting Lag
Q	ft	Spectral Window
Q, Q'	dimensionless	Parameters Specifying Over-all Quality of PSD Curves
\bar{Q}, \bar{Q}'	dimensionless	Mean Values of Q and Q'
r	dimensionless	Lag Index
T	sec	Dummy Time Variable
T	ft	Dummy Space Variable
T	ft	Record Length
T'	ft	Lag
T_r	dimensionless	Factor for Removal of Preshitener
t	dimensionless	Index Denoting Data Point
t	sec	Time
t	ft	Distance
t'	sec	Particular Value of t
u_r	$\text{ft}^2 / (\text{rad}/\text{ft})$	Smoothed Power Spectral Density
u_r'	$\text{ft}^2 / (\text{rad}/\text{ft})$	Power Spectral Density
V	fps	Taxiing Velocity
V_r	$\text{ft}^2 / (\text{rad}/\text{ft})$	Cosine Series Transform of C_r
W	dimensionless	Weighting Function
W	cycles/sec	Frequency

Contrails

LIST OF SYMBOLS (Cont.)

X_x	ft	Position of kth Mass
X_n	ft	Position of nth Mass
X_t	ft	Runway Data
\tilde{X}_n	ft	Smoothed Runway Data
X_t'	ft	Prewhitened Runway Data
X_{t_0}	ft	Runway Data
$X(t)$	ft	Random Function of Time
Y_t	ft	Adjusted Runway Data
$Y(t)$	ft	Random Function of Time
$Z(t)$	ft	Random Function of Time
α	dimensionless	Constant for Prewhitening Data
α	dimensionless	Constant for Smoothing Mass Heights
α_k	dimensionless	Constant for Smoothing Mass Heights
α_t	dimensionless	Constant for Smoothing Mass Heights
β	dimensionless	Constant for Removal of Linear Trend
β	dimensionless	Constant for Smoothing Mass Heights
$\hat{\beta}$	dimensionless	Value of β for Removal of Linear Trend
γ	$\text{ft}^2 / (\text{rad}/\text{ft})$	Parameter for Power Spectral Density
$\hat{\gamma}$	dimensionless	Value of γ for Removal of Mean
γ	dimensionless	Constant for Removal of Mean
Δ	ft	Distance between Adjacent Data Points
Δ	ft	Allowable Height Deviation between Adjacent Data Points
δ	rad/sec	Frequency Range

LIST OF SYMBOLS (Cont.)

δ	deg	Angular Deviation
ξ_t	ft	Independent Gaussian Variables
σ		Standard Deviation
τ	ft	Dummy Space Variable
ϕ	$\text{ft}^2 / (\text{rad}/\text{ft})$	Power Spectral Density
$\bar{\phi}$	$\text{ft}^2 / (\text{rad}/\text{ft})$	Power Spectral Density
$\hat{\phi}$	$\text{ft}^2 / (\text{rad}/\text{ft})$	Estimated Power Spectral Density
$\underline{\hat{\phi}}$	$\text{ft}^2 / (\text{rad}/\text{ft})$	Power Spectral density
Ω	rad/ft	Spatial Frequency
ω	rad/ft	Dummy Frequency Variable
ω_0	rad/ft	Particular Value of Frequency

Contrails

SECTION IINTRODUCTION

The landing gear of modern aircraft represent a major portion of the air frame, contributing a substantial share of the air frame weight. The landing gear, useless components in flight, are designed purely to resist ground loads. Moreover, the design of a considerable portion of the over-all air frame structure (in terms of weight) also is controlled by ground loads. Thus, ground loads are recognized to represent an important part of the air frame design problem.

In past years considerable attention has been paid to the rational determination of ground loads and associated design criteria. As a result of enormous attention to the loads developed during landing, it now appears that the majority of the unsolved problems are concerned with taxiing or ground operation. These problems concern taxiing dynamics and fatigue, brake chatter, wheel shimmy and skidding oscillations.

This report considers design criteria related to the taxiing mode of operation on prepared surfaces, i. e., on runways, taxiways and ramps. With the advent of larger and more flexible structures and configurations employing large external stores, the problem of determining satisfactory design strength criteria has become both more critical and difficult to resolve. The excitation to the landing gear and air frame caused by irregularities in the surfaces on which the vehicle operates can produce a variety of difficulties, ranging from fatigue damage and structural failure to pilot's complaint. Studies to date of the 'runway roughness' problem have been concerned primarily with the statistics of taxiing operations, landing gear dynamics during taxiing, and the quantitative determination of the roughness characteristics of many runways in this country and abroad.

Current research in this country is directed in part toward establishing meaningful characterization of runway profiles for both vehicle design and runway specifications. Early attempts to determine representative "bump shapes", amplitudes and vehicle speeds, to allow design techniques analogous to those for atmospheric gust disturbances met with little success. Attempts have been made to extrapolate from one satisfactory design to the next, even though

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Contrails

the reasons for success in the first case might be largely unknown. Thus, a maximum level of runway roughness was inferred from the successful design on the basis of analysis, and the analysis in turn applied to a new design. Though essentially irrational, this approach met with some success and acceptance until the advent of more radical departures in air frame flexibility and configuration.

The most promising approach to the aircraft taxiing problem at this time appears to be the application of the techniques of generalized harmonic analysis. A power-spectral characterization of runway roughness has proved a most concise way of portraying the essential aspects of the profile in that it shows at a glance the distribution of roughness (amplitude) with wave length. Moreover, this representation suggests a means for judging the severity of runway roughness by compiling the spectra of many different satisfactory runways. In this manner, spectra which have application both to specifications for new runways and to the basis for a rational requirement in the design of aircraft for taxiing loads may be devised.

The purpose of the research program described in this report was to collect all available measured prepared surface profile and power spectral data, to ascertain the reliability of these data, to establish from these data sets of design criteria for vehicles operating on prepared surfaces, and to demonstrate the applicability of these design criteria.

Only one vehicle model was used in the analyses to demonstrate applicability of the design criteria. Therefore, results of this effort serve primarily as a guide for the design engineer. In using these results, the designer must evaluate and classify the input data with respect to the class of vehicles being considered.

SECTION II DATA COLLECTION AND HANDLING

A list of organizations which might possess or have knowledge of prepared surface profile and power spectral data was compiled. This list included the Aeronautical Systems Division, the National Aeronautics and Space Administration, selected aircraft companies or corporations, selected research institutes, and the NATO Advisory Group for Aeronautical Research and Development. In addition, organizations suggested by these contacts were added to the list.

Table 1-1 is a complete list of the organizations contacted. Each organization on this list was requested to furnish any prepared surface profile and power spectral data it compiled and also any available information as to where any such data could be obtained. From the results of this search one hundred and two sets of data were located and obtained in addition to the one hundred and eighty-four sets of data from reference 1-1. A data set consists of the profile and the associated power spectra for a single track or a runway, taxiway, or ramp. Eighty-two of these data sets were received from NASA, seventeen were supplied by Lockheed Aircraft Corporation, and three were supplied by the Boeing Company. The eighty-two data sets supplied by NASA included data collected by the NATO Advisory Group for Aeronautical Research and Development. Appendix IV is a profile record book containing descriptions of each of the data sets.

Each data set located in the data collection phase of this program was assigned a distinct identification number. Data collected from NASA were assigned project identification numbers 1 through 82. Boeing data were assigned identification numbers 82 through 85 and Lockheed data received identification numbers 86 through 102. The 184 sets of data from reference 1-1 were assigned identification numbers 1001 through 1184. A total of 94 data sets were translated into punched cards. Cards were punched for data sets 1 through 73 and 75 through 95. Data set 74 could not be put on cards since no raw data were available for this runway. Data sets 96 through 102 were not punched on cards since these data describe very short sections of runways more completely described in other data sets. The 184 sets of data which appear in reference 1-1 are already available in card form at ASD, thus they were not punched onto cards.

Distinct IBM card identification numbers, differing from the project identification number, were assigned to each data set. These numbers are found in the profile record book, as well as in the last four columns of each card containing data from the relevant data set.

Table 1-1 Organizations Contacted in Data Search

<p>Aerolab Development Company 330 W. Holly Street Pasadena 3, California</p> <p>Aerojet General Corporation 6353 N. Irwindale Road Azusa, California</p> <p>Aeronautical Systems Division Wright-Patterson Air Force Base, Ohio</p> <p>Aerospace Industries Ass'n. of America 610 Shoreham Building Washington 5, D. C., Attention: Mr. Orval R. Cook, Gen. Mgr.</p> <p>Mr. Vaughn Beals, Chairman Lighting Dynamics Committee Aircraft Industries Association Panel 58 A North American Aviation, Inc. 4300 East 5th Avenue Columbus 16, Ohio</p> <p>Airport Operators Council 1700 K. Street N. W. Washington 6, D. C. Attention: Mr. E. Thos. Burnard Executive Vice-President</p> <p>Allied Research Associates, Inc. 43 Leon Street Boston 15, Massachusetts</p> <p>American Association of Airport Executives Box 767 Wilmington 99, Delaware Attention: Mr. E. Russel Hoyt, Executive Secretary</p> <p>Avidyne Research, Inc. 7 Laurence Road Woburn, Massachusetts</p> <p>Beech Aircraft Corporation East Central Avenue Wichita 1, Kansas</p> <p>Bell Aircraft Corporation P. O. Box One Buffalo, 5, New York Aircraft Division</p> <p>Boeing Airplane Company Wichita Division Wichita, Kansas</p> <p>The Boeing Company Transport Division P. O. Box 707 Renton, Washington</p> <p>California Institute of Technology 1201 East California Street Pasadena, California</p> <p>Cessna Aircraft Company 5800 Pawner Road Wichita, Kansas</p> <p>Champion Aircraft Corporation Osceola, Wisconsin</p> <p>Chance Vought Aircraft, Inc. P. O. Box 5907 Dallas, Texas</p> <p>Cleveland Pneumatic Tool Co. 3781 East 77th Street Cleveland 5, Ohio</p> <p>Convair Division General Dynamics Corporation Pomona, California</p>	<p>Convair Division General Dynamics Corporation 3165 Pacific Highway San Diego, California</p> <p>Cornell Aeronautical Laboratory, Inc. P. O. Box 235 Buffalo 21, New York</p> <p>Department of Transport Air Services Branch Number 3 Building Ottawa, Ontario, Canada</p> <p>Douglas Aircraft Company, Inc. 2000 N. Memorial Drive Tulsa, Oklahoma Douglas Aircraft Company, Inc. Long Beach Plant P. O. Box 200 Long Beach 1, California</p> <p>Douglas Aircraft Company, Inc. 3000 Ocean Park Boulevard Santa Monica, California</p> <p>Douglas Aircraft Company 827 Lapham Street El Segundo, California</p> <p>Dynamic Devices, Inc. 3170 Valleywood Drive Dayton 20, Ohio</p> <p>Fairchild Engine and Airplane Corp. Aircraft Division Hagerstown, Maryland</p> <p>Flight Safety Foundation 468 Park Avenue South New York 16, New York Attention: Mr. Jerome Lederer Managing Director</p> <p>Forrestal Research Center Department of Aeronautical 309 Sayre Hall (Engineering Princeton, New Jersey</p> <p>General Dynamics P. O. Box 748 Fort Worth 1, Texas</p> <p>Grumman Aircraft Engineering Corp. Bethpage, Long Island New York</p> <p>Hughes Aircraft Company Building 20, Mail Station 1018 Culver City, California</p> <p>Institute of Transportation and Traffic Engineering University of California Berkeley, California</p> <p>International Air Transport 500 Fifth Avenue (Association New York 36, New York Attention: Mr. E. Pefanis, Secretary</p> <p>KLM Royal Dutch Airlines The Hague Holland Attention: Dr. Taub</p> <p>Mr. W. H. Statler Chief Engineer, Aircraft Lockheed Aircraft Company Burbank, California</p> <p>Lockheed Aircraft Corporation Marietta, Georgia</p> <p>Lockheed Aircraft Corporation Missile Systems Division Van Nuys, California</p>	<p>Luftfahrt-Bundesamt Braunschweig, Germany</p> <p>The Martin Company Baltimore, 3, Maryland</p> <p>Massachusetts Institute of Technology Aeroelastic and Structures Research Lab 77 Massachusetts Avenue Cambridge 39, Massachusetts</p> <p>McDonnell Aircraft Company Lambert-St. Louis International Agency Box 516 St. Louis 66, Missouri</p> <p>Ministry of Aviation Shell Mex House Strand London WC2, England</p> <p>National Aeronautics and Space Administration Langley Research Center Langley Field, Virginia</p> <p>NORAIR 1001 East Broadway Hawthorne, California</p> <p>North American Aviation, Inc. 4300 East Fifth Avenue Columbus 16, Ohio</p> <p>North American Aviation, Inc. Los Angeles Airport Los Angeles 45, California</p> <p>North Atlantic Treaty Organization 64 Rue de Varenne Paris VII France Attention: F. Bollenrath, Deputy Chairman Structures and Materials Panel</p> <p>Northrop Division Northrop Aircraft, Inc. P. O. Box 1525 1001 East Broadway Hawthorne, California</p> <p>Piper Aircraft Corporation Lock Haven, Pennsylvania</p> <p>Republic Aviation Corporation Conklin Street Farmingdale, Long Island New York</p> <p>Ryan Aeronautical Company 2701 Harbor Drive San Diego 12, California</p> <p>Secretariat-General A l'Aviation Civile a et Commerciale Administration Central 93 Boulevard du Montparnasse Zone 6 Paris, France</p> <p>Society of Automotice Engineers 29 West 39th Street New York 18, New York Attention: Mr. Stoner, Mr. Meldrum, Committee 58A</p> <p>Southwest Research Institute P. O. Box 2296 San Antonio 6, Texas</p> <p>Temco Aircraft Corporation P. O. Box 6191 Dallas 22, Texas</p>
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The data were punched and verified using a convenient card format. They were then translated by an IBM 1401 digital computer into the x-y format specified in Table 1-2.

Table 1-2
IBM Card Format

Column	Contents	Column	Contents
1	Blank	40-44	x
2	0	45-46	Blank
3	Decimal point	47-48	Integral part of y
4-8	x	49	Decimal point
9-10	Blank	50-54	Decimal part of y
11-12	Integral part of y	55	Blank
13	Decimal point	56	0
14-18	Decimal part of y	57	Decimal point
19	Blank	58-62	x
20	0	63-64	Blank
21	Decimal point	65-66	Integral part of y
22-26	x	67	Decimal point
27-28	Blank	68-72	Decimal part of y
29-30	Integral part of y	73	Blank
31	Decimal point	74	0
32-36	Decimal part of y	75	Decimal point
37	Blank	76	0
38	0	77-80	Runway numbers
39	Decimal point		

A sample card is shown in Fig. 1-1. This card gives the elevations in feet ($Y = 12.12345, 12.22348, 12.30798, \text{ and } 12.34476$ for positions ($x = 17, 18, 19, \text{ and } 20$) along a certain runway (IBM Card Deck Identification No. 6111). Since the interval between measurements was 2 feet, the positions $x = 17, 18, 19$ and 20 correspond to distances of 34, 36, 38 and 40 feet along the runway.

There was, of course, no way to determine the recording accuracy of the data received; however, the accuracy of translation to punched cards was checked by having the 1401 print-out a list of those adjacent y-values which differed by more than 0.1 ft. These lists were delivered to ASD with the cards. When a difference greater than 0.1 ft was found to be due to a card punching error, this was corrected and noted; where such a difference was found but could not be traced to a card punching error, no change

SECTION III

COMPUTATION OF POWER SPECTRAL DENSITIES

1. The Computer Program

To check the accuracy and the statistical validity of the power spectral densities collected, it was necessary to construct a digital computer program to compute power spectra. A flexible program which allows the analyst to vary the computational procedures to determine their effect on the computed spectral densities was written for the UNIVAC 1105 digital computer. A summary of the major features of the program follows.

- (1) The data are read from a magnetic tape, prepared on off-line equipment, into the 1105.
- (2) All adjacent data points are checked. When a pair of data points is found with values differing by more than an input constant Δ ; these values are printed out and the value of the second point in the pair is set equal to the value of the first point.
- (3) A mean, linear, or quadratic trend is removed as desired. It is, of course, true that trends higher than quadratic exist in most runway data; however, by a careful choice of runways, it was possible to investigate the advantages and disadvantages of trend removal without building a capability for removing trends higher than quadratic into the program. The formulas are

$$Y_t = X_t - \gamma - \beta \left(t - \frac{N+1}{2} \right),$$

where X_t is the raw data, Y_t the adjusted data, and N the number of observations. Let

$$\hat{\gamma} = \frac{1}{N} \sum_{t=1}^N X_t, \quad \hat{\beta} = \frac{\sum_{t=1}^N tX_t - \frac{N(N+1)}{2} \left(\frac{1}{N} \sum_{t=1}^N X_t \right)}{\frac{1}{6} N(N+1)(2N+1) - \frac{1}{4} N(N+1)^2}$$

If only a general mean is to be removed, then calculations are performed with $\gamma = \hat{\gamma}$, $\beta = 0$. If only a linear trend is to be removed, then $\gamma = 0$, $\beta = \hat{\beta}$. If both are to be removed, then $\gamma = \hat{\gamma}$, $\beta = \hat{\beta}$. If neither, then $\gamma = 0$, $\beta = 0$.

Contrails

(4) The data are prewhitened by

$$X_t = X'_t - aX'_{t-1}$$

where $\{X'_t\}$ is the original data, $\{X_t\}$ the prewhitened data, and a a constant.

(5) Autocovariances are computed by

$$C_r = \frac{1}{N-1} \sum_{t=1}^{(N-1)-r\Delta} X_t \cdot X_{t+r\Delta} \quad 0 \leq r \leq M,$$

where C_r is the autocovariance with lag r , N the number of original data points, and Δ the distance between adjacent data points (for all data available, $\Delta = 2$ ft).

(6) At this point options are available, allowing the analyst to dispose of the autocovariances as he likes: he can stop computation, have the autocovariances printed, and resume computation later (this means that the autocovariances are saved so that when computation is resumed the autocovariances need not be recalculated). He can continue computation without interruption and have the autocovariances printed or not, as he sees fit. In any case, the autocovariances are always saved in a form suitable for restarting calculation from this point. (They are always saved, whether or not they are printed out is optional).

(7) A finite cosine series transform of the C_r is taken

$$V_r = \frac{\Delta}{\pi} \left[C_0 + 2 \sum_{p=1}^{M-1} C_p \cos \frac{pr\pi}{M} + C_M \cos r\pi \right].$$

The V_r are smoothed (to change the "effective" Bartlett spectral window into one with more desirable properties) by

$$U_r = a_0 V_r + a_1 [V_{r+1} + V_{r-1}].$$

where $V_{-1} = V_1$, $V_{M+1} = V_{M-1}$, and a_0 , a_1 are arbitrary. In practice, only the Hamming window with $a_0 = 0.54$, $a_1 = 0.23$, and Hanning window with $a_0 = 1/2$, $a_1 = 1/4$, will be needed.

(8) An option is available at this point for printing out the U_r .

(9) The next step is the removal of the prewhitening by dividing the U_r by T_r , where $T_r = (1 + a^2) - 2a \cos \frac{r\pi}{M}$, and a is the constant used in the prewhitener:

$$U'_r = \frac{U_r}{T_r}$$

(10) The U'_r are printed out.

2. The Validity of Spectral Density Estimates

(a) Basic Definitions

We define the autocovariance function $C(\tau)$ of the real valued, zero mean, stationary stochastic process $X(t)$ by

$$C(\tau) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T X(t) \cdot X(t + \tau) dt.$$

This is sometimes referred to as the autocorrelation function; however, this term should be more properly reserved for $C(\tau)/C(0)$. Note that $C(\tau) = C(-\tau)$, and that $C(0)$ is the variance of the process. We define the two-sided spectral density $P(f)$ of $X(t)$ by

$$P(f) = \int_{-\infty}^{\infty} C(t) \cdot e^{-i\omega t} dt,$$

where $\omega = 2\pi f$. Observe that f has the units of cycles per unit of the variable t . In the case of runway data, f is in cycles per foot. This implies that ω has the units of radians per foot. Since

$$C(\tau) = \int_{-\infty}^{\infty} P(f) \cdot e^{i\omega\tau} df,$$

and since we may prefer to have $P(f)$ written as a function of ω rather than f , we see that

$$C(\tau) = \int_{-\infty}^{\infty} P_1(\omega) \cdot e^{i\omega\tau} d\omega,$$

where $P_1(\omega) = \frac{P(\omega/2\pi)}{2\pi}$. It follows that we must write

$$P_1(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} C(t) \cdot e^{-i\omega t} dt. \quad (1-2)$$

Since $C(\tau)$ equals $C(-\tau)$, this becomes

$$P_1(\omega) = \frac{1}{\pi} \int_{-\infty}^{\infty} C(t) \cdot \cos \omega t dt$$

A negative frequency is of no use to us, so we define the one-sided spectral density as $\phi(\omega) = 2P_1(\omega)$ or

$$\phi(\omega) = \frac{2}{\pi} \int_0^{\infty} C(t) \cdot \cos \omega t dt. \quad (1-2)$$

Thus

$$C(\tau) = \int_0^{\infty} \phi(\omega) \cdot \cos \omega \tau d\omega. \quad (1-3)$$

(b) Spectral Density Estimates

The natural estimate of $\phi(\omega)$ is called the periodogram, and for a given record length T it is defined by

$$I_T(\omega) = \frac{2}{\pi} \int_0^T C(t) \cdot \cos \omega t dt.$$

This natural estimate, the periodogram, has the unfortunate property that, for large T and for gaussian $X(t)$, its variance is proportional to a multiple of a random variable distributed like a chi-square variable with only two degrees of freedom. This means that no matter how large we take T , the chance that $I_T(\omega)$ will fall in a band of given width about the true value $\phi(\omega)$ is a constant; or in other words, by taking large and larger values of T we cannot bring our estimate $I_T(\omega)$ closer to $\phi(\omega)$. To overcome this difficulty, Bartlett (Ref. 1-2) has suggested, essentially, that we estimate

$$\bar{P}_1(\omega) = \frac{1}{2\delta} \int_{\omega-\delta}^{\omega+\delta} P_1(\omega) d\omega \quad (1-4)$$

i. e., estimate the average of $\phi(\omega)$ over some interval about ω .
Let

$$Q(\omega) = \begin{cases} 1/2 & \text{if } |\omega| \leq \delta \\ 0 & \text{if } |\omega| > \delta \end{cases}$$

then we can rewrite equation (1-4)

$$\bar{P}_1(\omega_0) = \frac{1}{2\pi} \int_{-\infty}^{\infty} Q(\omega - \omega_0) \cdot P_1(\omega) d\omega. \quad (1-5)$$

and recalling that the convolution of two functions (such as equation (1-5)) is equal to the Fourier transform of the product of the Fourier transforms of each of the functions, we have from (1-1) and (1-5)

$$\bar{P}_1(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} D(t) \cdot C(t) \cdot \cos \omega t dt \quad (1-6)$$

where

$$D(t) = \int_{-\infty}^{\infty} Q(\omega) \cdot \cos \omega t d\omega.$$

Let $\bar{\phi}(\omega) = 2\bar{P}_1(\omega)$ and $G(t) = D(t) + D(-t) = 2D(t)$. Then

$$\bar{\phi}(\omega) = \frac{2}{\pi} \int_0^{\infty} G(t) \cdot C(t) \cdot \cos \omega t dt, \quad (1-7)$$

and our estimate for a given record length T is

$$\hat{\phi}_T(\omega) = \frac{2}{\pi} \int_0^T G(t) \cdot C(t) \cdot \cos \omega t dt. \quad (1-8)$$

The function $D(t)$ is called a lag window, and the function $Q(\omega)$ is called a spectral window. For easy computation, we would like $D(t)$ to go to zero as fast as possible, since this would minimize the computing of autocovariances; however, a function and its Fourier transform cannot both go to zero too rapidly, consequently we must compromise, and use something other than a rectangle for $Q(\omega)$ in equation (1-5). For lag windows in common use, it can be shown that, for gaussian $X(t)$, $\hat{\phi}_T(\omega)$ is distributed like a multiple of a chi-square variable with $2T/T'$ degrees of freedom, where T' is the maximum lag for which the lag window is reasonably different from zero. (See, for example, reference 1-3.) Unfortunately, we cannot decrease our variability indefinitely by

merely taking T' smaller and smaller, since the mass of the window is approximately concentrated in an interval of $\tau \pi/T'$ rad/ft about the frequency ω . It follows that the smaller T' is taken the greater the ω -range over which $\phi(\omega)$ is being averaged and consequently the greater the smearing, and the less we will be able to say about any individual frequency.

(c) Prefiltering

The only real problem in the estimation of runway spectra is the removal of the line at zero frequency. This line, caused by the shape of the earth over which a runway is laid, is of no importance in the design of alighting gear. If it is not removed, however, there will be no basis for comparison between the estimated spectra from two different runways, since this line dominates the estimates at other frequencies.

Two techniques, trend removal and prefiltering, have been used to remove this line in the estimates of runway spectra that have been made available. The only practical method that exists for deciding between these two techniques, and determining whether or not estimates produced by them can be considered accurate is to use both techniques on the same body of runway data. This was done and the results are shown in Figures 1-2 and 1-3.

The results obtained by applying the two techniques to runways 41 and 39 are shown in these figures. Figures 1-4 and 1-5 show the profiles for these runways. Runway 41 was laid on earth with a linear shape; hence, by removing a mean and a linear trend, as in curve a, we were able to eliminate the effect of the line at zero frequency on the higher frequencies. On the other hand, the same curve was obtained by using a prewhitener of $X_n = 0.98 X_{n-1}$, and by removing only the mean. Runway 39 was laid on earth that appears to have a quadratic shape. This is illusionary since by comparing curves a and b, we see that a better estimate can be found by using a good prewhitener. It follows, therefore, that trend removal may be used, but great care must be taken to ensure that maximum reduction is obtained.

Curve a, in Figure 1-2 and curve a in Figure 1-3 are essentially the same as the curves obtained by Thompson in Reference 1-4 for these two runways. The differences, which are too small to show on graphs plotted to the scale of Figures 1-2 and 1-3, are due to the fact that Thompson used a prewhitener of $X_n - X_{n-1}$. The only objection to a prewhitener such as Thompson's is that it makes an estimate of the spectral density at zero frequency impossible to obtain. This is, of course, no real objection for our purposes.

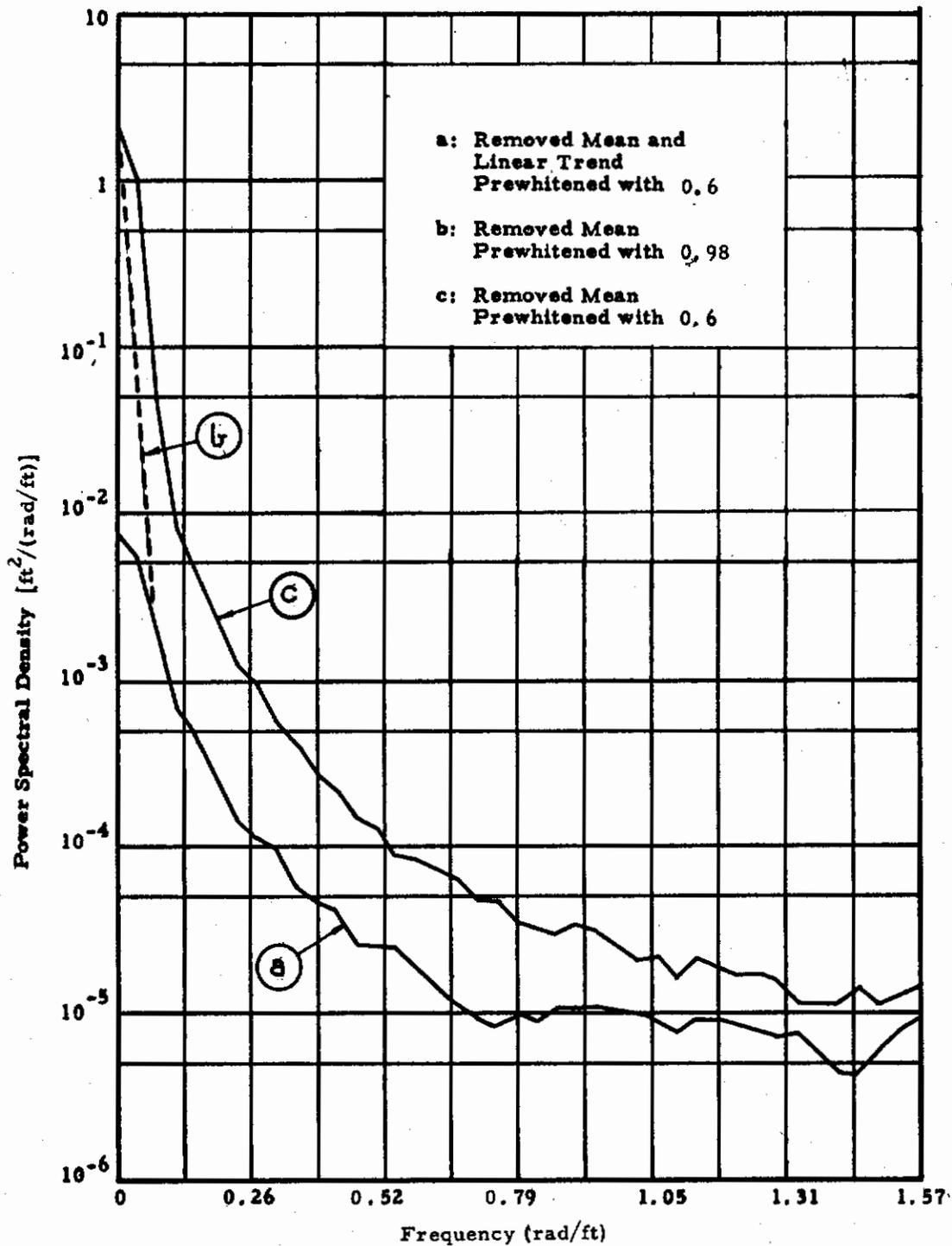


Fig. 1-2 Comparison of Technique for Removing Power at Zero Frequency (Runway 41)

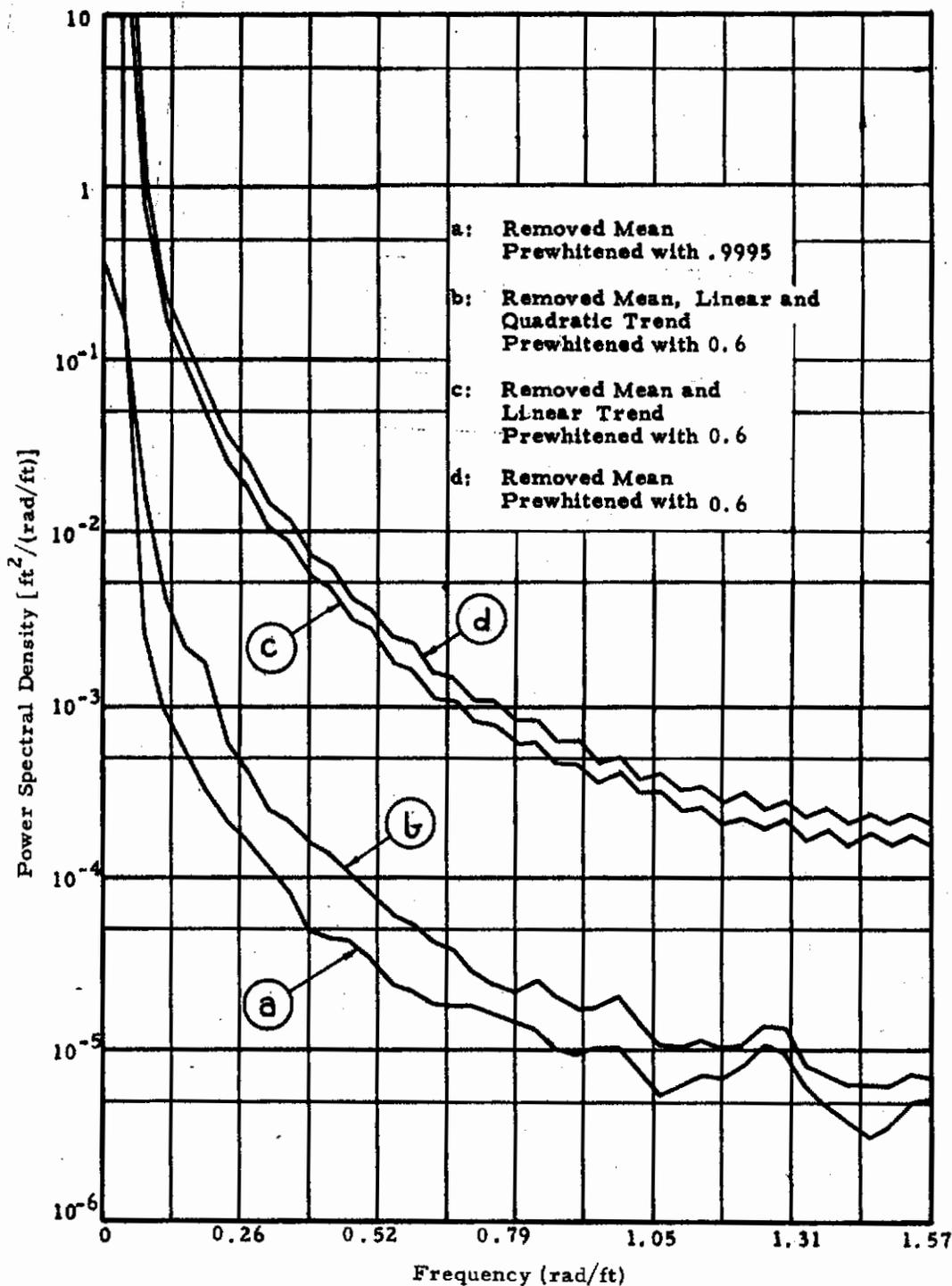


Fig. 1-3 Comparison of Technique for Removing Power at Zero Frequency (Runway 39)

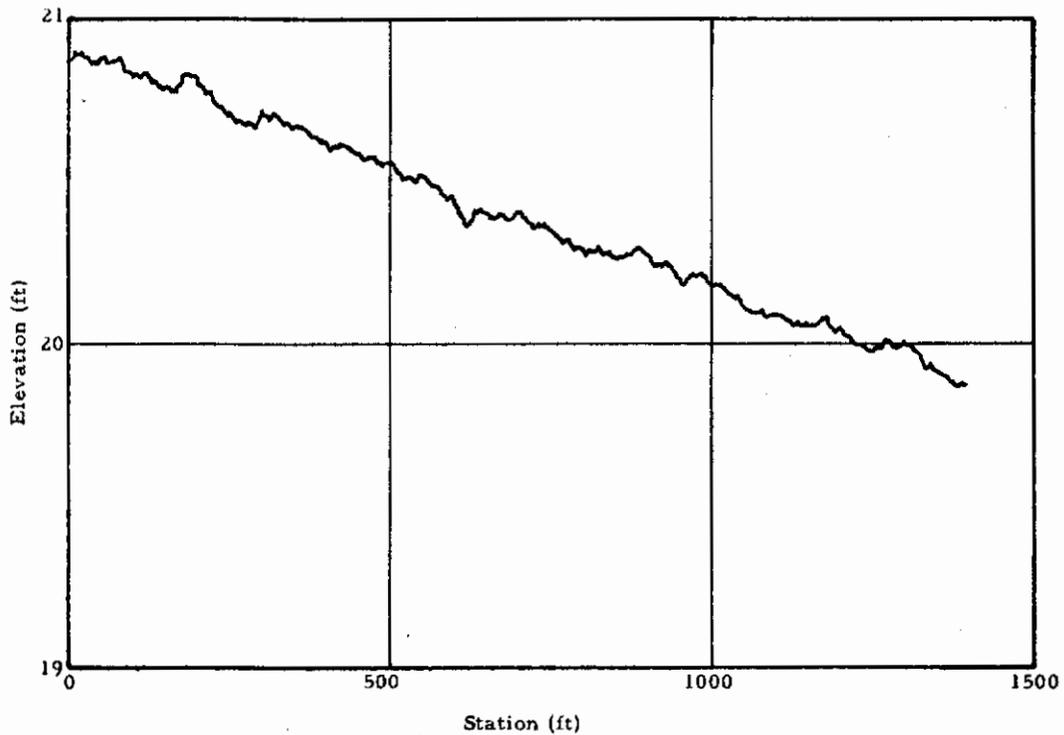


Fig. 1-4 Profile of Runway 41

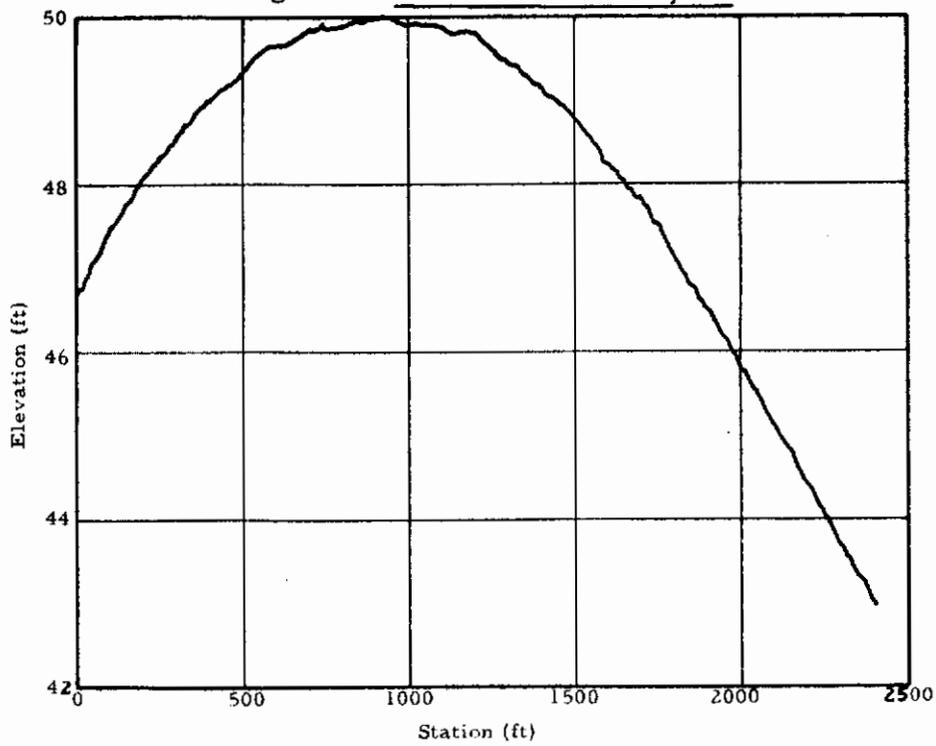


Fig. 1-5 Profile of Runway 39

(d) Windows, Lags, and Aliasing

All estimates were computed using both the Hamming and the Hanning spectral windows. No significant difference between these windows was found for runway data. In Figure 1-6, we have plotted typical estimates which differ only in the use of the two windows. As may be seen, the differences are slight.

In theory one must strike a balance between variability and width of the spectral window because the fewer the lags the greater the width of the window and the smaller the variability. This effect was not noted in our estimates. When the number of lags was increased, the variability increased, but the supposedly narrower spectral windows so obtained did not seem to be better able to reject the line at zero frequency. This is illustrated in Figure 1-7 where estimates based on 40 and 120 lags are plotted. We know that better estimates than that obtained with 40 lags are available for this runway; however, 120 lags does not seem to give a better estimate, only a more variable one. The computational formulas seem to interpose themselves between theory and practice, so that increasing the number of lags does not have the effect on the rejection of lines that theory would seem to indicate.

Since runway data are available only at set intervals Δ , the problem of aliasing must concern us. The fastest wave that was recorded is one of π/Δ rad/ft. If an appreciable variance exists at frequencies greater than this, then this variance will be erroneously spread over those frequencies, less than π/Δ rad/ft, which we can observe. For most runway data, $\Delta=2$ ft, and so we must concern ourselves with the variance at frequencies greater than π/Δ rad/ft. Fortunately, this question can be answered satisfactorily by an examination of the spectral densities computed in reference 1-1. These data were taken for $\Delta=1/2$ ft. Roughly, these densities show that something less than 0.1 percent of the variance occurs at frequencies greater than $\pi/2$ rad/ft. It follows that aliasing does not present a problem for runway data taken at 2 ft intervals.

(e) Evaluation of Estimate

The estimates made by NASA all use Thompson's technique, and consequently may be considered satisfactory. The estimates made by Boeing also use Thompson's technique, and they too are satisfactory. The estimates made by Lockheed are of variable quality. A careful inspection of these estimates suggests that the estimates of the four Lockheed runways 92, 93, 94, and 95 (project identification numbers) be discarded. These estimates were obtained with a moving average scheme, and are not as accurate as the other estimates. The remaining six Lockheed estimates appear to be satisfactory, and it is suggested that they be retained.

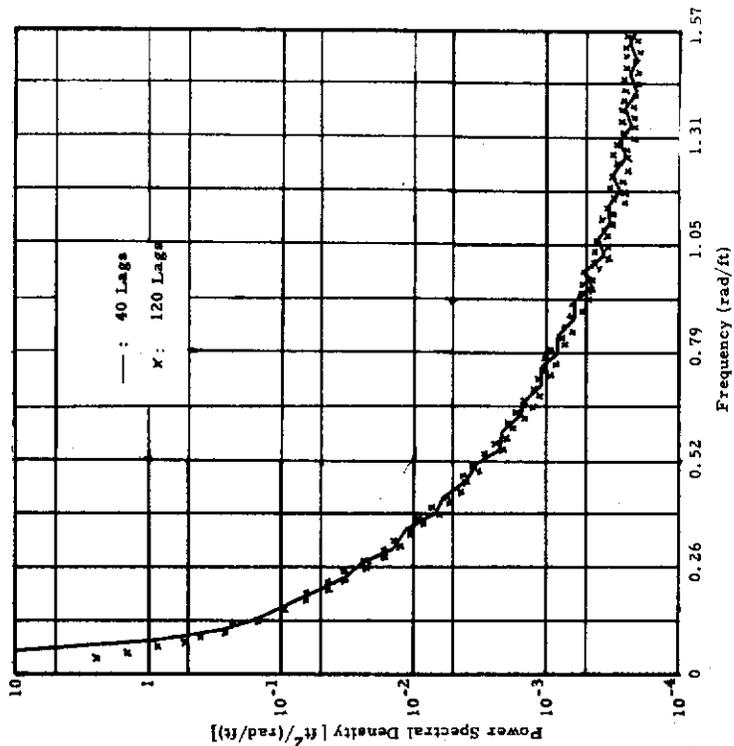


Fig. 1-7 Comparison of Spectra Computed Using 40 Lags Versus 120 Lags

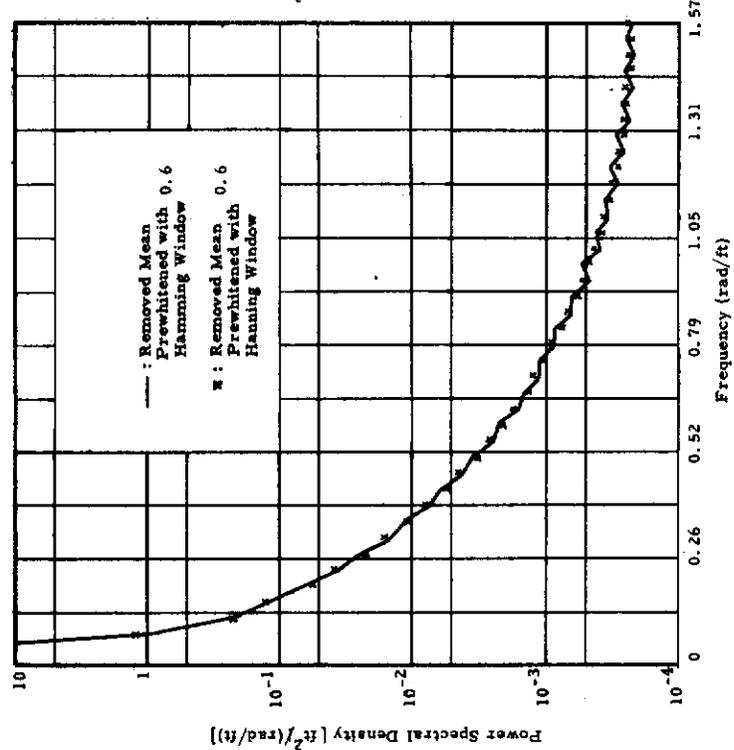


Fig. 1-6 Comparison of Spectra Computed Using Hamming and Hanning Windows

SECTION IV

DEVELOPMENT OF DESIGN CRITERIA

The design criteria developed for vehicles operating on prepared surfaces take several forms. In subsection 1 power spectral densities for "rough", "medium" and "smooth" runways, taxiways and ramps are obtained. These power spectra and the associated profiles establish one set of criteria. The distribution of discrete bumps for a selected group of runways, taxiways and ramps, selected from surfaces having exceptional roughness or smoothness from their power spectral densities or operation of aircraft in these surfaces, are given in subsection 2, thus establishing a second set of design criteria. Both sets of criteria are necessary for the rational design of flight vehicles to be operated on prepared surfaces. Some of the limitations and areas of application of these criteria are given in subsection 3.

1. Power Spectra Criteria

The power spectral densities which were found to be accurately computed were classified to obtain representative "rough", "medium" and "smooth" power spectral density curves. Since the general form of the power spectral density curves is similar except for a translation and a rotation, two parameters were necessary to classify the data. The two parameters chosen were horizontal position of the power spectral density curve at a spectral density of $1.0 \text{ in.}^2/(\text{rad}/\text{ft})$ (N) and vertical position of the curve at a reduced frequency of $2\pi \text{ rad}/\text{ft}$ (D) or at $\pi/2 \text{ rad}/\text{ft}$ (D') for non-ASD spectra since these curves only extended to $\pi/2$. Figure 1-8 shows the master diagram used to classify the power spectral density plots. A single parameter $Q = (N+D)/2$ was also computed for each power spectra in an attempt to show the over-all quality of a runway with a single parameter.

The values of N, D or D', and $Q = (N+D)/2$ or $Q' = (N+D')/2$ are tabulated for the various power spectra in Table 1-3. Distribution curves for these parameters are given in Figures 1-9, 1-10, 1-11, 1-12, 1-13, 1-14 and 1-15. Table 1-4 gives some of the interesting statistics of these parameters. The results of this classification are given separately for the data which was obtained using 2-ft measurement intervals (all non-ASD data) and the data obtained using 6-in. measurement intervals (all ASD data). In addition, the six different groupings of the ASD data are considered giving seven groupings in all. These groupings are: 1) all non-ASD data, 2) all ASD data, 3) ASD runways, 4) ASD runways longer than 8,000 ft, 5) ASD runways shorter than 8,000 ft, 6) ASD taxiways and 7) ASD ramps.

Figures 1-16, 1-17, 1-18, 1-19, 1-20, 1-21, and 1-22 show the power spectra of rough, medium and smooth runways for the seven data groupings. Runways, taxiways or ramps having high values of N, D, Q, D' or Q' were considered to be rough, those with low values were considered smooth. The medium runways, taxiways and ramps have approximately the average N, D and Q or N, D' and Q' classifications. Table 1-5 is a listing of these rough, medium and smooth runways, taxiways and ramps.

Table 1-3 Spectral Density Classification

Project I.D. No.	N	D'	Q'	Project I.D. No.	N	D'	Q'	Project I.D. No.	N	D'	Q'	Project I.D. No.	N	D'	Q'
1	8	17	12.5	26	8	20	14	51	8	18	13	79	7	21	14
2	8	24	16	27	10	20	15	52	9	24	16.5	81	6	16	11
3	8	21	14.5	28	8	24	16	55	12	37	24.5	82	8	20	14
4	8	21	14.5	29	11	26	18.5	56	7	18	12.5	84	9	27	18
5	8	26	17	30	9	24	16.5	58	7	17	12	84	10	20	15
6	8	22	15	31	8	20	14	59	6	17	11.5	86	12	24	18
7	8	20	14	32	8	15	11.5	60	9	25	17	87	13	24	18.5
8	8	19	13.5	33	8	15	11.5	61	10	25	17.5	88	12	26	19
9	8	19	13.5	34	9	21	15	62	9	18	13.5	89	11	24	17.5
10	8	19	13.5	35	7	18	12.5	63	5	20	12.5	90	9	22	15.5
11	8	19	13.5	36	8	19	13.5	64	8	17	12.5	91	10	23	16.5
12	8	19	13.5	37	8	18	13	65	8	19	13.5				
13	8	20	14	38	8	17	12.5	66	8	23	15.5				
14	8	22	15	39	6	19	12.5	67	7	15	11				
15	8	20	14	40	7	17	12	68	9	28	18.5				
16	8	22	15	41	8	17	12.5	69	8	20	14				
17	9	22	15.5	42	8	20	14	70	7	16	11.5				
18	9	26	17.5	43	7	14	10.5	71	8	26	17				
19	8	21	14.5	44	7	15	11	72	8	24	16				
20	8	19	13.5	45	8	15	11.5	73	8	21	14.5				
21	8	19	13.5	46	9	21	15	74	6	22	14				
22	8	19	13.5	47	9	19	14	75	9	17	13				
23	8	19	13.5	48	8	17	12.5	76	8	20	14				
24	8	19	13.5	49	8	17	12.5	77	8	22	15				
25	8	20	14	50	7	16	11.5	78	7	16	11.5				

Project I.D. No.	N	D	Q	Project I.D. No.	N	D	Q	Project I.D. No.	N	D	Q	Project I.D. No.	N	D	Q
Ra-1001	7	13	10	T-1046	5	13	9	Rn-1091	7	8	7.5	Rn-1136	7	12	9.5
Ra-1002	7	11	9	Rn-1047	3	13	8	Rn-1092	6	9	7.5	Rn-1137	8	12	10
T-1003	4	13	8.5	Rn-1048	5	14	9.5	Rn-1093	7	7	7	Ra-1138	2	12	7
T-1004	4	12	8	Rn-1049	3	11	7	Rn-1094	6	10	8	Ra-1139	6	13	9.5
T-1005	4	12	8.5	Ra-1050	6	11	8.5	Rn-1095	7	11	9	Rn-1140	4	15	9.5
Rn-1006	3	12	7.5	Ra-1051	9	11	10	Rn-1096	7	7	7	Rn-1141	4	13	8.5
Rn-1007	6	12	9	Rn-1052	6	12	9	Rn-1097	7	8	7.5	Rn-1142	4	14	9
Rn-1008	6	13	9.5	Ra-1053	5	16	10.5	Rn-1098	6	10	8	T-1143	8	16	12
Ra-1009	11	13	12	Ra-1054	4	14	9	T-1099	5	10	7.5	T-1144	6	14	10
Ra-1010	11	10	10.5	Rn-1055	7	15	11	T-1100	8	11	9.5	T-1145	6	13	9.5
T-1011	9	12	10.5	Rn-1056	6	13	9.5	T-1101	9	11	10	Ra-1146	6	14	10
T-1012	8	14	11	Rn-1057	6	14	10	Ra-1102	1	14	7.5	Ra-1147	5	10	7.5
T-1013	6	10	8	T-1058	7	13	10	Ra-1103	12	13	12.5	Rn-1148	6	13	9.5
Rn-1014	6	13	9.5	T-1059	6	14	10	Ra-1104	13	12	12.5	Rn-1149	7	13	10
Rn-1015	8	13	10.5	T-1060	6	13	9.5	Ra-1105	8	12	10	Rn-1150	6	12	9
Rn-1016	7	16	11.5	Rn-1061	6	13	9.5	Ra-1106	2	15	8.5	Rn-1151	5	15	12
Rn-1017	6	15	10.5	Rn-1062	6	14	10	Rn-1107	4	12	8	Rn-1152	5	17	11
Rn-1018	8	14	11	Ra-1063	7	13	10	Rn-1108	9	13	11	Rn-1153	5	18	11.5
Rn-1019	7	14	10.5	Ra-1064	7	10	8.5	Rn-1109	9	13	11	Rn-1154	4	18	11
Rn-1020	7	13	10	Rn-1065	5	14	9.5	Rn-1110	9	13	11	T-1155	6	16	11
Rn-1021	7	12	9.5	Rn-1066	6	13	9.5	T-1111	7	11	9	T-1156	6	16	11
Rn-1022	7	11	9	T-1067	3	14	8.5	T-1112	7	10	8.5	Rn-1157	7	15	11
T-1023	8	13	10.5	T-1068	4	11	7.5	T-1113	7	11	9	Rn-1158	7	16	11.5
T-1024	7	13	10	T-1069	5	15	10	Rn-1114	5	14	9.5	Rn-1159	7	17	12
T-1025	6	13	9.5	Ra-1070	8	11	9.5	Rn-1115	5	15	10	T-1160	6	16	11
Ra-1026	8	14	11	Ra-1071	10	14	12	Rn-1116	5	14	9.5	T-1161	8	19	13.5
Ra-1027	10	12	11	Rn-1072	5	15	10	T-1117	9	9	9	T-1162	8	19	13.5
T-1028	7	12	9.5	Rn-1073	6	14	10	T-1118	8	12	10	T-1163	8	18	13
T-1029	8	12	10	Rn-1074	6	13	9.5	T-1119	10	15	12.5	T-1164	5	16	10.5
T-1030	8	11	9.5	Rn-1075	6	14	10	T-1120	7	10	8.5	T-1165	6	13	9.5
Rn-1031	5	13	9	Rn-1076	6	15	10.5	T-1121	8	10	9	Rn-1166	4	20	12
Rn-1032	7	13	10	Rn-1077	7	14	10.5	T-1122	9	12	10.5	Rn-1167	3	17	10
Rn-1033	6	15	10.5	Ra-1078	9	12	10.5	T-1123	6	15	10.5	Rn-1168	4	17	10.5
Ra-1034	7	15	11	Ra-1079	9	13	11	Rn-1124	5	15	10	Rn-1169	7	13	10
Ra-1035	7	15	11	T-1080	3	14	8.5	T-1125	6	11	8.5	Rn-1170	6	17	11.5
T-1036	7	13	10	T-1081	5	12	8.5	T-1126	7	14	10.5	Rn-1171	7	17	12
T-1037	7	12	9.5	T-1082	5	11	8	T-1127	7	12	9.5	T-1172	8	16	12
T-1038	7	12	9.5	T-1083	6	11	8.5	Ra-1128	6	13	9.5	T-1173	8	16	12
Rn-1039	5	13	9	T-1084	6	12	9	T-1129	9	13	11	T-1174	8	15	11.5
Rn-1040	4	12	8	T-1085	5	10	7.5	T-1130	10	14	12	Rn-1175	5	17	11
Rn-1041	5	13	9	Rn-1086	4	11	7.5	T-1131	9	16	12.5	Rn-1176	7	14	10.5
Ra-1042	8	16	12	Rn-1087	5	10	7.5	Rn-1132	7	12	9.5	Rn-1177	4	13	8.5
Ra-1043	5	15	10	Rn-1088	5	11	8	Rn-1133	8	13	10.5	Rn-1178	4	15	9.5
T-1044	4	12	8	Rn-1089	6	11	8.5	Rn-1134	7	13	10	Rn-1179	4	16	10.0
T-1045	5	14	9.5	Rn-1090	7	9	8	Rn-1135	8	11	9.5	Rn-1180	8	15	11.5
												Rn-1181	4	13	8.5
												T-1182	4	14	9.0
												Ra-1183	6	16	11.0
												Ra-1184	7	17	12.0

Table 1-4 Statistics for Spectral Density

Data Grouping	Parameter	Minimum	Maximum	Median	Mean	Standard Deviation
All Non-ASD Data	N	5	13	8	8.27	1.32
	D'	14	37	20	20.35	3.64
	Q'	1	24.5	14	14.32	2.29
All ASD Data	N	1	13	6	6.37	1.86
	D	7	20	13	13.22	2.13
	Q	7	13.5	10	9.81	1.38
ASD Runways	N	3	9	6	5.90	1.42
	D	7	20	13	13.32	2.41
	Q	7	12	9.5	9.63	1.26
ASD Runways Longer than 8,000 ft	N	3	8	6	5.39	1.*23
	D	7	20	13	12.98	2.55
	Q	7	12	9.5	9.19	1.23
ASD Runways Shorter than 8,000 ft	N	4	9	7	6.93	1.20
	D	11	18	14	14.00	1.89
	Q	9	12	10.5	10.53	.83
ASD Taxiways	N	3	10	7	6.63	1.65
	D	9	19	13	13.08	2.20
	Q	7.5	13.5	9.5	9.86	1.76
ASD Ramps	N	1	13	7	7.16	2.72
	D	10	17	13	13.13	1.80
	Q	7	12.5	10	10.14	1.44

Table 1-5 Power Spectral Density Criteria

Data Grouping	Project Identification Number	Class	N	D or D'	Q or Q'
All Non-ASD Data	87	rough	13	24	18.5
	55	rough	12	37	24.5
	7	medium	8	20	14
	63	smooth	5	20	12.5
	43	smooth	7	14	10.5
ASD Data	1104	rough	13	12	12.5
	1166	rough	4	20	12
	1161	rough	8	19	13.5
	1148	medium	6	13	9.5
	1102	smooth	1	14	7.5
	1093	smooth	7	7	7
ASD Runways	1108	rough	9	13	11
	1166	rough	4	20	12
	1148	medium	6	13	9.5
	1049	smooth	3	11	7
	1093	smooth	7	7	7
ASD Runways Longer than 8,000 ft	1180	rough	8	15	11.5
	1166	rough	4	20	12
	1148	medium	6	13	9.5
	1049	smooth	3	11	7
	1093	smooth	7	7	7
ASD Runways Shorter than 8,000 ft	1108	rough	9	13	11
	1153	rough	5	18	11.5
	1077	medium	7	14	10.5
	1154	smooth	4	18	11
	1022	smooth	7	11	9
ASD Taxiways	1119	rough	10	15	12.5
	1161	rough	8	19	13.5
	1058	medium	7	13	10
	1080	smooth	3	14	8.5
	1117	smooth	9	9	9
	1068	smooth	4	11	7.5
ASD Ramps	1104	rough	13	12	12.5
	1184	rough	7	17	12
	1001	medium	7	13	10
	1102	smooth	1	14	7.5
	1147	smooth	5	10	7.5
	1138	smooth	2	12	7

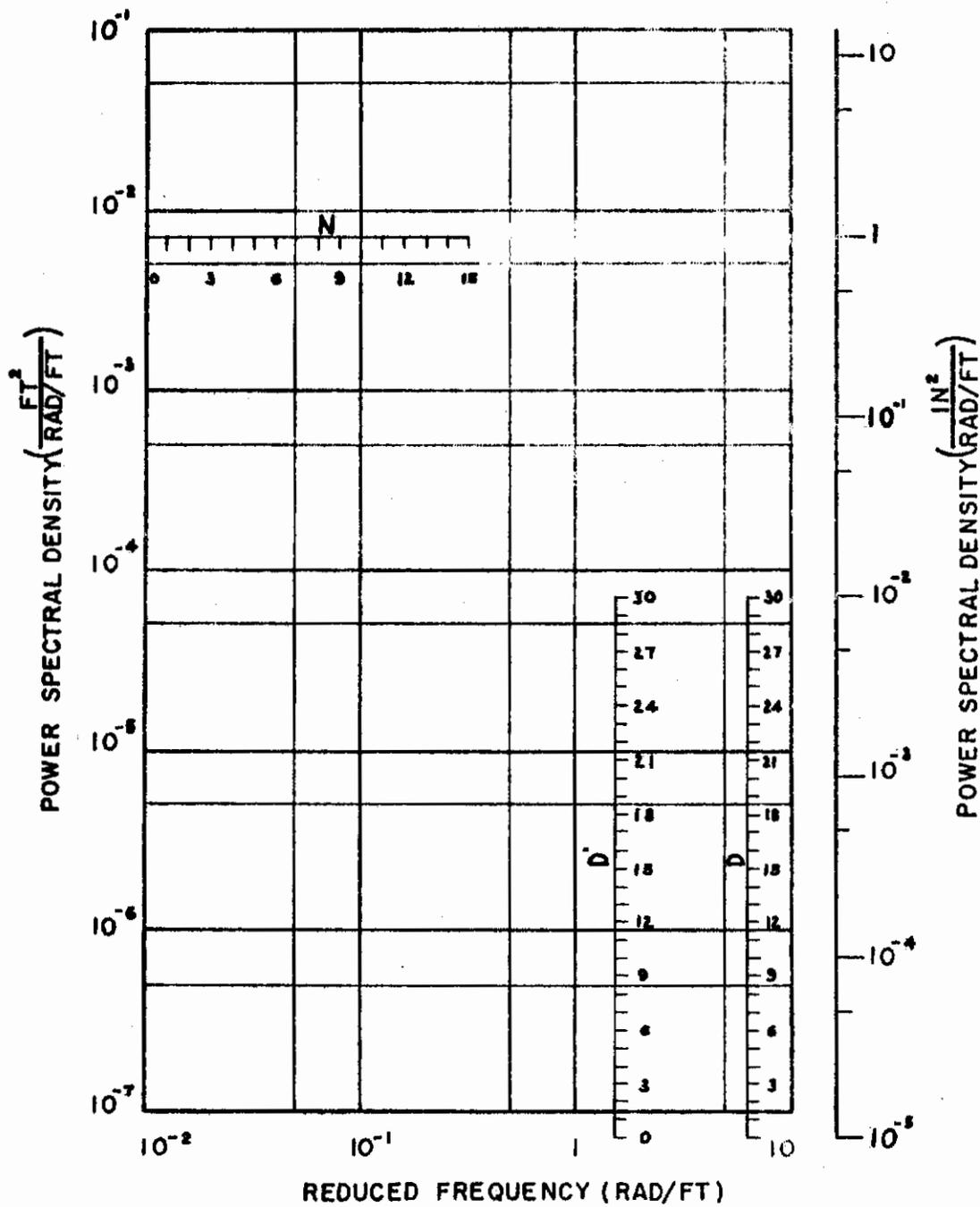


Fig. 1-8 Power Spectral Density Roughness Classification Diagram

Contrails

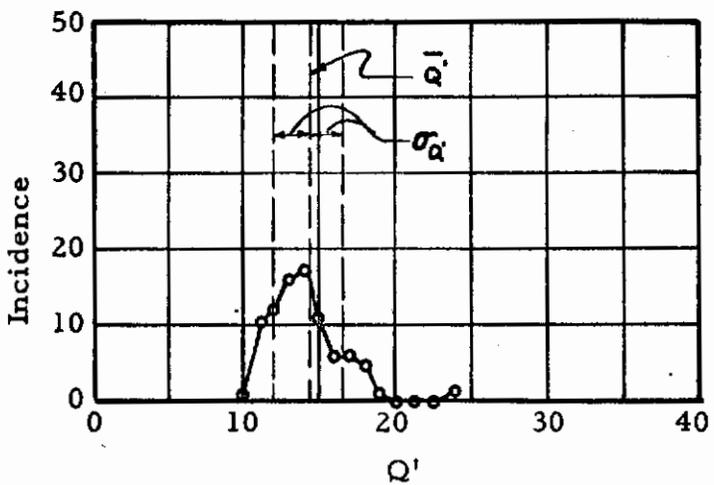
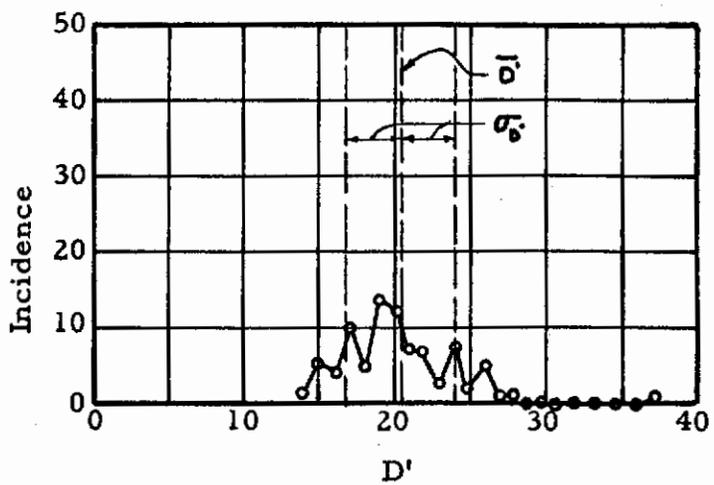
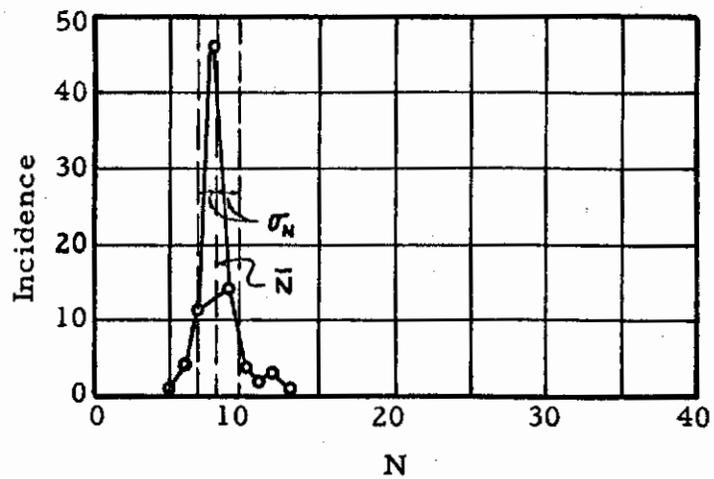


Fig 1-9 Distributions for N, D' and Q'
All Non-ASD Data

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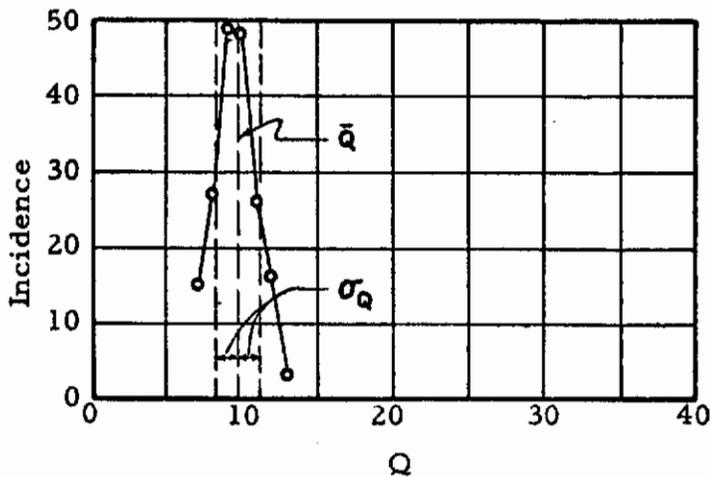
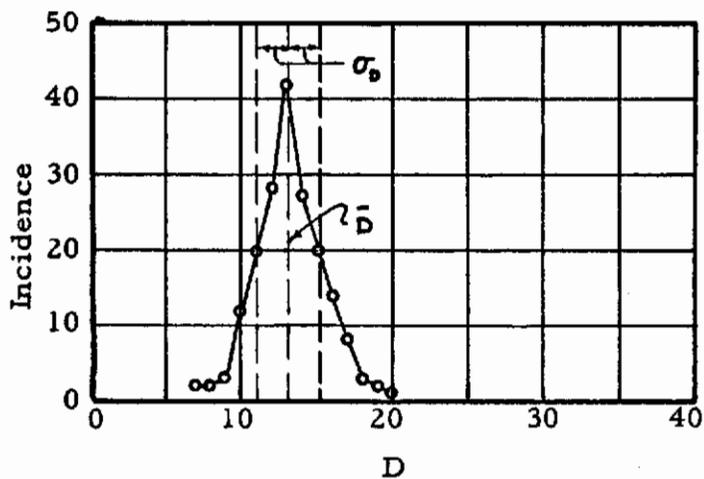
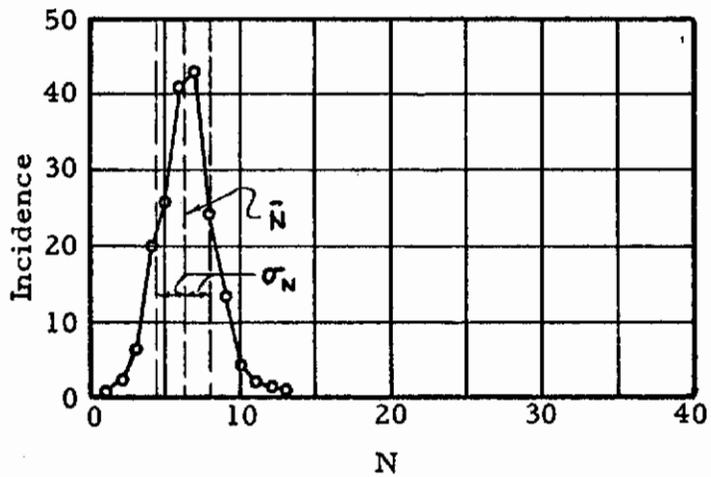


Fig. 1-10 Distributions for N, D and Q;
All ASD Data

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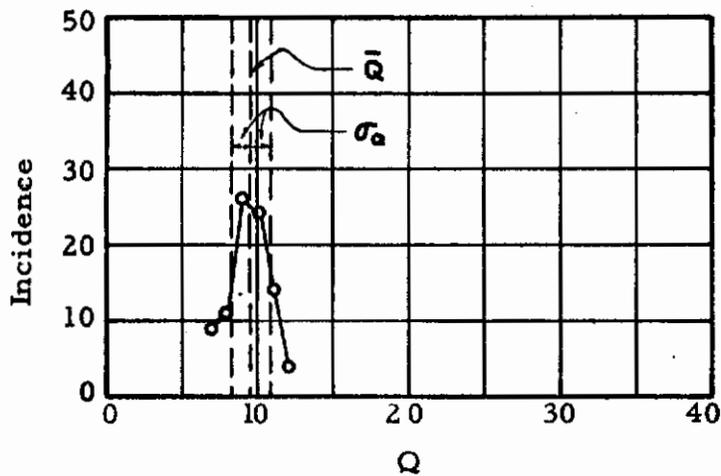
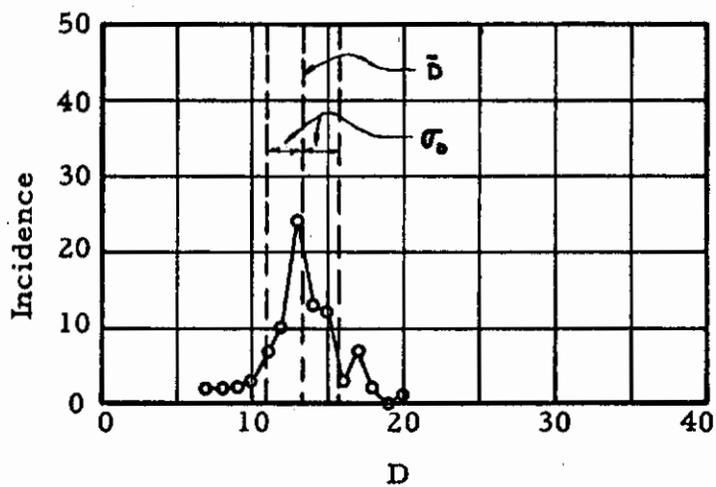
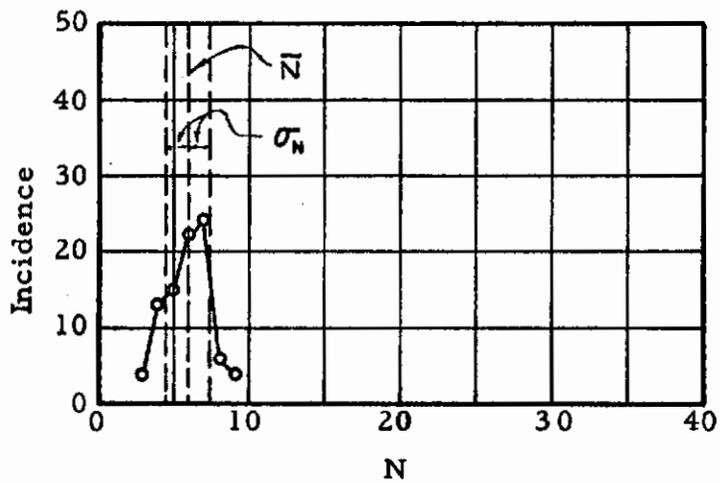


Fig. 1-11 Distributions for N, D and Q;
ASD Runways

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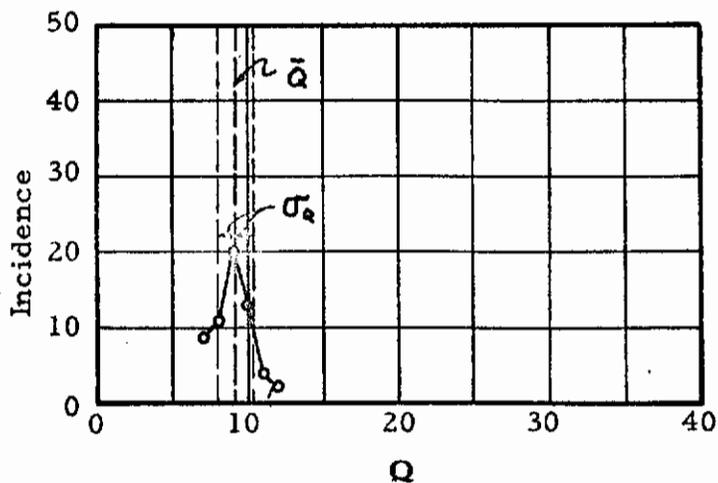
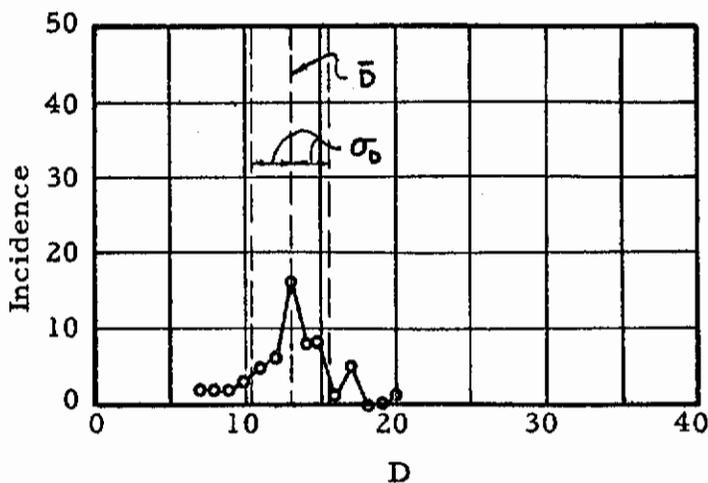
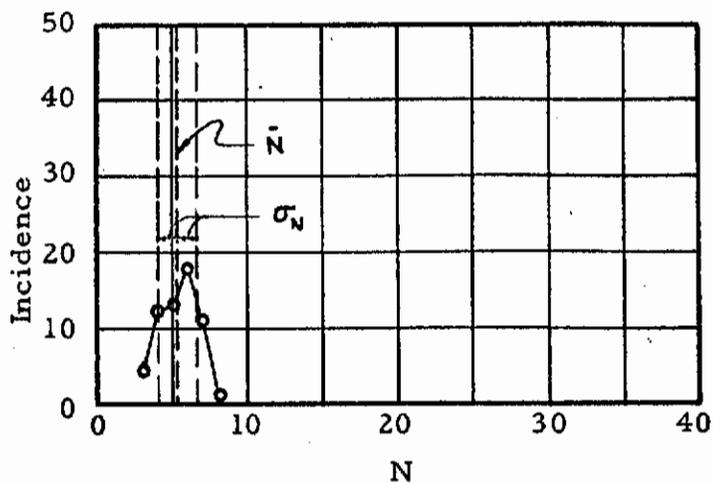


Fig. 1-12 Distributions for N, D and Q;
ASD Runways Longer Than 8000 ft

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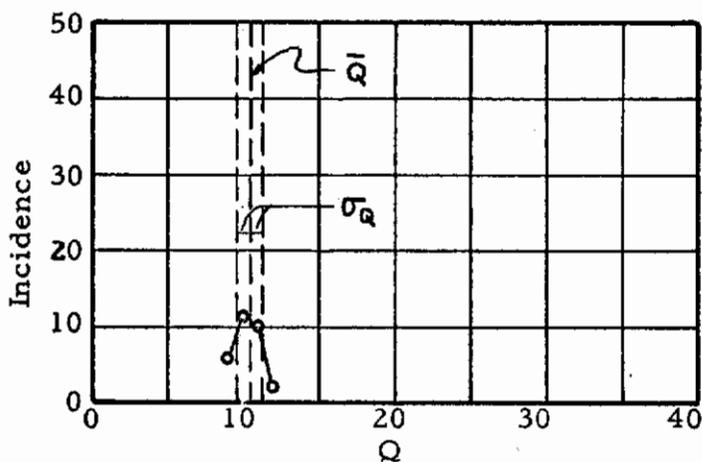
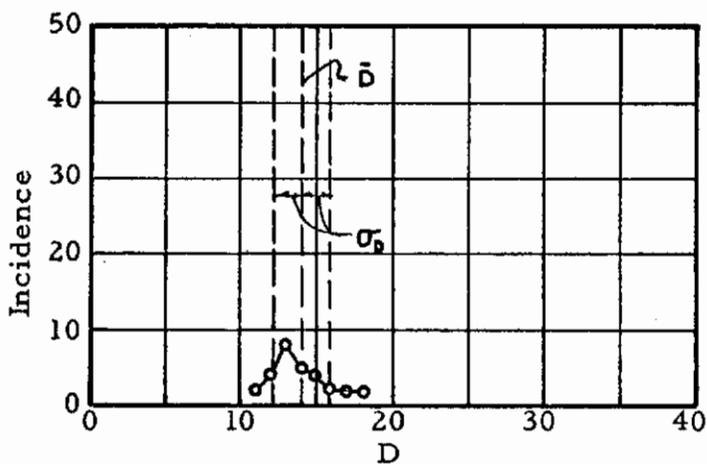
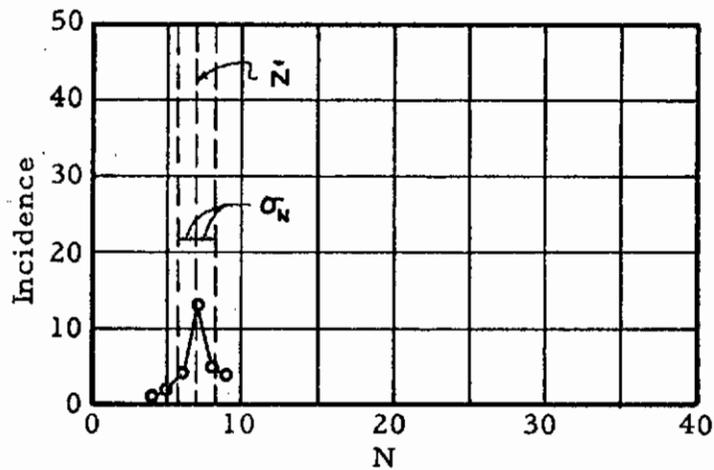


Fig. 1-13 Distributions for N, D and Q;
ASD Runways Shorter Than 8000 ft

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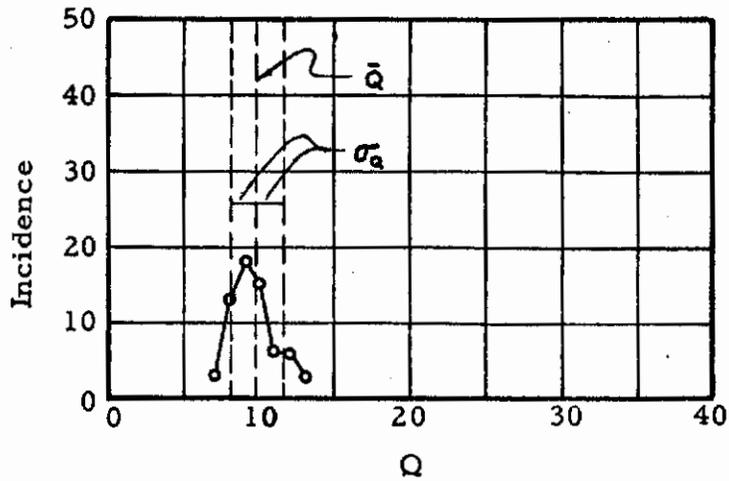
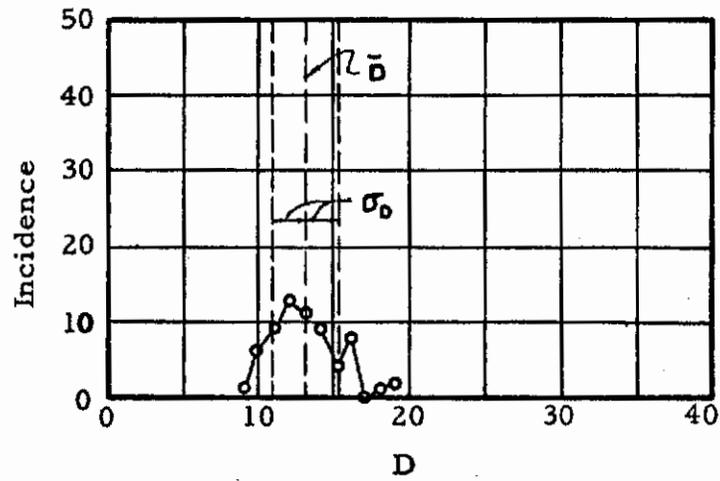
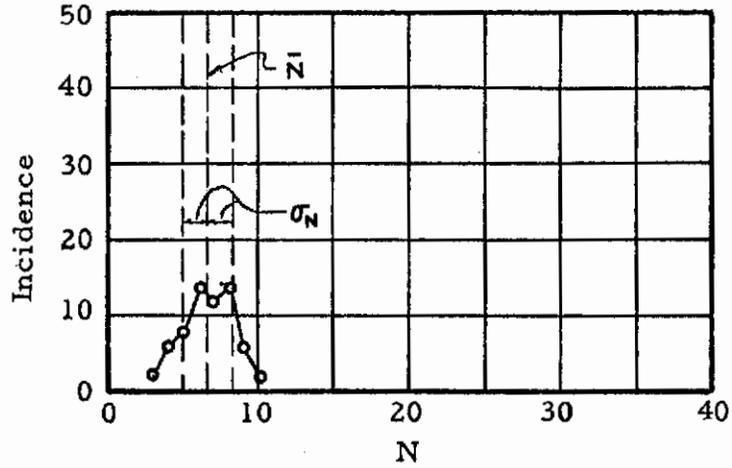


Fig. 1-14 Distributions for N, D and Q;
ASD Taxiways

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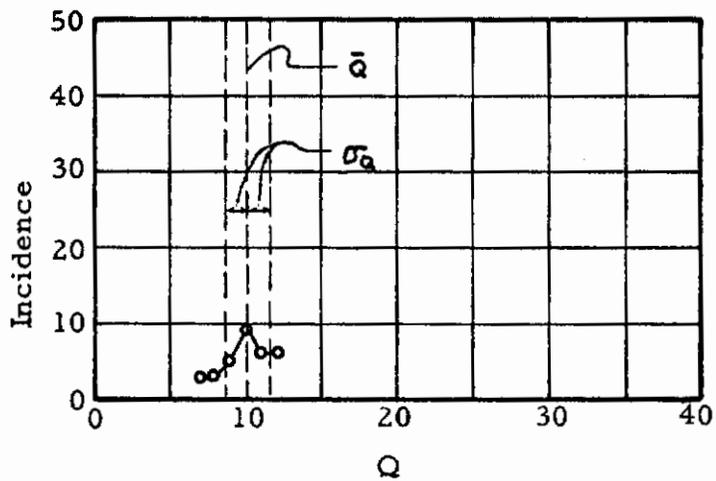
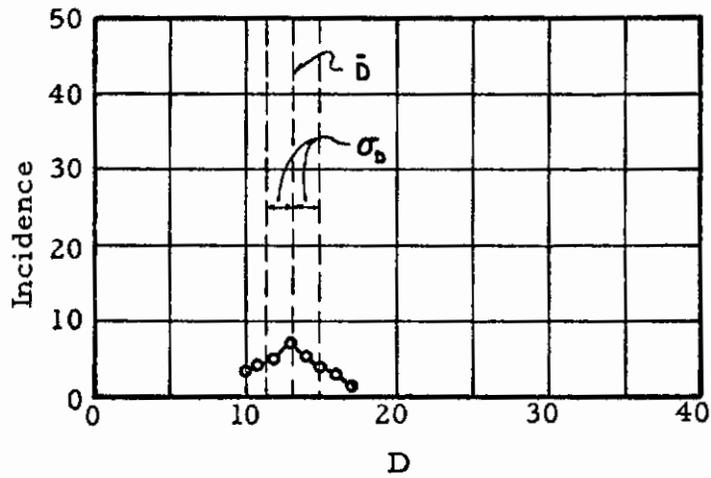
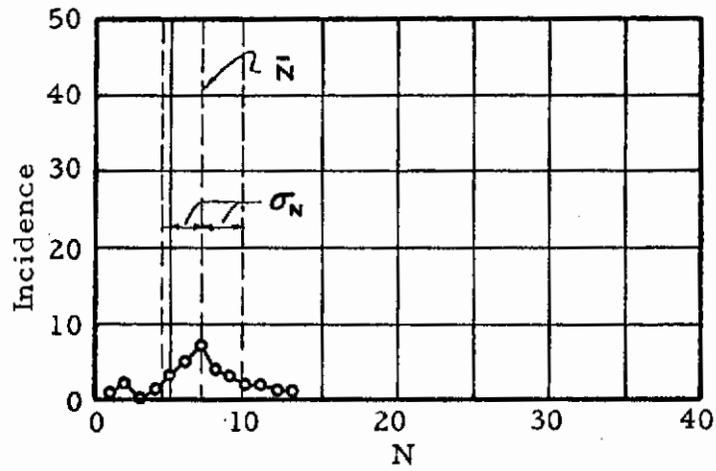


Fig. 1-15 Distributions for N, D and Q;
ASD Ramps

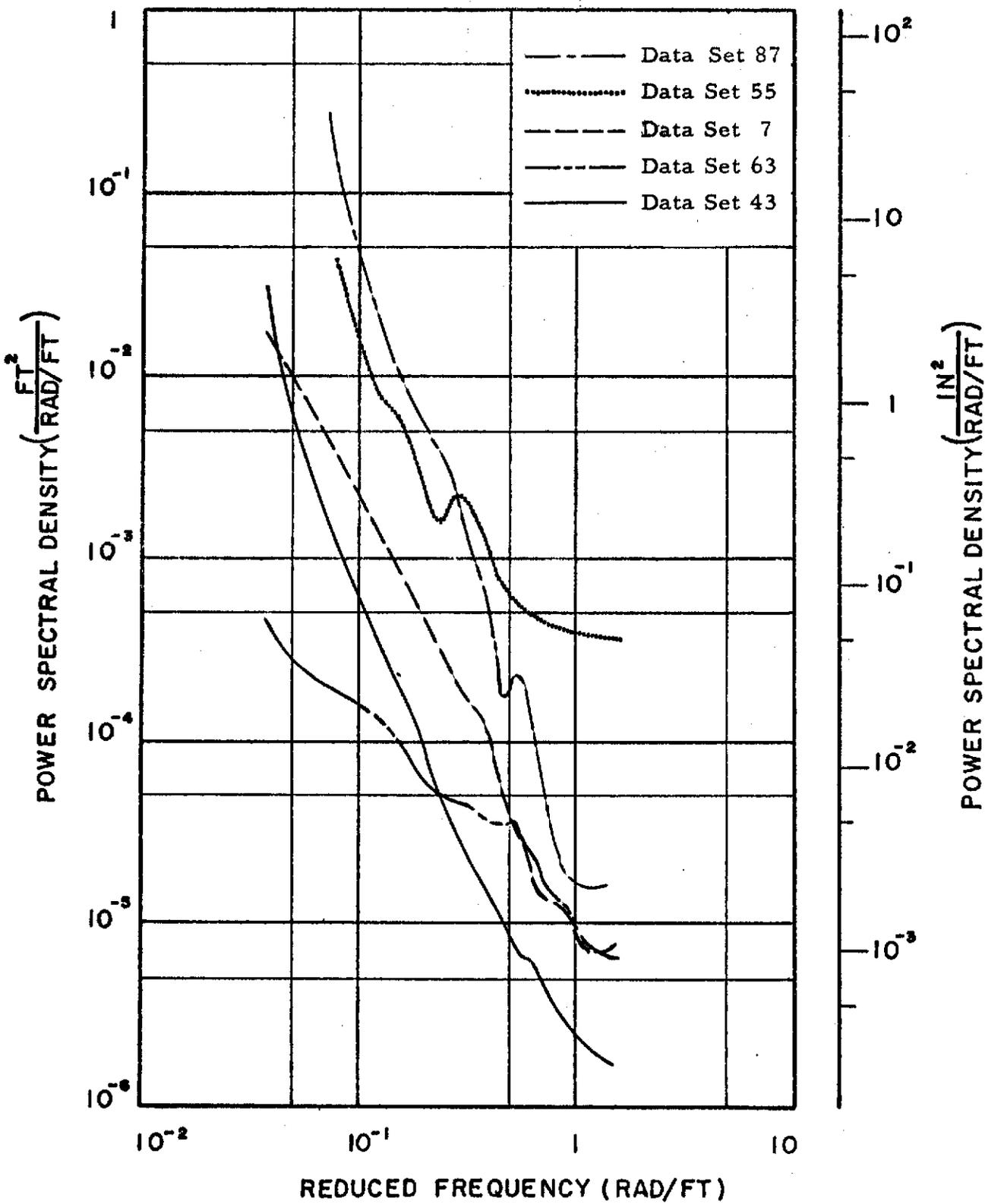


Fig. 1-16 Power Spectral Density Criteria;
All Non-ASD Data

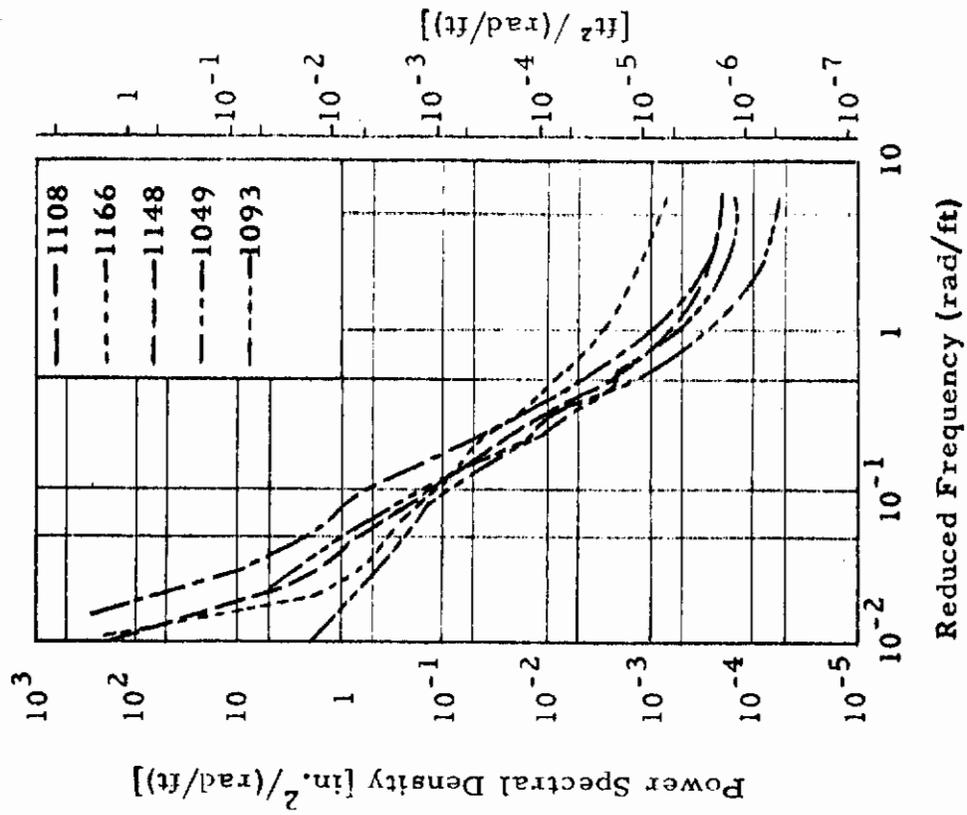


Fig. 1-18 Power Spectral Density Criteria;
ASD Runways

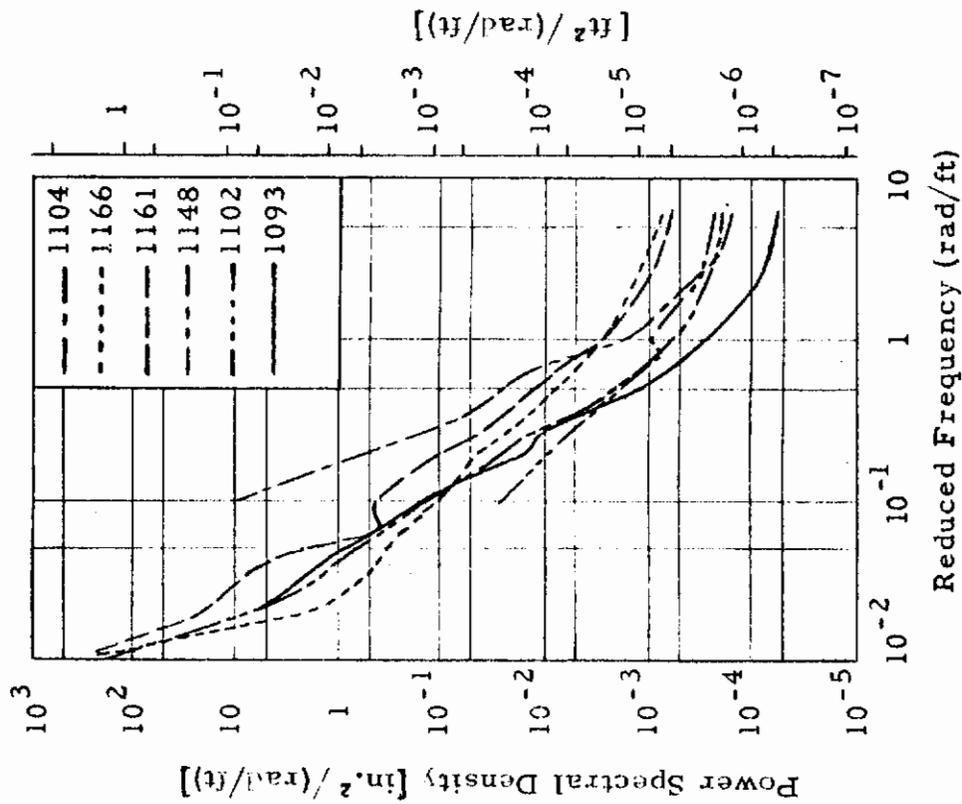


Fig. 1-17 Power Spectral Density Criteria;
ASD Data

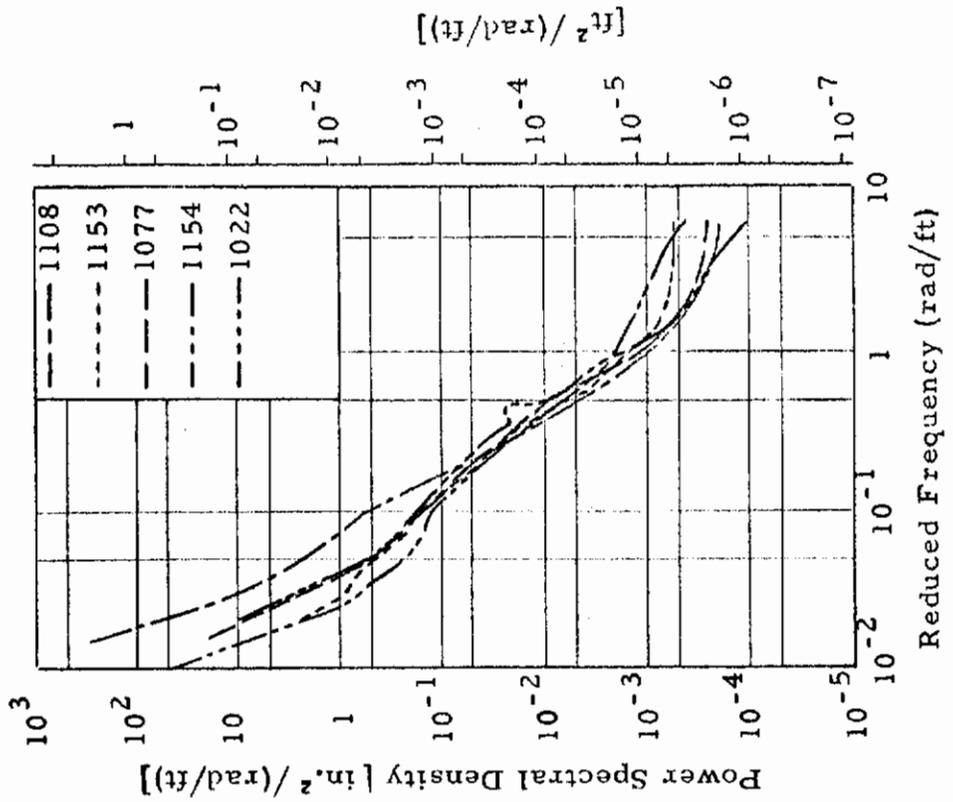


Fig. 1-20 Power Spectral Density Criteria;
ASD Runways Shorter Than 8000 ft

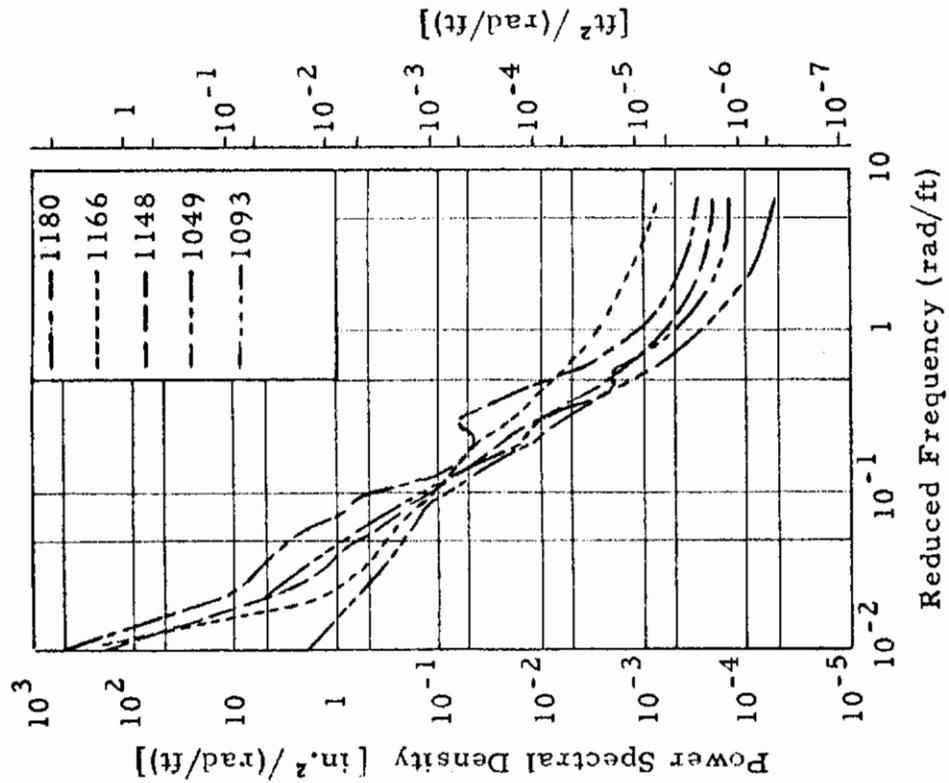


Fig. 1-19 Power Spectral Density Criteria;
ASD Runways Longer Than 8000 ft

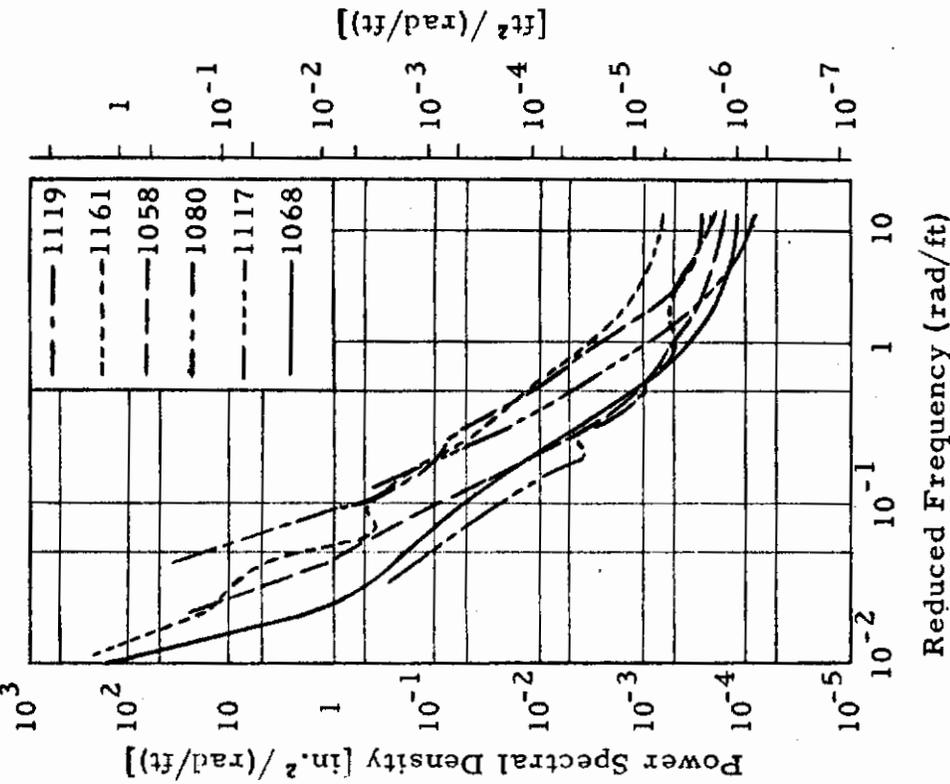


Fig. 1-21 Power Spectral Density Criteria;
ASD Taxiways

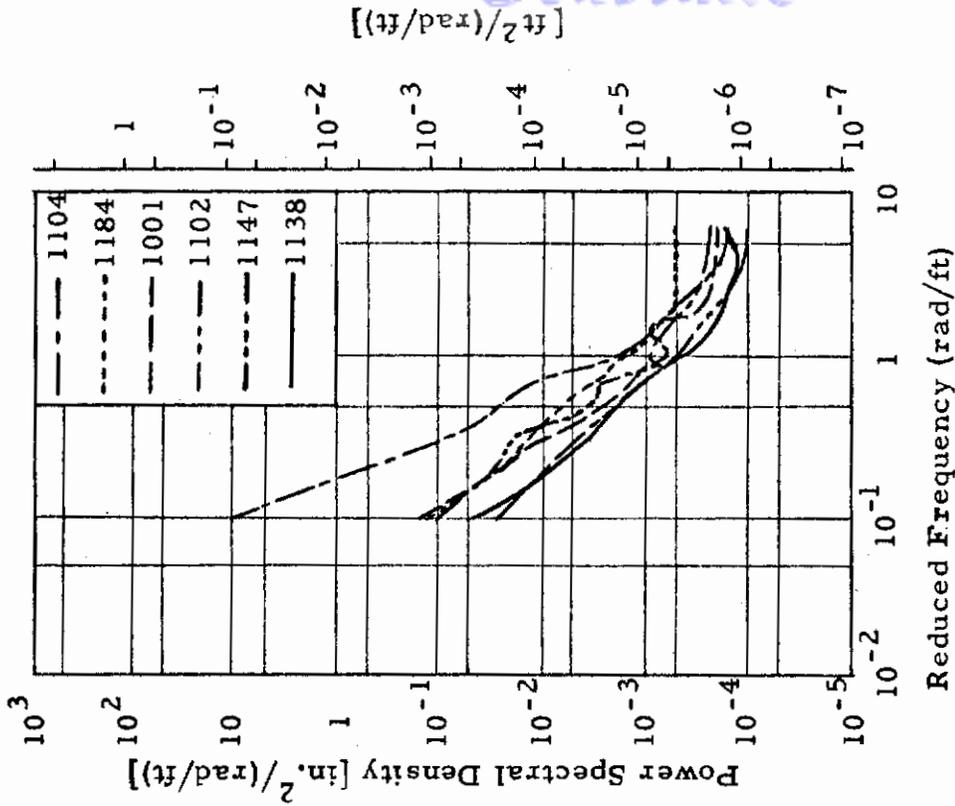


Fig. 1-22 Power Spectral Density Criteria;
ASD Ramps

2. Discrete Bump Criteria

Strip chart recordings supplied by ASD for twenty-five data sets were examined to obtain discrete bump data. They were plotted to a scale of one inch per one hundred feet of profile length and one inch per foot of elevation. The strip charts were examined to obtain data on bumps, dips and included angles between grades. The lengths of the bumps and dips were measured to an accuracy of +5 ft. The heights were accurate to +0.025 ft. The angles were measured to an accuracy of + 0.1 deg. The measurements taken from these charts are tabulated in Appendix III. Distribution plots for bump length, ratio of bump height to length, dip length, ratio of dip depth to length, and angular deviation from 180 deg are given in Figures 1-23, 1-24, 1-25, 1-26, and 1-27. The mean values and standard deviations for these various distribution are:

$$\begin{aligned} \bar{L}_{\text{bump}} &= 72.13 \text{ ft} & \sigma &= 66.42 \text{ ft} \\ \overline{(h/L)}_{\text{bump}} &= 0.001856 & \sigma &= 0.001099 \\ \bar{L}_{\text{dip}} &= 57.43 \text{ ft} & \sigma &= 47.86 \text{ ft} \\ \overline{(h/L)}_{\text{dp}} &= 0.001894 & \sigma &= 0.001184 \\ \delta &= 0.85 \text{ deg} & \sigma &= 0.41 \text{ deg.} \end{aligned}$$

Tables 1-6 and 1-7 show the frequency of occurrence of pairs of values of height and length for the bumps and dips.

3. Limitations and Areas of Application of Criteria

Since large amplitudes of vibration will occur in the vicinity of the natural frequencies of aircraft, the portion of the power spectral density curves which will excite these frequencies is most important. The natural frequencies f_n (in cps) can be converted to spatial frequency Ω (in rad/ft) using the formula

$$\Omega = 2\pi f_n / V$$

where V is the taxiing velocity of the aircraft.

Table 1-8 gives some of the characteristics of the various classes of aircraft. This table was provided by ASD. The last four columns of this chart gives the general range of values of the natural frequencies of cargo, fighter, bomber and miscellaneous types of aircraft. The column preceding the natural frequencies contains the approximate landing speeds of these types of aircraft. Utilizing this information and applying the formula given above we find that the entire range of the power spectral densities given as design criteria are important in the design of aircraft. In addition reduced frequencies below and above the range for which the power

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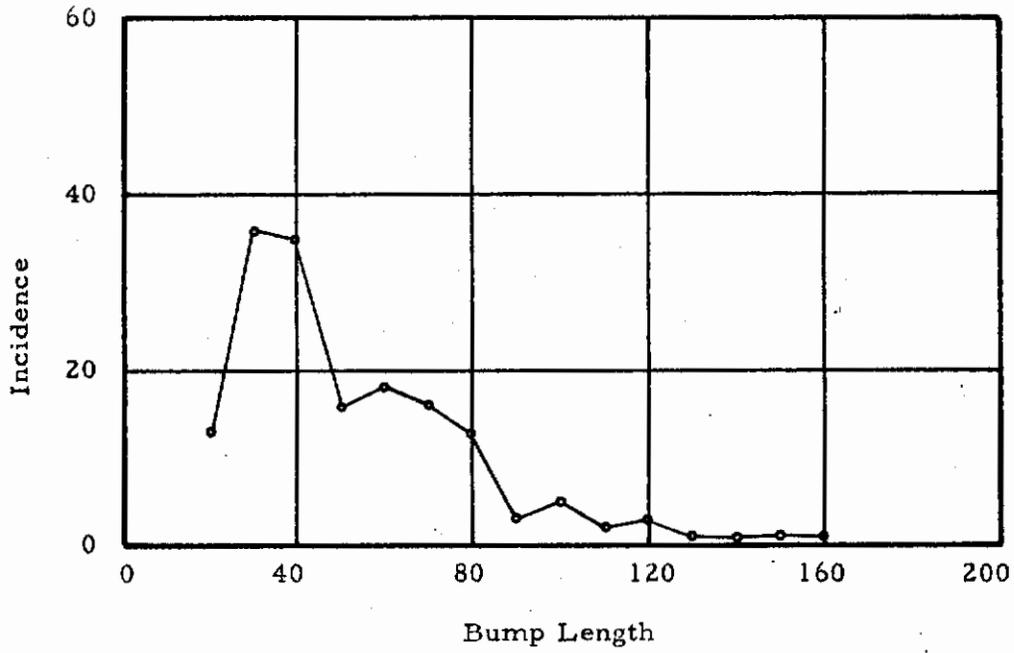


Fig. 1-23 Distribution of Bump Length

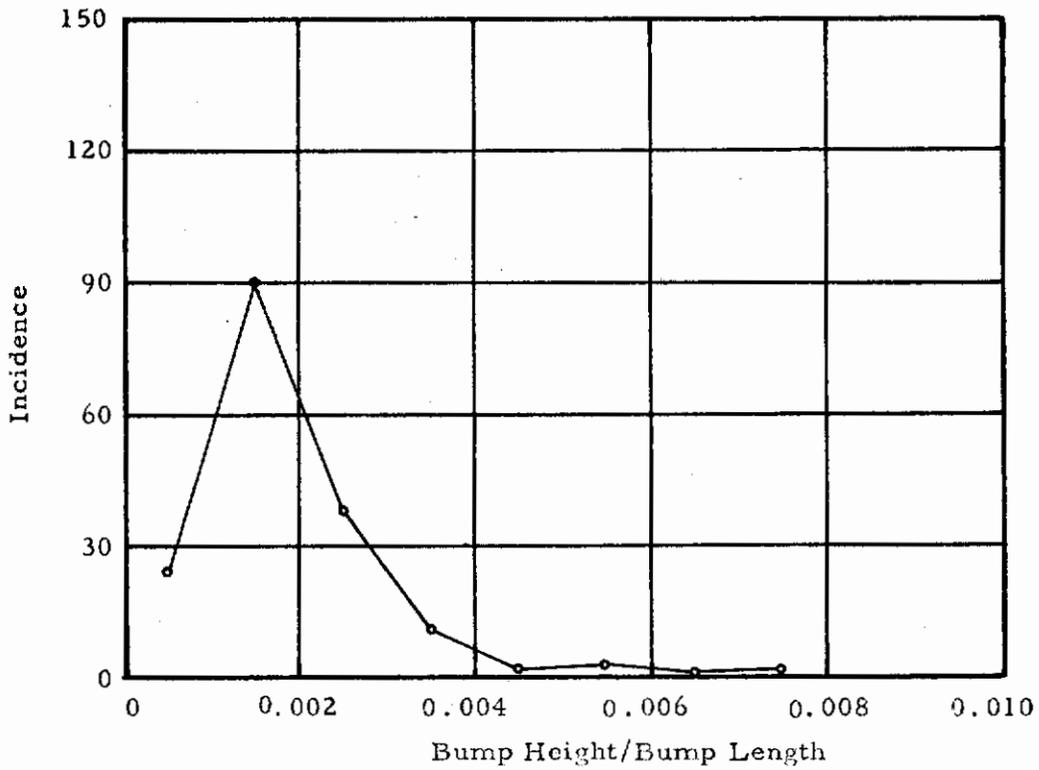


Fig. 1-24 Distribution of Bump Height to Bump Length Ratio

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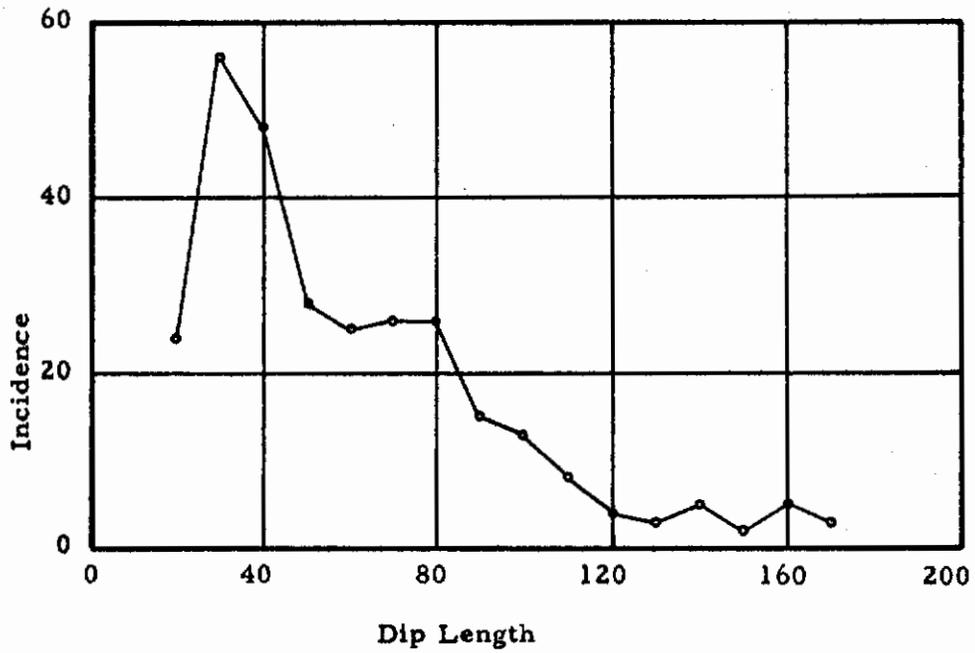


Fig. 1-25 Distribution of Dip Length

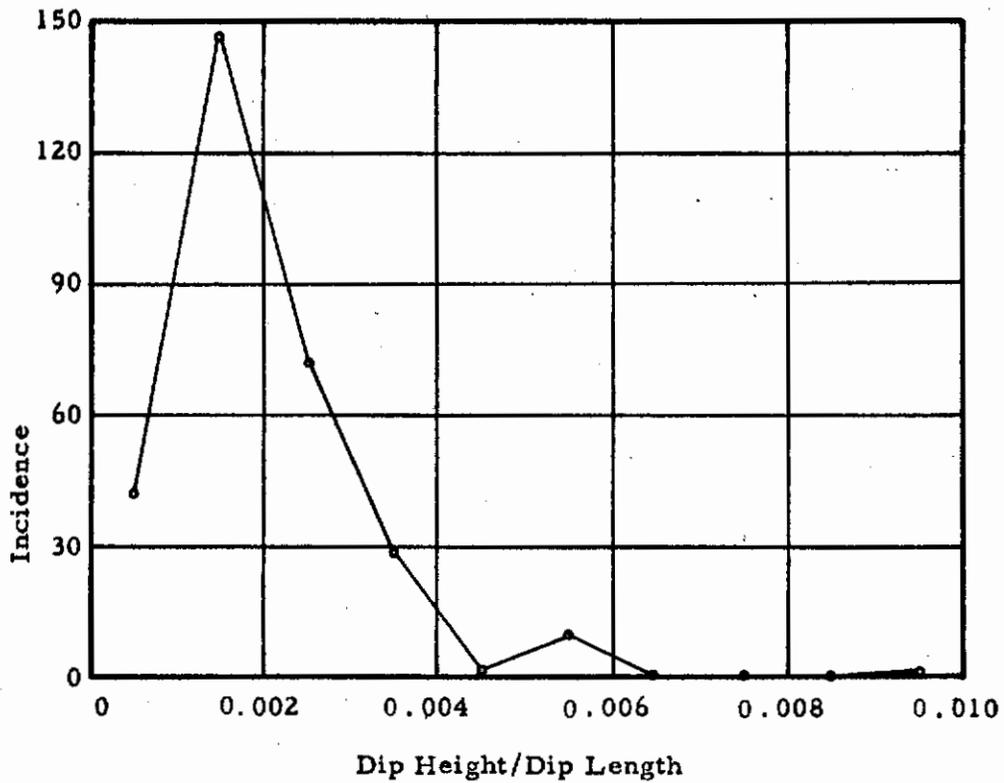


Fig. 1-26 Distribution of Dip Height to Dip Length Ratio

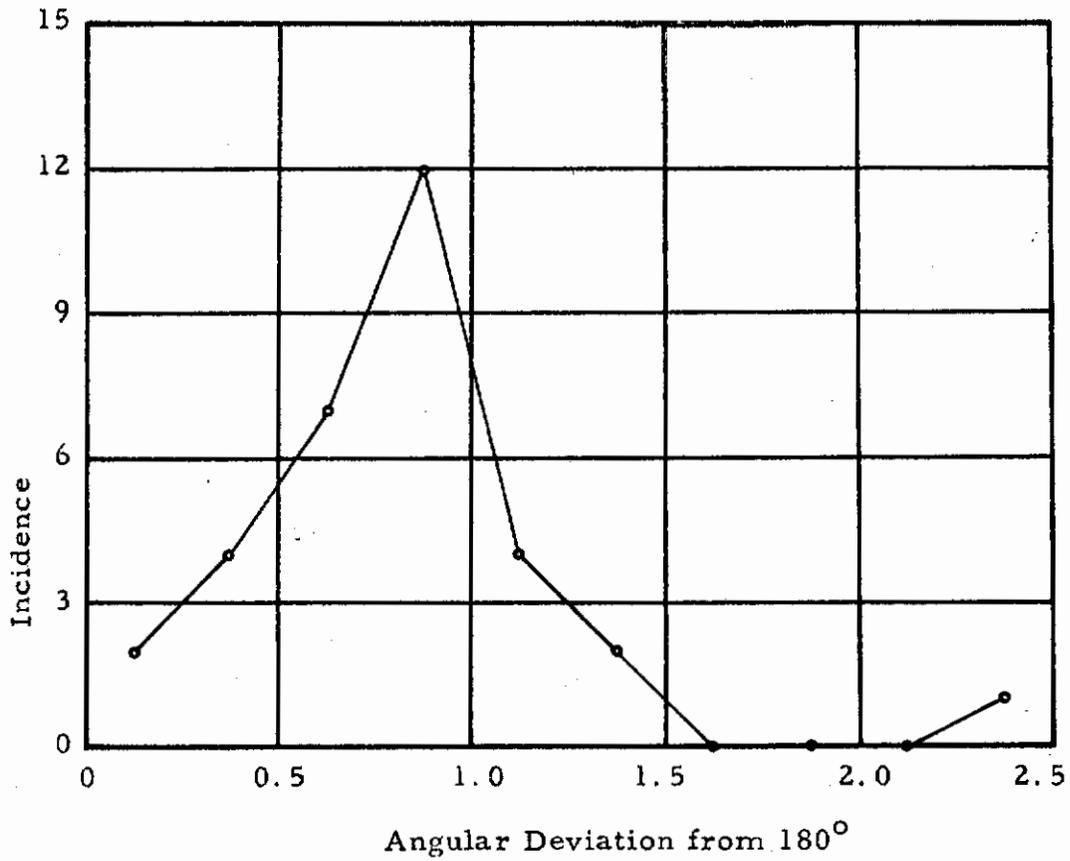


Fig. 1-27 Distribution of Angular Deviation from 180 Deg

Table 1-6 Distribution of Bumps by Height and Length

L H	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	220	230	240	260	270	290	320	330	390	500	510
0.05		24	33	23	19	9	7	5	3	2			1															
0.10		2	19	16	9	14	13	14	10	5	3	3		2	1	2						1						
0.15			3	4	3	4	5	3	1	4	2		1	2		1	2			1								
0.20				1			1	3	1	1	1		1	1	1	1							1					
0.25											1	1				1												
0.30			1					1			1																	
0.35																												
0.40										1						1												
0.45																												
0.50																									1			
0.55																												
0.60																												
0.65																												
0.70																												
0.75																												
0.80																										1		
0.85																												
0.90																												
0.95																												
1.00																												
1.05																												
1.10																												
1.15																												1

Table 1-7 Distribution of Dips by Depth and Length

L H	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	350	470
	0.05	7	27	19	7	9	4	3		1		1					
0.10	4	8	12	7	9	10	9	2	2		1	1					
0.15	2		3		1	2	1		1	1	1		1				
0.20		1	1	2			1		1					1	1		1
0.25								1								1	
0.30																	

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Table 1-8 Typical Characteristics of Aircraft

Type Aircraft	AF Designation	Weight		Wing Span (ft)	Wing Area (ft ²)	Fuselage Length (ft)	Tread		Wheel Base (ft)	1,2 V _s (fps)	Natural Frequencies (cps)		General Range of Values
		Empty (lb)	Max (lb)				Main (ft)	Outrigger (ft)			Rigid Body Pitch Translation	Flexible Body 1st Fundamental	
Light Cargo	C-47	17,865	33,000	95	987	64	18.5		36.5	132			
Light Cargo	C-54	38,656	82,500	117.5	1547	93.8	24.7		28.0	178			
Medium Cargo	C-97	76,143	175,000	141.2	1768	110.3	28.5		36.4	219	1	1.5	2
Medium Cargo	C-121	72,815	145,000	123.0	1650	116.2	28.0		43.6	194			1.5
Medium Cargo	C-130	59,328	124,200	132.6	1745	97.8	14.3		31.3	191			
Heavy Cargo	C-124	96,726	200,000	173.3	2510	127.1	34.2		29.75	201			
Heavy Cargo	KC-135	95,546	297,000	130.8	2433	136.2	22.1		45.65	270			
Heavy Cargo	C-133	120,263	300,000	180.0	2673	157.0	17.5		58.91	214			
Fighter	F-86	13,498	20,000	37.0	287	40.3	8.3		---	227	1	1.7	7.0
Fighter	F-89	25,194	46,700	60.0	650	53.8	21.9		11.4	239	1.5	3.5	9.0
Recon.	RF-101	25,335	51,000	40.0	370	70.0	20.0		21.3	348			
Light Bomber	B-57	27,091	56,965	64.0	960	65.5	15.8		14.3	219	0.7	0.7	1.0
Light Bomber	B-66	42,549	83,000	72.5	780	75.2	10.8		27.6	265	0.5	1.0	1.5
Medium Bomber	RB-47	81,000	200,000	116.0	1428	109.8	3.0	44.3	36.3	318	1	1	3
Heavy Bomber	B-52	164,936	450,000	185.0	4000	156.5	11.4	148.4	49.75	298			
Misc.	L-23	4,947	7,000	45.0	277	31.5	12.8		---	149	NASA TR 510 1.25	NASA TR 510 1.25	
Trainer	T-38	7,146	9,920	25.3	170	44.2	---		19.4	273		3.0	

spectra were computed may be important. For instance the B-66 light bomber aircraft lands at approximately 265 fps and has its first natural frequency at 0.5 cps. These values lend to a spatial frequency of 0.012 rad/ft which is below the minimum spatial frequency for which power spectra were computed which was approximately 0.02 rad/ft. Also the B-66 has a natural frequency of 2 cps and might taxi as low as 1 fps, which leads to a spatial frequency of 12.6 rad/ft which is above the range of power spectral density plots since the maximum reduced frequency for which power spectra were computed was 6.28 rad/ft. Since the B-66 has natural frequencies between 0.5 and 2 cps and may taxi at speeds between 265 fps and zero fps the total range of the power spectral density plots are important in its design. Similar conclusions can be drawn for all of the different types of aircraft.

Although it was shown above that the entire range of spatial frequency is important in the design of aircraft, examination of the power spectra show that much greater power exists at the lower frequencies and therefore these frequencies can be more important than the frequencies at the high end of the scale. On the average the power at 0.1 cps is two orders of magnitude greater than the power at 1.0 cps. A rather large variation in the magnitudes of the runway power spectra was noted. The variation in the power spectra between the smooth and the rough runways was between one and two orders of magnitude.

The several groupings of power spectral density design criteria provide different criteria to be used for different classes of aircraft and for the same type of aircraft in different modes of operation. For instance, aircraft similar to the B-52 bomber or the F-104 fighter must operate from runways longer than 8,000 ft, so the criteria developed from runways longer than 8,000 ft should be used for such aircraft. Other aircraft similar to the B-47 bomber or the F-102 fighter can operate from shorter runways, so different criteria apply to these aircraft. In addition, the same aircraft will operate at different velocities on runways, taxiways and ramps, so criteria for each type of profile should be considered separately. The bump criteria given here does not include such irregularities as runway lights which may extend above the surface of the runway or the large bump which might occur should one of the wheels of the aircraft run off the paved runways. Such items as this must be considered in addition to the bump criteria given here.

The application of the bump criteria is again dependent on taxi speed. If the aircraft is taxiing at a velocity V a bump having length

$$L = V/f_n$$

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will excite the natural frequency f_n of the aircraft. The height of the bump will determine the amplitude of the excitation. For the B-66 aircraft a bump length of 530 ft will excite the lowest natural frequency, 0.5 cps, when the plane is taxiing at 265 fps. A bump length of 10 ft will excite the 2-cps natural frequency when the B-66 is taxiing at 30 fps. As the above example shows the full range of the bump criteria must be used in the design of any aircraft.

The effect of the spacing between bumps is not taken into account in the bump criteria. It is felt that this spacing is reflected in the power spectral density criteria. Since the bump data were obtained by visual inspection some human interpretation was necessary to differentiate between bumps and dips. Where such interpretation was necessary the data were biased toward bumps.

The criteria given here can be easily updated when new data become available by combining the new data with the presently available data and noting the effect of these data on the criteria established in the previous sections.

The effect of the time of the year during which the data were taken on the roughness of the profile was not evident from the available data. Several runways would need to be surveyed seasonably for a period of several years to obtain a large enough sampling of data to find the effect of the season on the profile roughness.

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APPENDIX I

GENERATION OF PROFILES
FROM POWER SPECTRA

APPENDIX I

GENERATION OF PROFILES FROM POWER SPECTRA

1. Shape

It is quite easy to fit an ad hoc equation to a runway spectral density curve. The equation $\phi(x) = ax^{-b}$ works very nicely; however, such an equation tells us nothing about the stochastic process by which runways are generated. We would like therefore to obtain an equation which illustrates this stochastic process.

If we assume that discrete masses of material are placed at fixed intervals on the ground and then smoothed, we can derive a shape for the resulting spectra. Suppose the height of the nth mass is X_n , which height we will assume is normally distributed about some height which we can assume without loss of generality to be zero, then the smoothed height will be

$$\bar{X}_n = \sum_{K=-\infty}^{\infty} a_K X_K$$

If we assume that the smoothing process works with only two masses at a time (not unreasonable) then $\bar{X}_n = X_n - \alpha X_{n-2}$ and the resulting spectral density is

$$\phi(x) = \frac{\gamma}{(1 + \alpha^2) - 2\alpha \cos x}$$

where γ is a function of both α and the variance at X_n . This equation fits the runway data available almost as well as does ax^{-b} , and for some values of x it fits better. A slight generalization to the case where $\bar{X}_n = X_n - \alpha X_{n-1} - \beta X_{n-2}$ produces the spectral density

$$\phi(x) = \frac{\gamma}{(1 + \alpha^2 + \beta^2) - 2\alpha \cos x - 2\beta \cos x + 2\alpha\beta \cos x}$$

which is an excellent fit to all the spectral densities available.

Since this last equation fits so well, we can say that if runways were constructed by laying down masses and then smoothing, the spectra would be those observed. How justified we would be in reversing this statement and saying that runways are made this way because our curve fits, remains to be seen.

2. Generating Random Profiles in Theory

The first method that comes to mind for generating random profiles is to construct a moving average

$$X'_\tau = \sum_{t=1}^P a_t X'_{\tau-t}$$

where the a_t are chosen so that

$$\sum_{\tau} \left(X_\tau - \sum_{t=1}^P a_t X_{\tau-t} \right)^2$$

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is a minimum for $\{X_T\}$ from a given runway. This method should give good prediction for any given runway. If we desired to construct a single moving average, however, to represent several runways, then things would become complicated.

A slightly different approach assumes that runway data are gaussian stationary; it then follows that the second moments completely specify runway data and if $\phi(\omega)$ is the spectral density of a runway, then

$$\phi(\omega) = |T(\omega)|^2 k$$

where $T(\omega)$ is the Fourier transform of a weighting function $W(t)$, and k , a constant, is the spectral density of the process $\{\xi_t\}$. In the time domain we have, if $\{X_t\}$ is runway data

$$X_{t_0} = \int_{-\infty}^{\infty} W(t-t_0) \xi_t dt.$$

The fact that k is a constant implies that

$$\text{Cov } \xi_t \xi_{t'} = \begin{cases} \sigma^2 & \text{if } t' = t \\ 0 & \text{if } t' \neq t \end{cases}$$

or that is to say, the $\{\xi_t\}$ are independent gaussian variables.

In practice we would simulate runway data with estimated spectral densities $\hat{\phi}(\omega)$ by finding a cosine polynomial $G(\omega) = |T(\omega)|^2$ such that $[\hat{\phi}(\omega)/G(\omega)] = \text{constant}$, finding a polynomial $T(\omega)$ in $\exp(-it\omega)$ satisfying $G(\omega) = |T(\omega)|^2$, taking the Fourier transform of $T(\omega)$ to get $W(t)$, and calculating the simulated runway data by

$$X'_{t_0} = \sum_{t=t_0-P}^{t=t_0+P} W(t-t_0) \xi_t$$

where of course, the $\{\xi_t\}$ are independent gaussian variables.

The advantages of this procedure over the moving average procedure are: 1) There is no need to let transients die down. 2) We know that $\log \hat{\phi}(\omega)$ is approximately normally distributed with constant variance for all ω , hence we can compare runways statistically and group similar runways for simulation, and 3) Intuitive insight can be developed by using the $\hat{\phi}(\omega)$ which could not be done with the $\{a_t\}$ of the moving average procedure.

3. Generating Profiles in Practice

If the equation for $\phi(x)$ in 1. is indeed an adequate description of runway spectra, then we have solved the problem of generating random profiles, for by selecting α , β , and γ properly we can generate a random profile in a computer by calculating

$$\tilde{X}_n = X_n - \alpha X_{n-1} - \beta X_{n-2},$$

where the $\{X_n\}$ are random normal numbers with variance adjusted to give the desired γ .

If we want to generate random profiles on a mechanical device, then due to the limited velocity with which a mechanical device can move, the following theory will have to be used.

The method of generating random profiles discussed above should be quite satisfactory if the random profiles are ends in themselves; however, it is quite likely that at some time in the future, it will be desirable to expose experimental models of alighting gear to random profiles. This means that a mechanical system (e. g., an endless belt) will have to be developed which is capable of exciting mechanically, the alighting gear in the same way that a runway might. Considering the speeds at which modern aircraft traverse runways, such a mechanical system would have to fluctuate randomly at rates up to 25 or 30 cps. Such rates of random mechanical movement seem quite unlikely to be realized, consequently, the following method of generating random profiles using low frequency random inputs was developed.

Let $x(t)$ and $y(t)$ be stationary, zero mean, statistically independent random functions of time t , with identical, band limited, two-sided spectral densities $P(f)$ for $|f| < W$. In symbols, our assumptions are

(a) Zero mean:

$$\lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t) dt = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T y(t) dt = 0$$

(b) Stationary, with same spectrum:

$$\lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t) x(t+t_0) dt = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T y(t) y(t+t_0) dt = C(t_0),$$

where

$$P(f) = \int_{-\infty}^{\infty} C(t) e^{-i2\pi ft} dt$$

(c) Statistically independent:

$$\lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t) y(t+t_0) dt = 0, \text{ for all } t_0.$$

Consider the random function $Z(t)$ produced by randomly modulating a cosine and a sine function with $x(t)$ and $Y(t)$, respectively.

$$Z(t) = x(t) \cos \omega_0 t + y(t) \sin \omega_0 t,$$

where $\omega_0 = 2\pi f_0$. Mechanically, this would correspond to superimposing a low frequency random movement on a sinusoidal mechanical motion. Achieving high frequency random mechanical motion is quite difficult due to the rapid directional changes required; however, neither the achievement of high frequency sinusoidal mechanical motion, nor the achievement of low frequency random mechanical motion is too difficult; hence, it should be possible to generate $Z(t)$ mechanically (at least in theory).

It is easily seen that $Z(t)$ has zero mean, since

$$-\frac{1}{2T} \int_{-T}^T [x(t) + y(t)] dt < \frac{1}{2T} \int_{-T}^T Z(t) dt < \frac{1}{2T} \int_{-T}^T [x(t) + y(t)] dt.$$

and as $T \rightarrow \infty$ both the left most and right most terms go to zero.

To find the spectrum of $Z(t)$, we first find the autocovariance function $C_Z(t)$ of $Z(t)$;

$$\begin{aligned} C_Z(t_0) &= \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T Z(t) Z(t+t_0) dt \\ &= \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T [x(t)x(t+t_0) \cos \omega_0 t \cos \omega_0 (t+t_0) \\ &\quad + y(t)y(t+t_0) \sin \omega_0 t \sin \omega_0 (t+t_0) \\ &\quad + x(t)y(t+t_0) \cos \omega_0 t \sin \omega_0 (t+t_0) \\ &\quad + y(t)x(t+t_0) \sin \omega_0 t \cos \omega_0 (t+t_0)] dt \end{aligned}$$

Contrails

$$\begin{aligned}
 &+ x(t) y(t+t_0) \cos \omega_0 t \sin \omega_0(t+t_0) \\
 &+ x(t+t_0) y(t) \cos \omega_0(t+t_0) \sin \omega_0 t \\
 &+ y(t) y(t+t_0) \sin \omega_0 t \sin \omega_0(t+t_0)] dt.
 \end{aligned}$$

Since

$$\begin{aligned}
 -\frac{1}{2T} \int_{-T}^T x(t) y(t+t_0) dt &< \frac{1}{2T} \int_{-T}^T x(t) y(t+t_0) \cos \omega_0 t \sin \omega_0(t+t_0) dt \\
 &< \frac{1}{2T} \int_{-T}^T x(t) y(t+t_0) dt,
 \end{aligned}$$

we have assumption c)

$$\lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t) y(t+t_0) \cos \omega_0 t \sin \omega_0(t+t_0) dt = 0$$

and by a similar argument we have

$$\lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t+t_0) y(t) \cos \omega_0(t+t_0) \sin \omega_0 t dt = 0.$$

We can therefore, write

$$\begin{aligned}
 C_Z(t_0) &= \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T [x(t) x(t+t_0) \cos \omega_0 t \cos \omega_0(t+t_0) \\
 &+ y(t) y(t+t_0) \sin \omega_0 t \sin \omega_0(t+t_0)] dt \\
 &= \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T \frac{1}{2} [x(t) x(t+t_0) (\cos \omega_0 t_0 + \cos \omega_0(2t+t_0)) \\
 &+ y(t) y(t+t_0) (\cos \omega_0 t_0 - \cos \omega_0(2t+t_0))] dt \\
 &= C(t_0) \cos \omega_0 t_0 + \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T \frac{1}{2} [x(t) x(t+t_0) \\
 &- y(t) y(t+t_0)] \cos \omega_0(2t+t_0) dt.
 \end{aligned}$$

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Since

$$\begin{aligned} -\frac{1}{4T} \int_{-T}^T [x(t)x(t+t_0) - y(t)(t+t_0)] dt &< \frac{1}{4T} \int_{-T}^T [x(t)x(t+t_0) \\ &- y(t)y(t+t_0)] \cos \omega_0 (2t + t_0) dt \\ &< \frac{1}{4T} \int_{-T}^T [x(t)x(t+t_0) - y(t)y(t+t_0)] dt \end{aligned}$$

and since both the left most and right most terms go to zero as $T \rightarrow \infty$, we have

$$C_Z(t) = C(t) \cos \omega_0 t.$$

This tells us that $Z(t)$ is a stationary process. Taking the Fourier transform, we get the spectral density:

$$P_Z(f) = \int_{-\infty}^{\infty} C(t) \cos \omega_0 t e^{-i2\pi ft} dt = \frac{1}{2} [P(f+f_0) + P(f-f_0)]$$

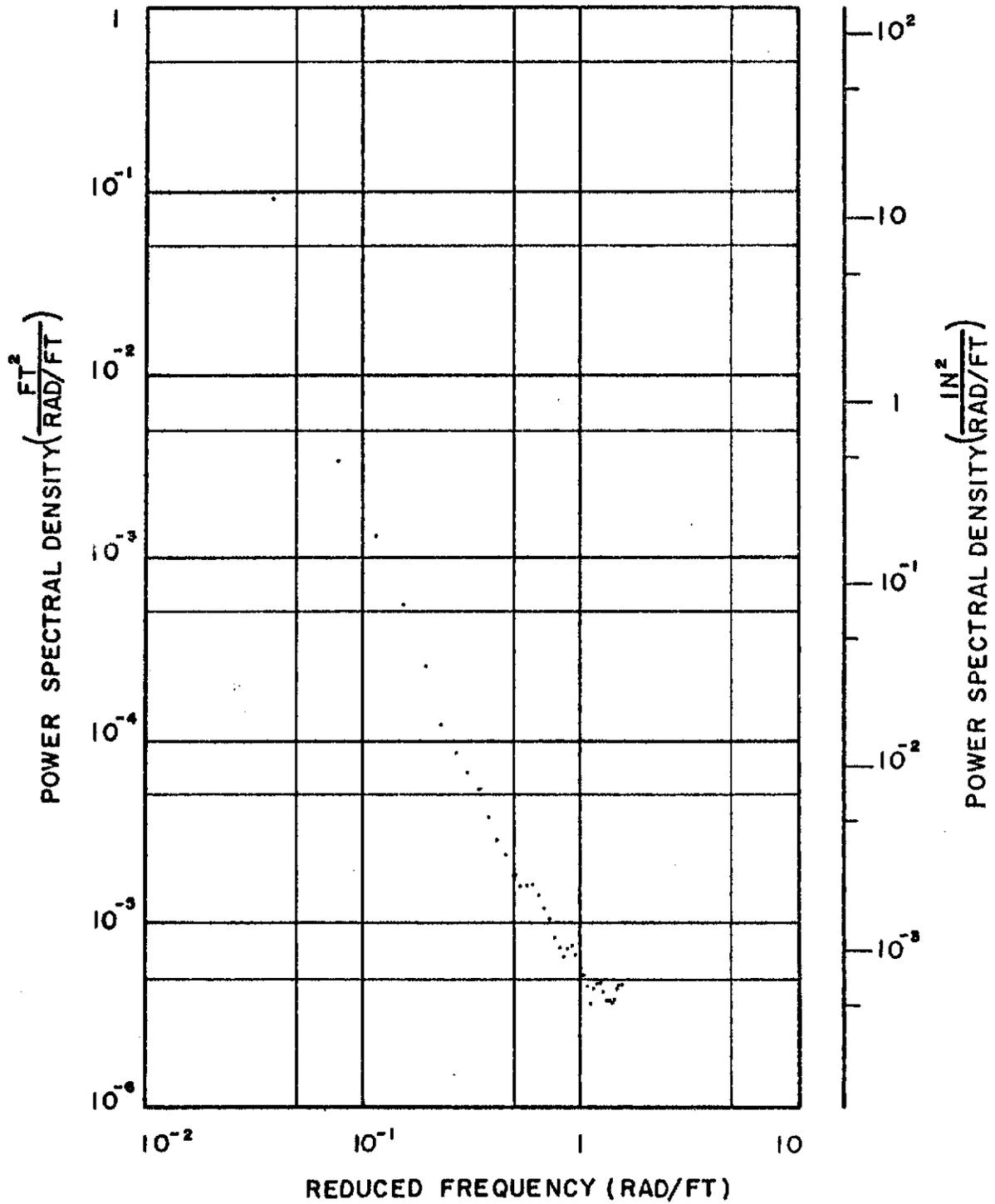
This last equation shows that the frequency range of $Z(t)$ is band limited: with all non-zero densities occurring in the frequency range $|f-f_0| \leq w$. It follows, therefore, that a mechanical system may, in theory, by using a low frequency, band limited, random input, generate a band limited, random disturbance about any given frequency.

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APPENDIX II

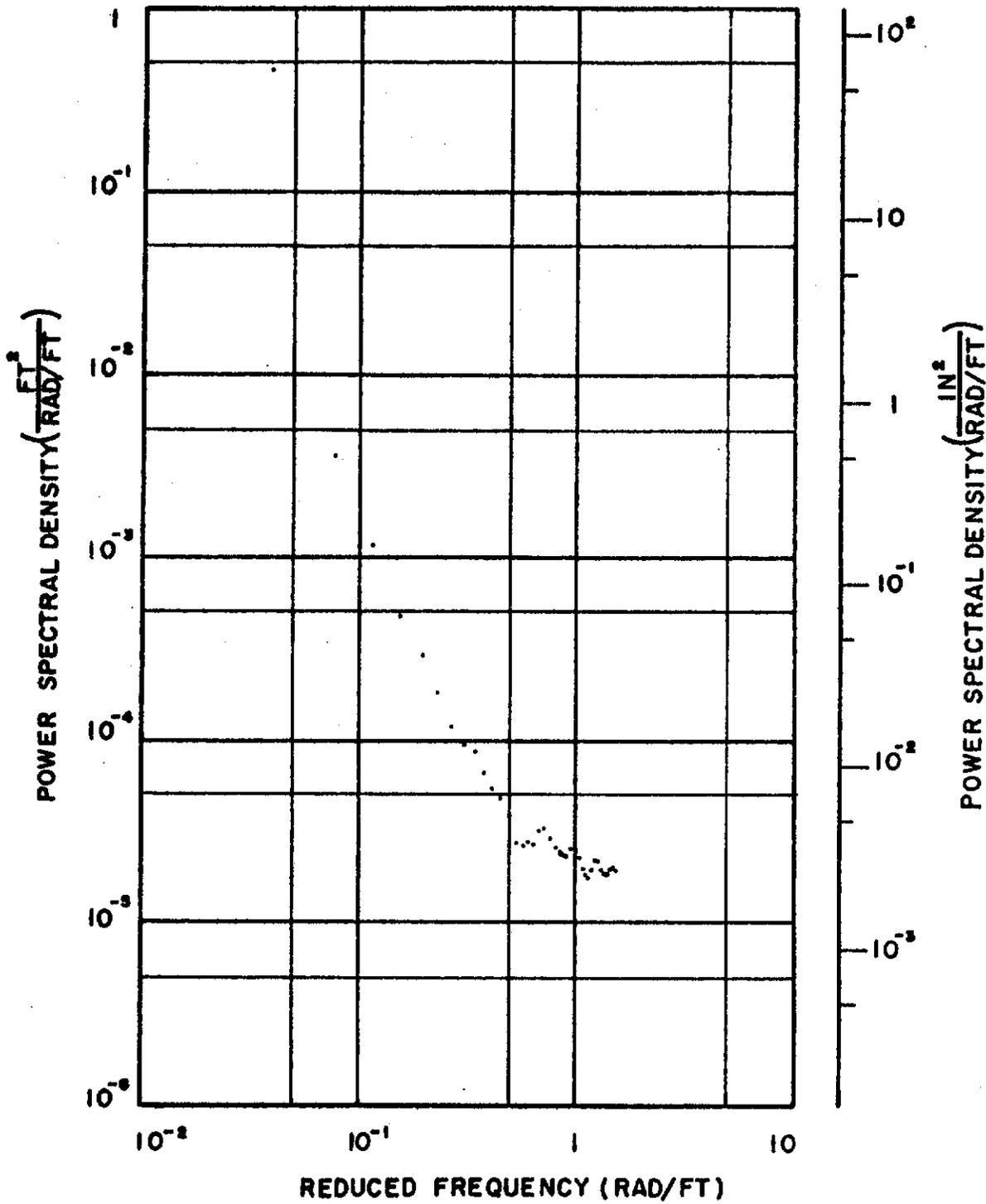
ALL NON-ASD POWER SPECTRAL DENSITIES

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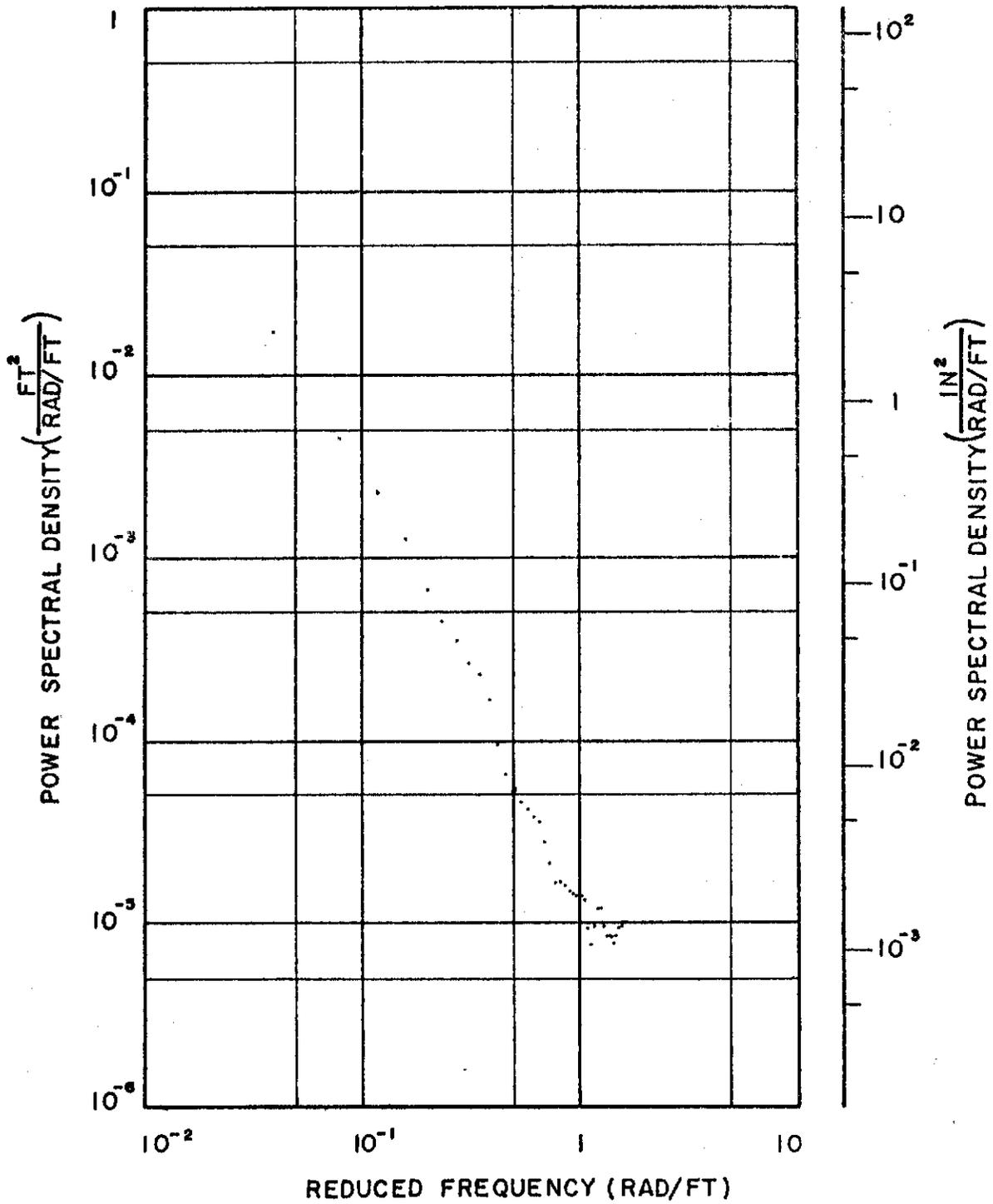
Runway 1

Contrails



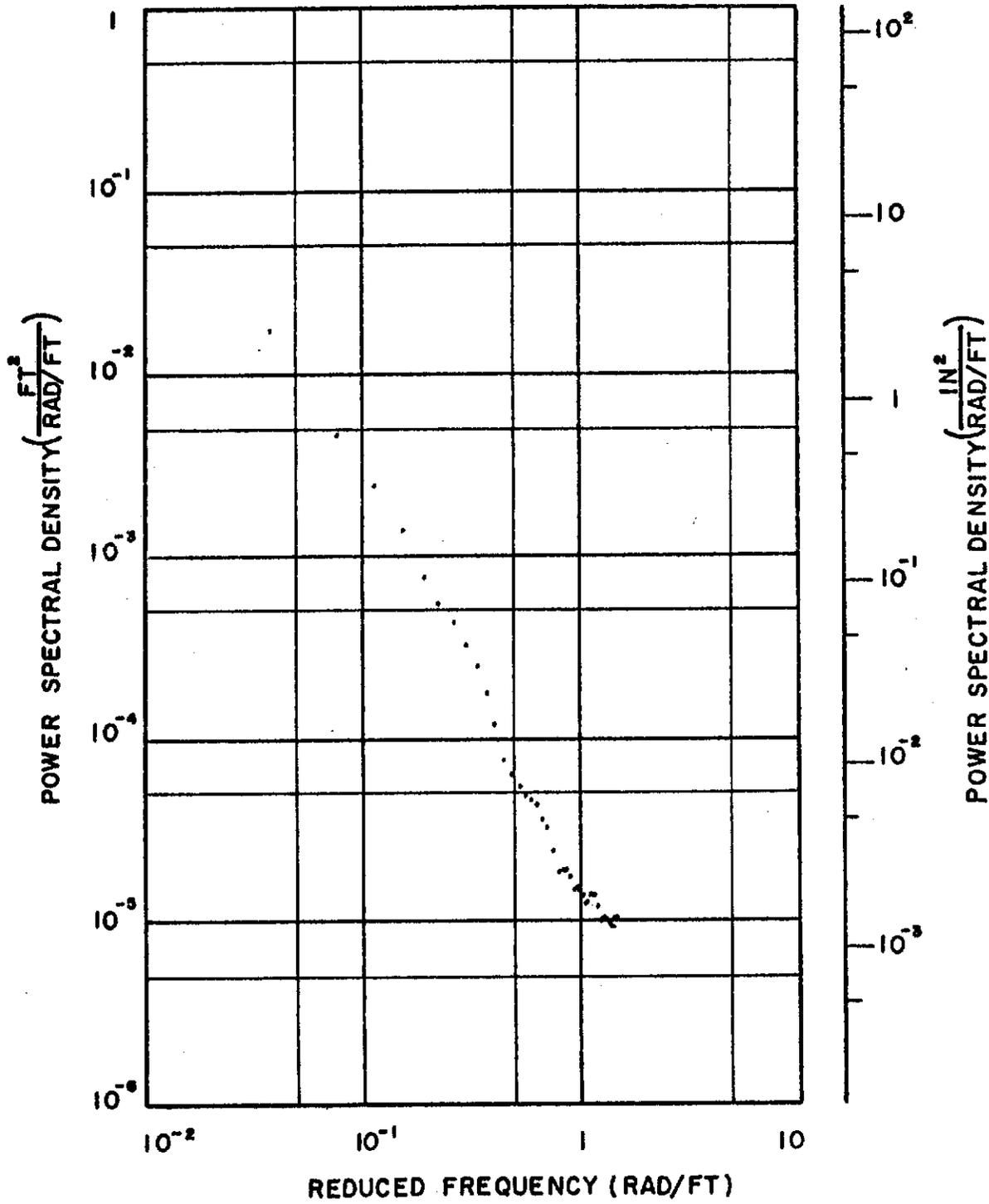
Runway 2

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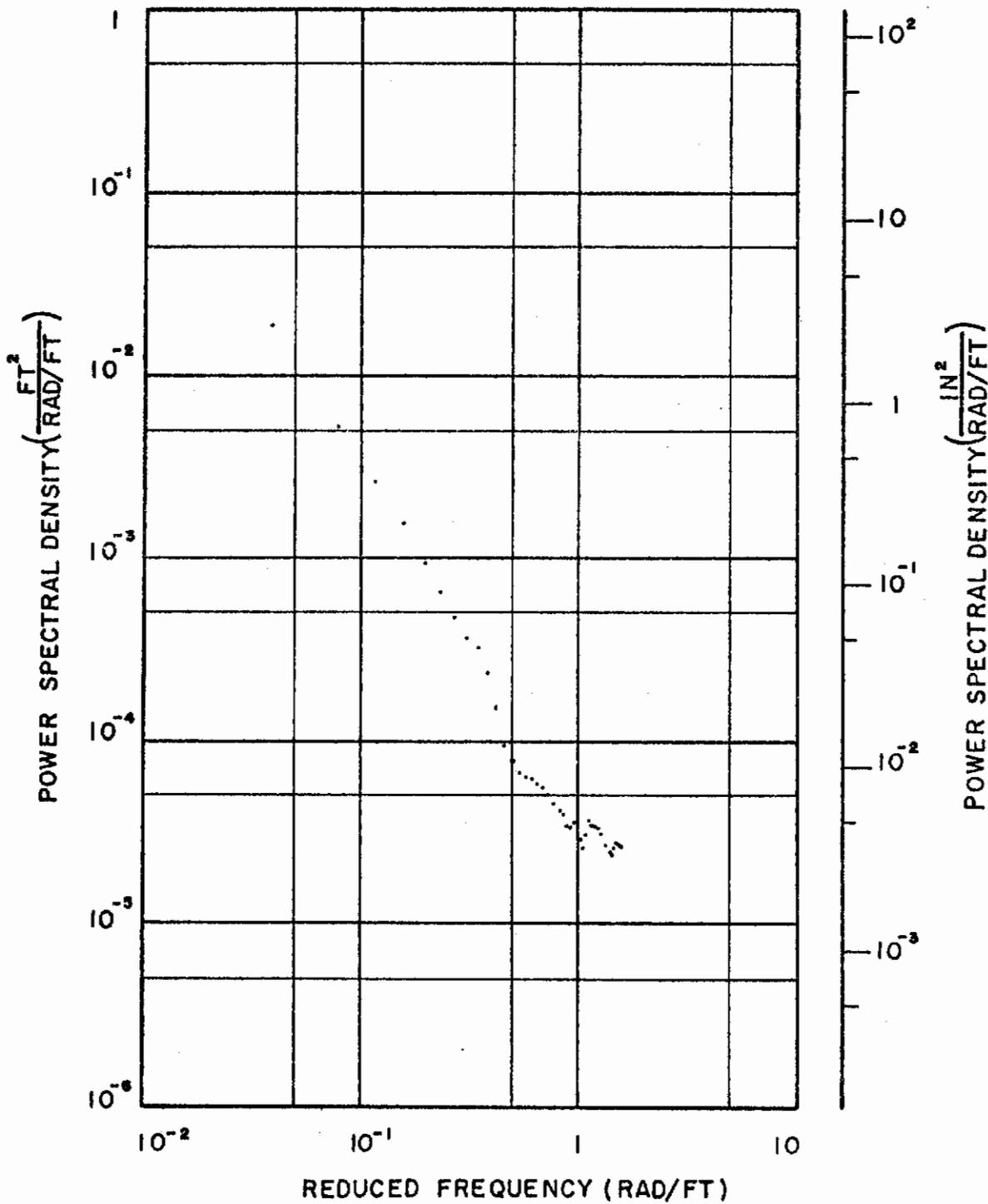


Runway 3

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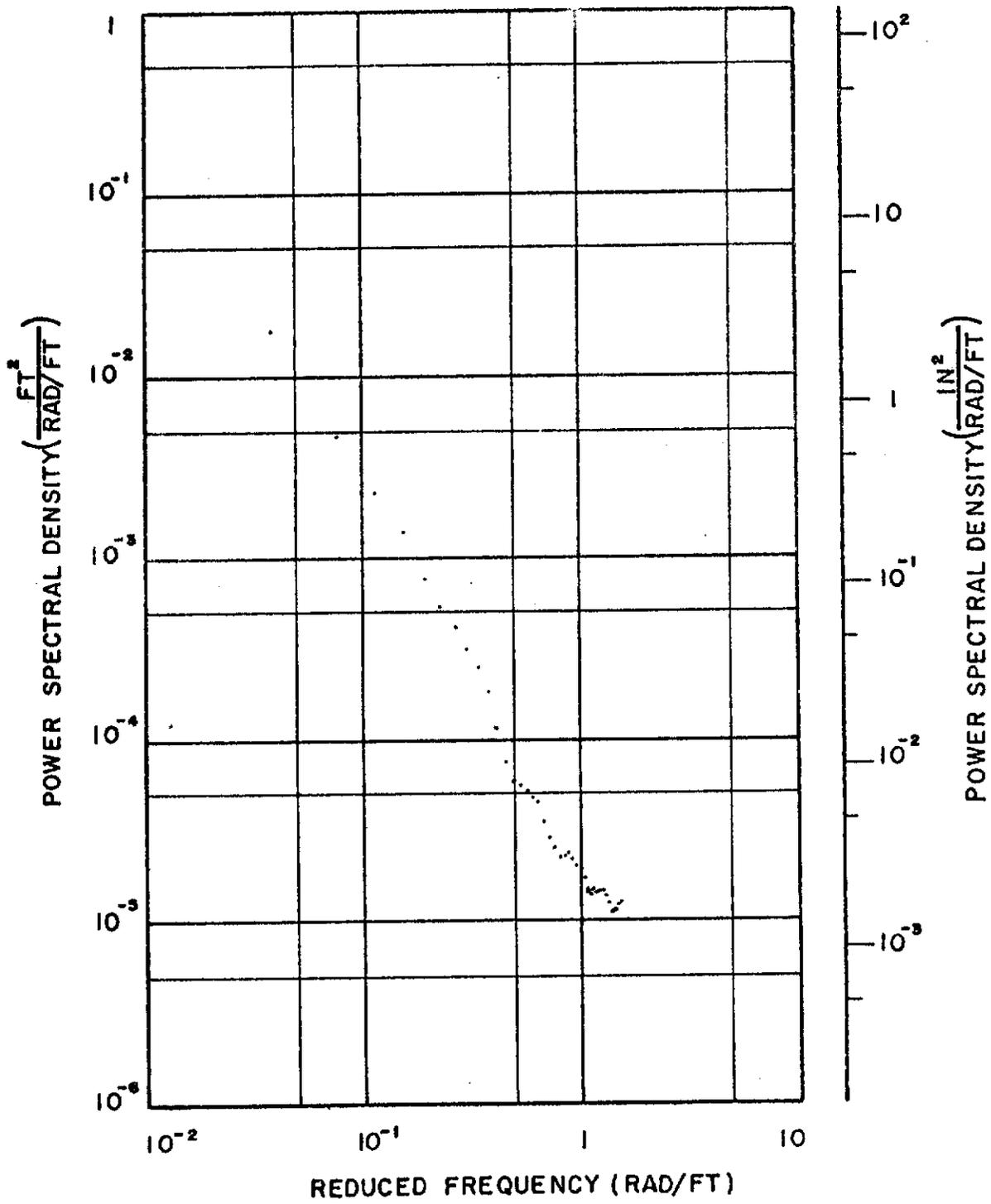


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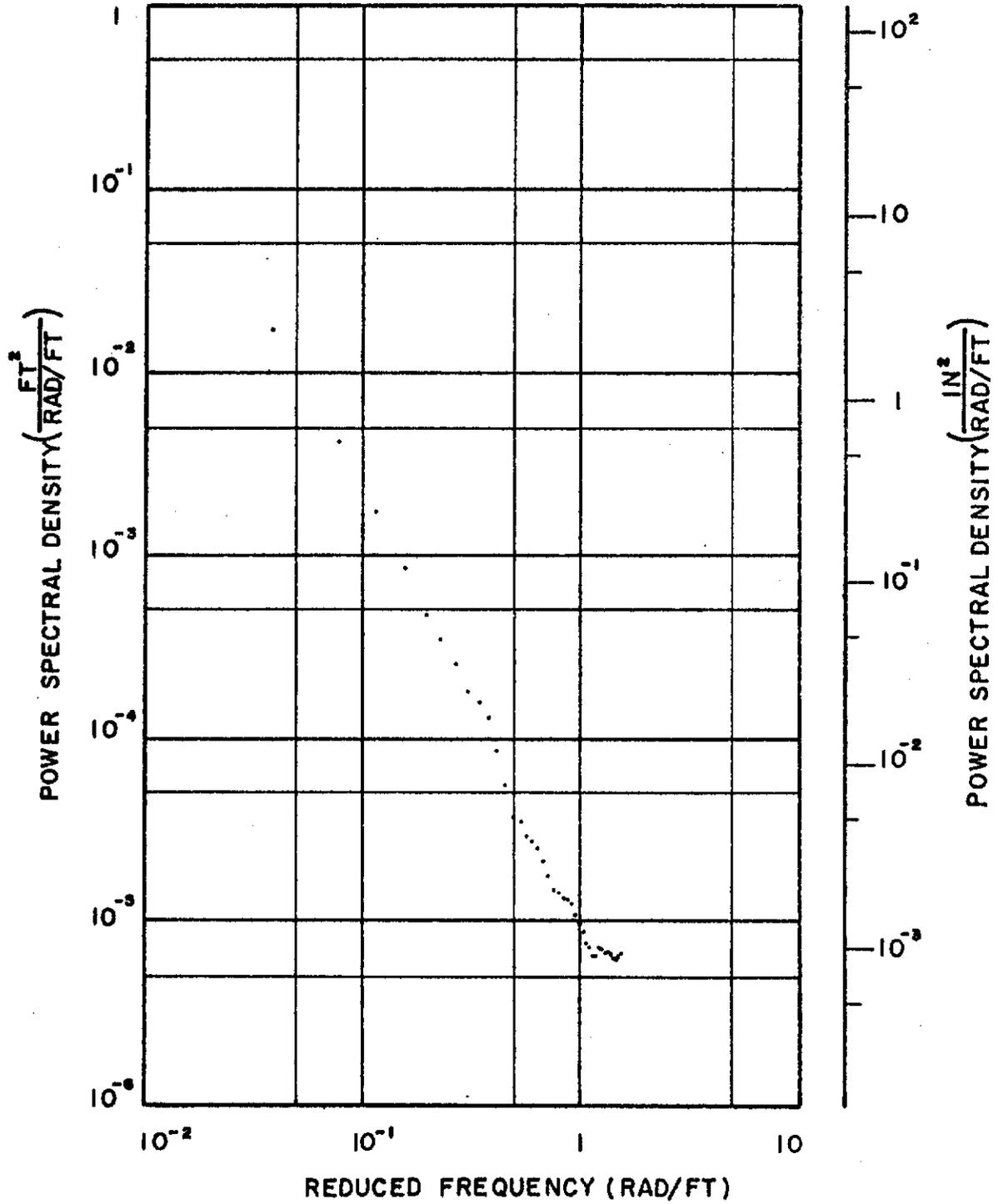
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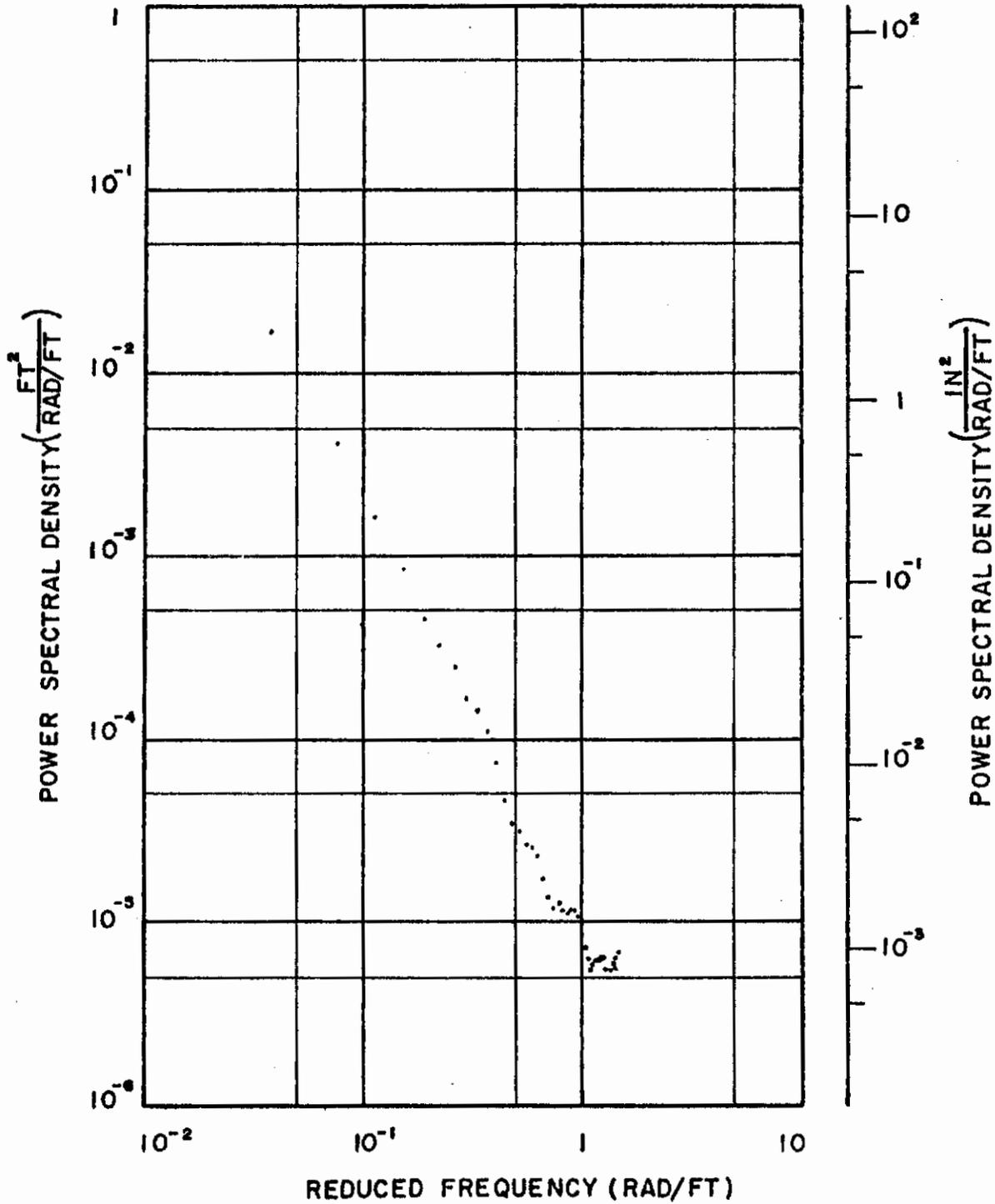
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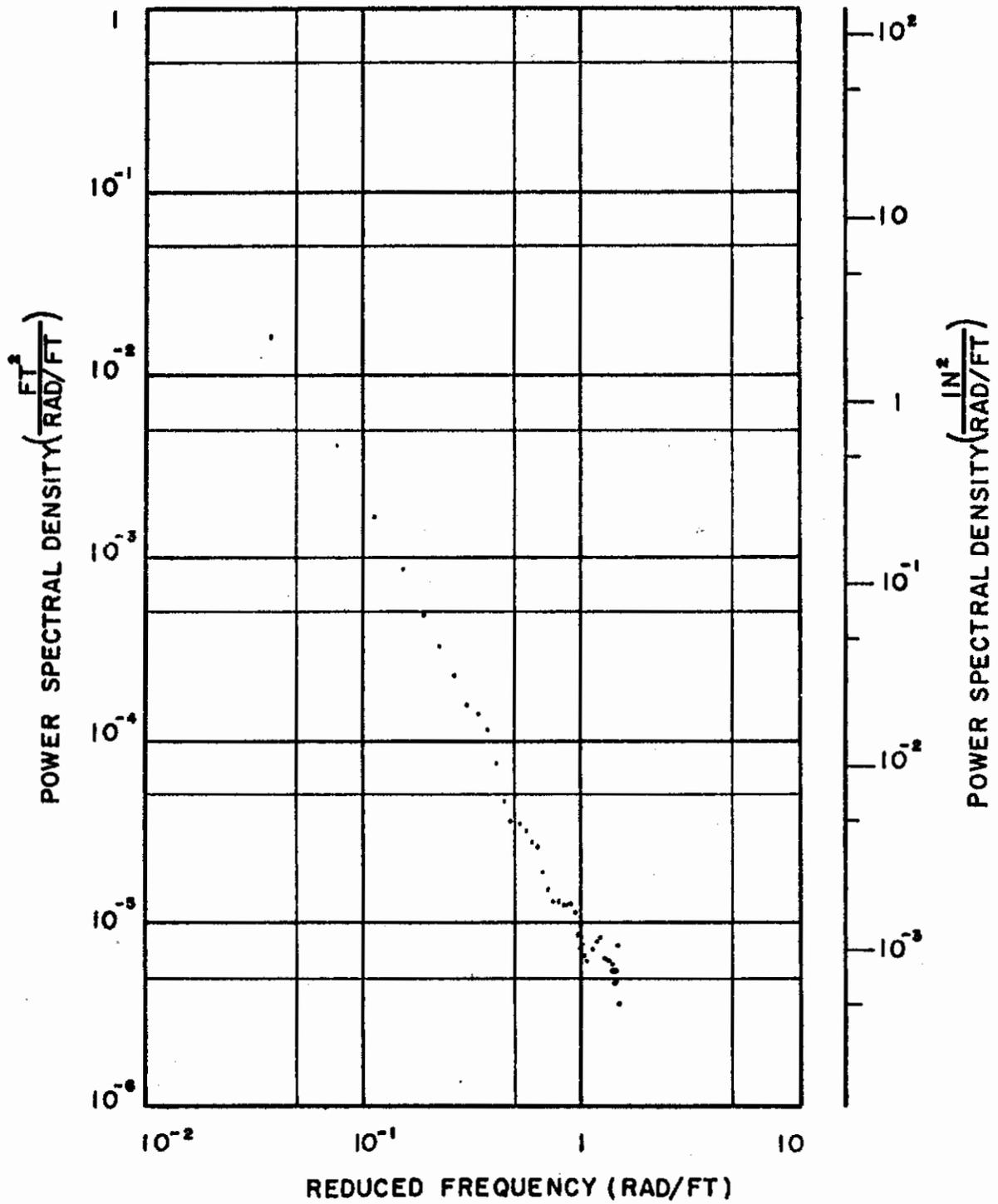
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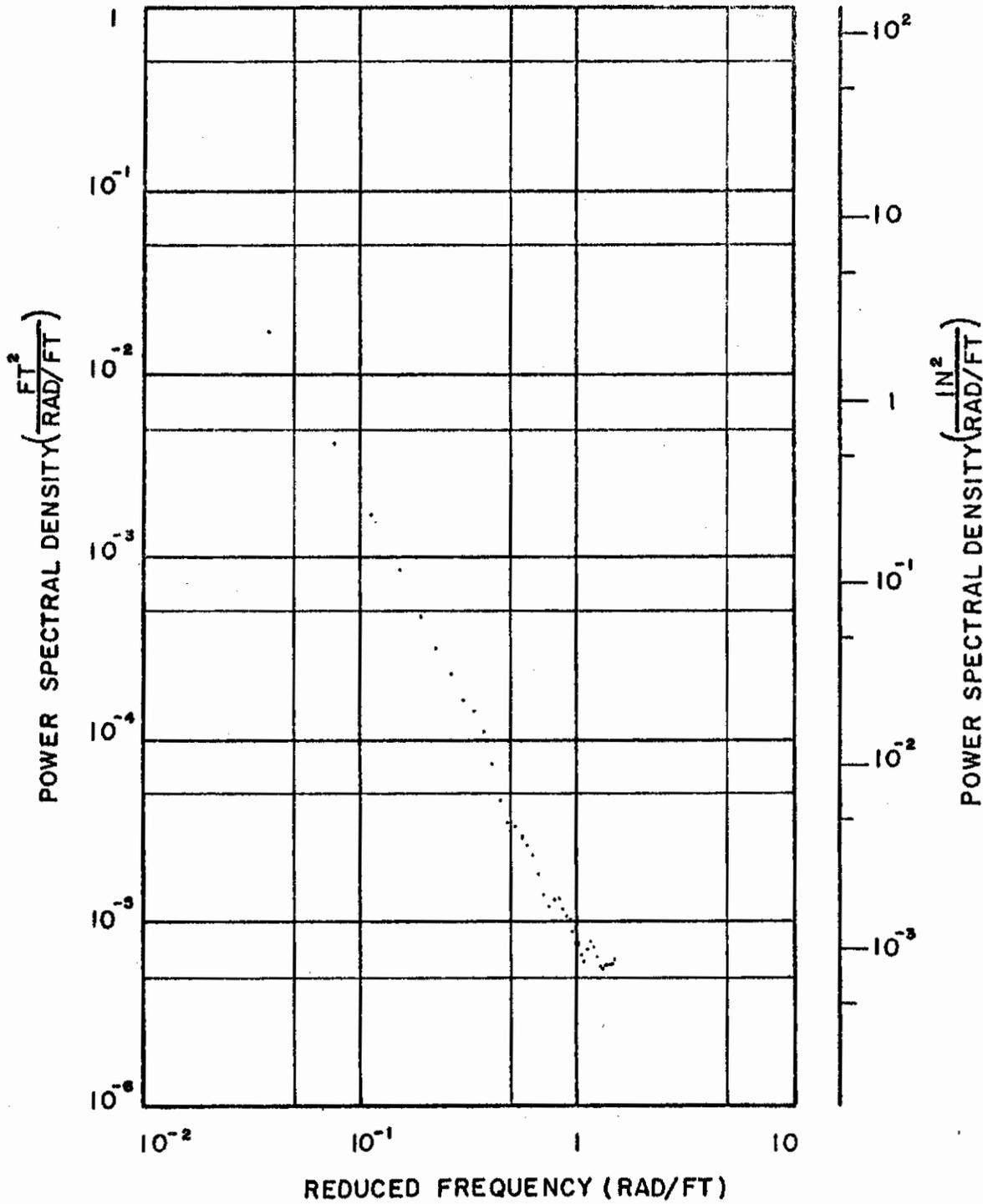
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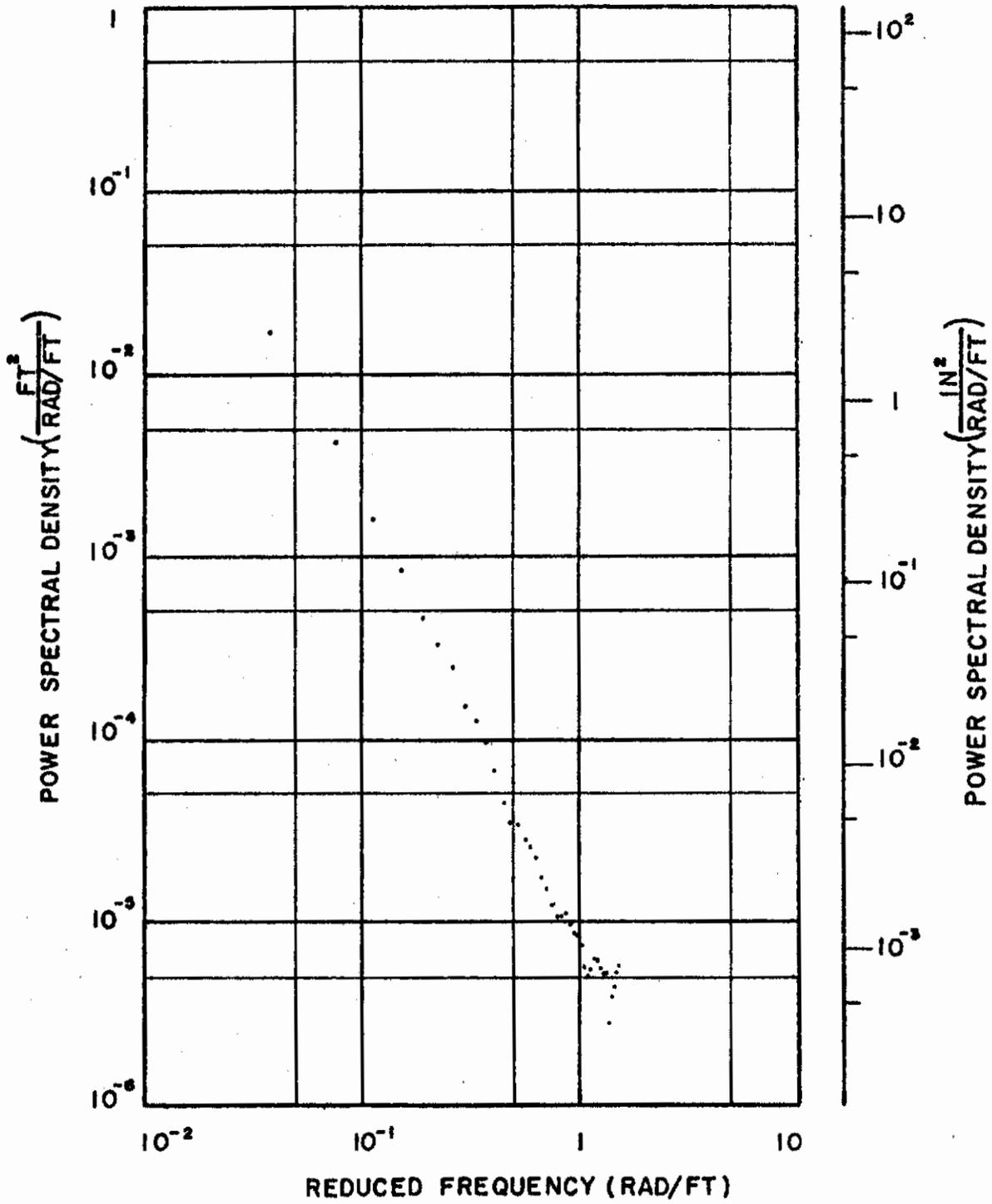
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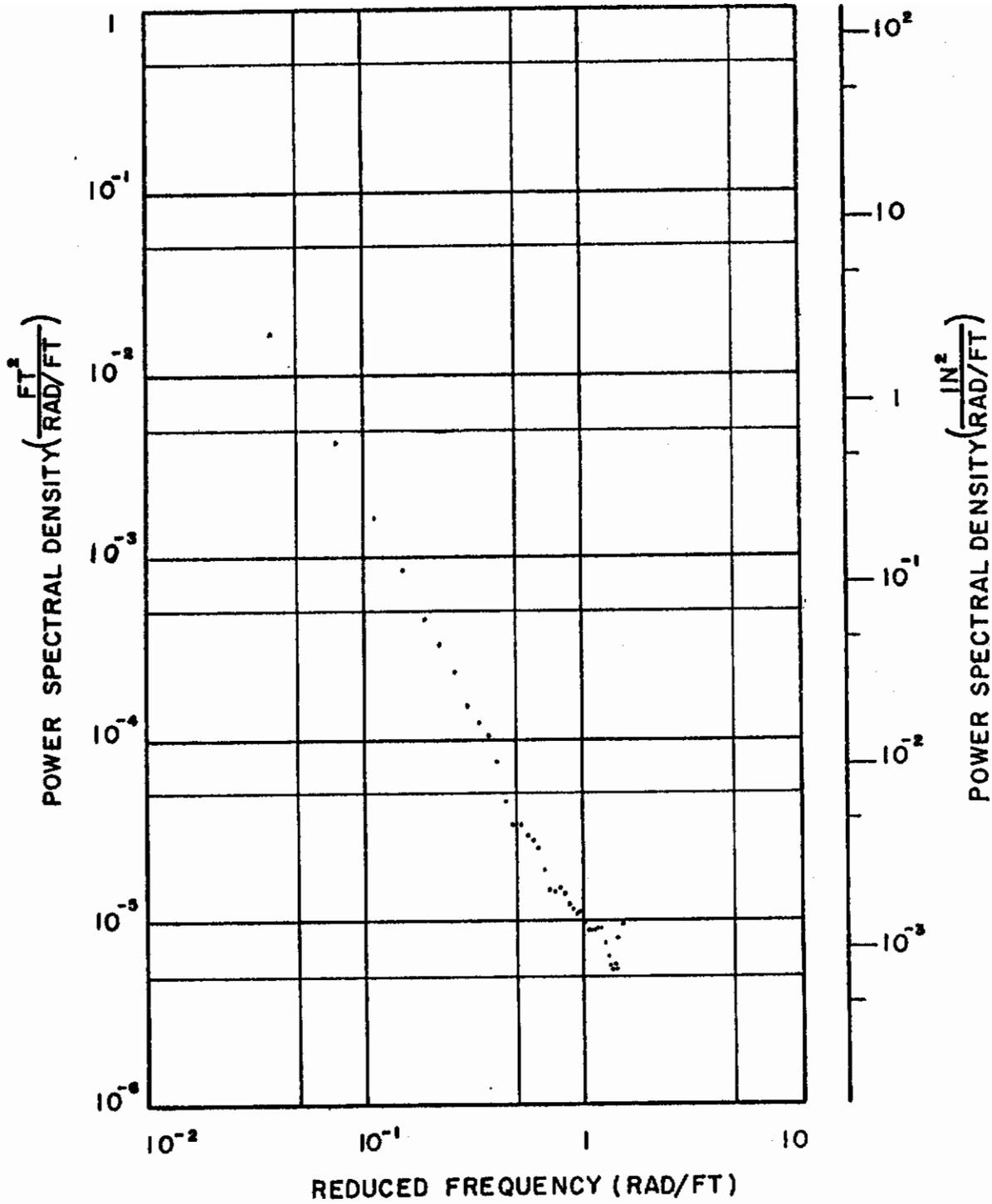
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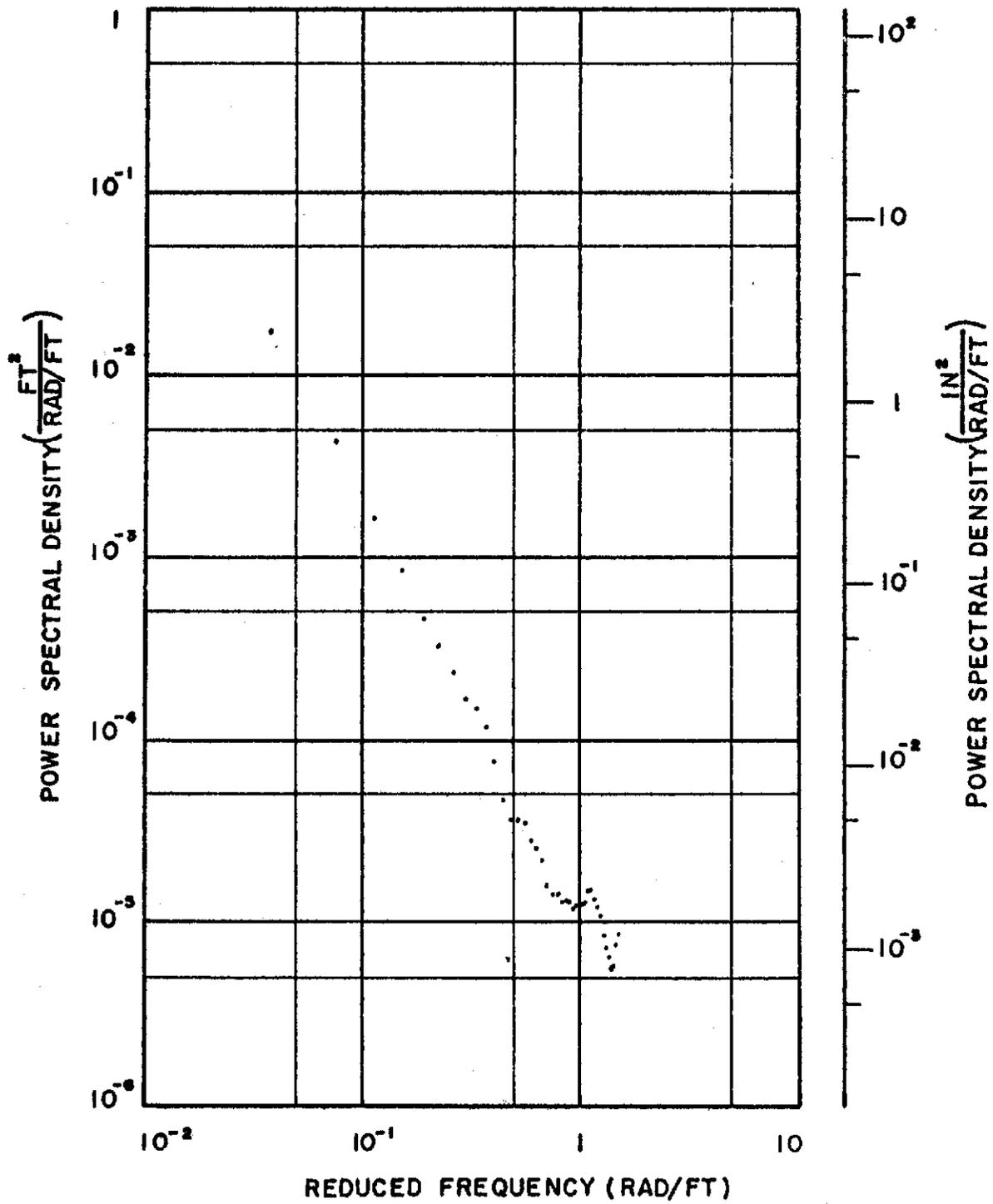
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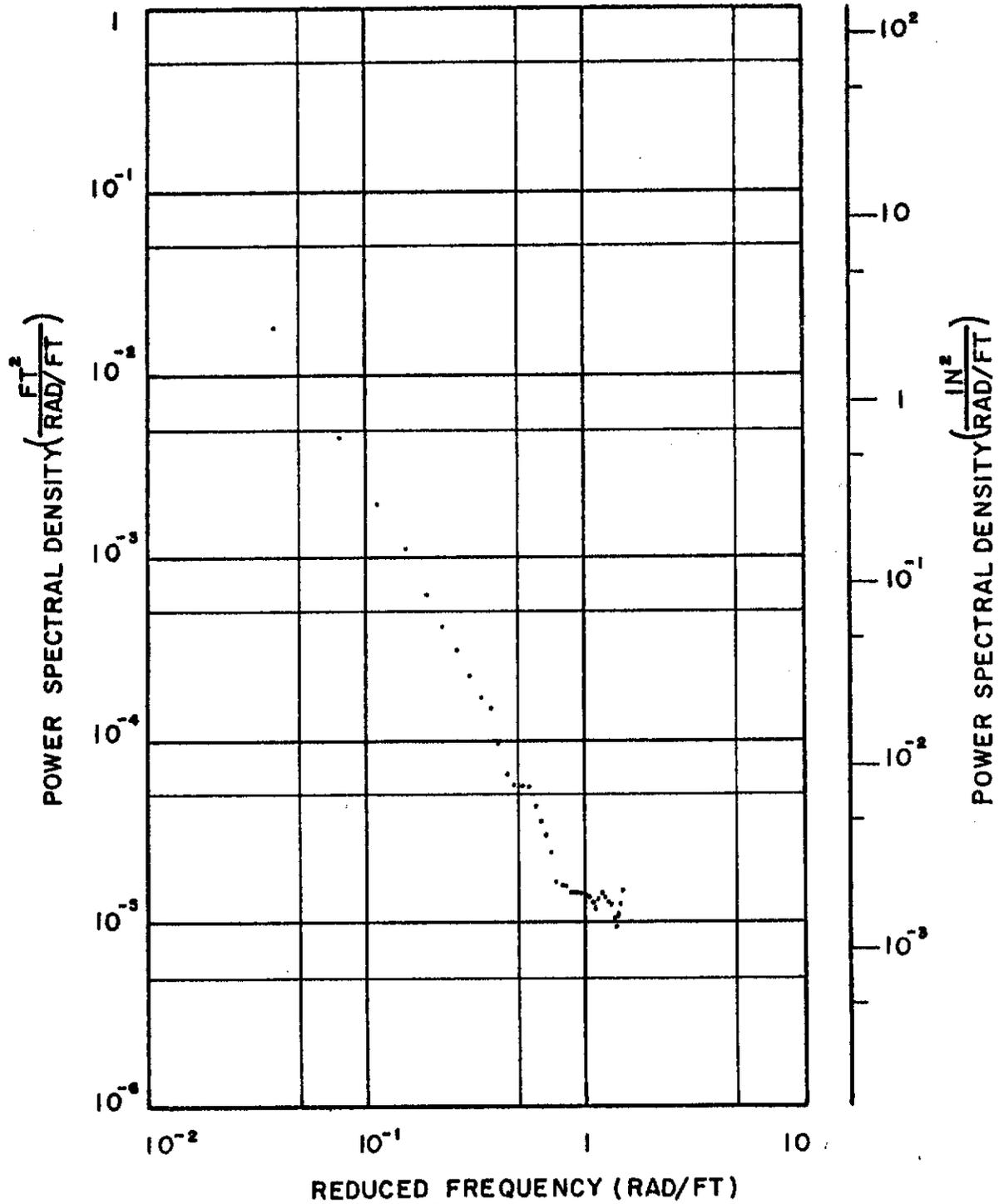
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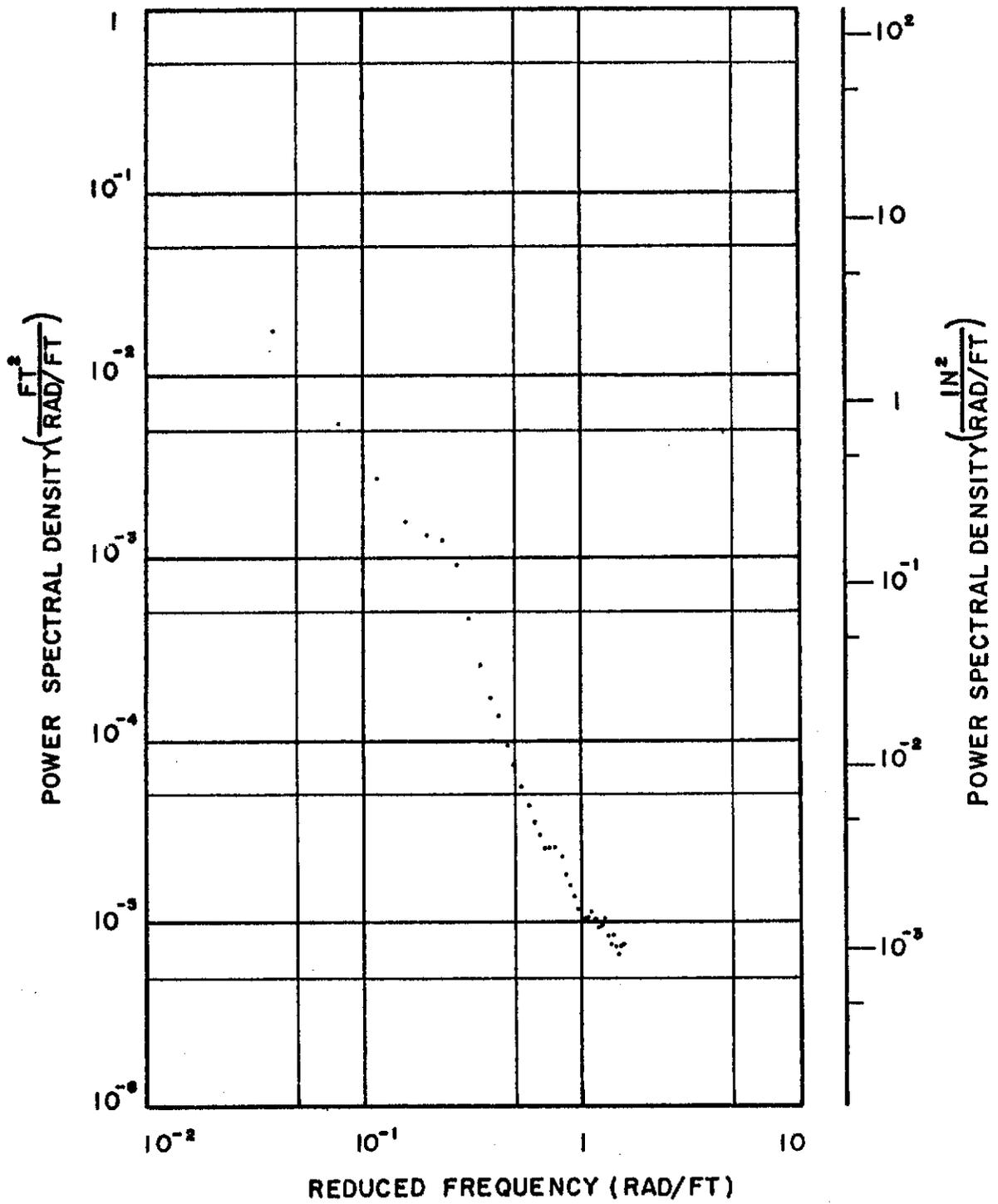
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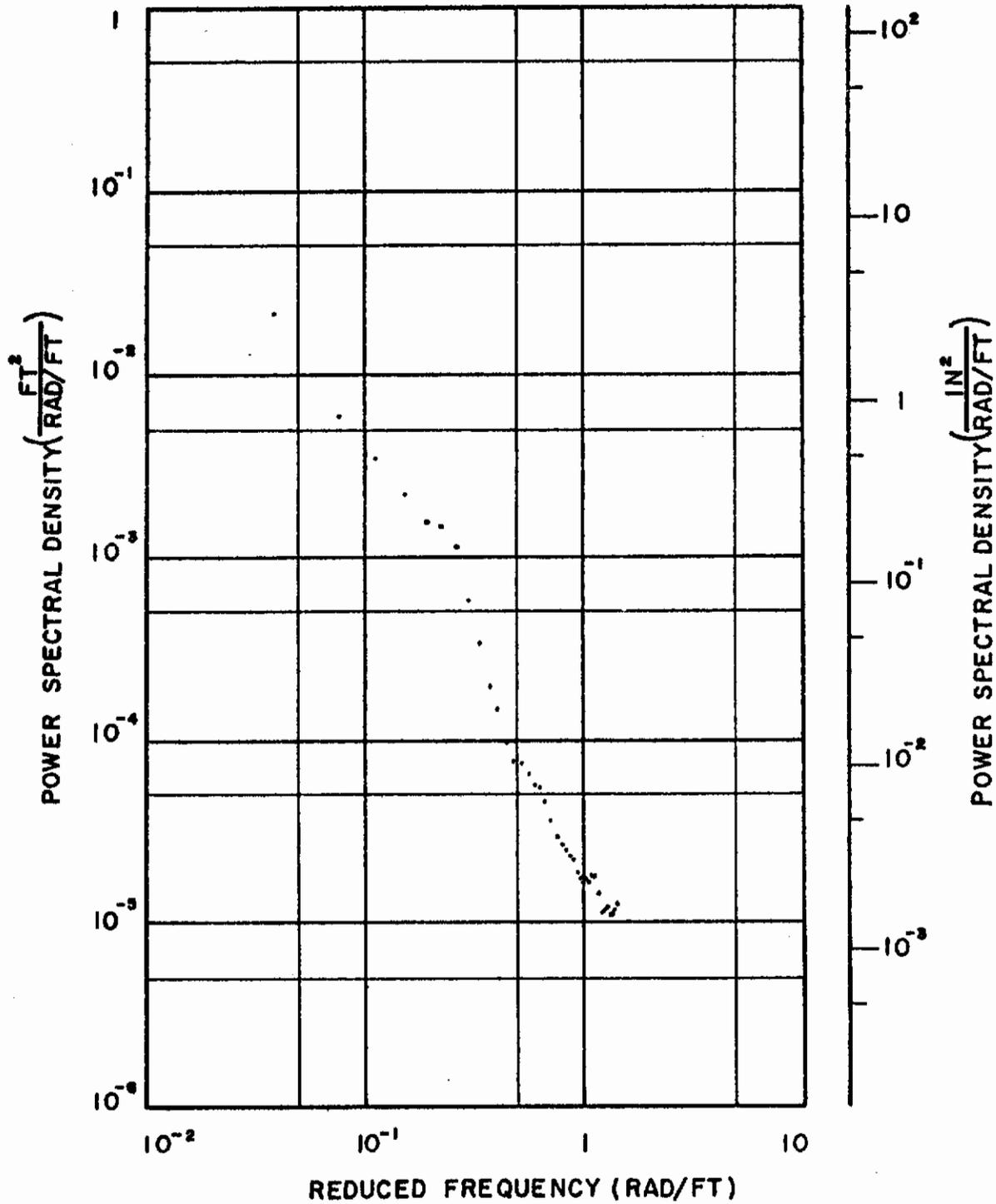
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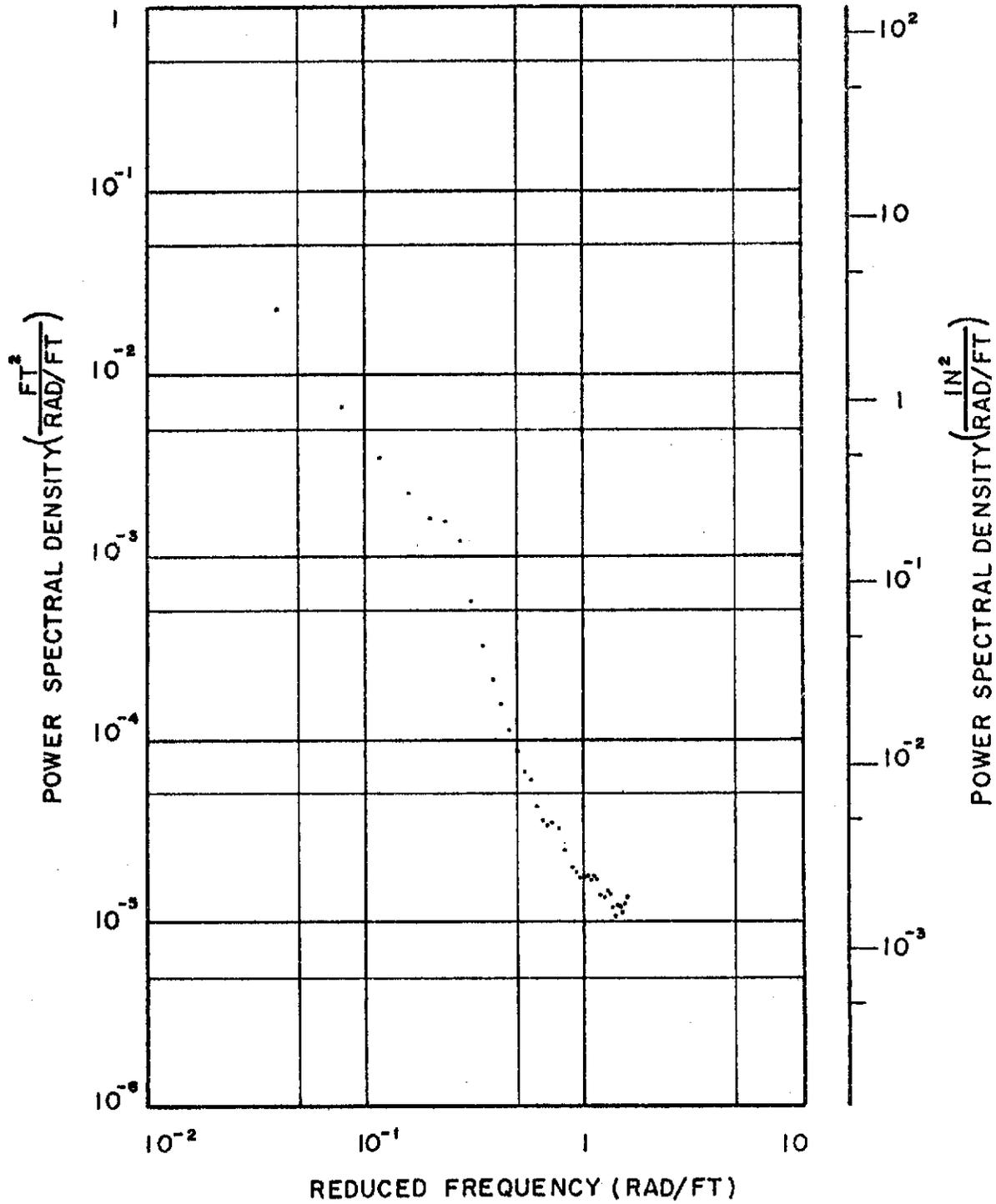
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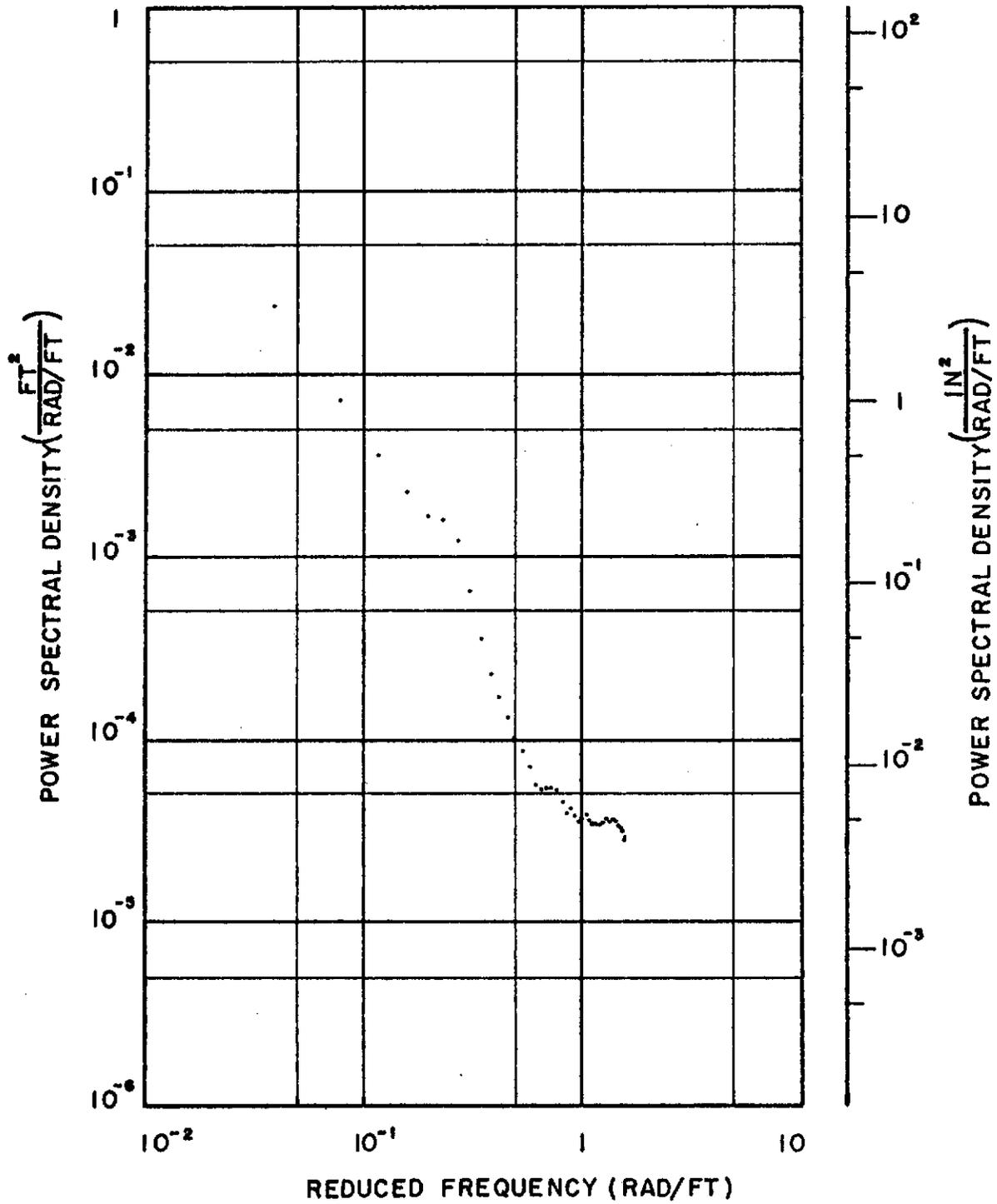
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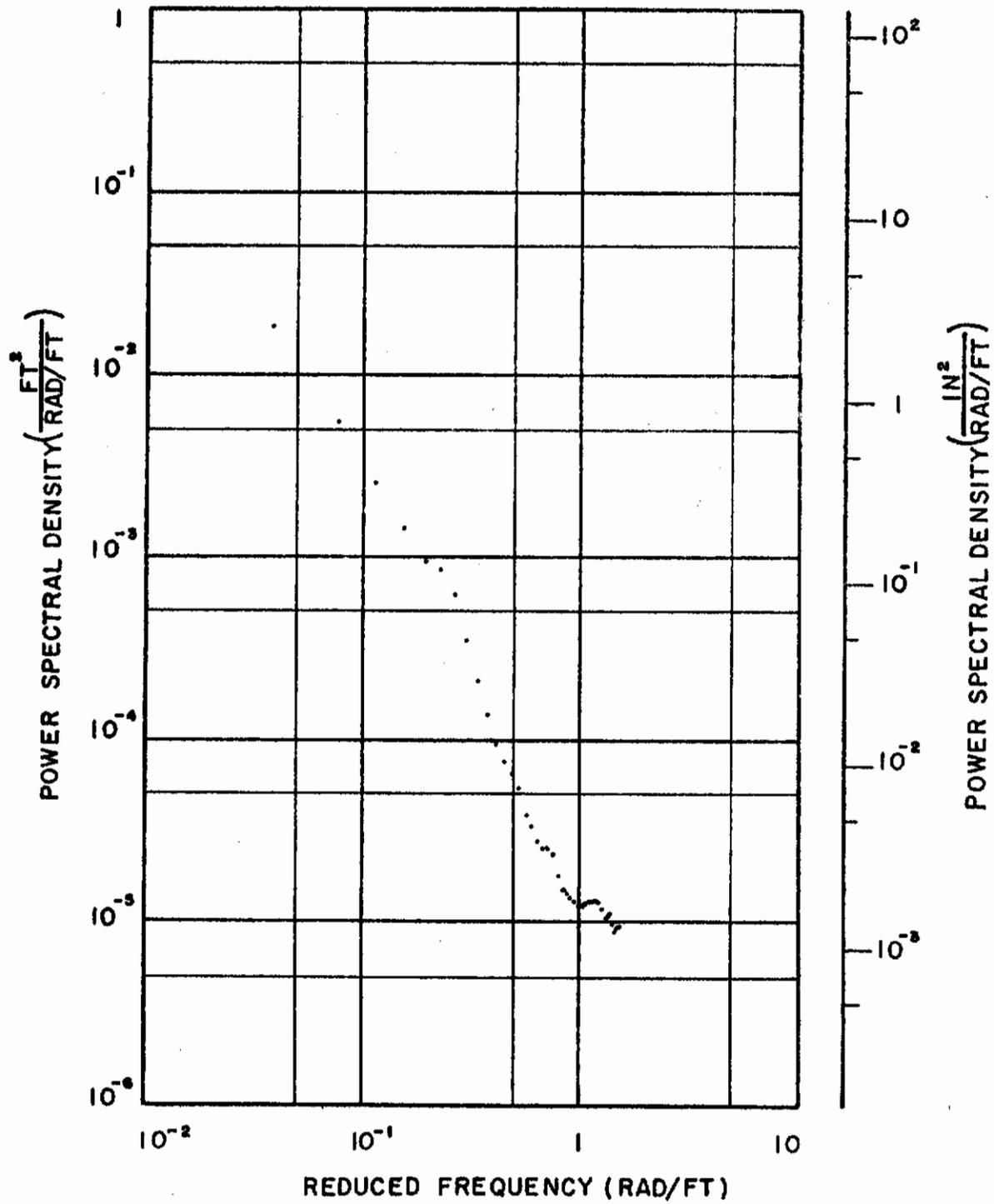
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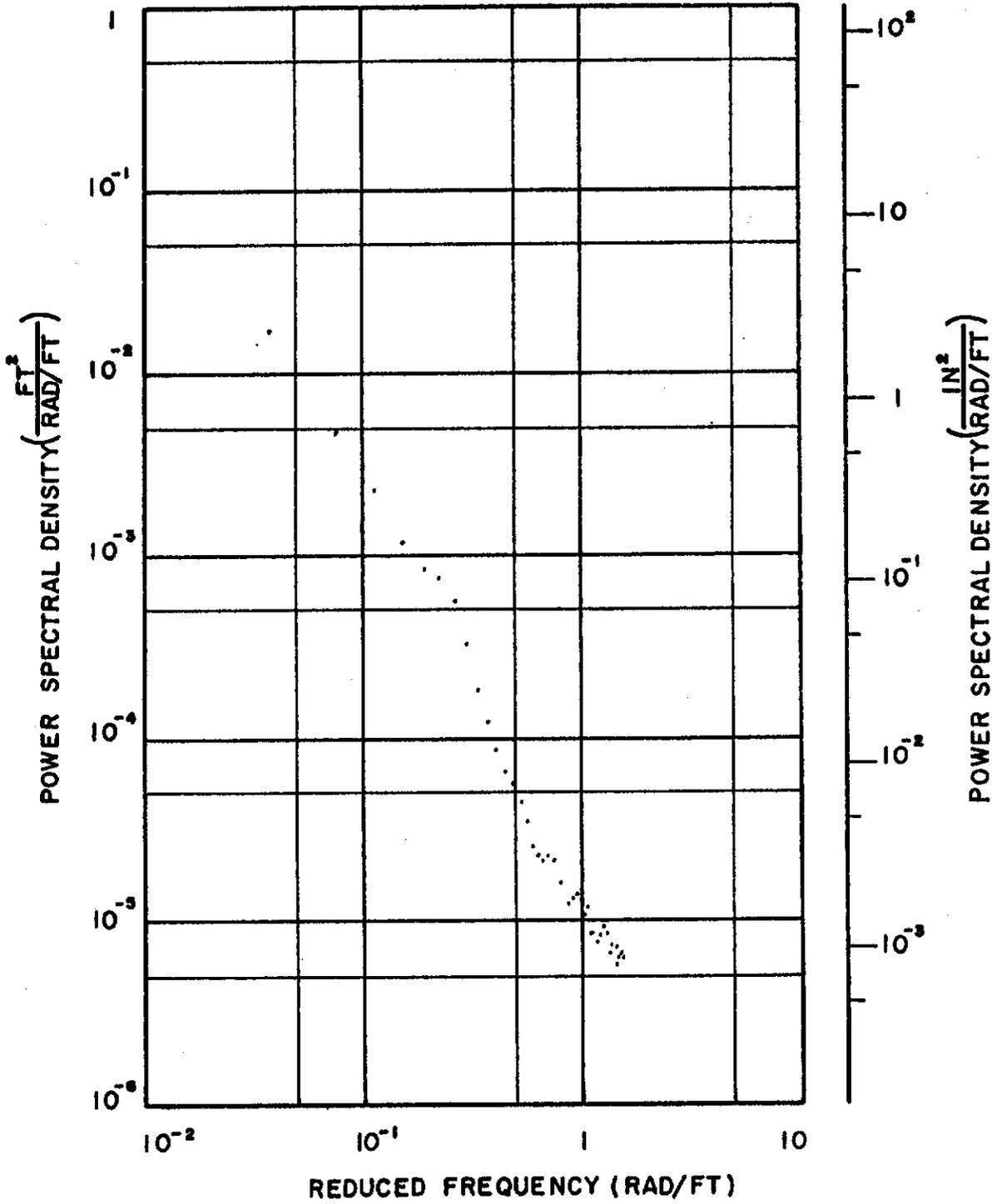
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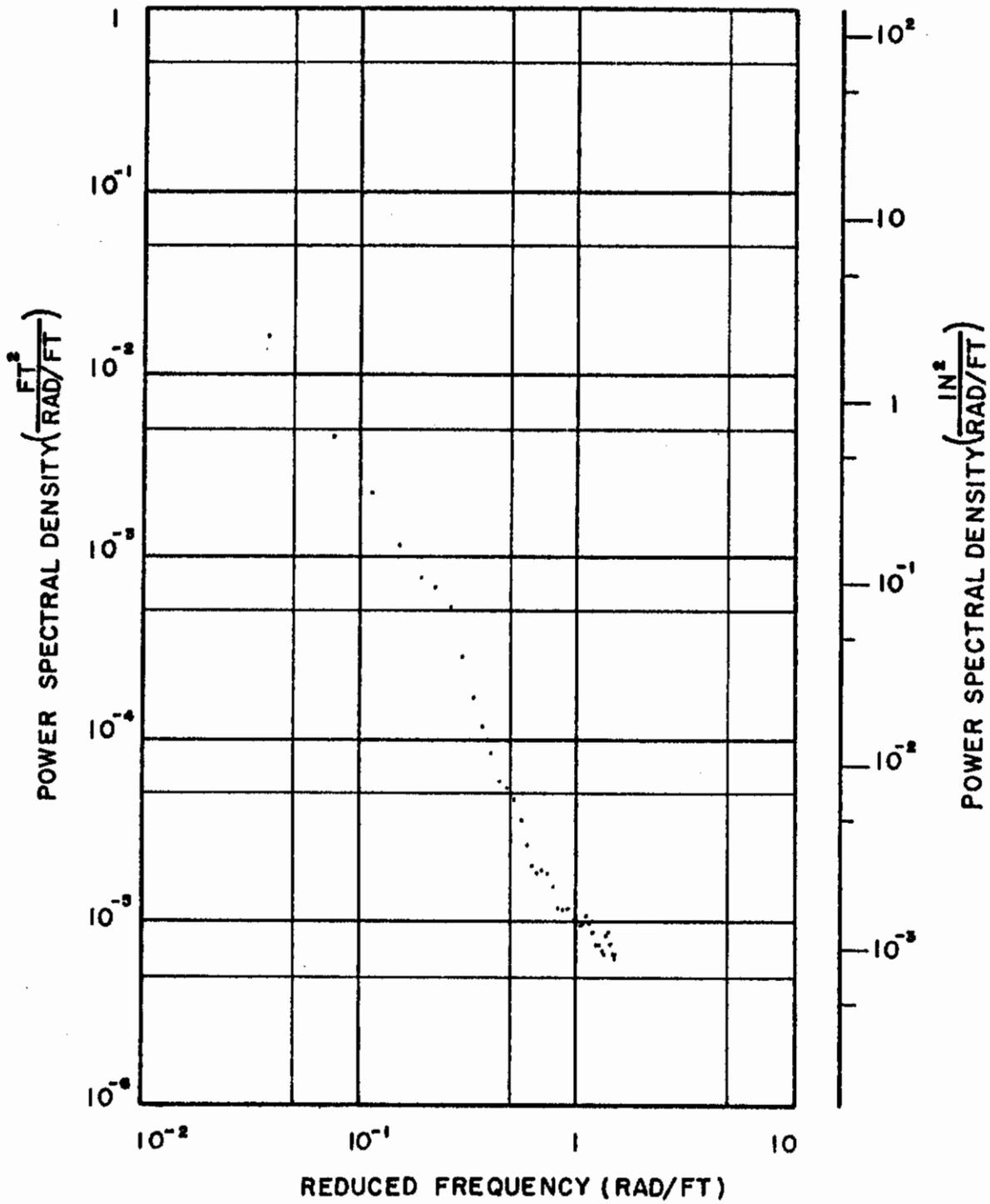
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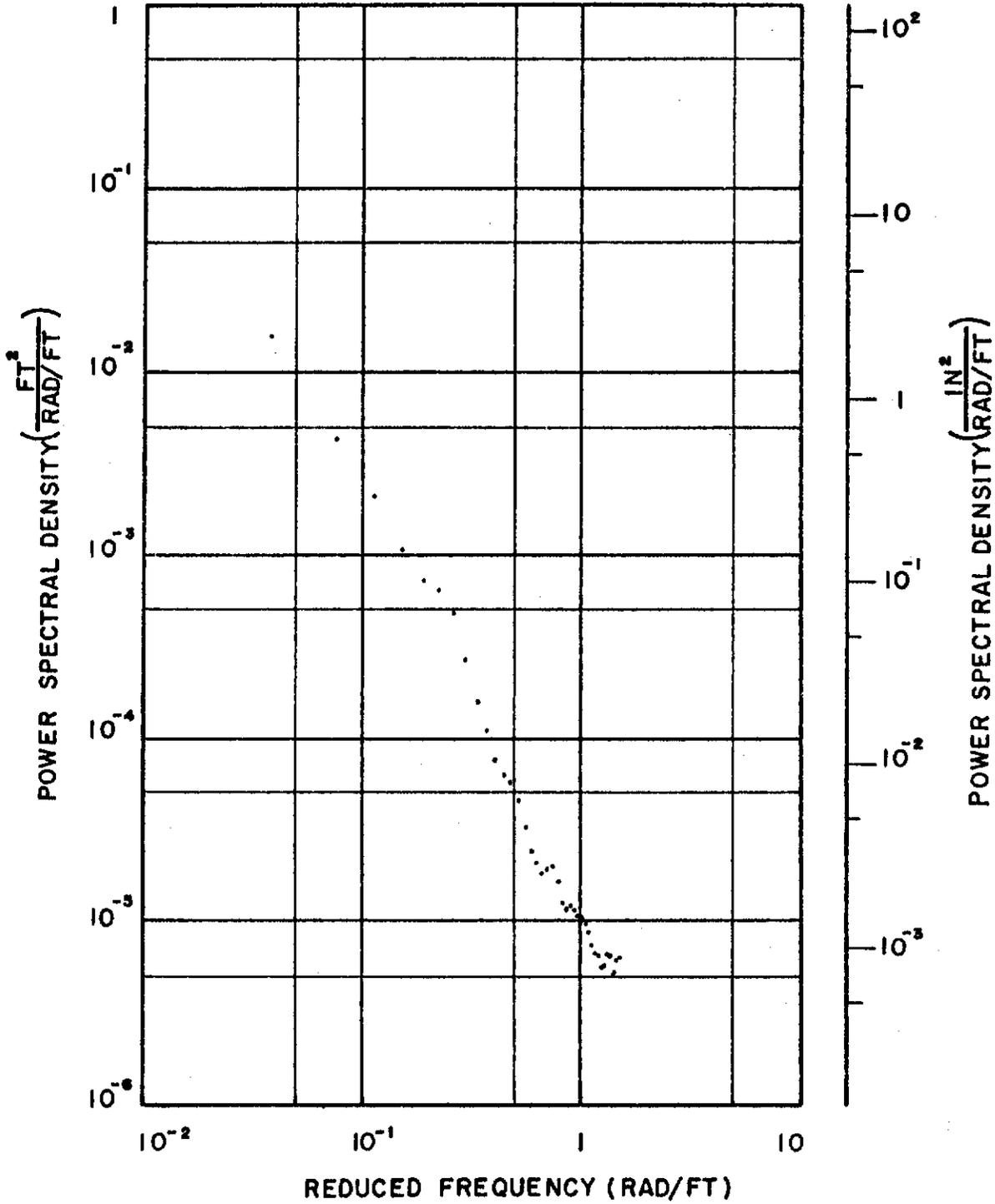
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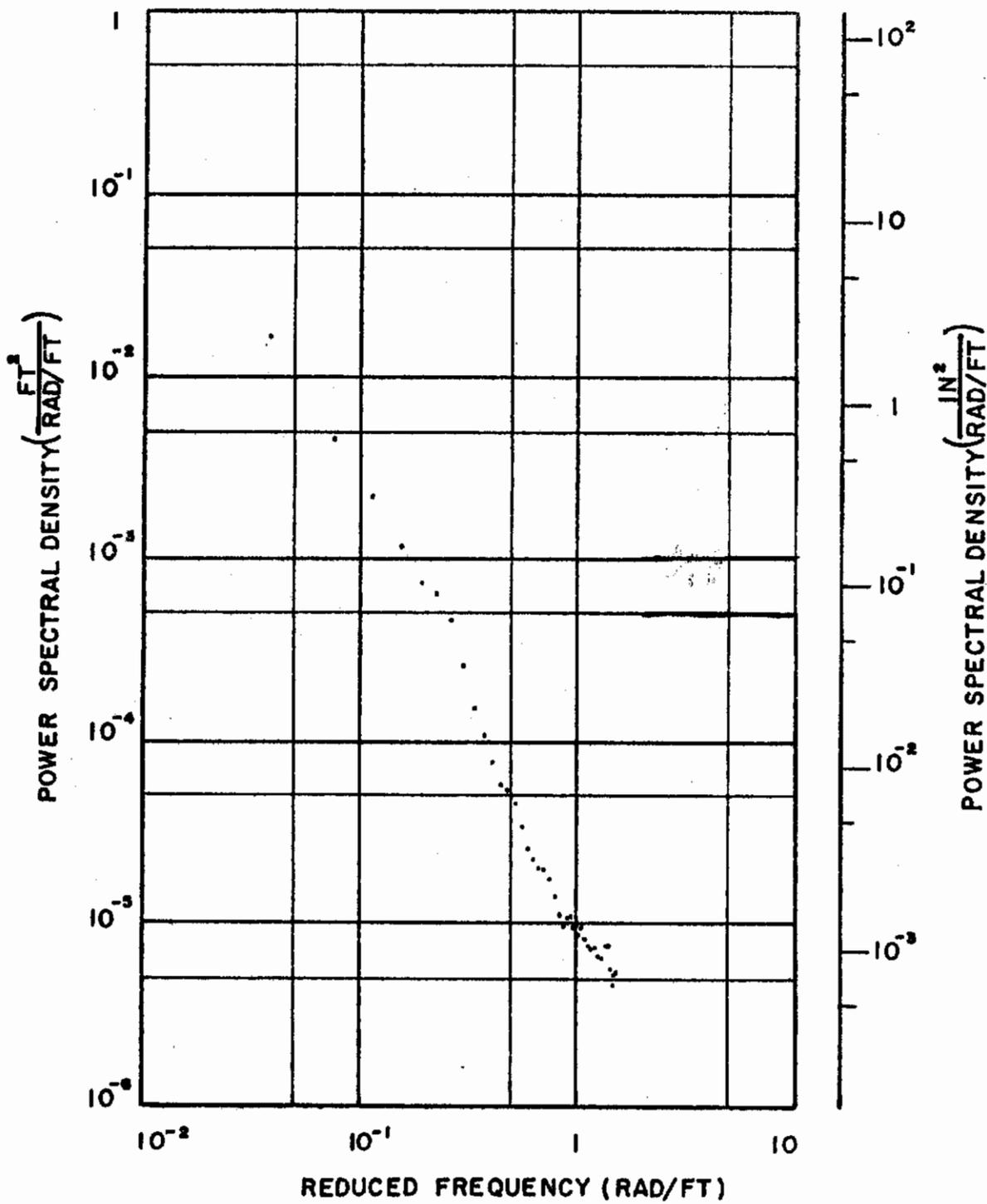
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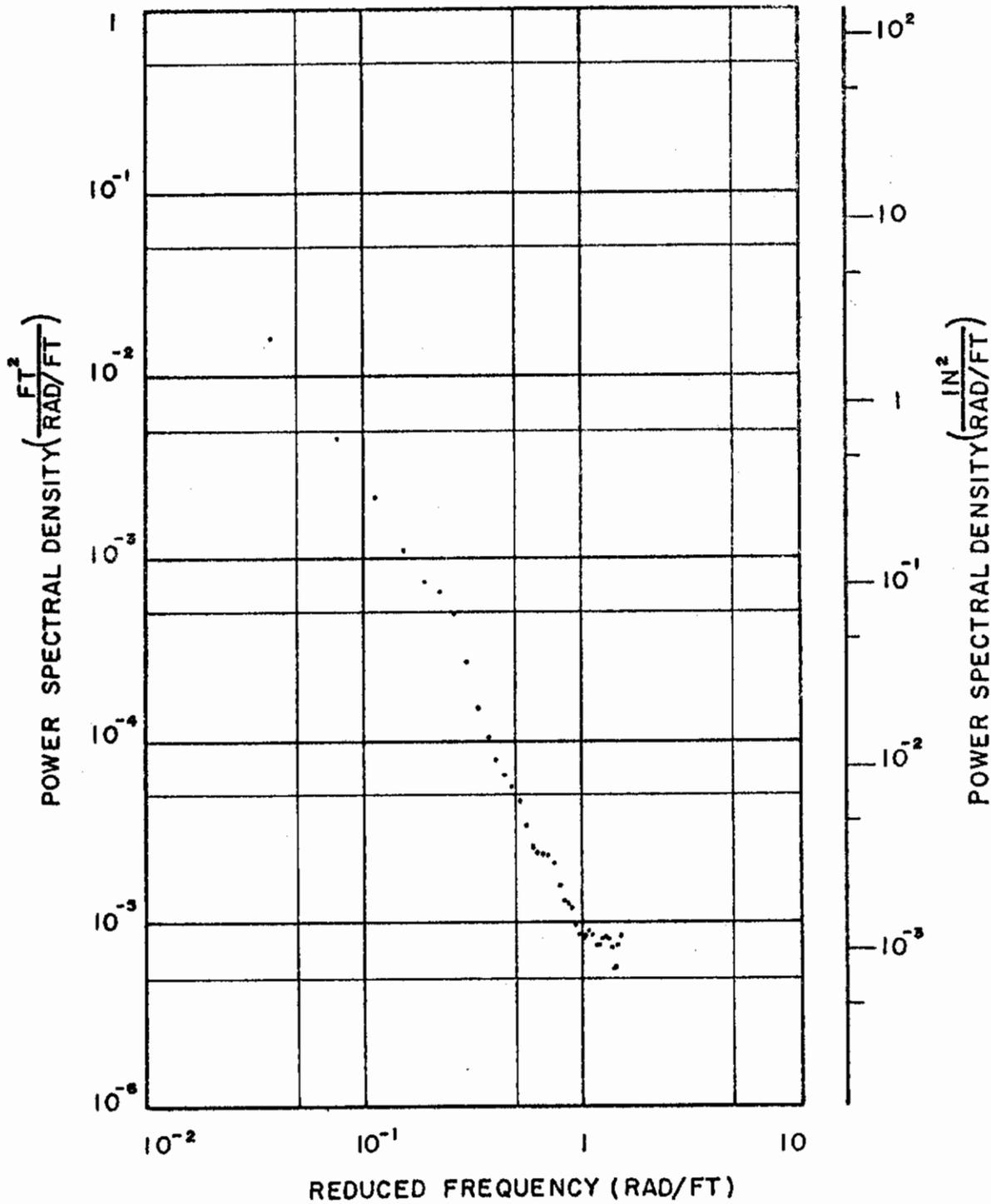
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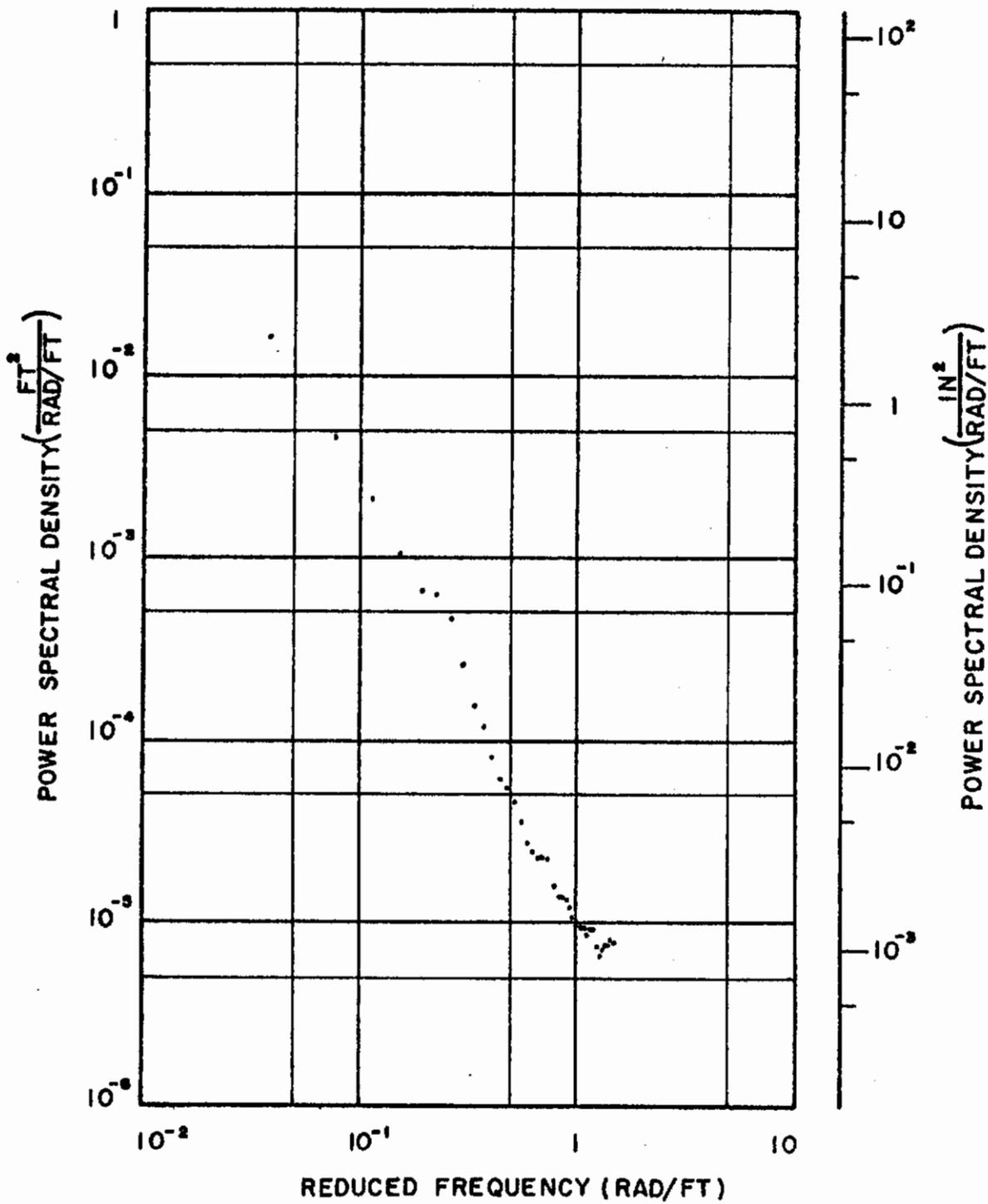
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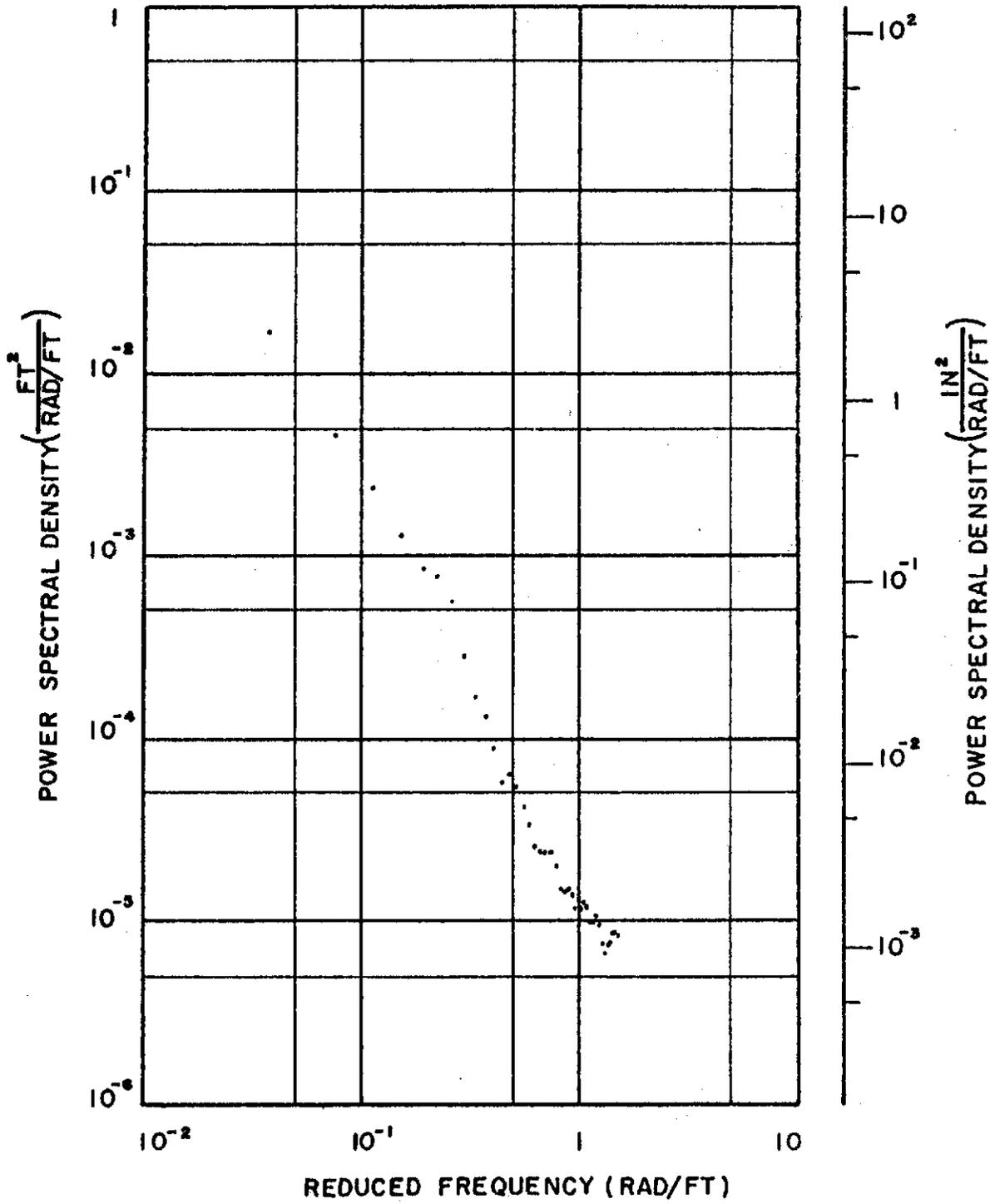
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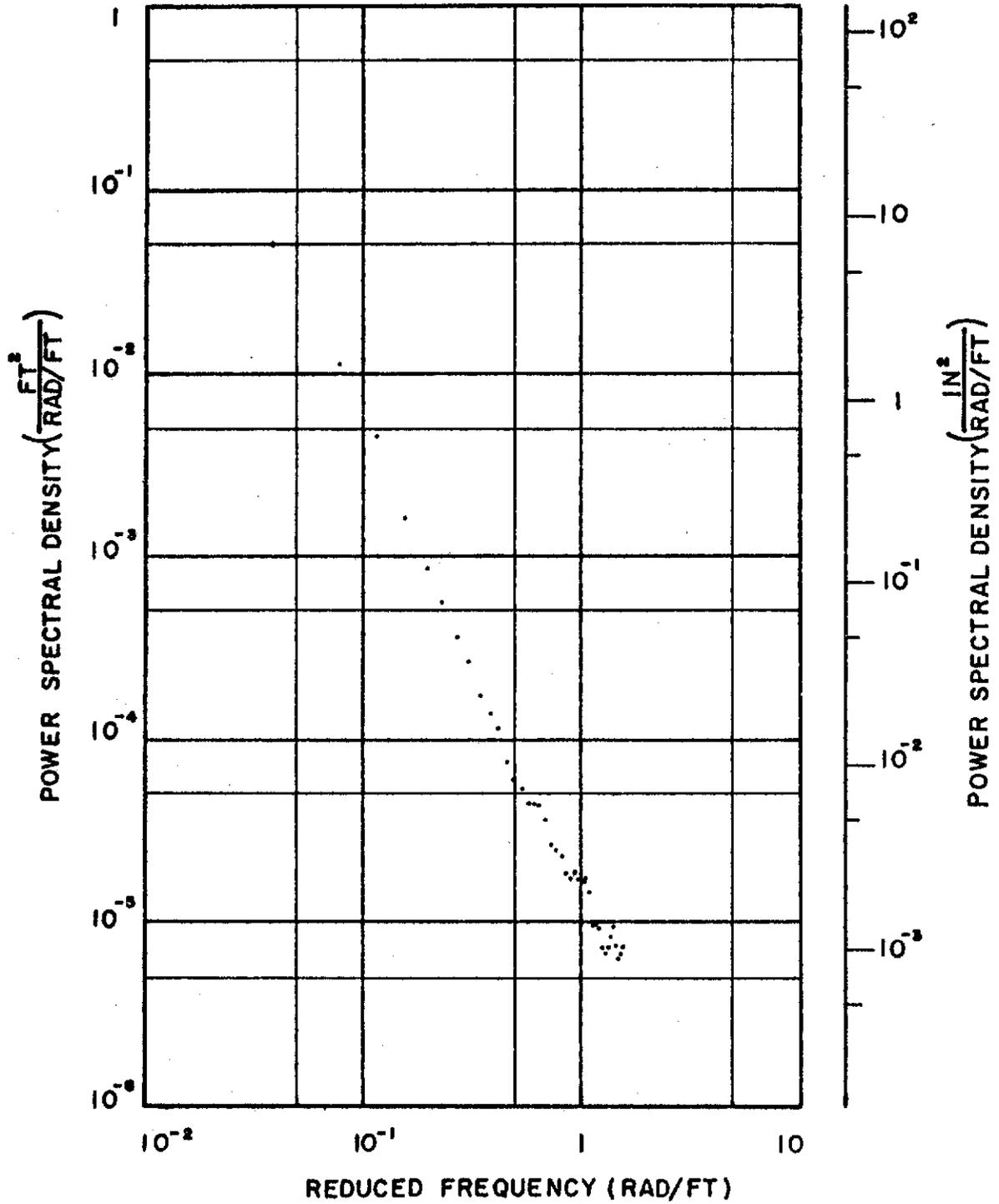
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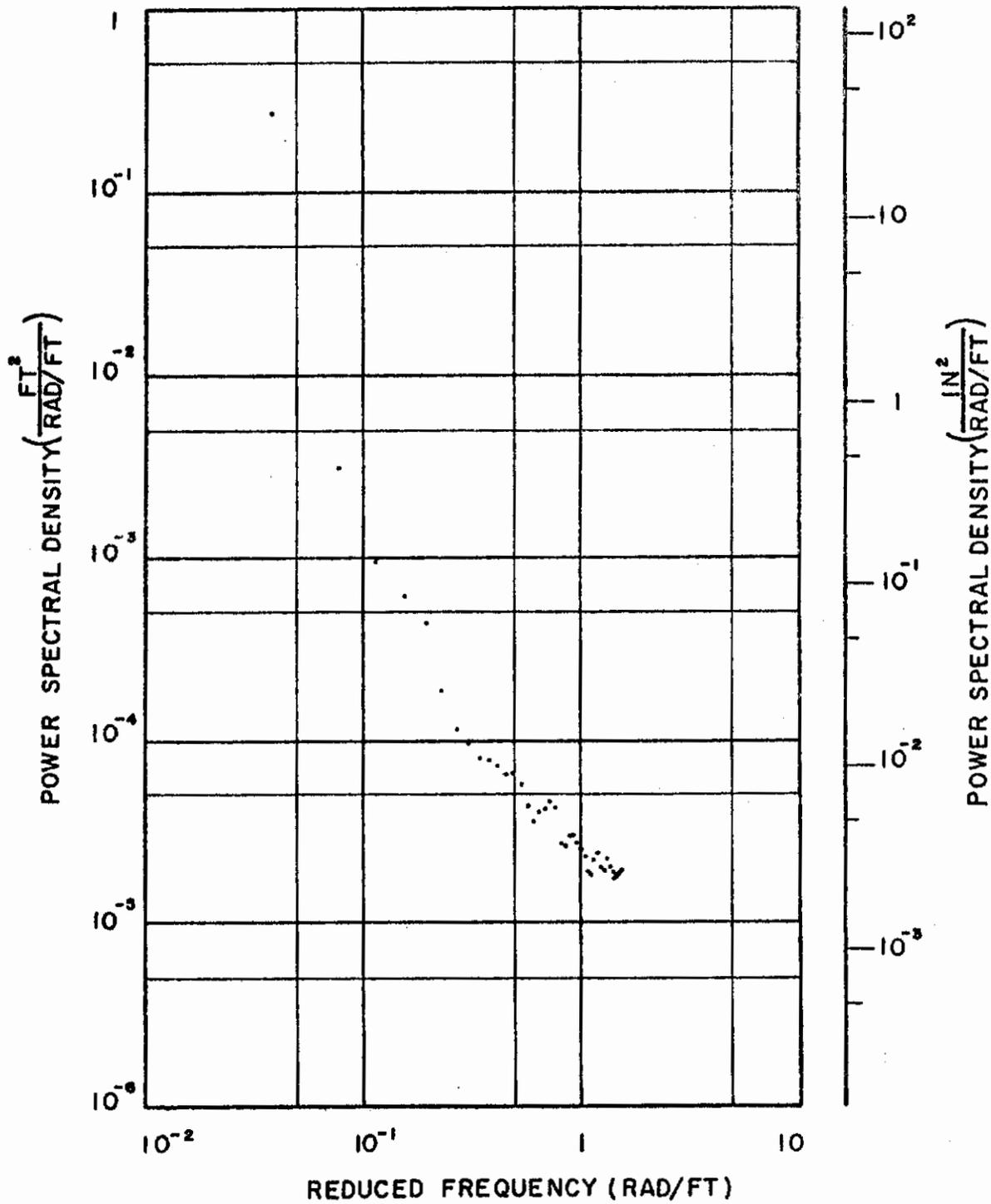
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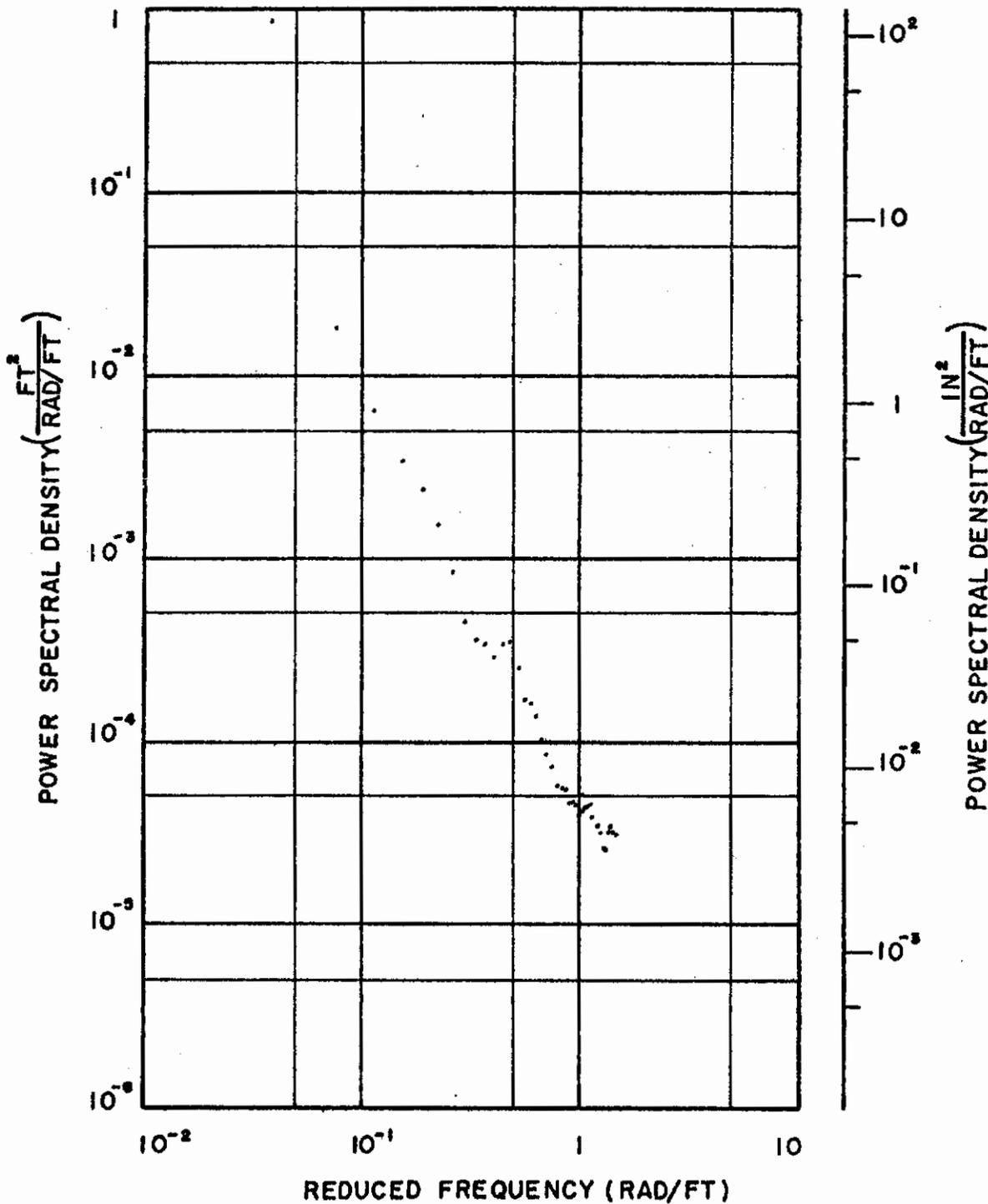
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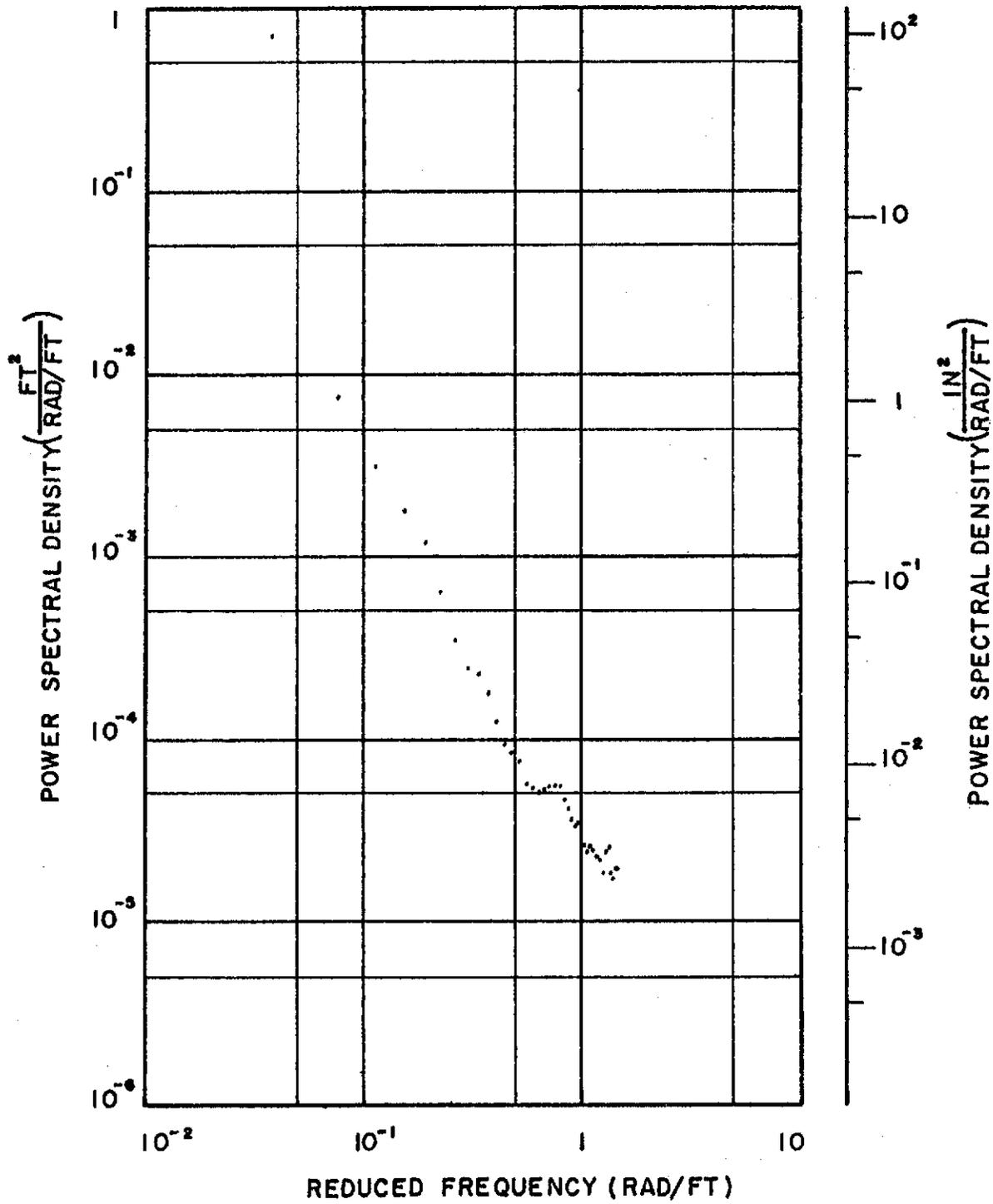
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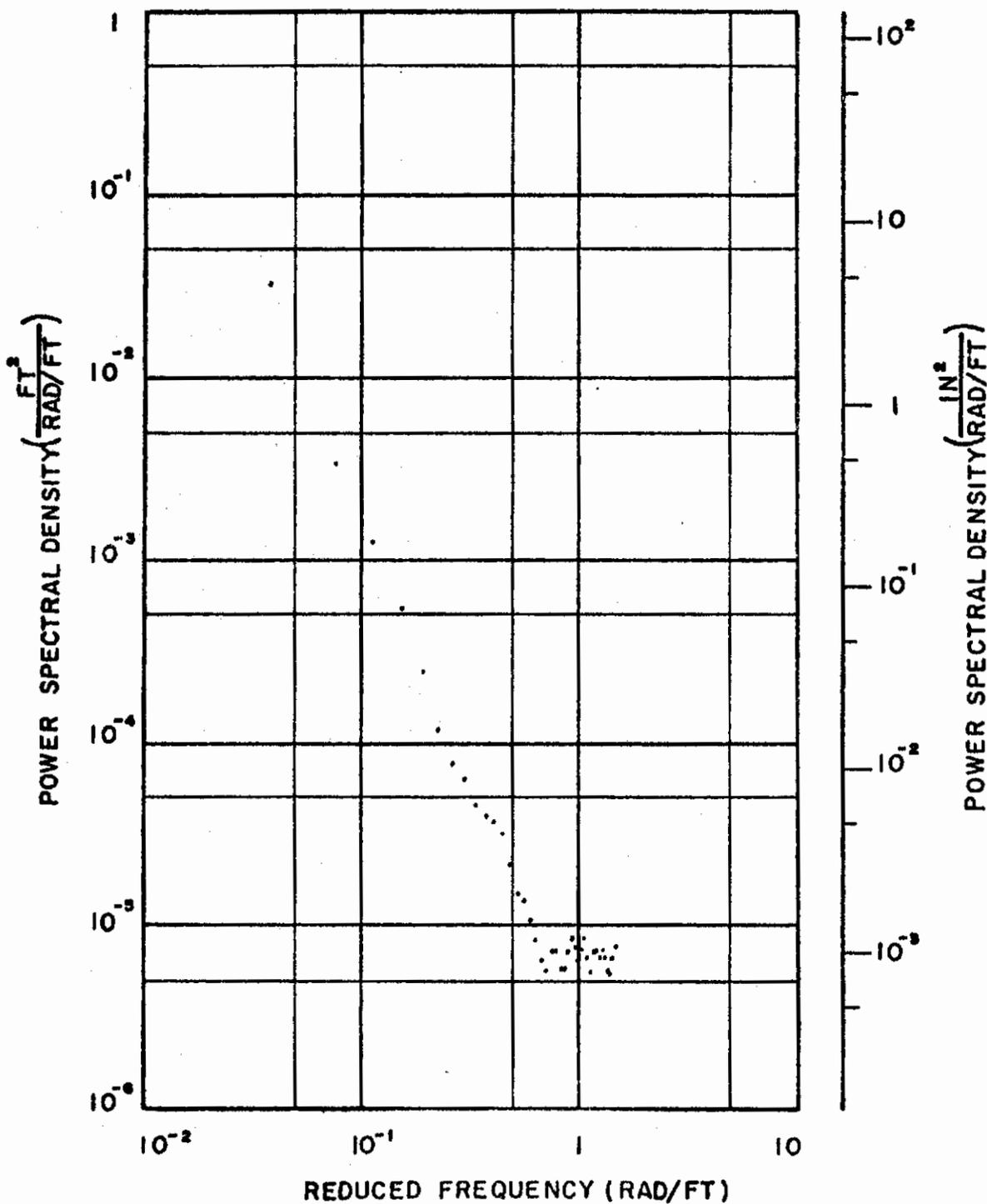


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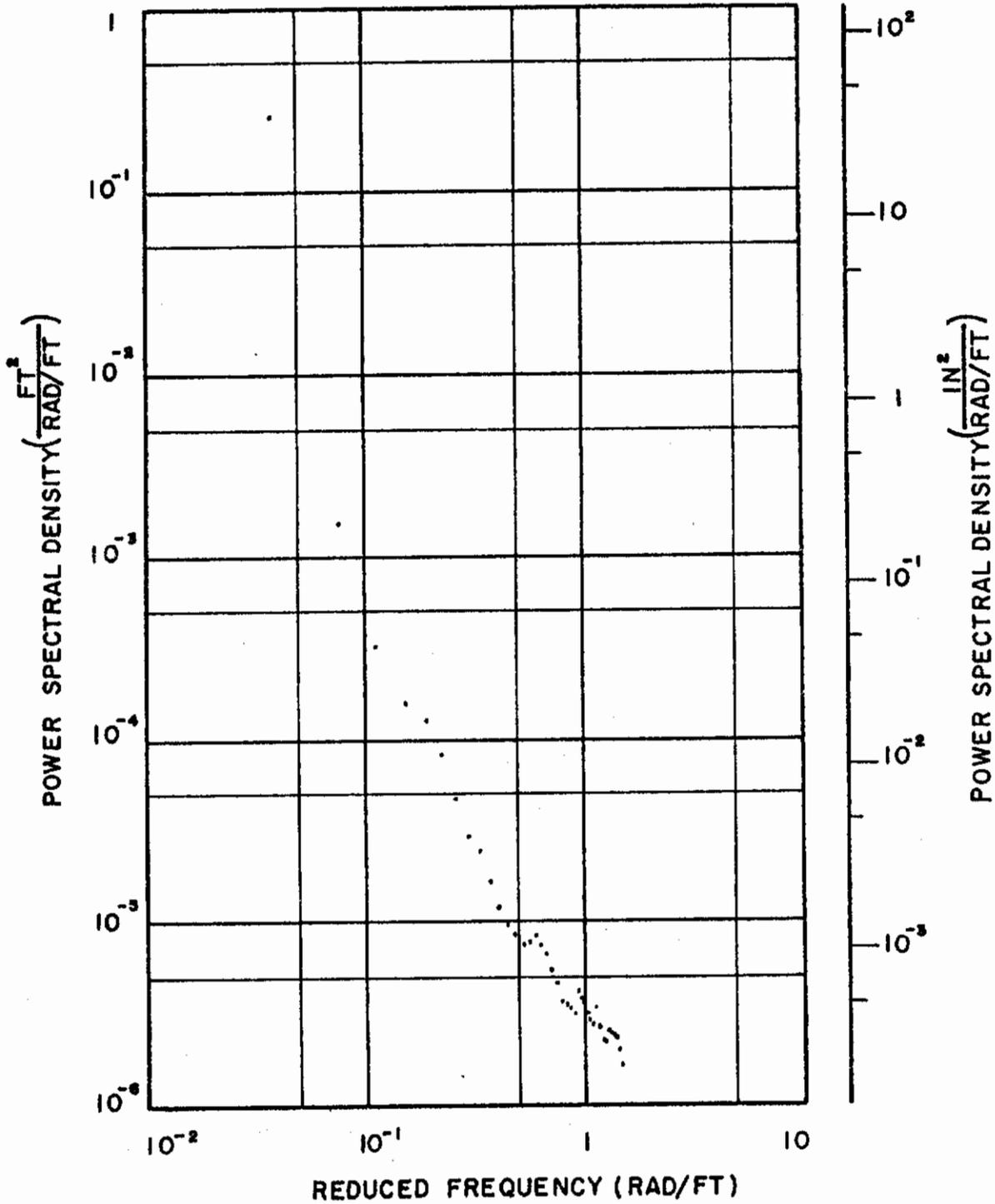


Runway 30



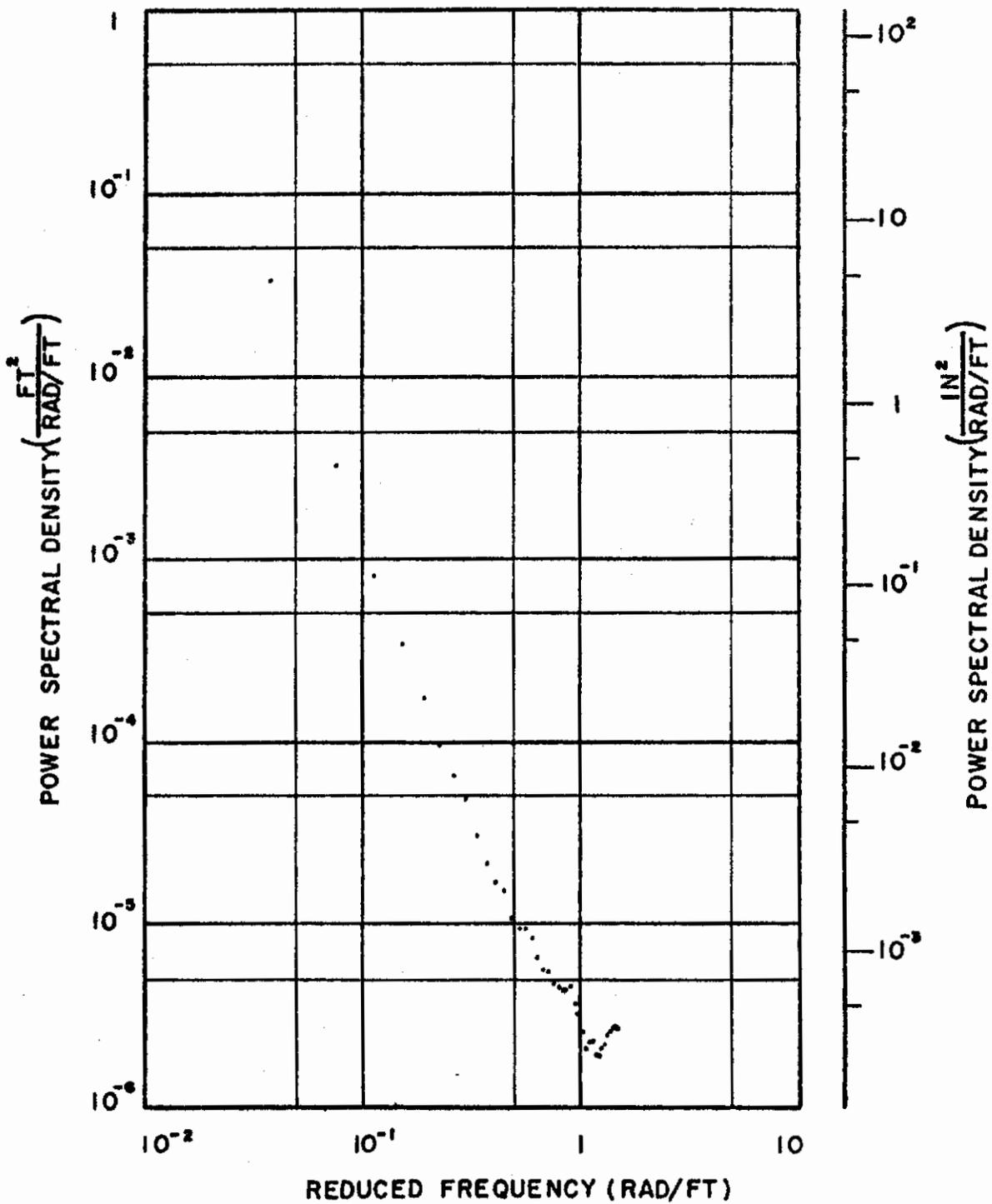
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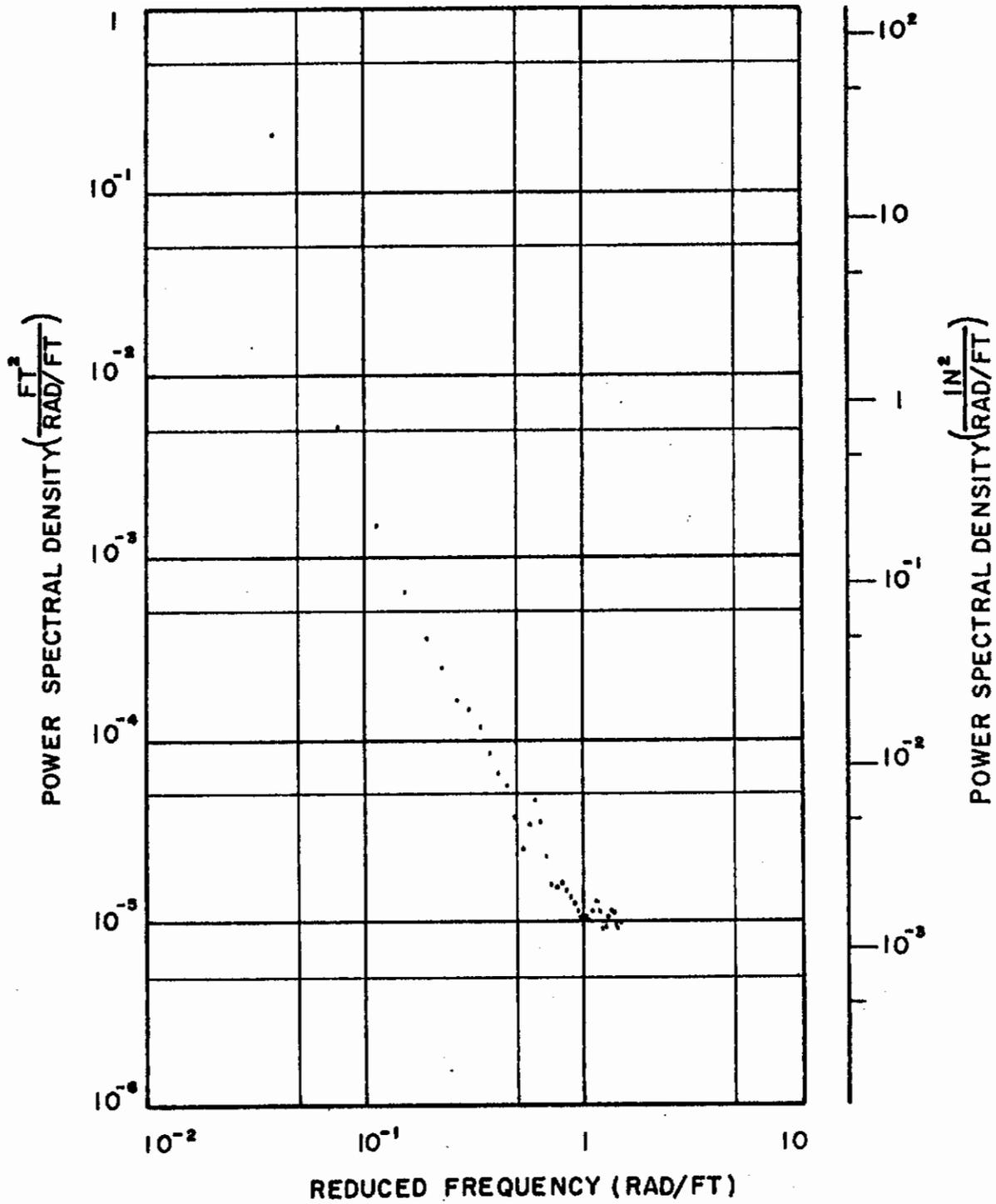
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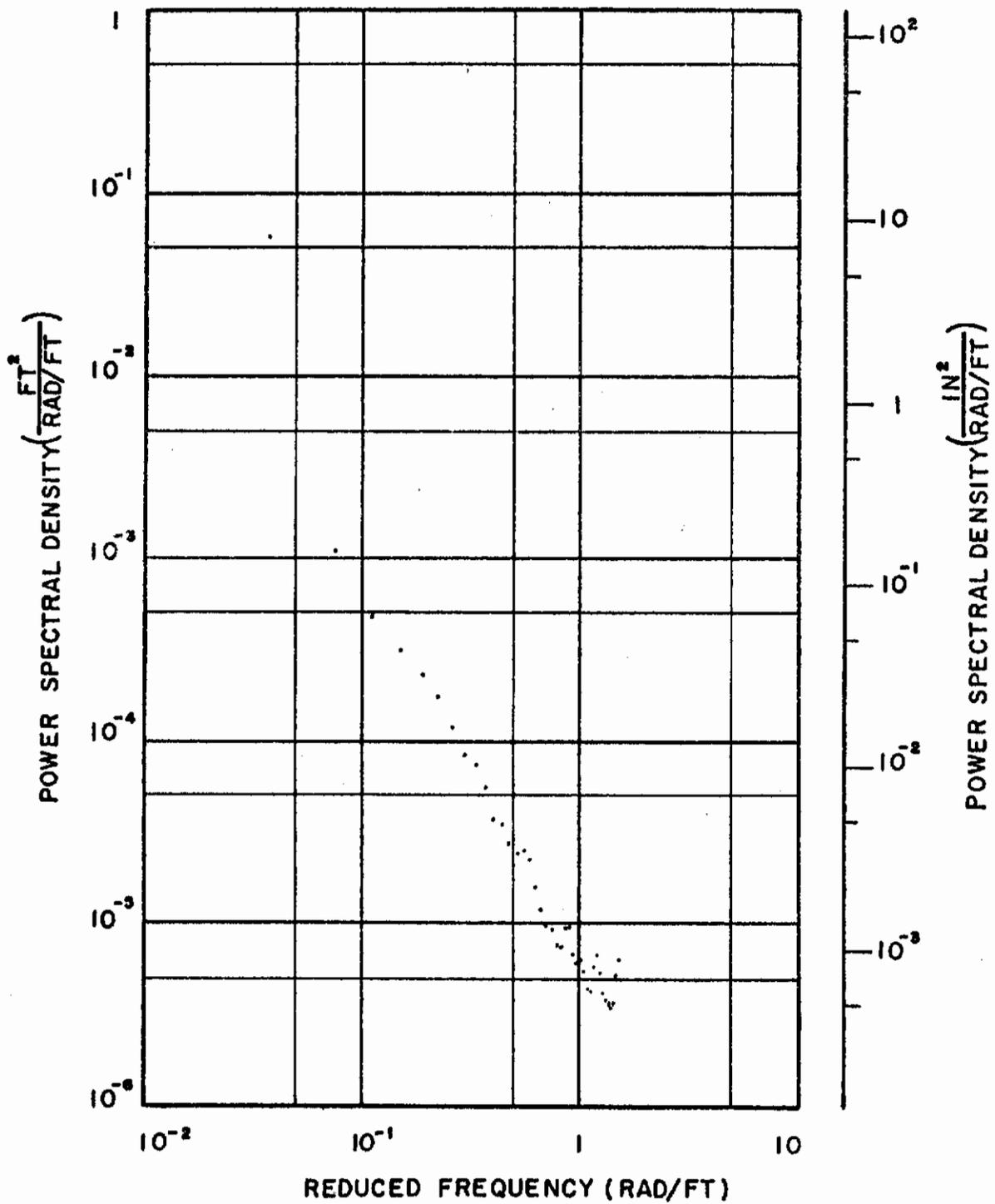
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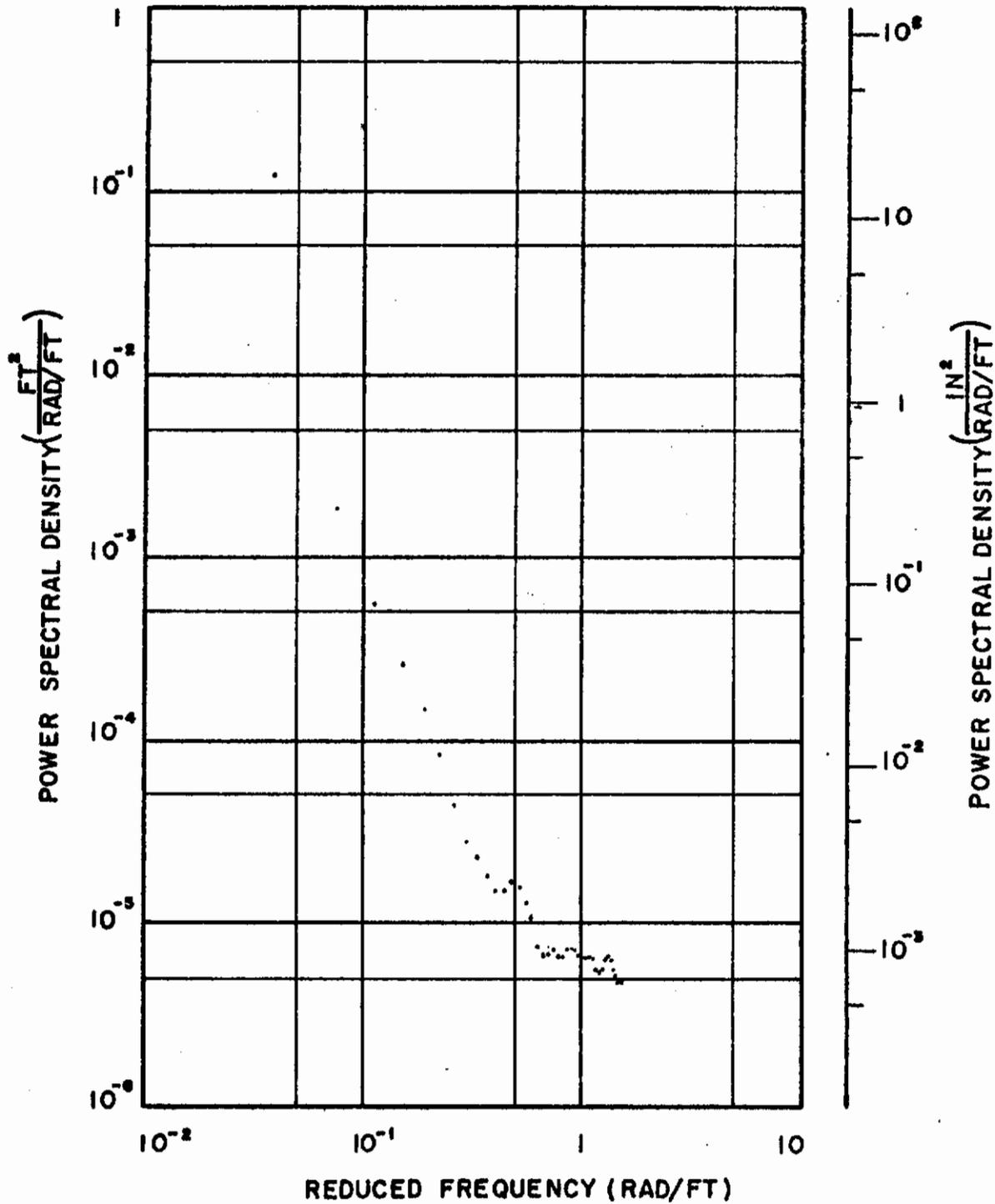
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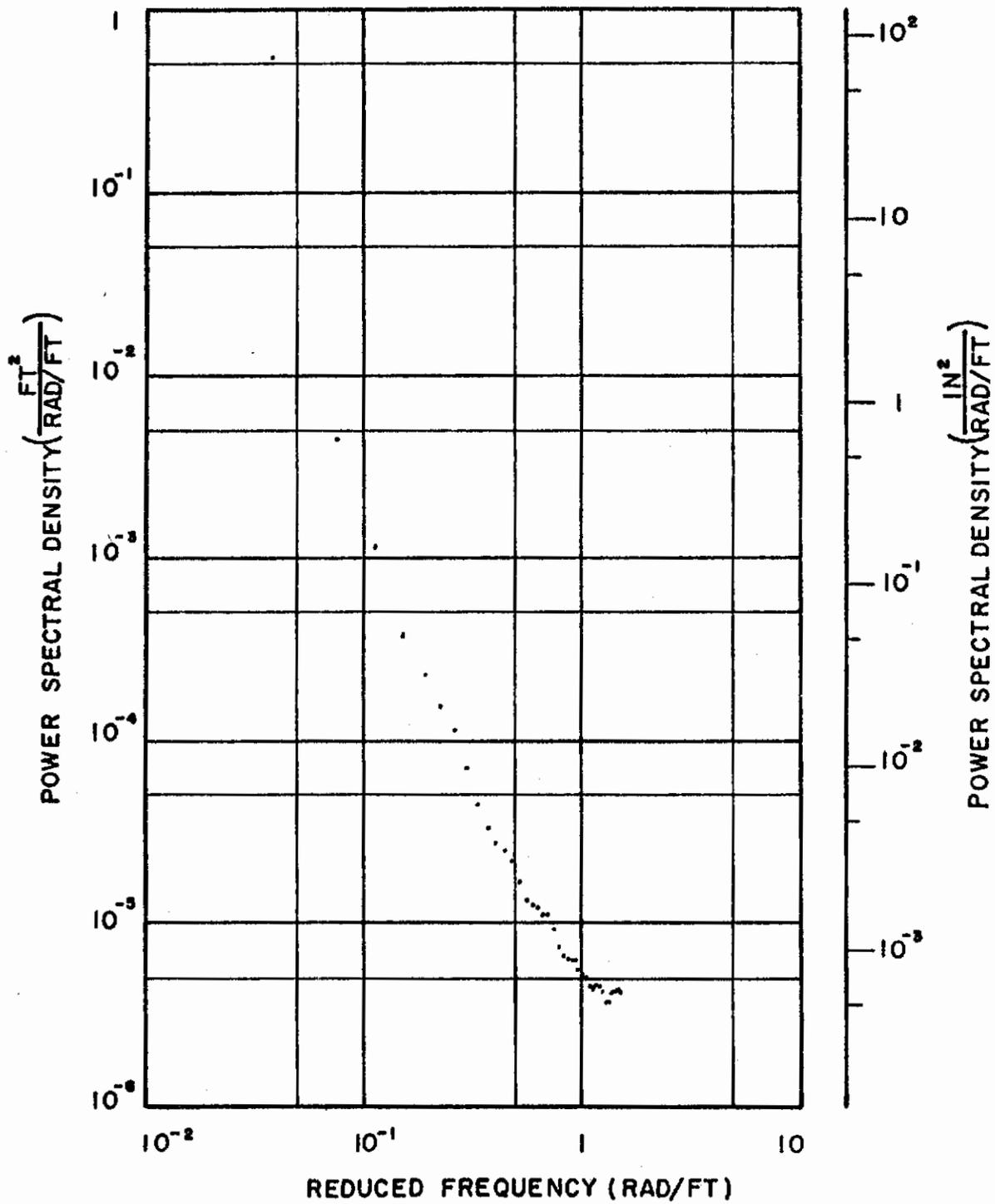
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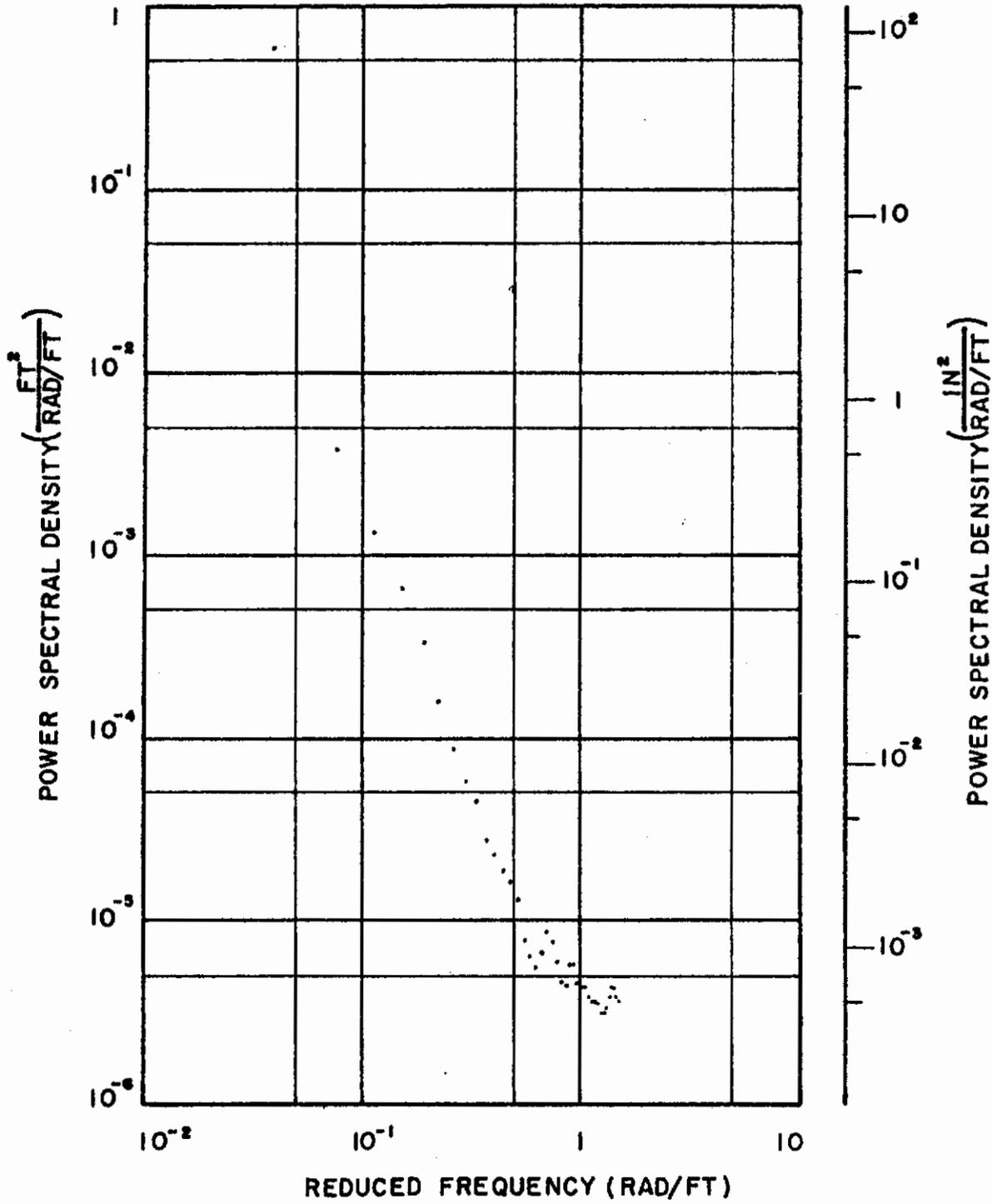
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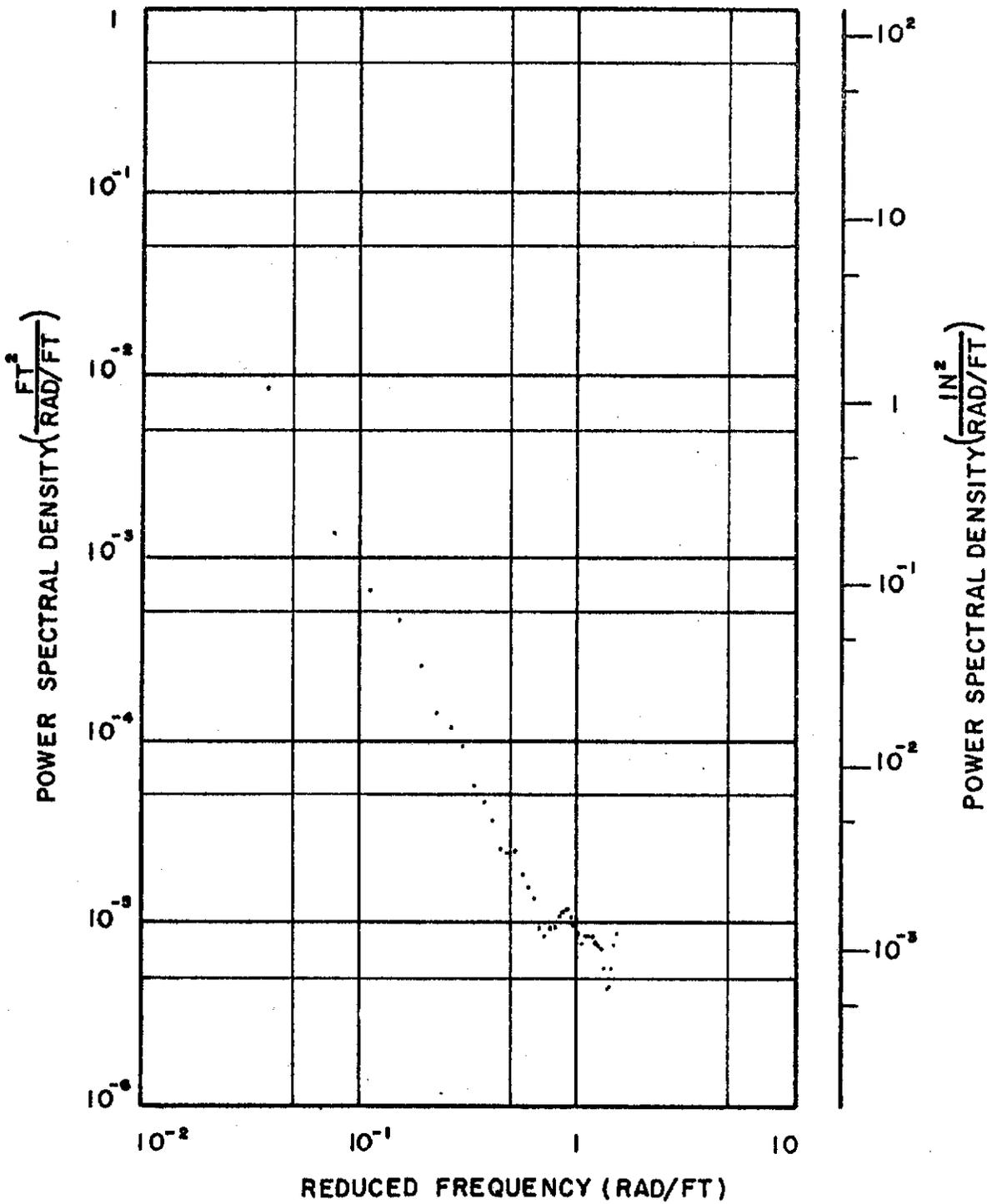
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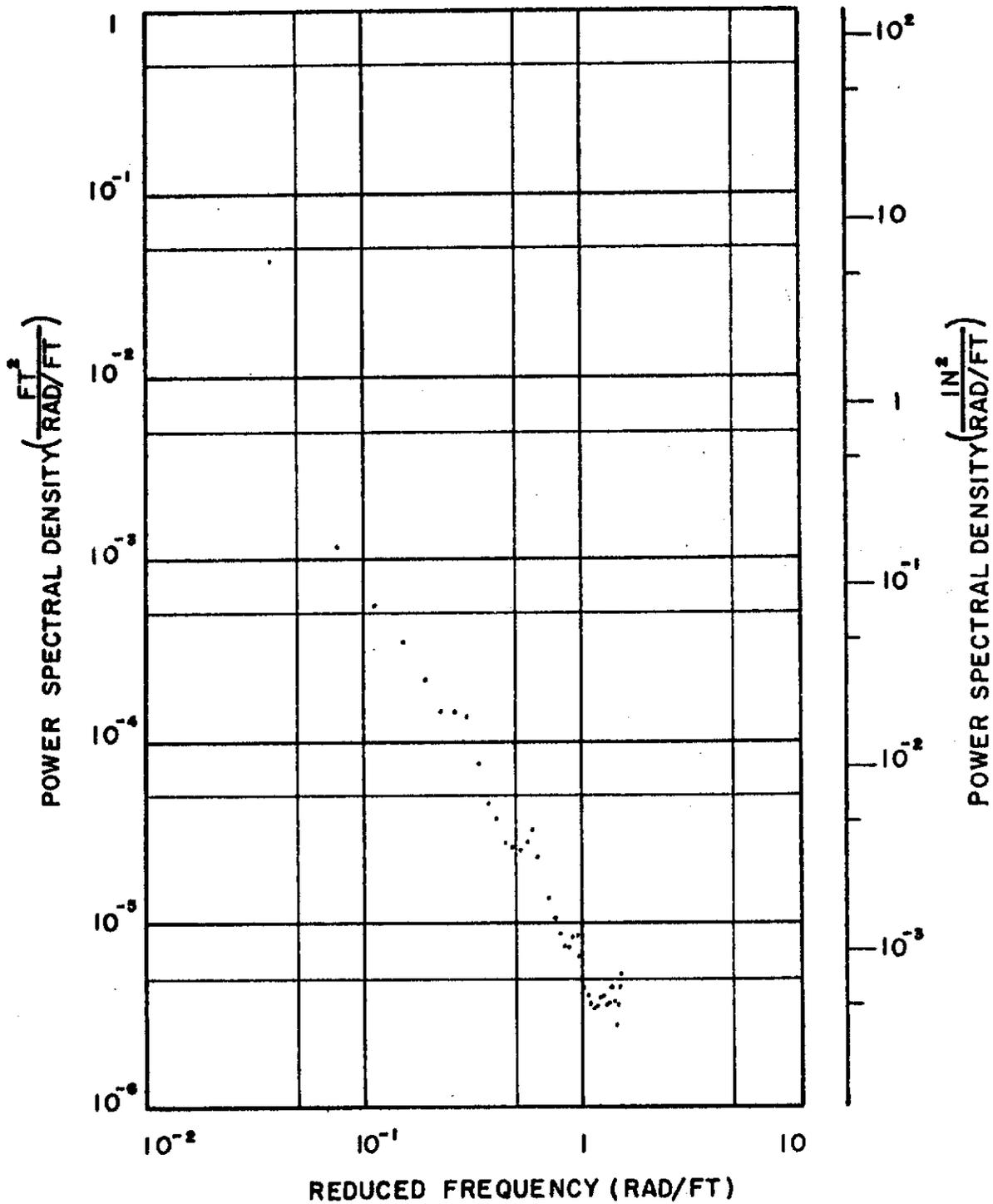
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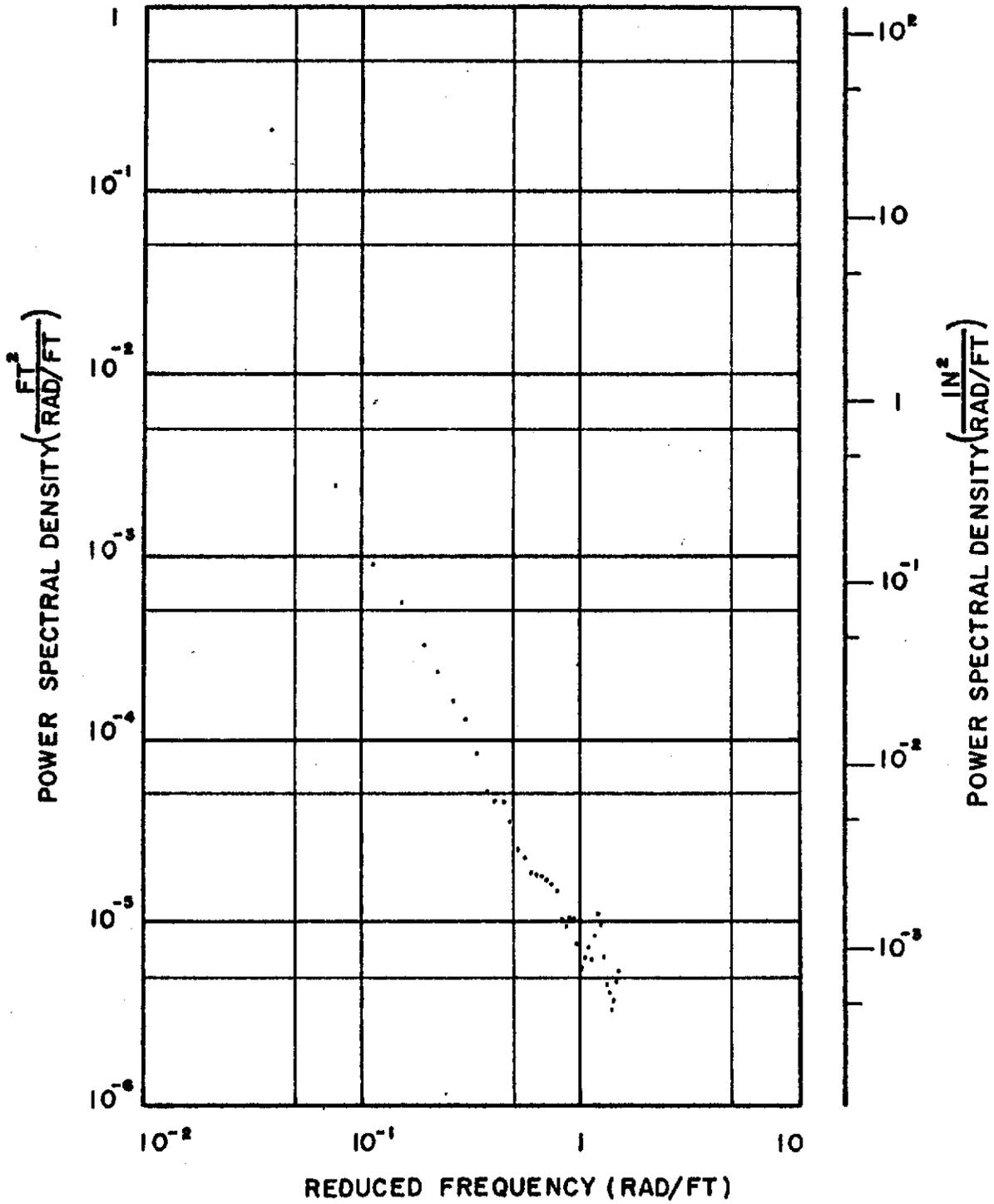
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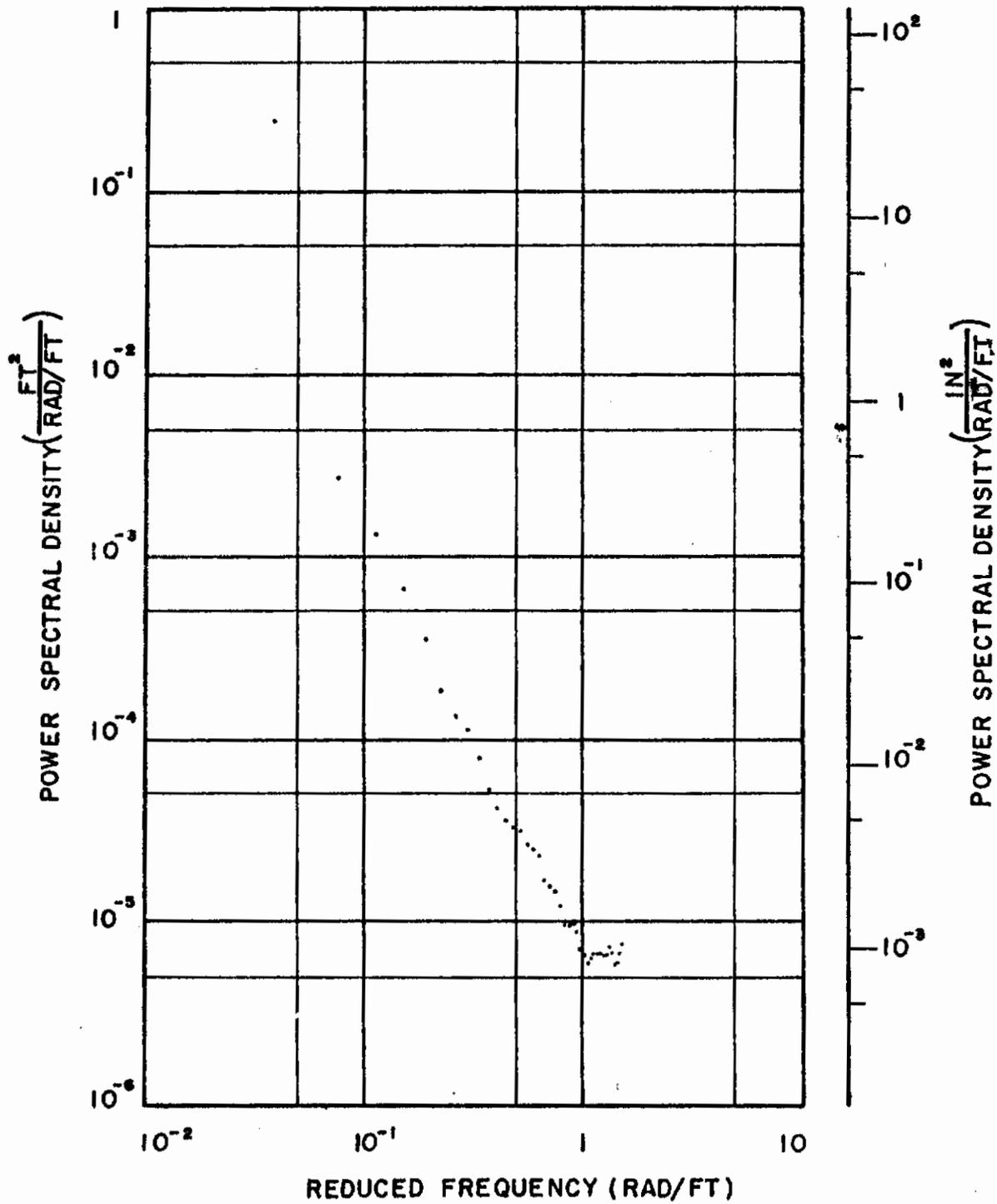
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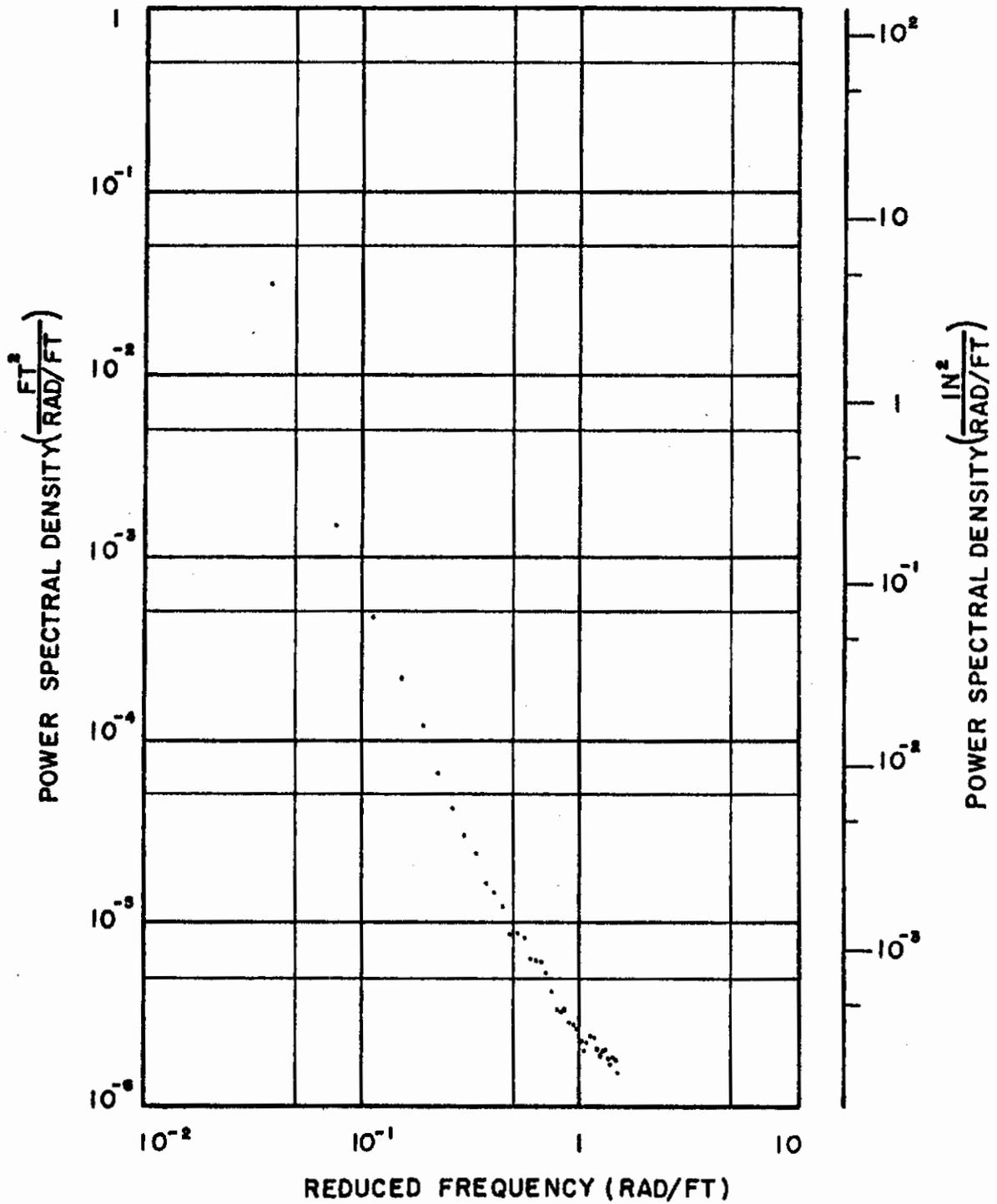
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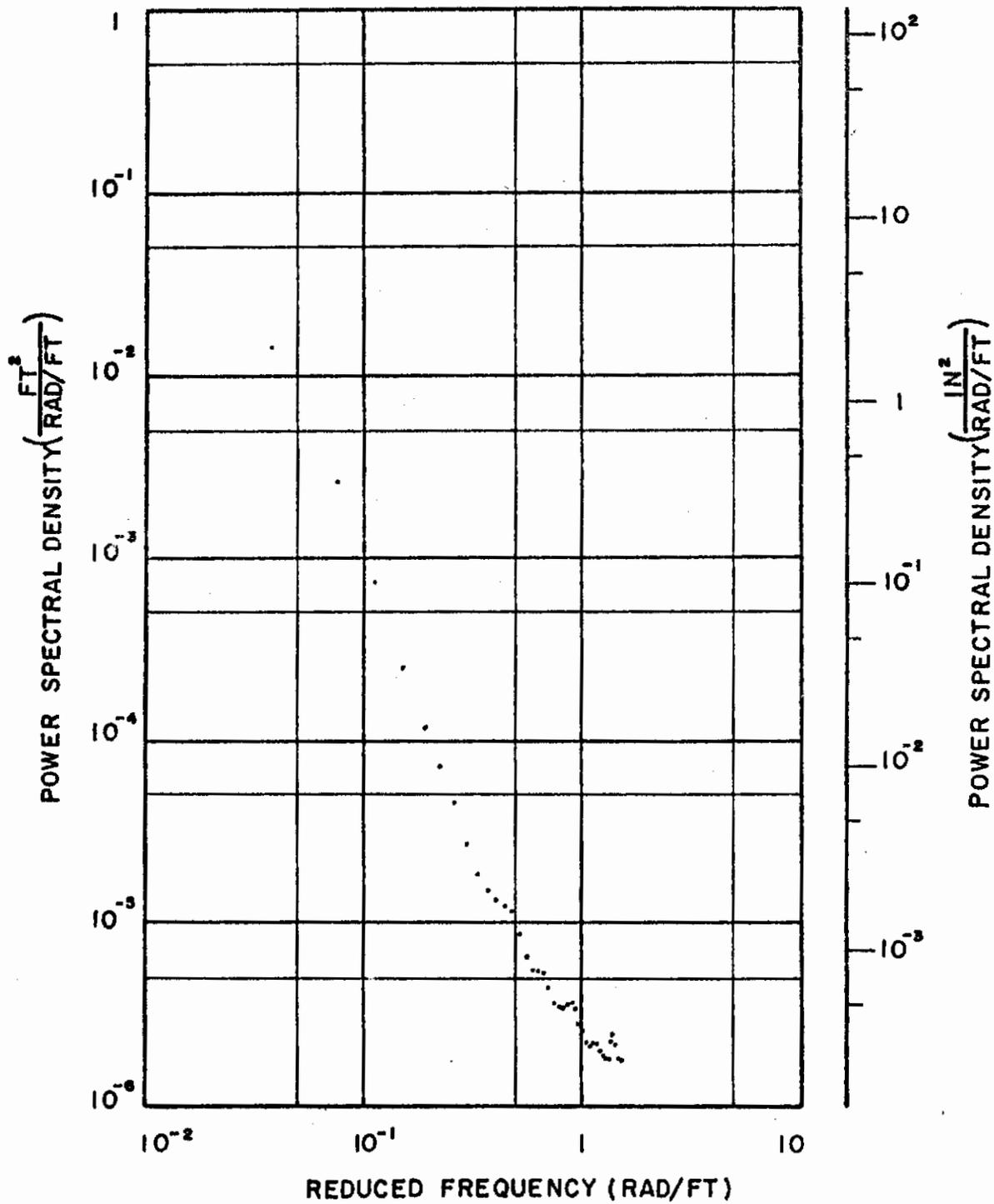
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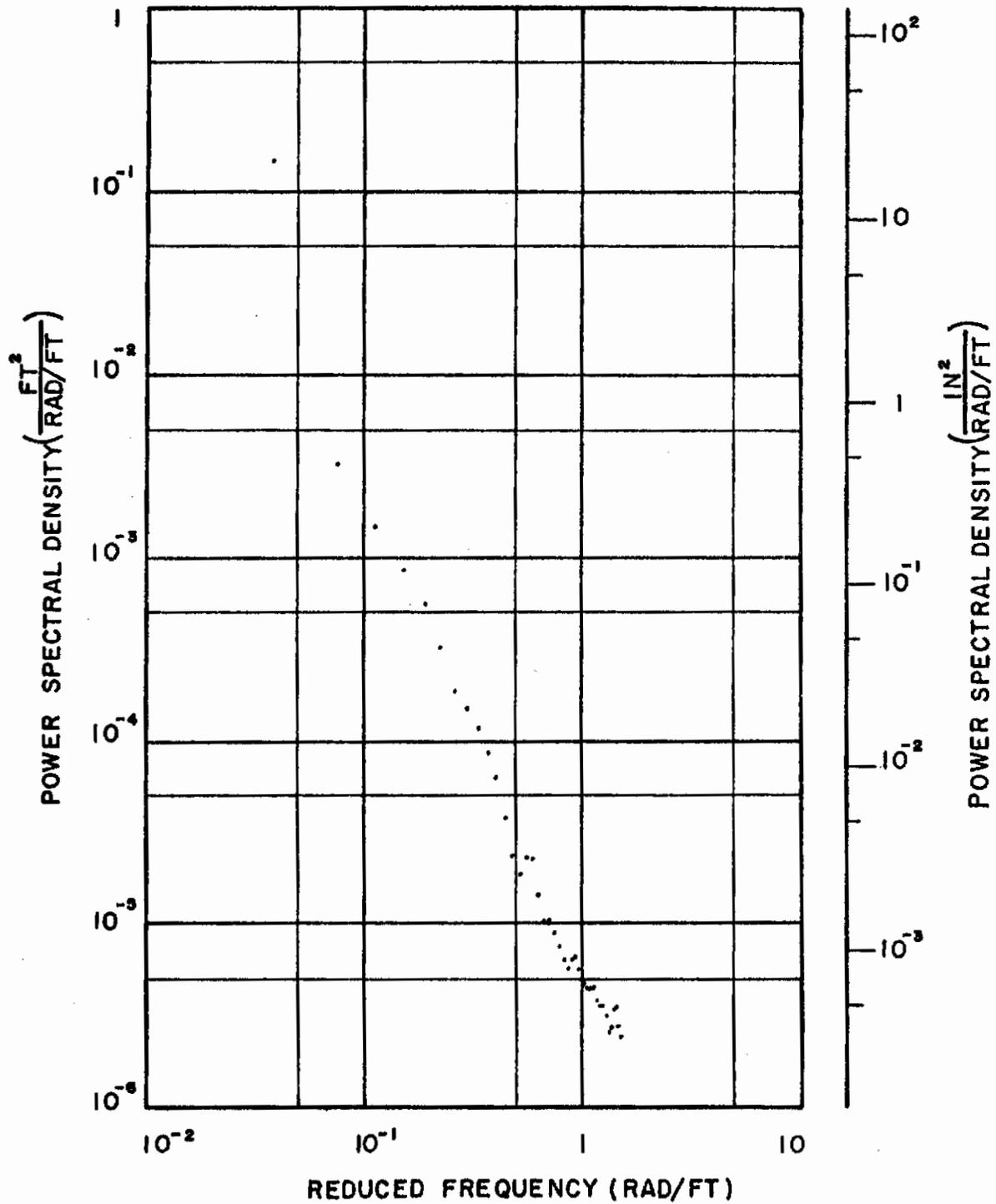
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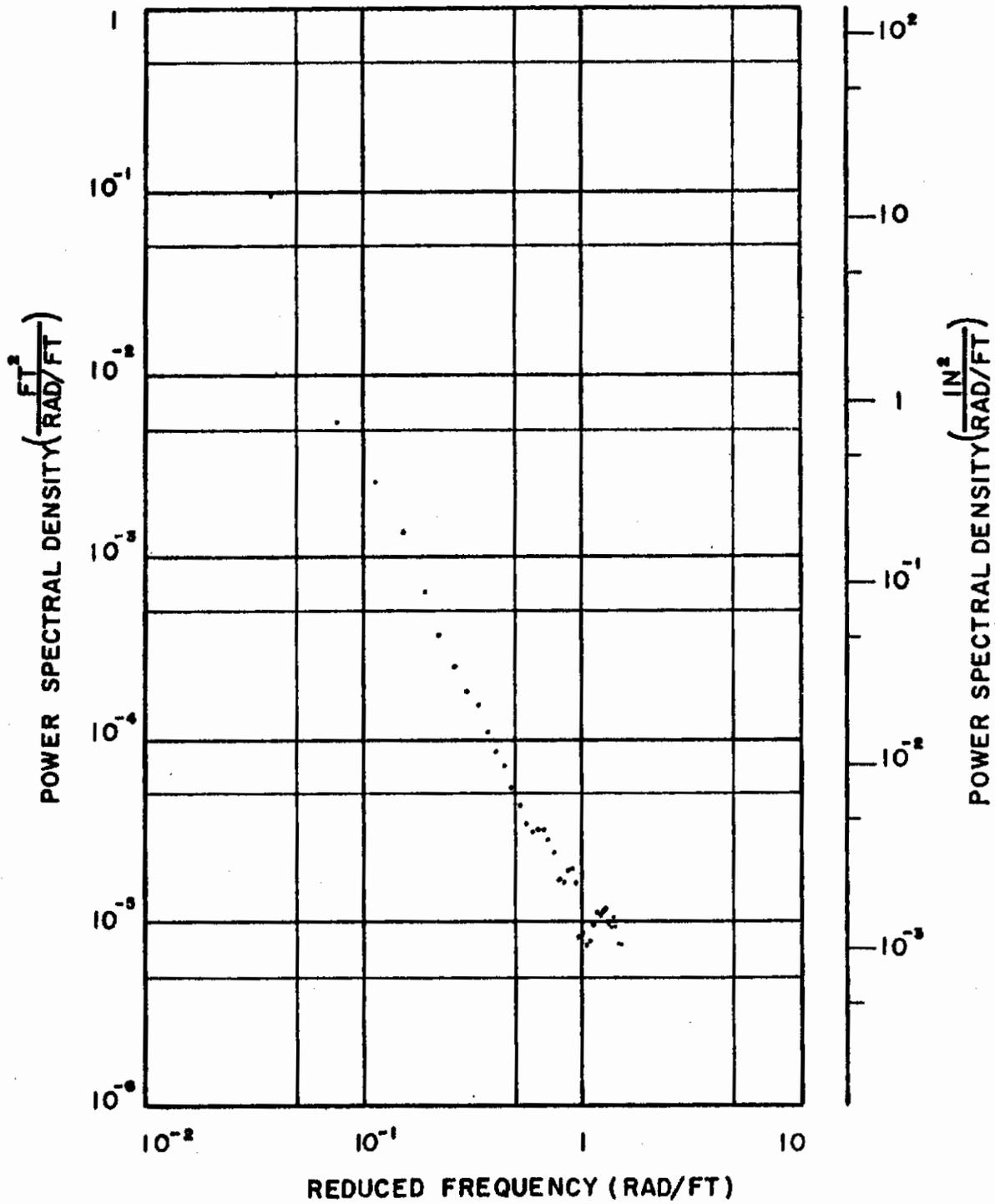
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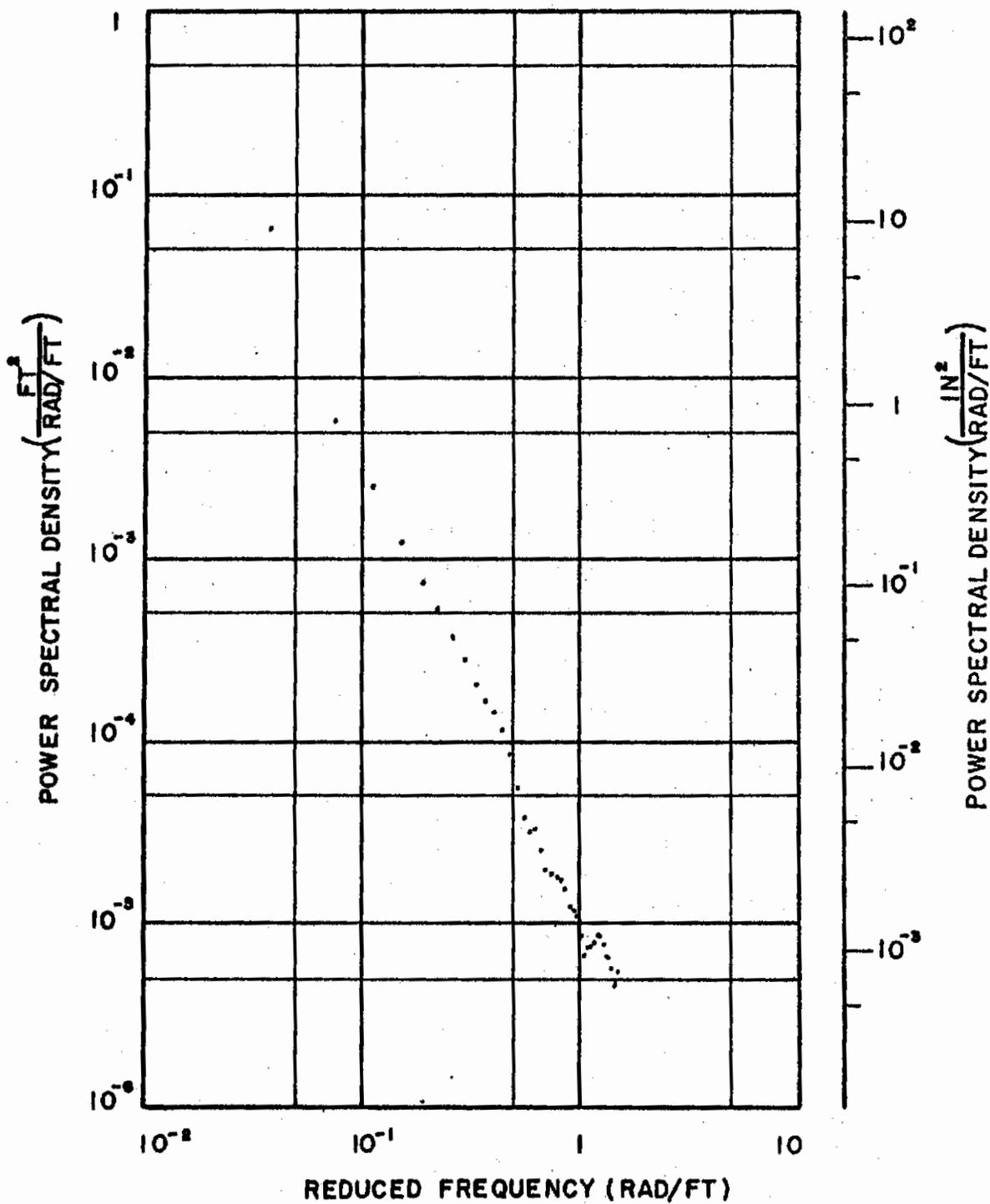
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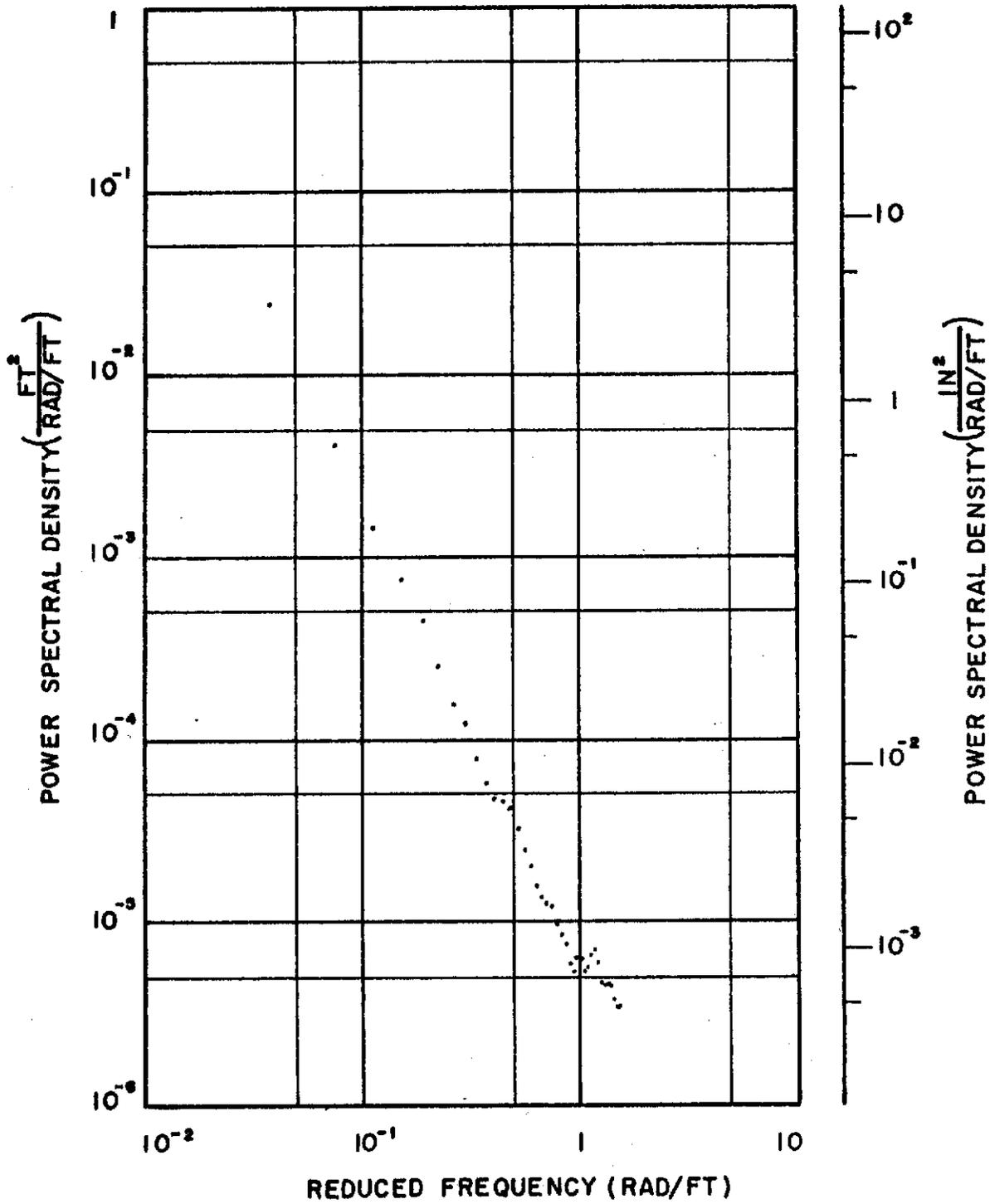
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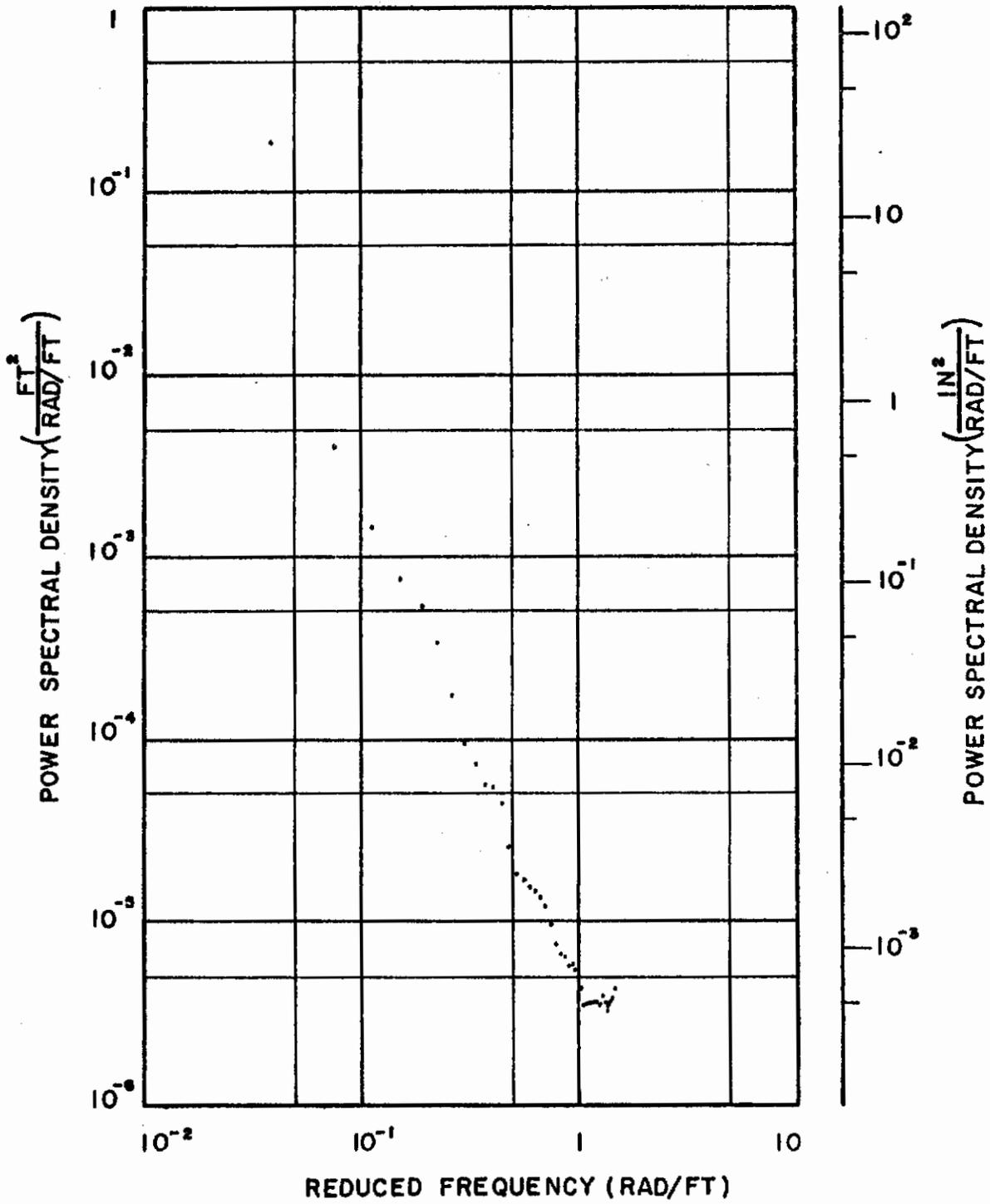
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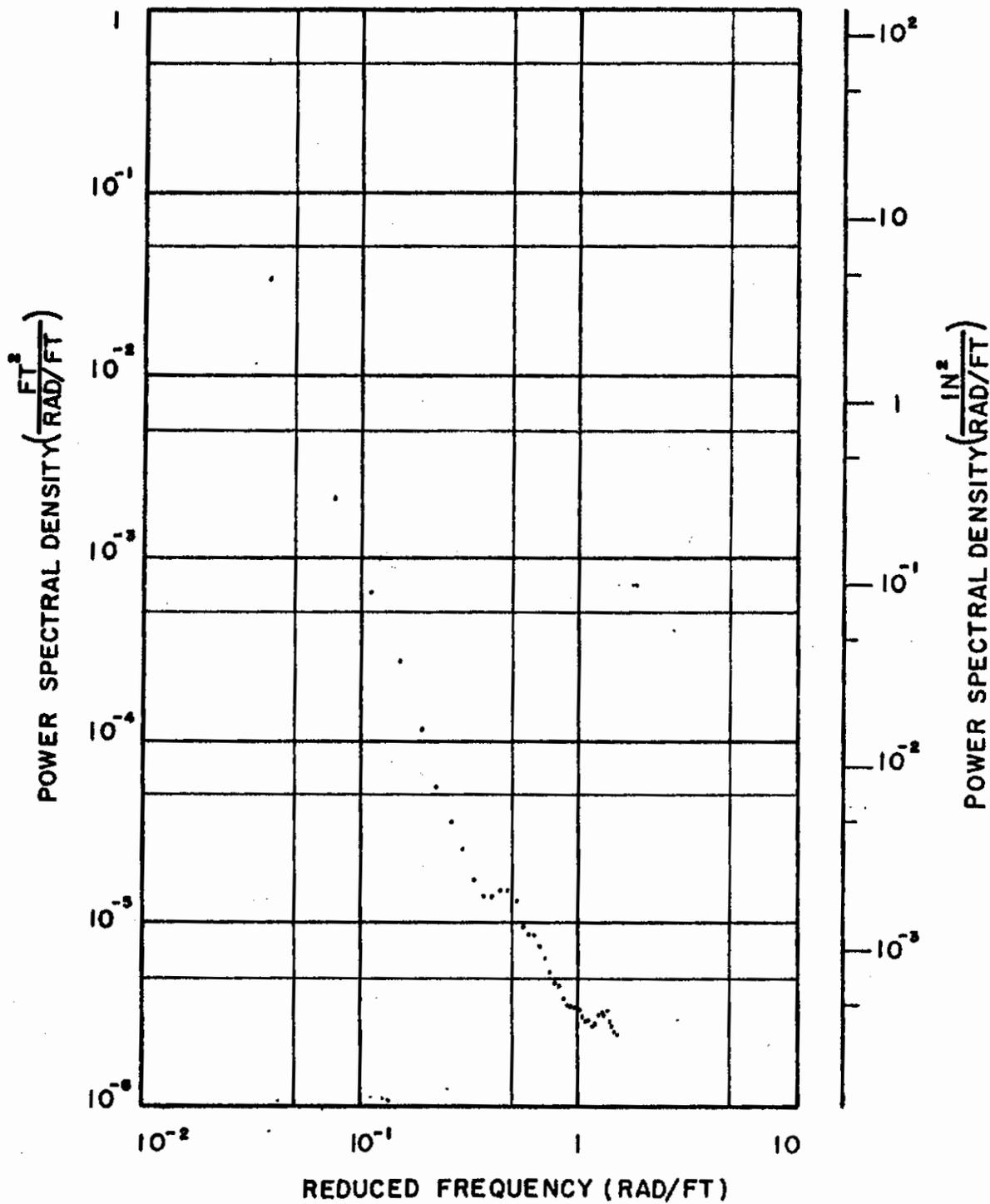
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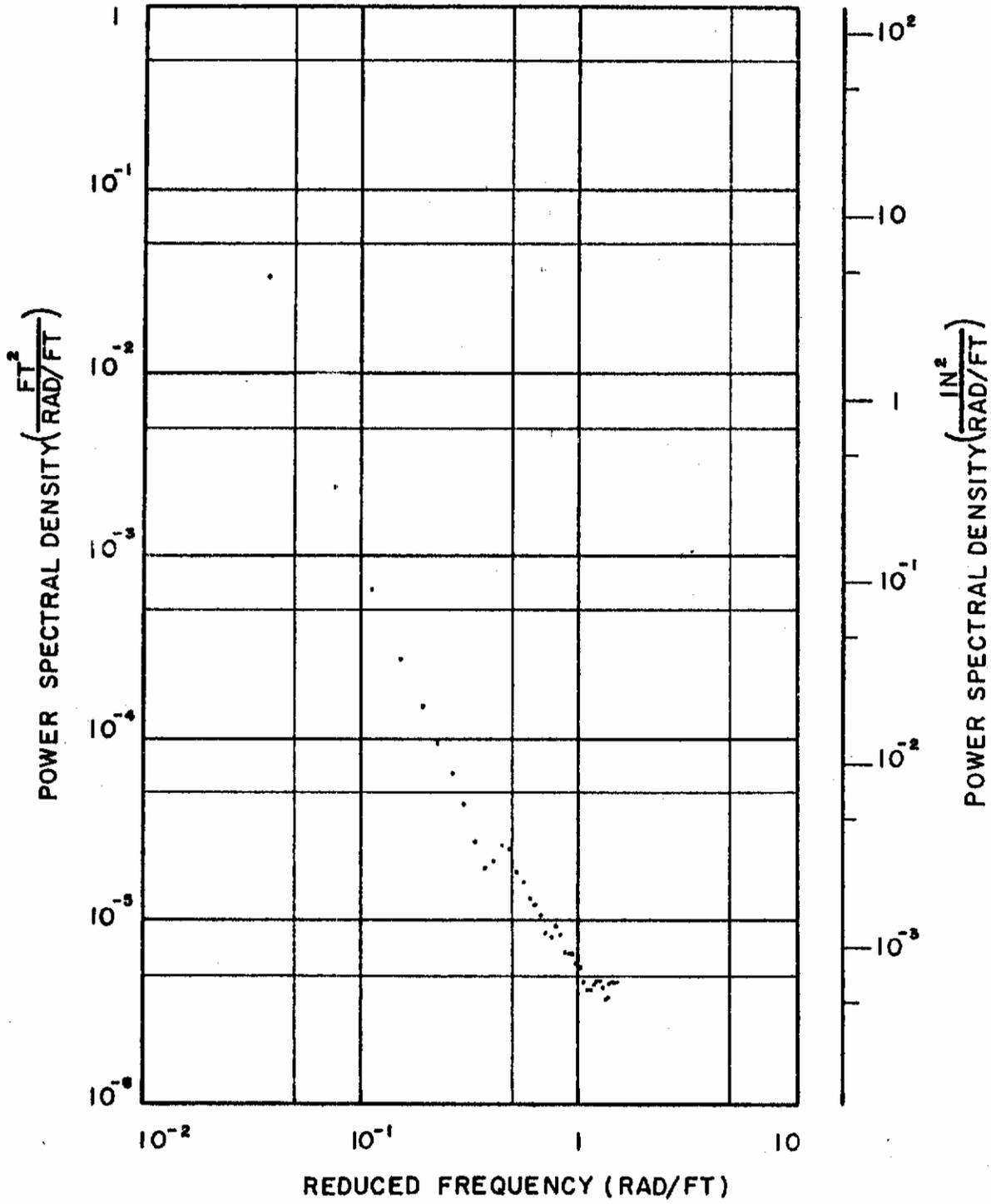
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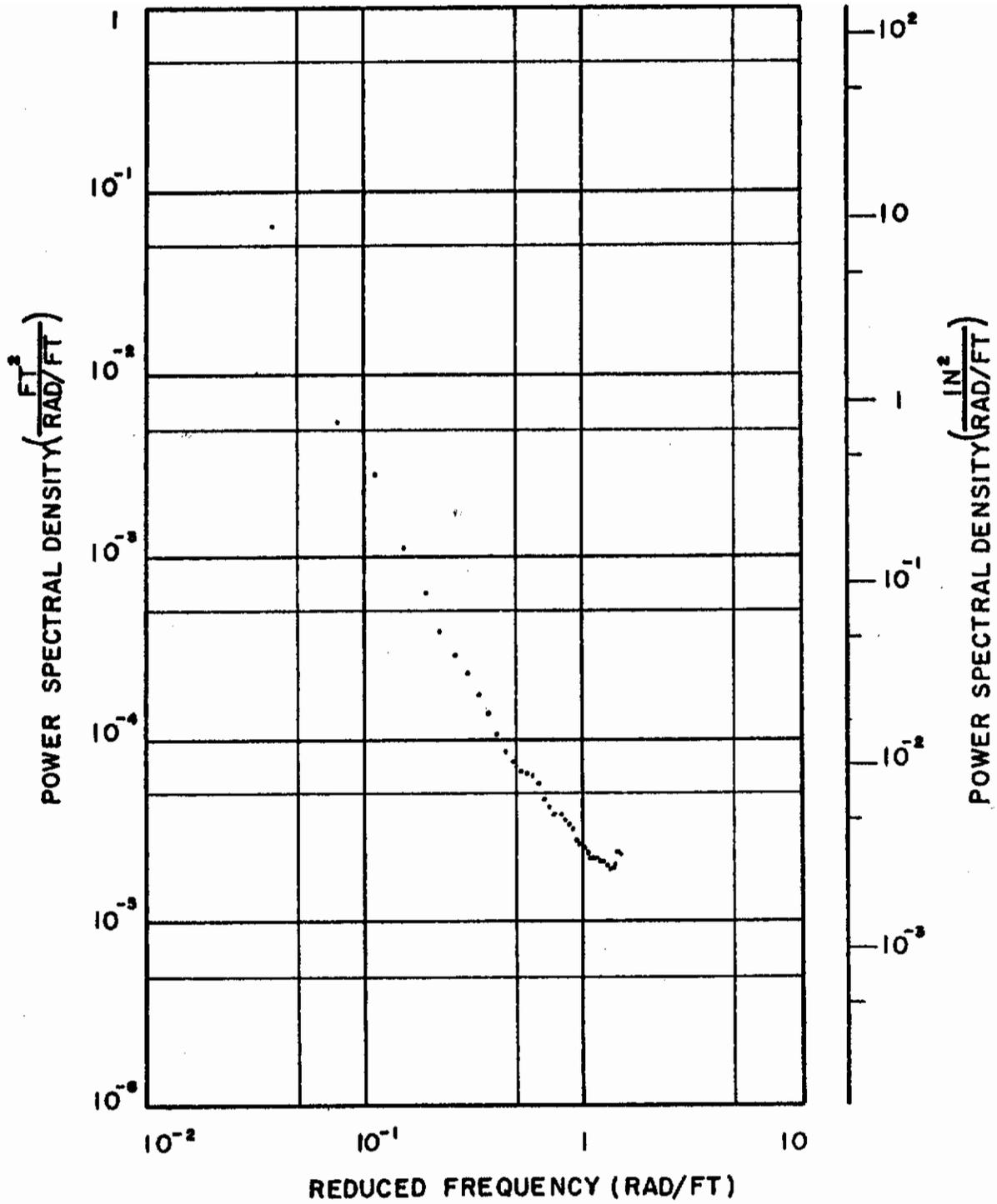
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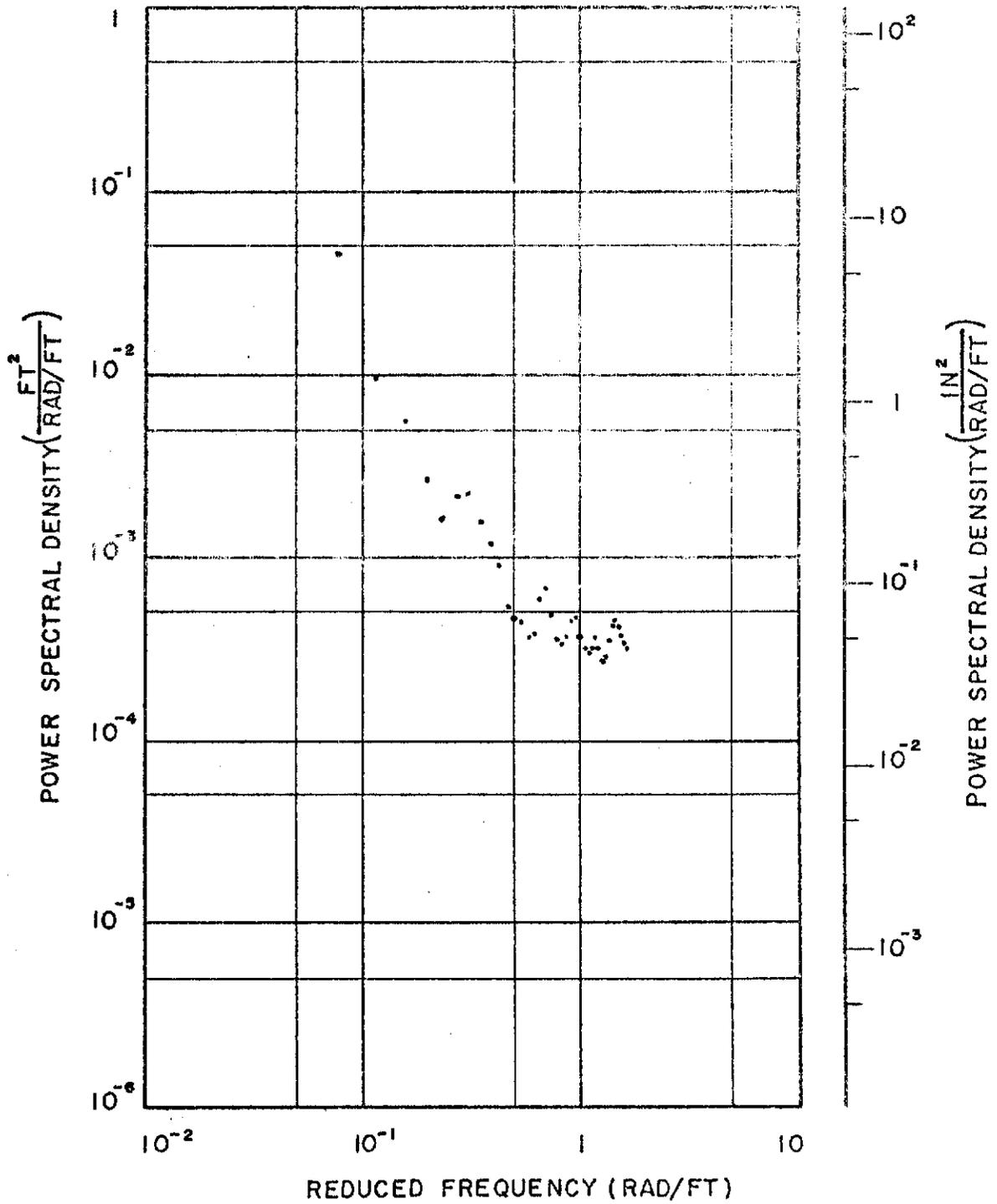
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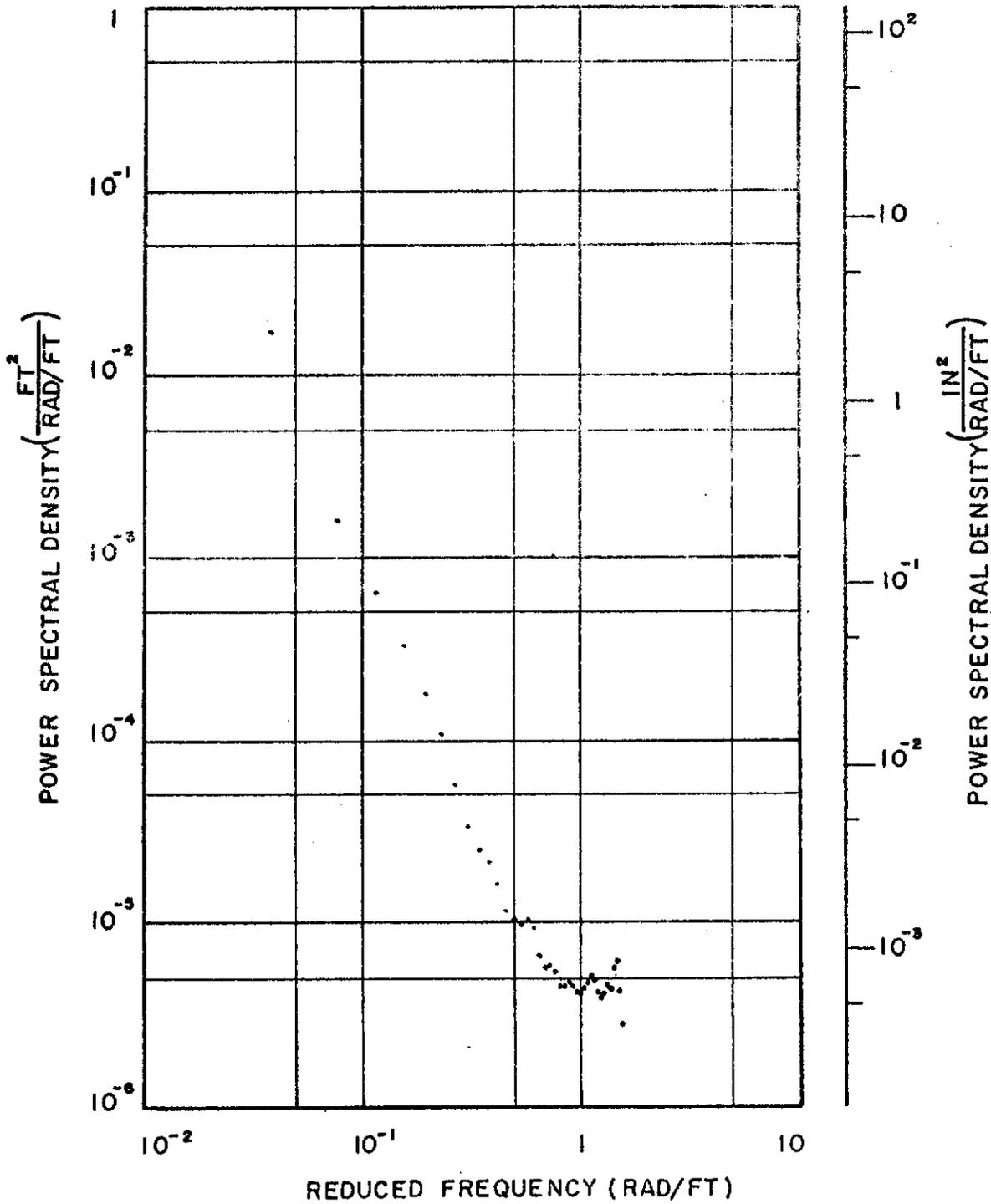
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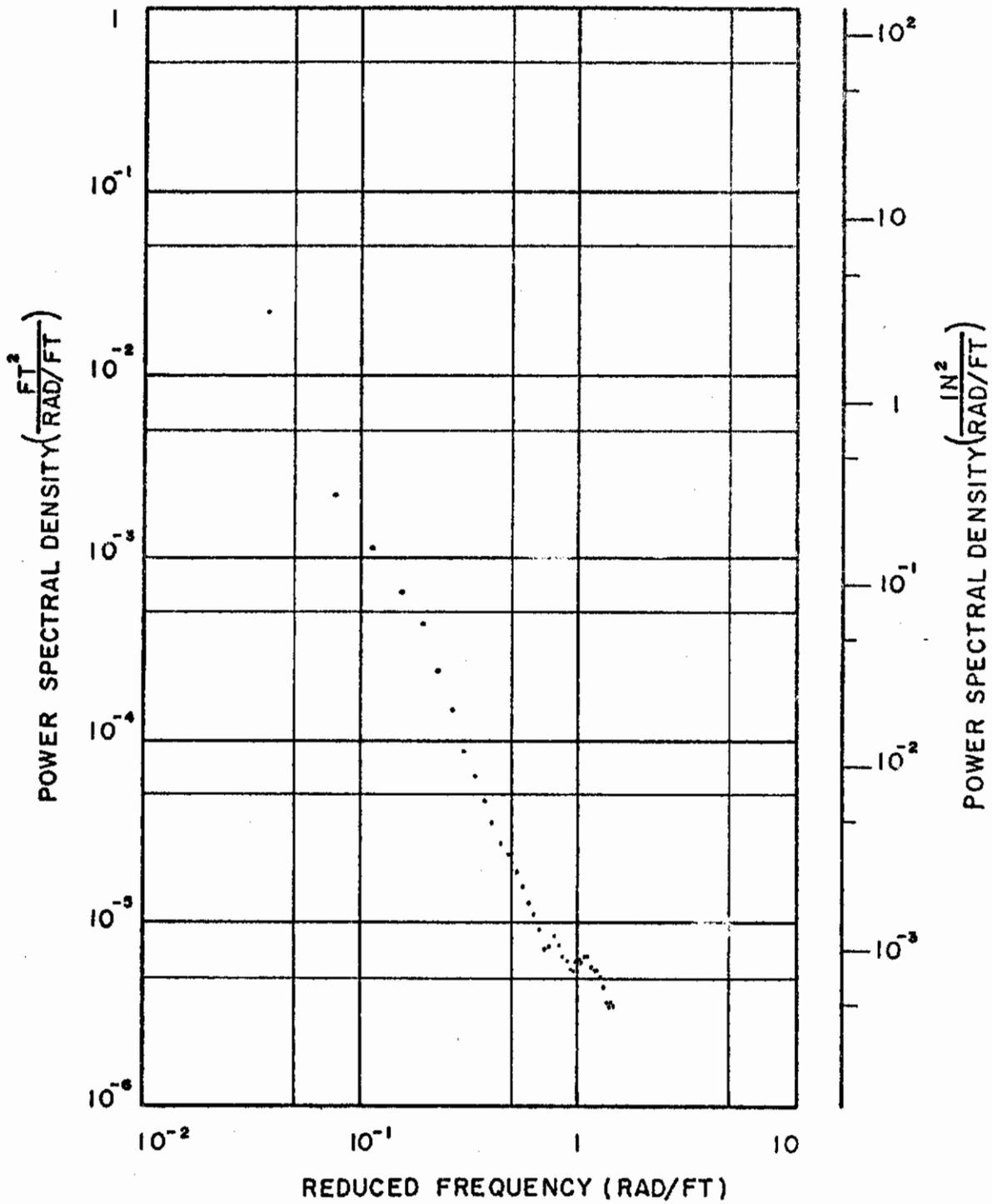
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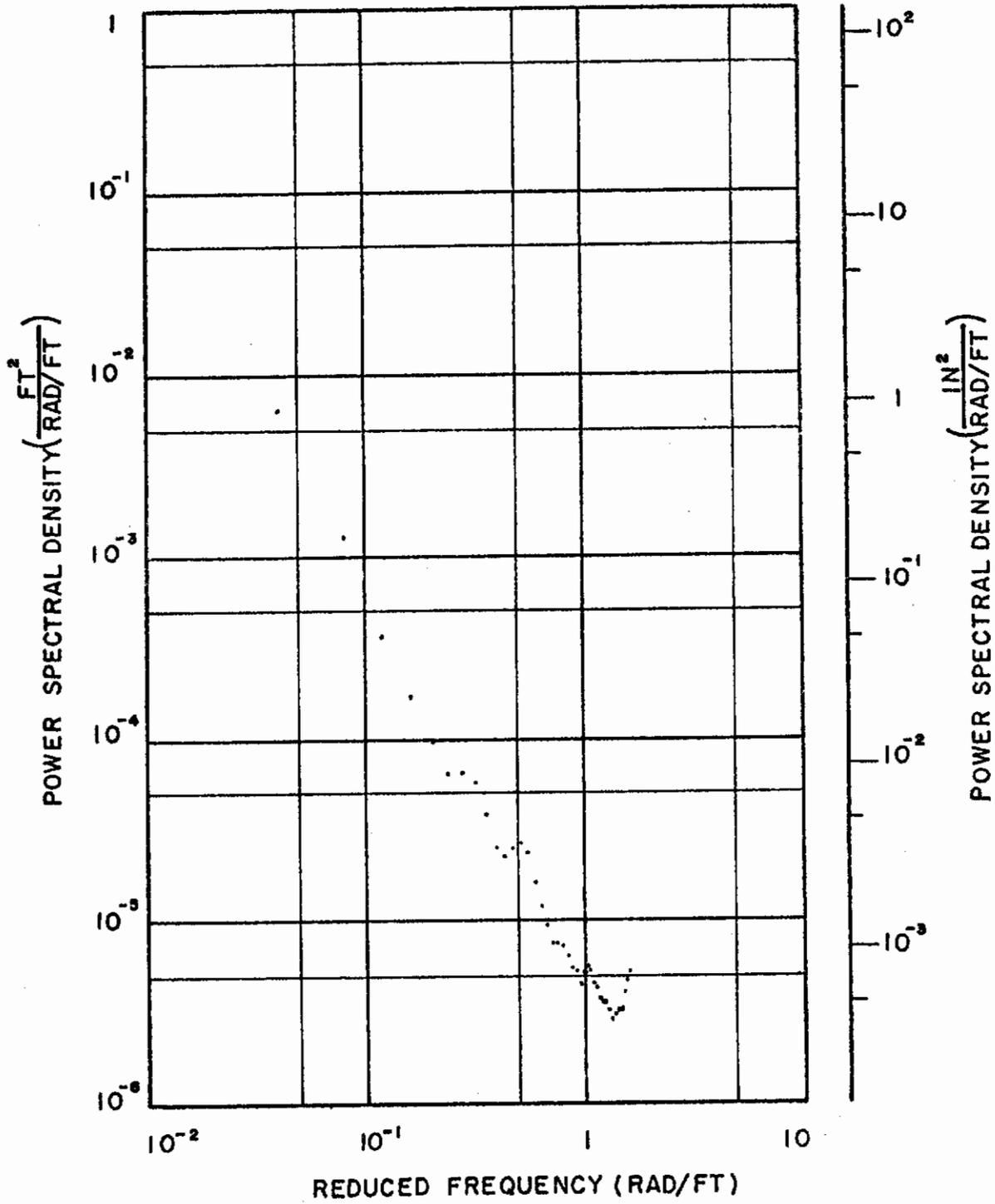


Runway 56

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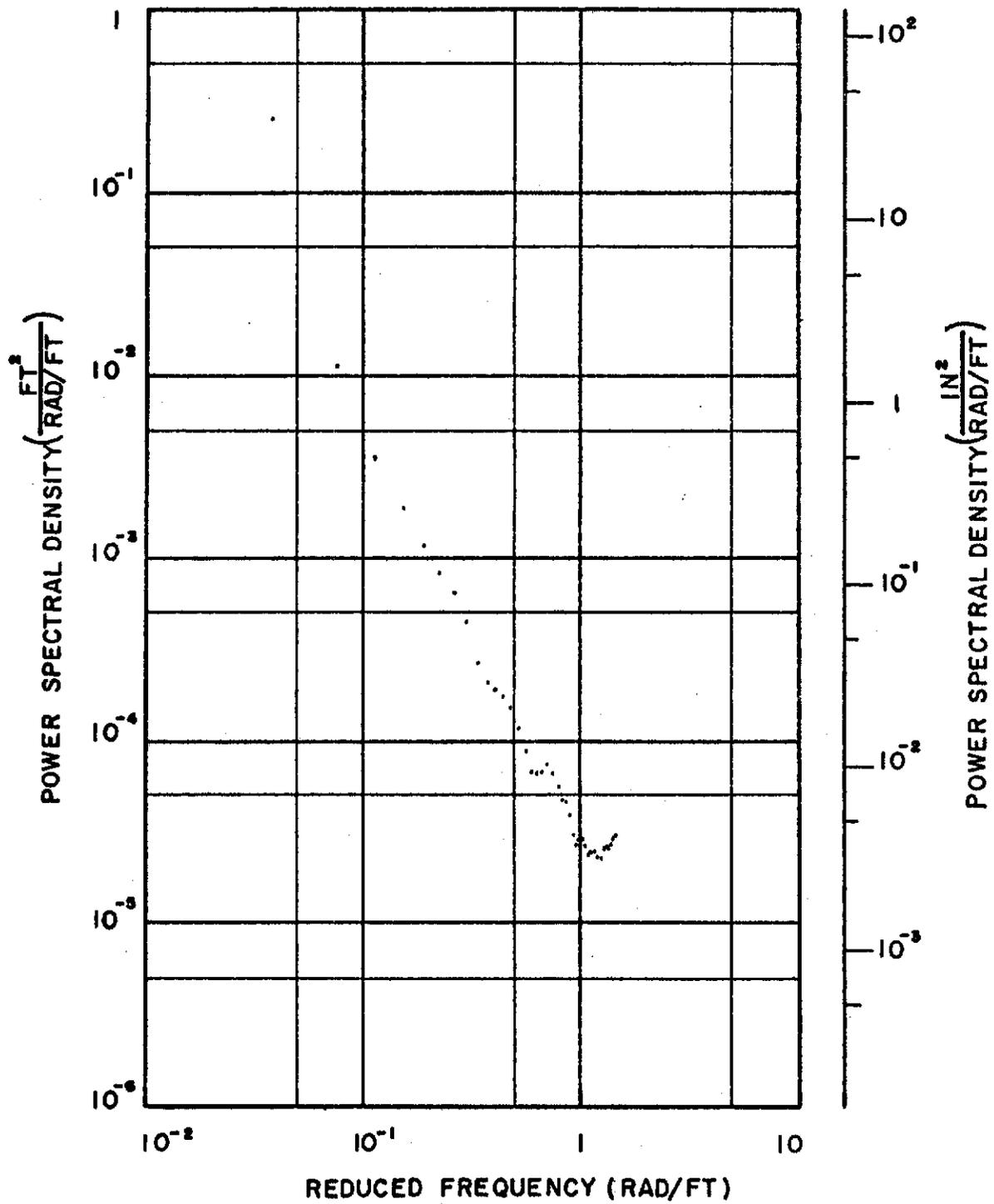


Runway 58



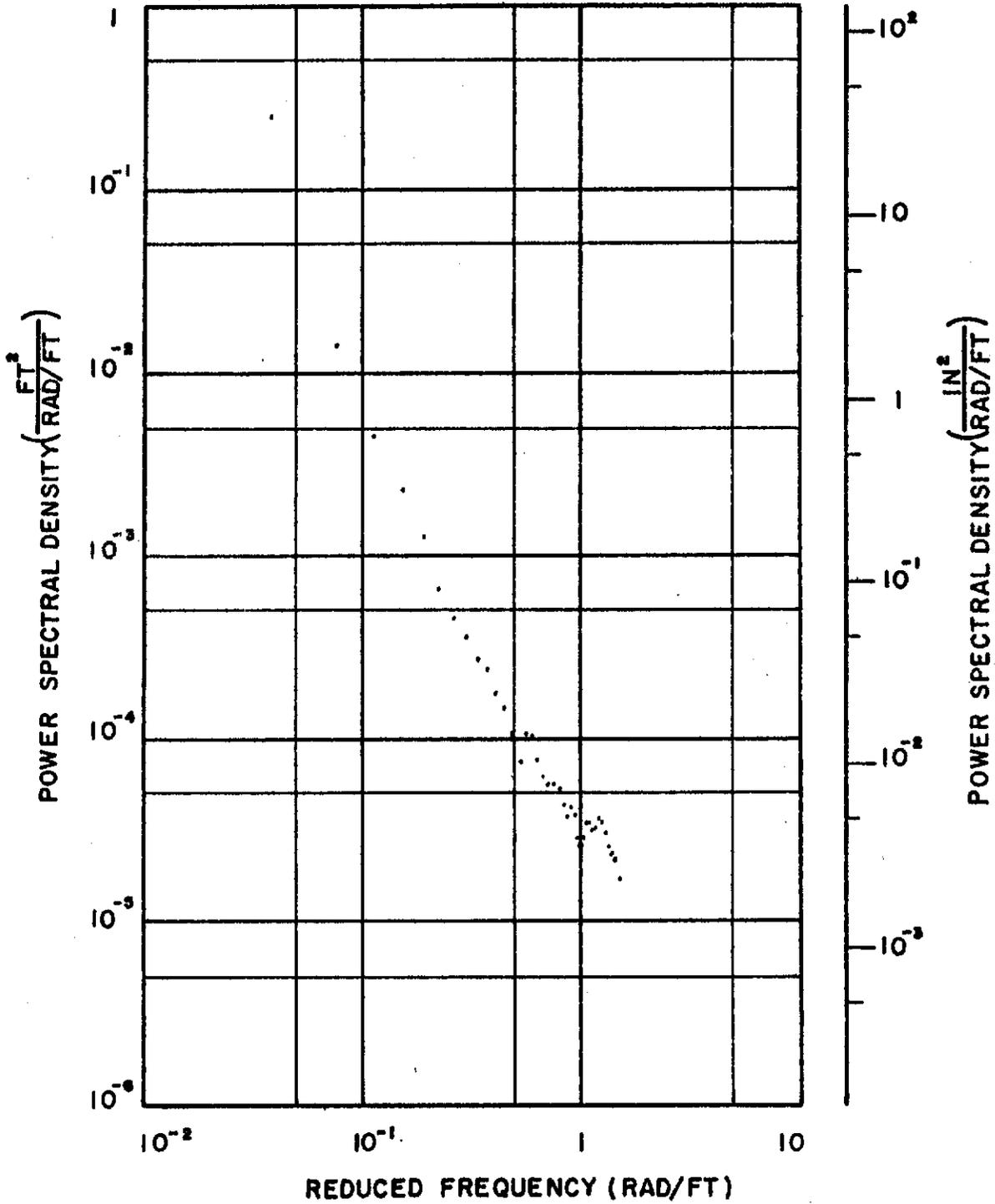
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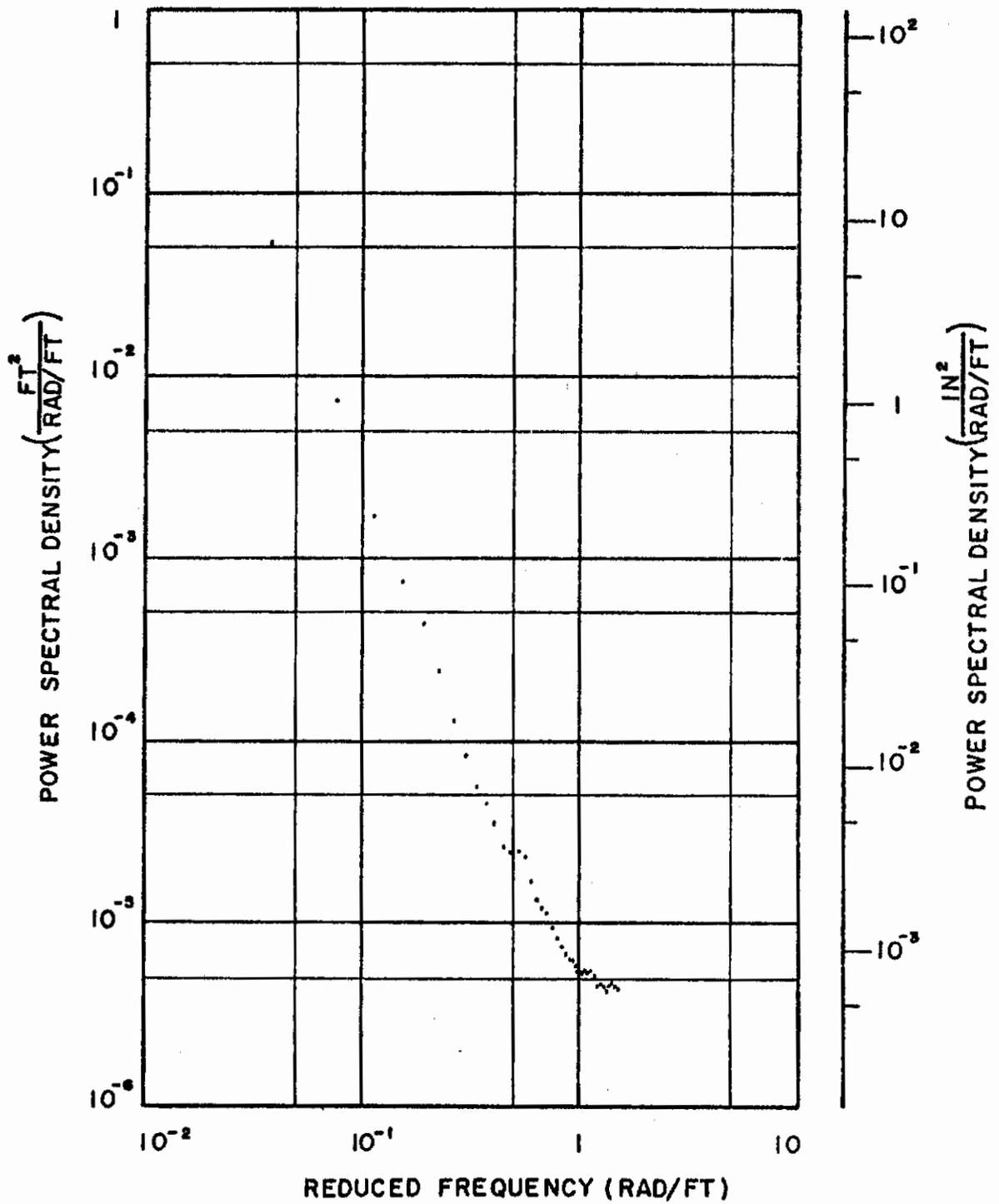
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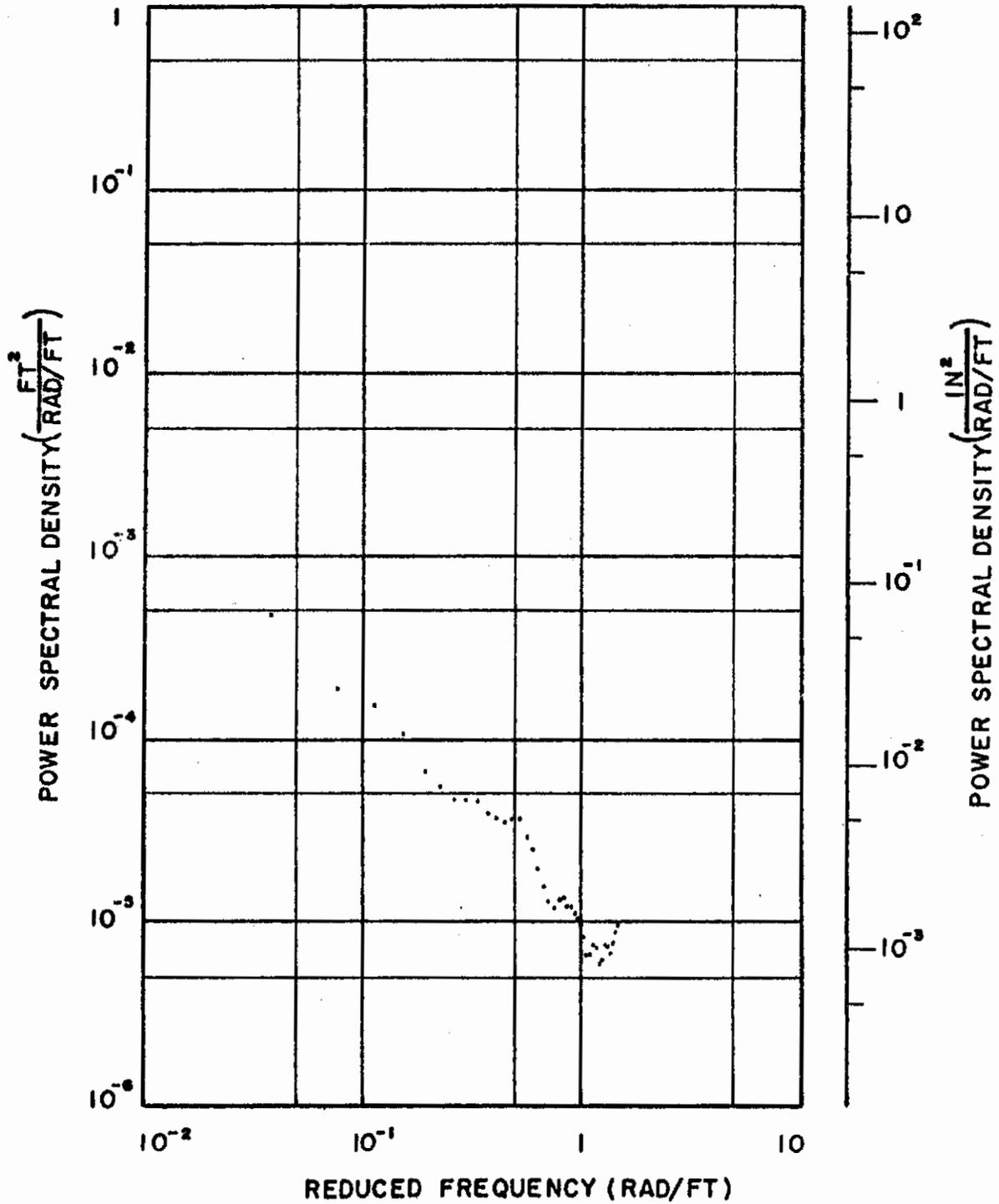
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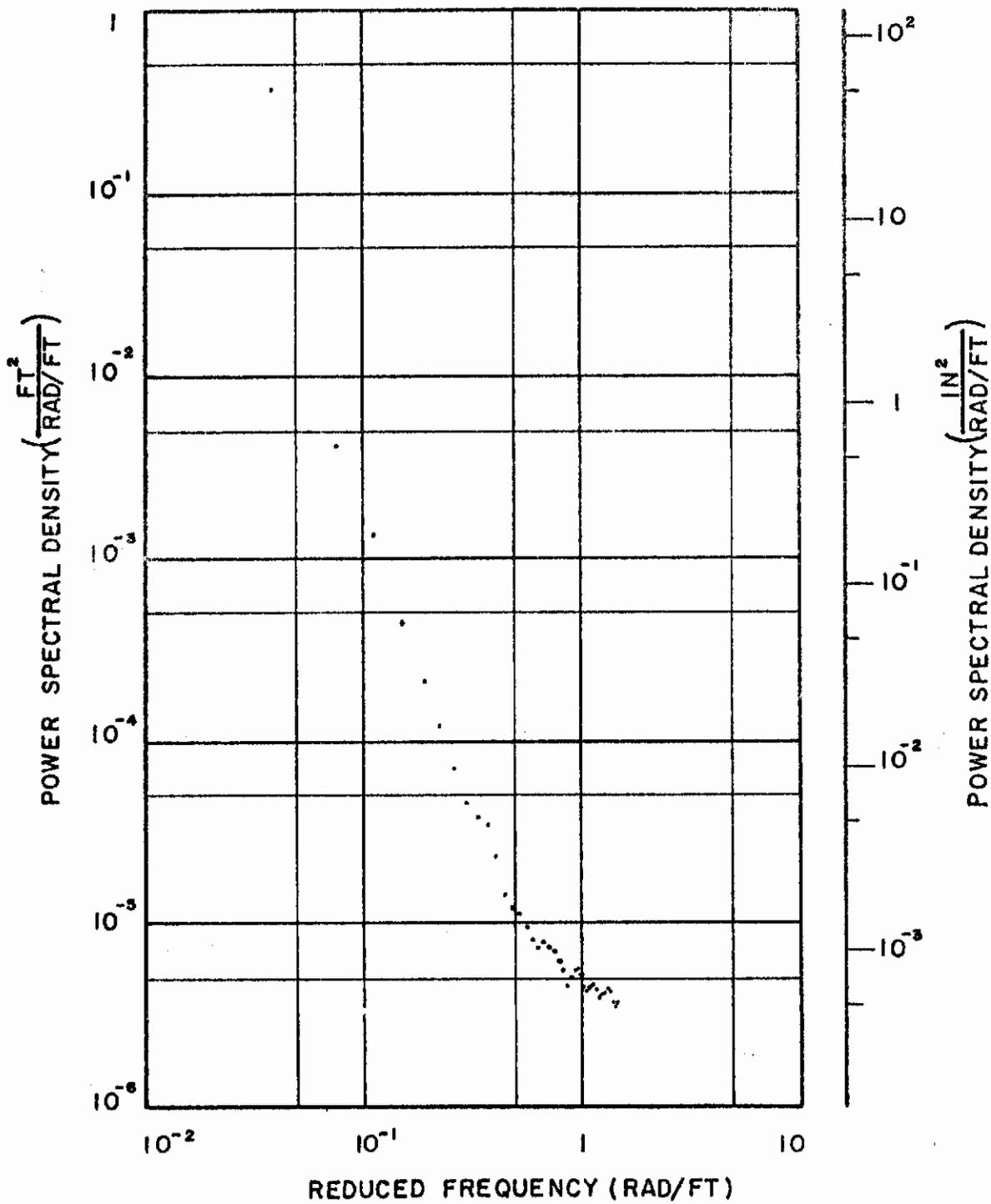
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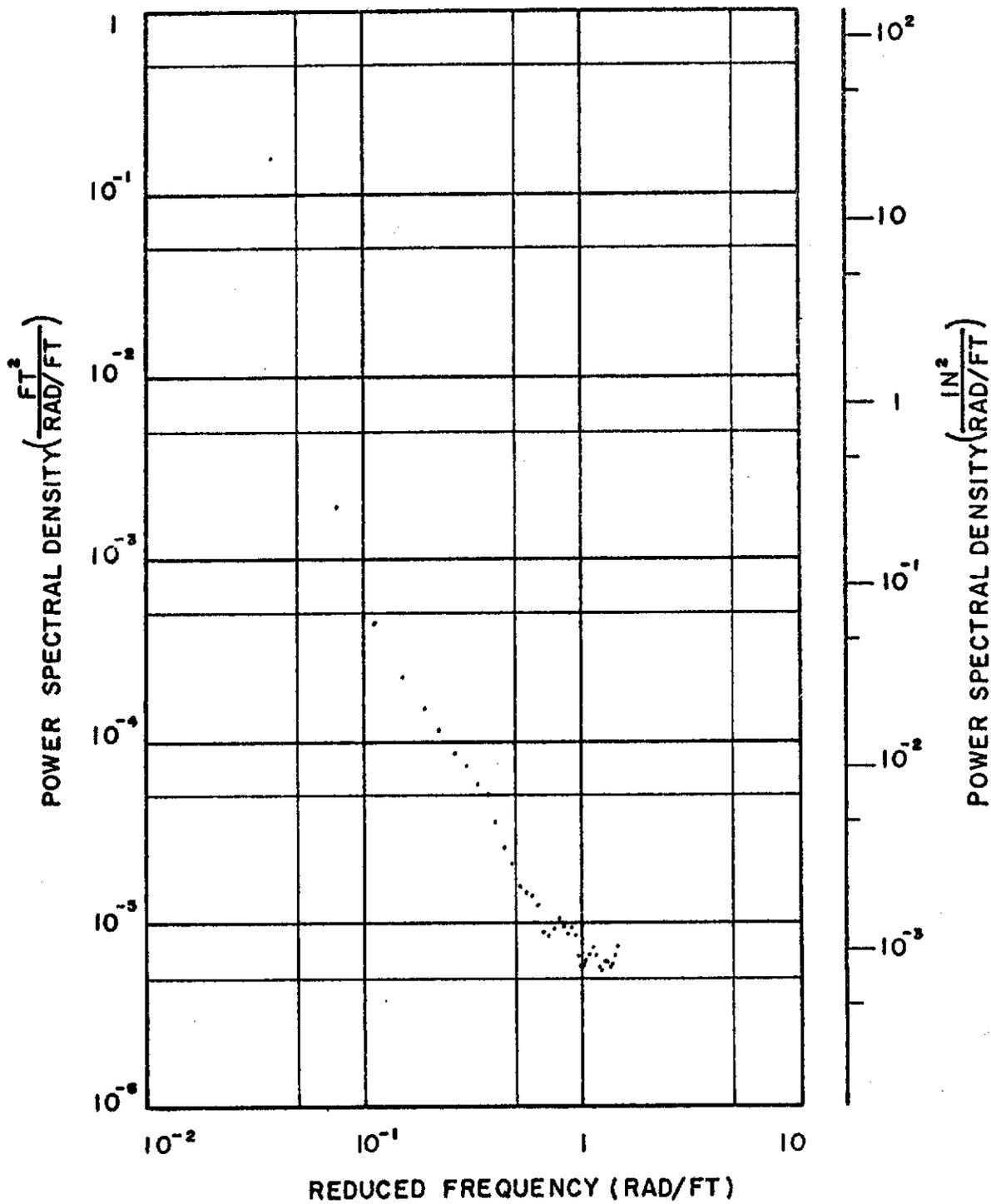
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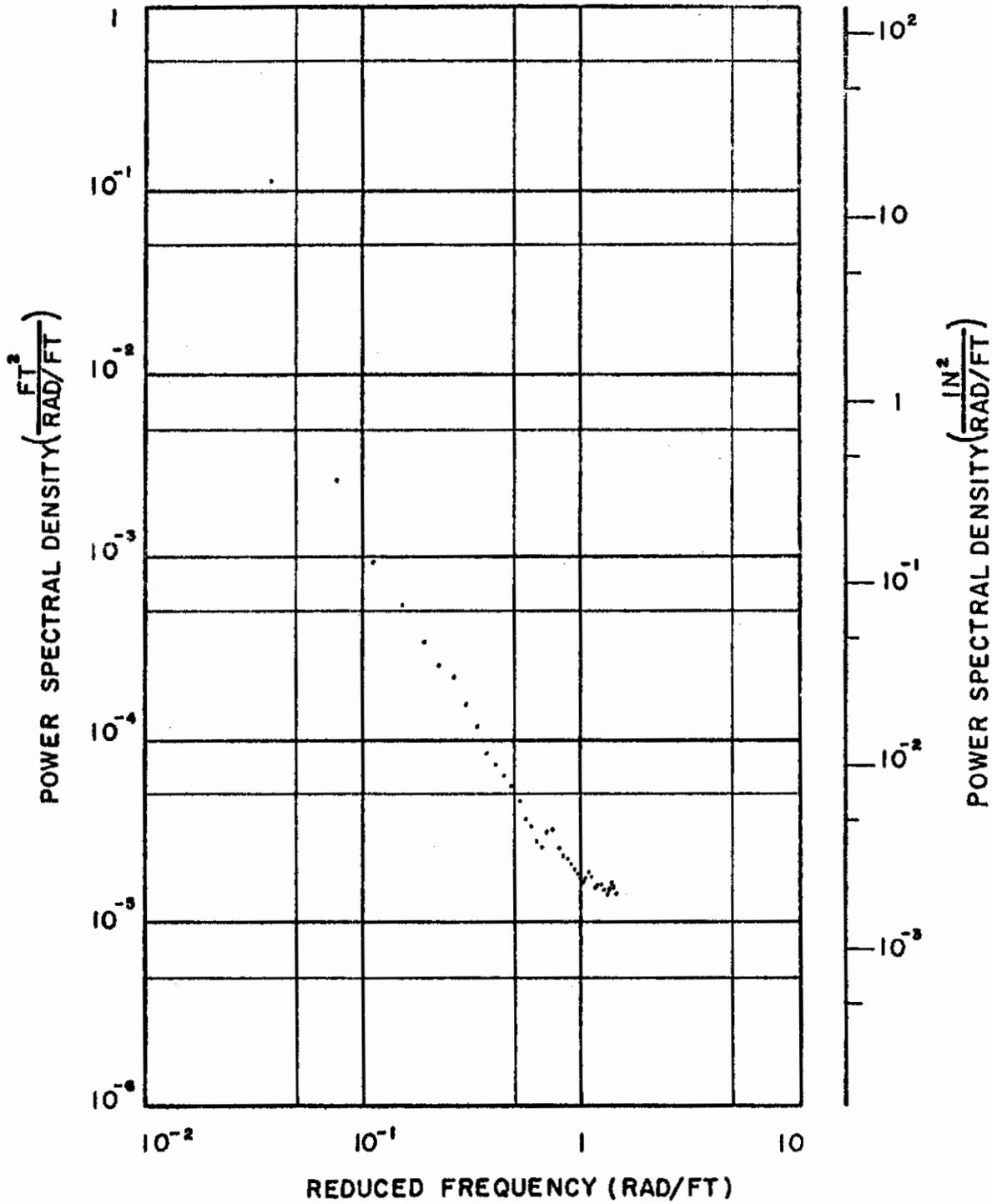
Runway 64

Contrails



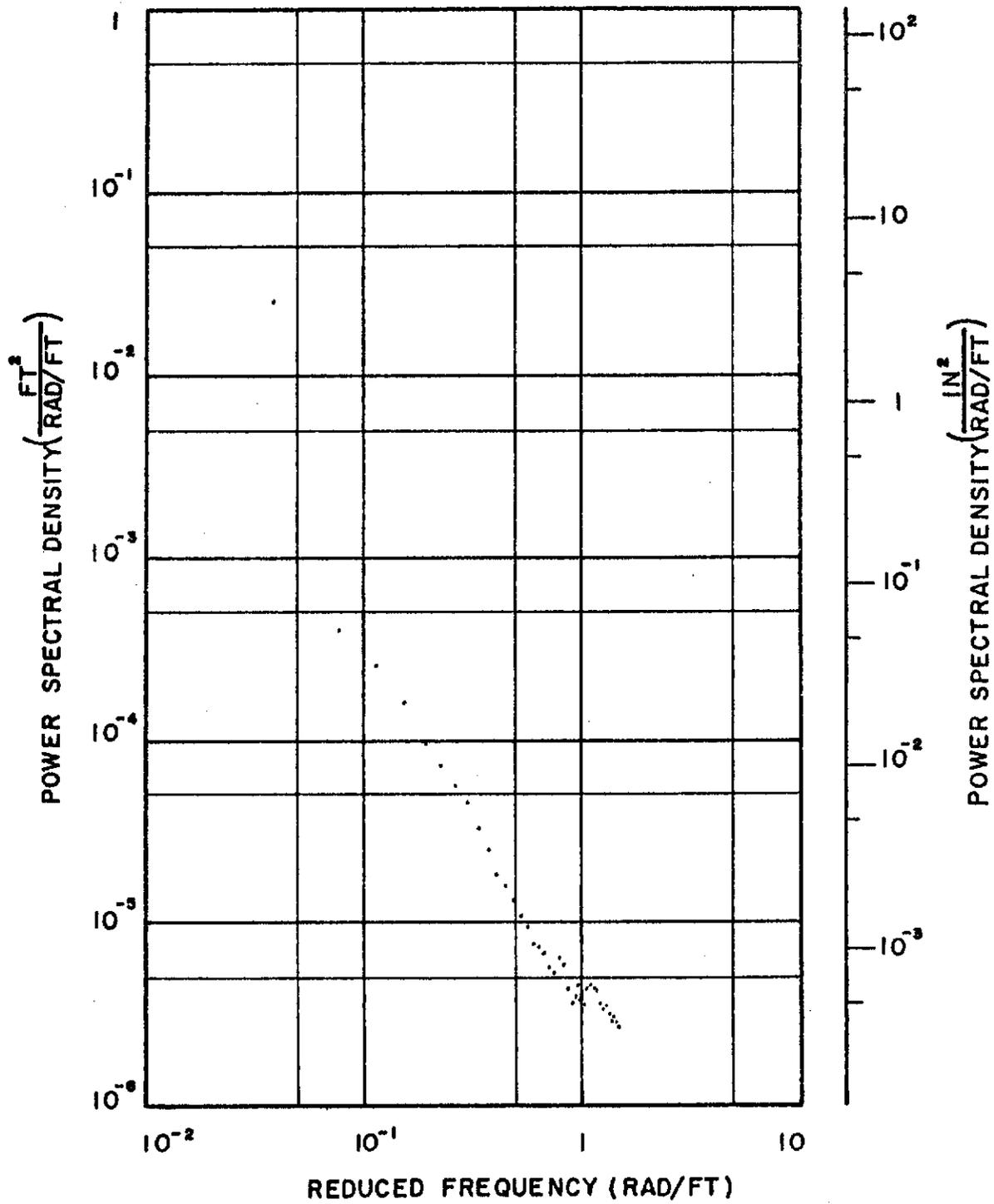
Runway 65

Contrails



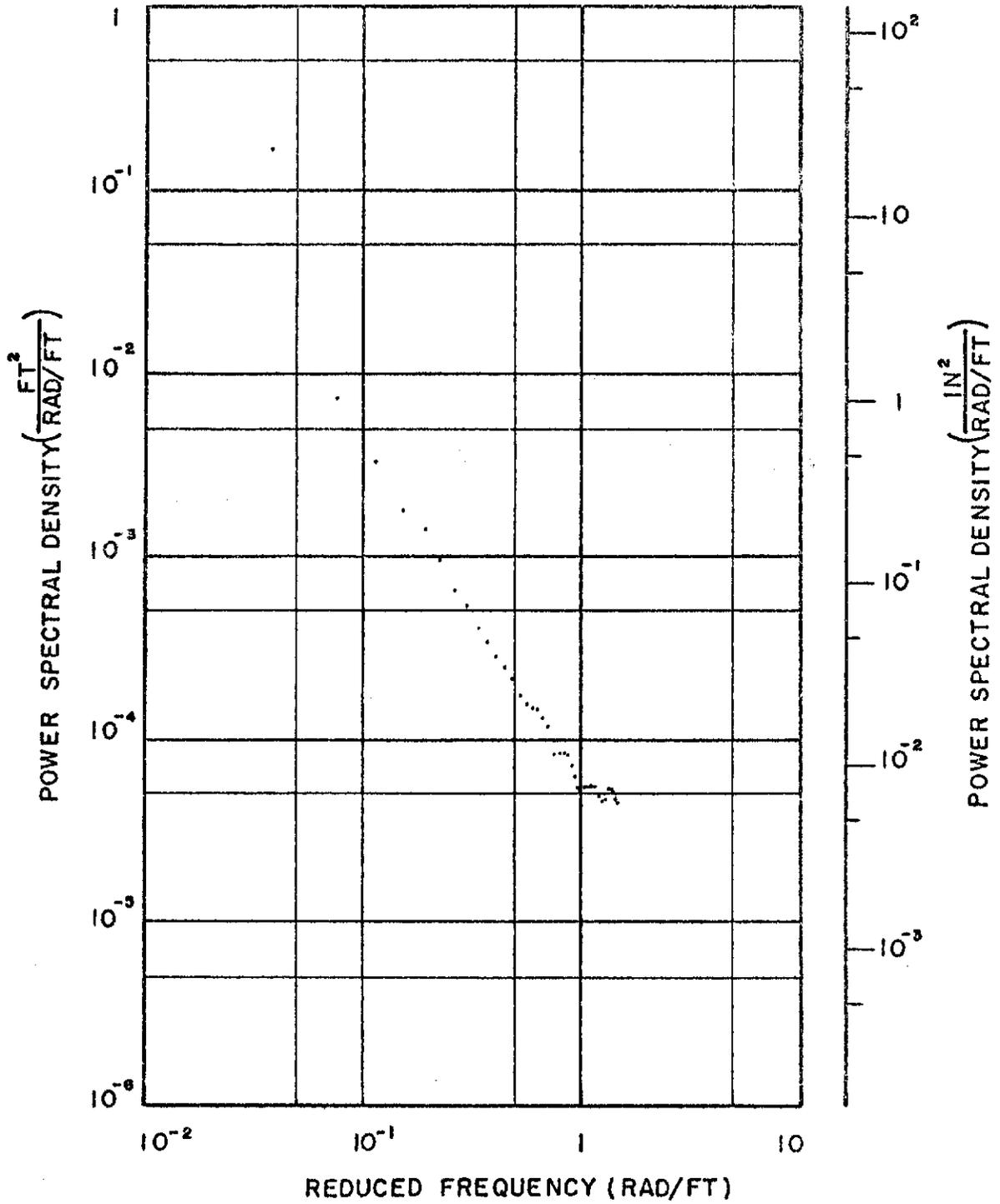
Runway 66

Contrails



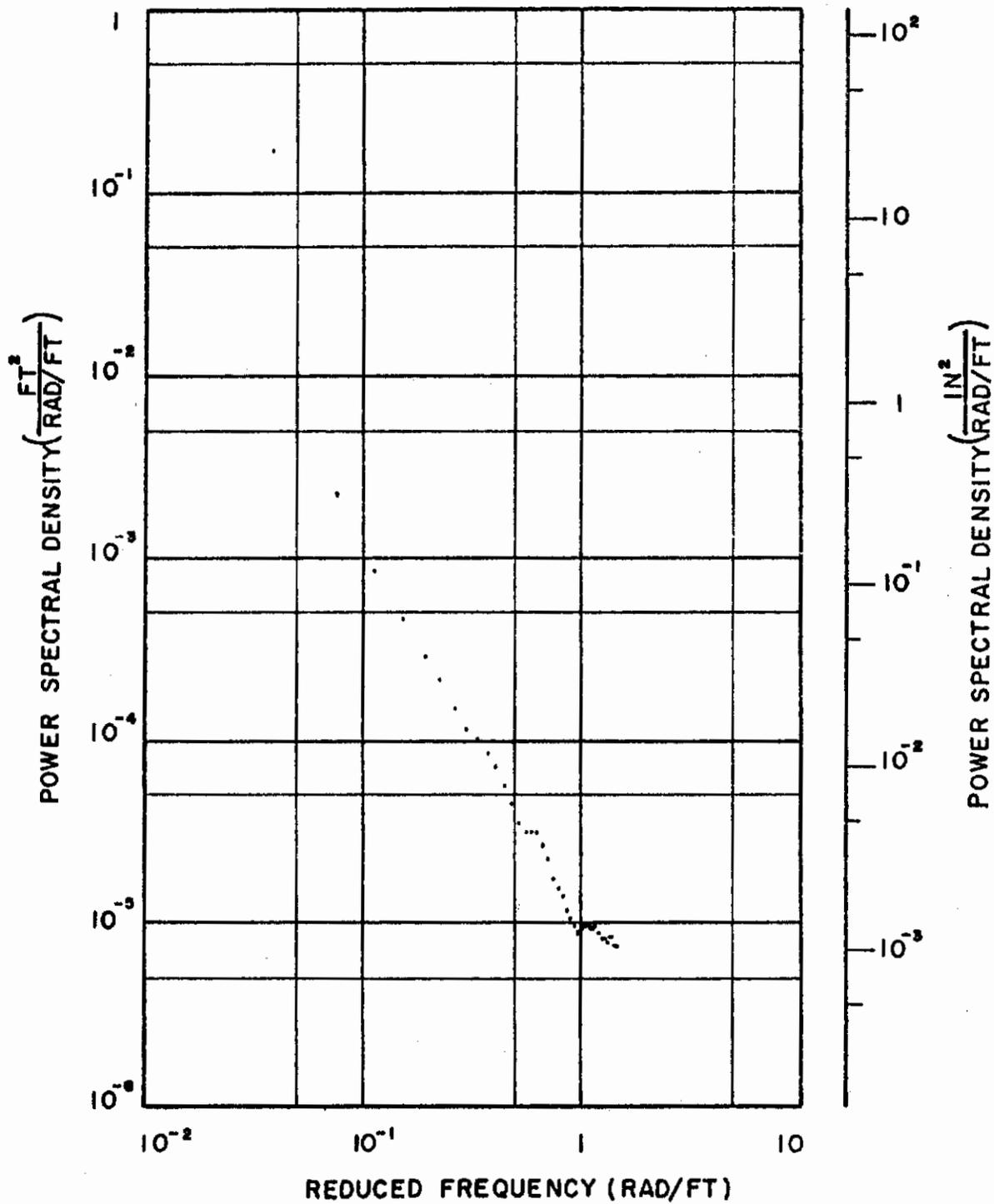
Runway 67

Contrails



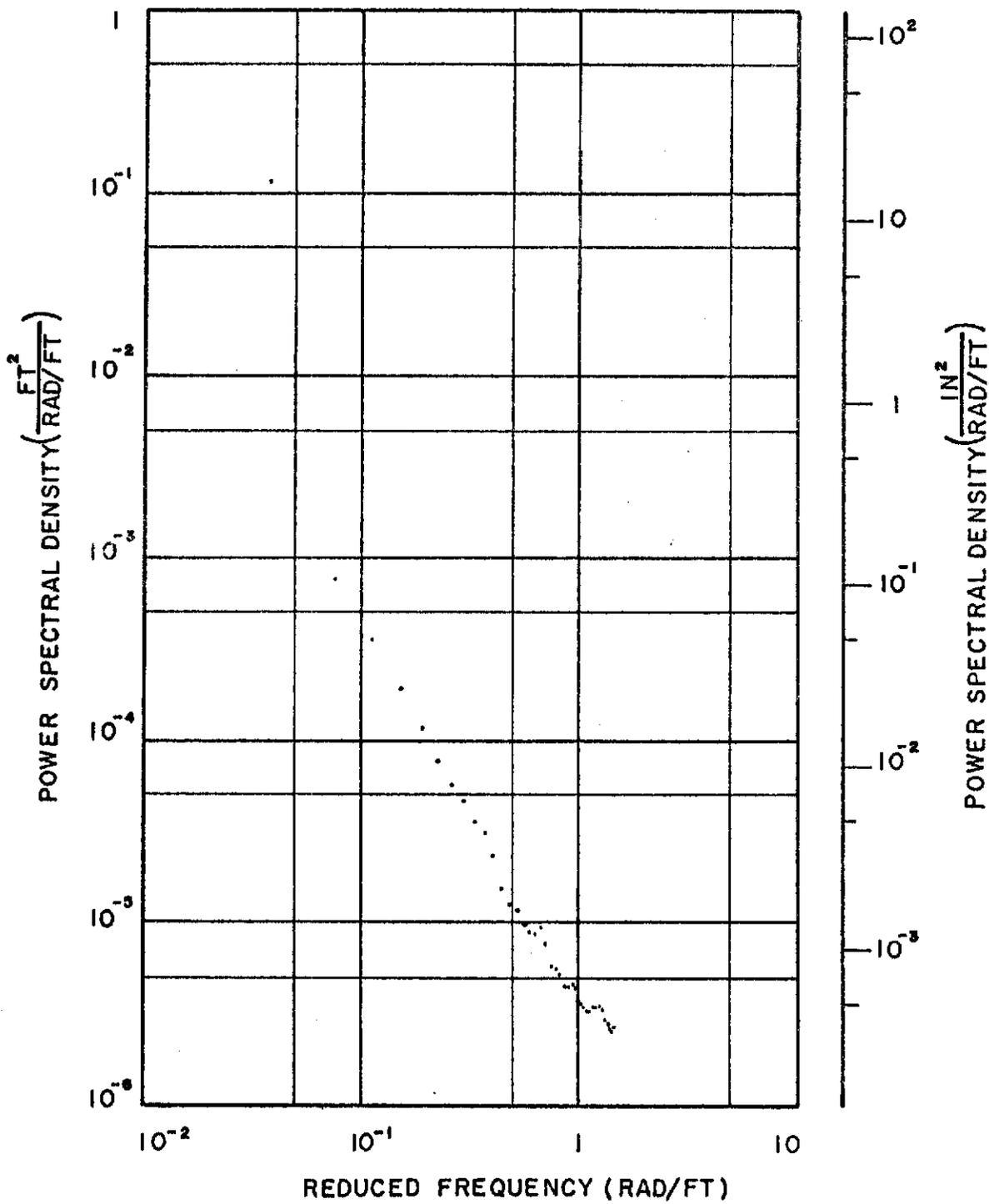
Runway 68

Contrails



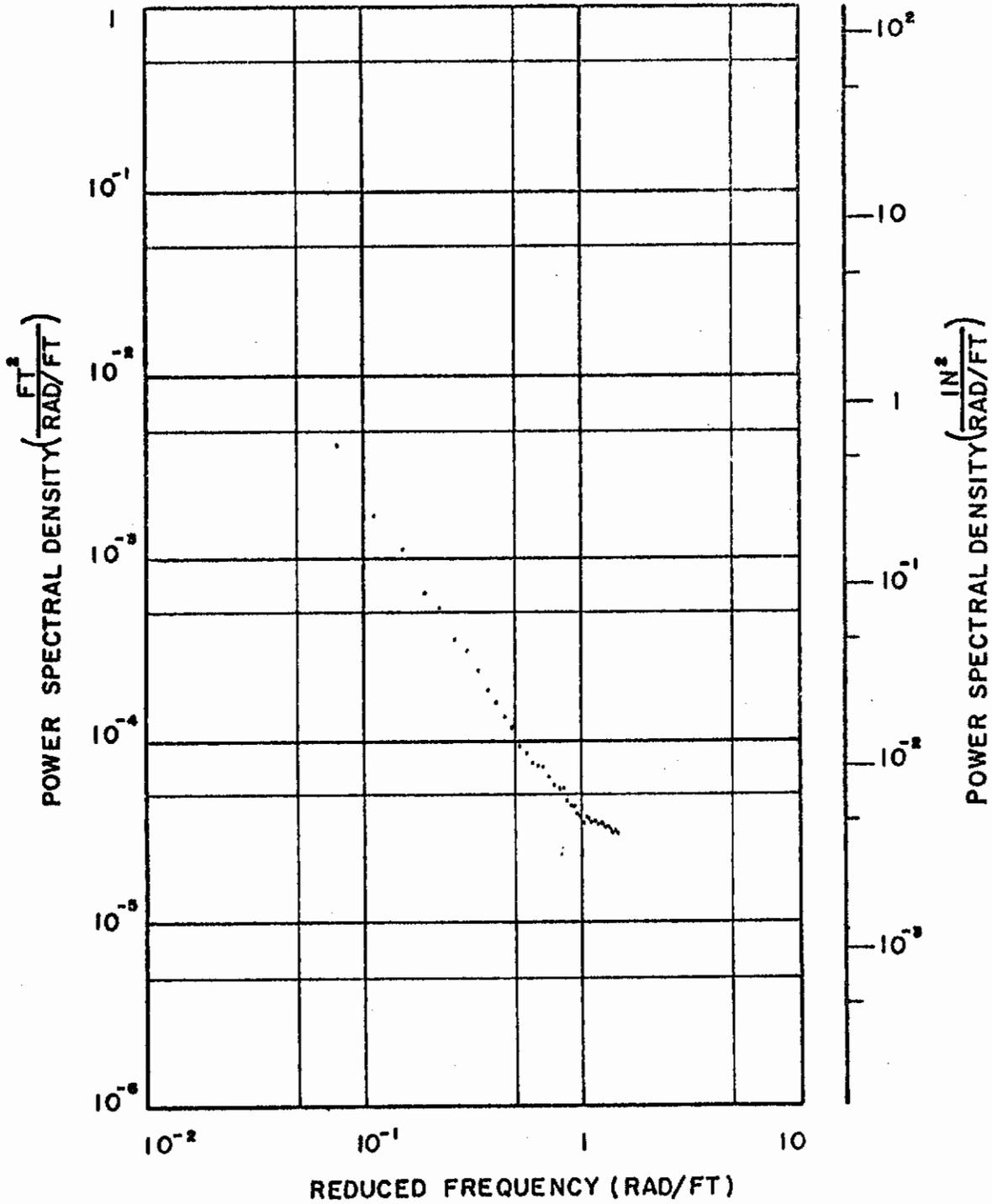
Runway 69

Contrails



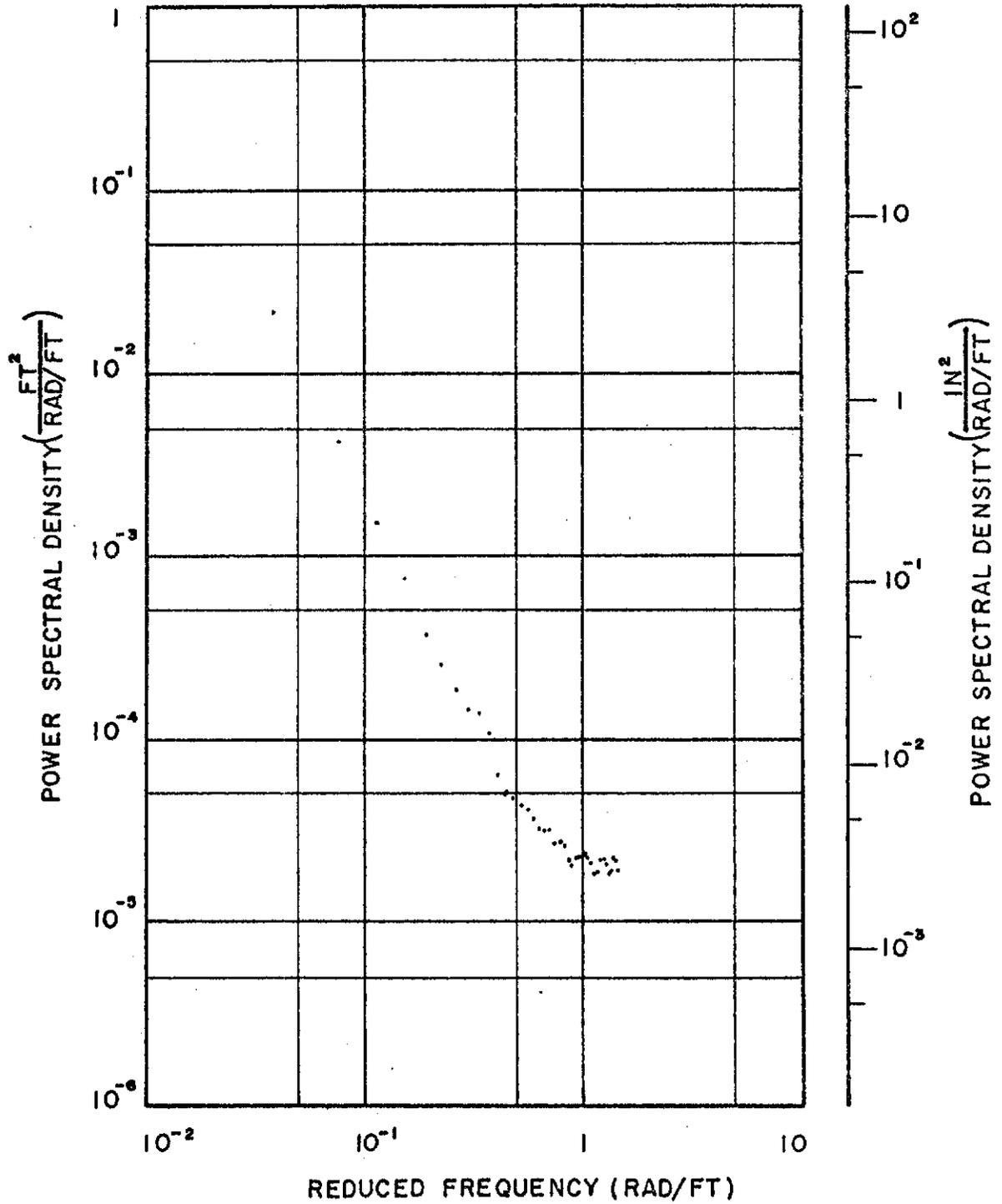
Runway 70

Contrails



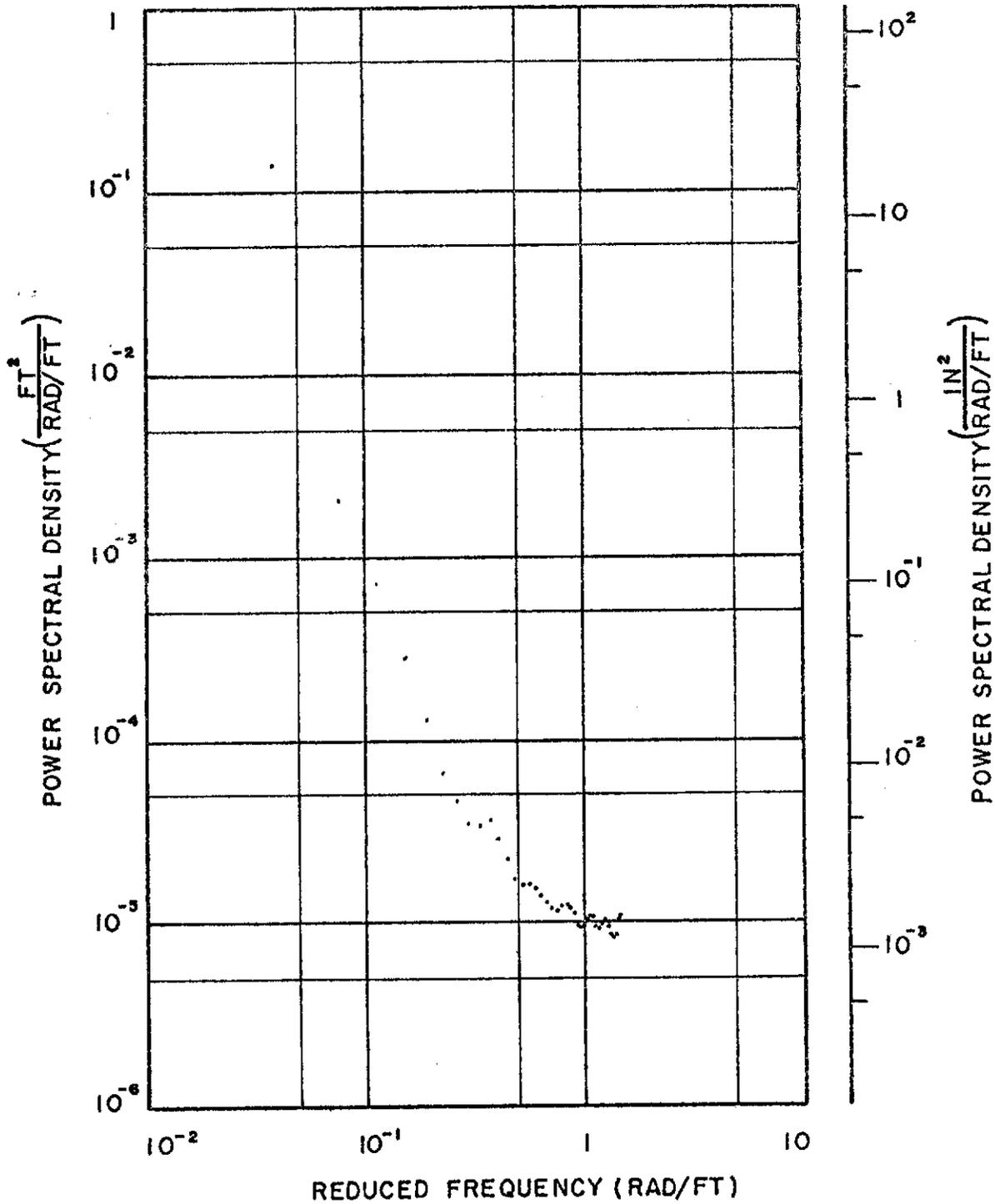
Runway 71

Contrails



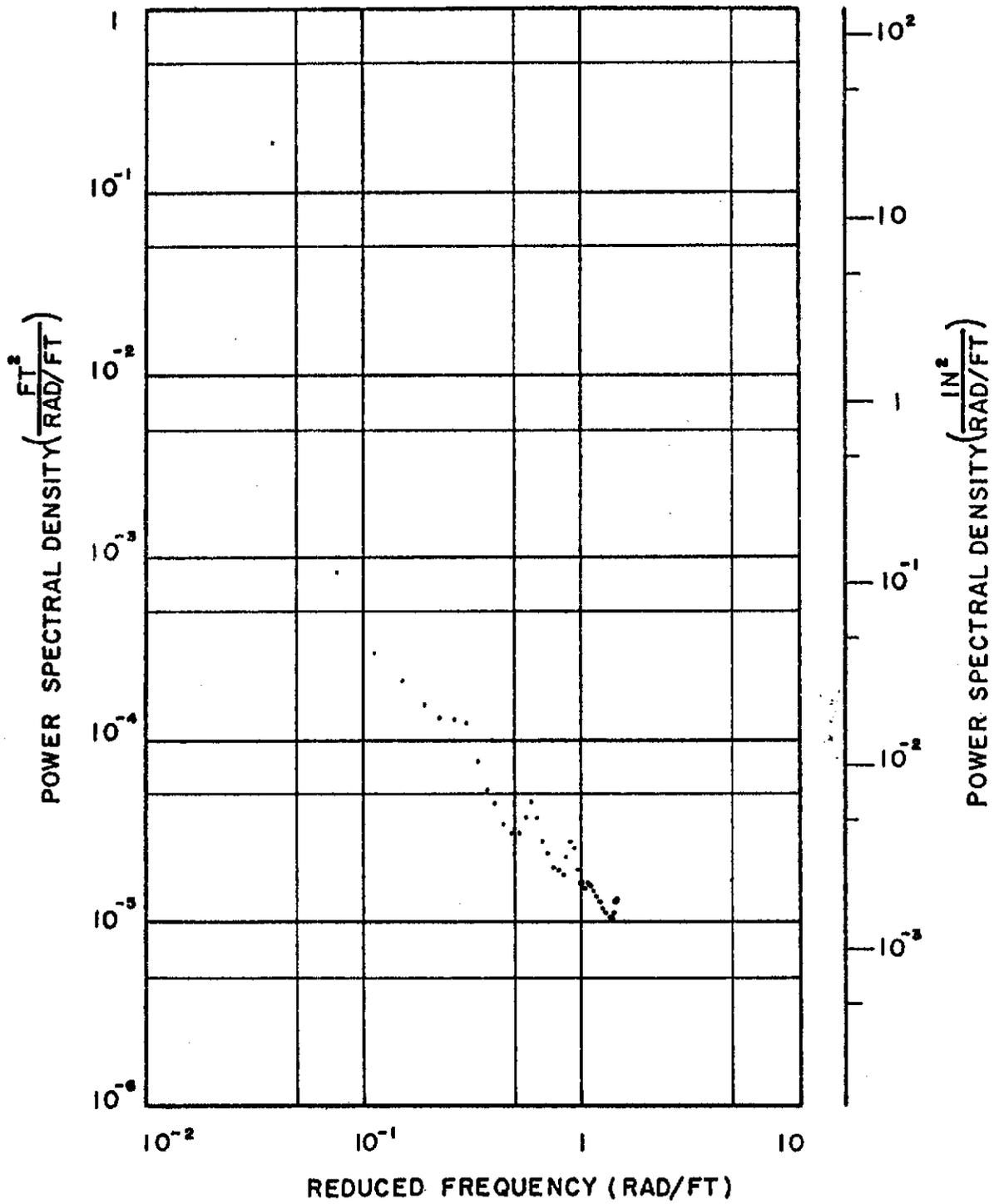
Runway 72

Contrails



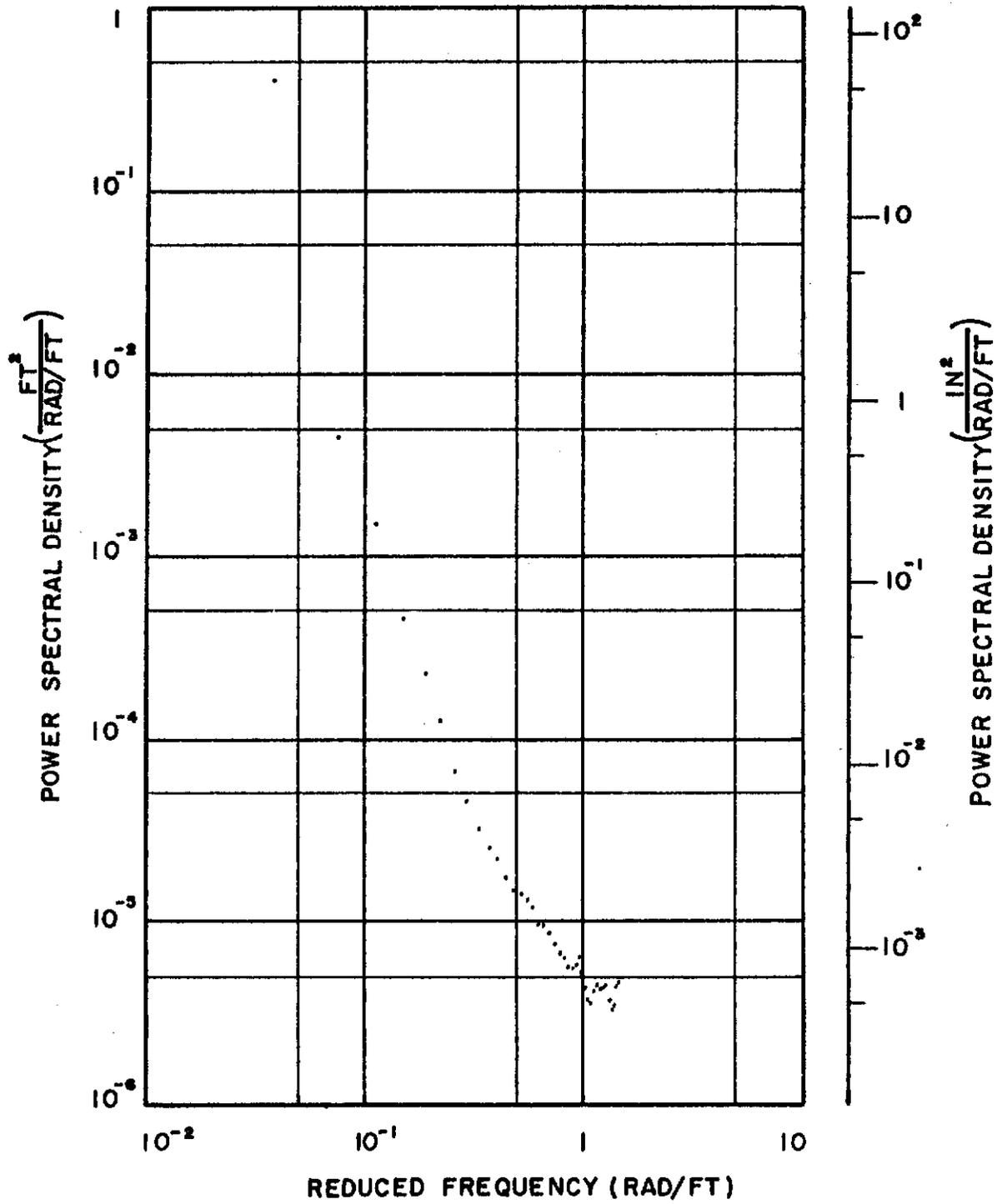
Runway 73

Contrails



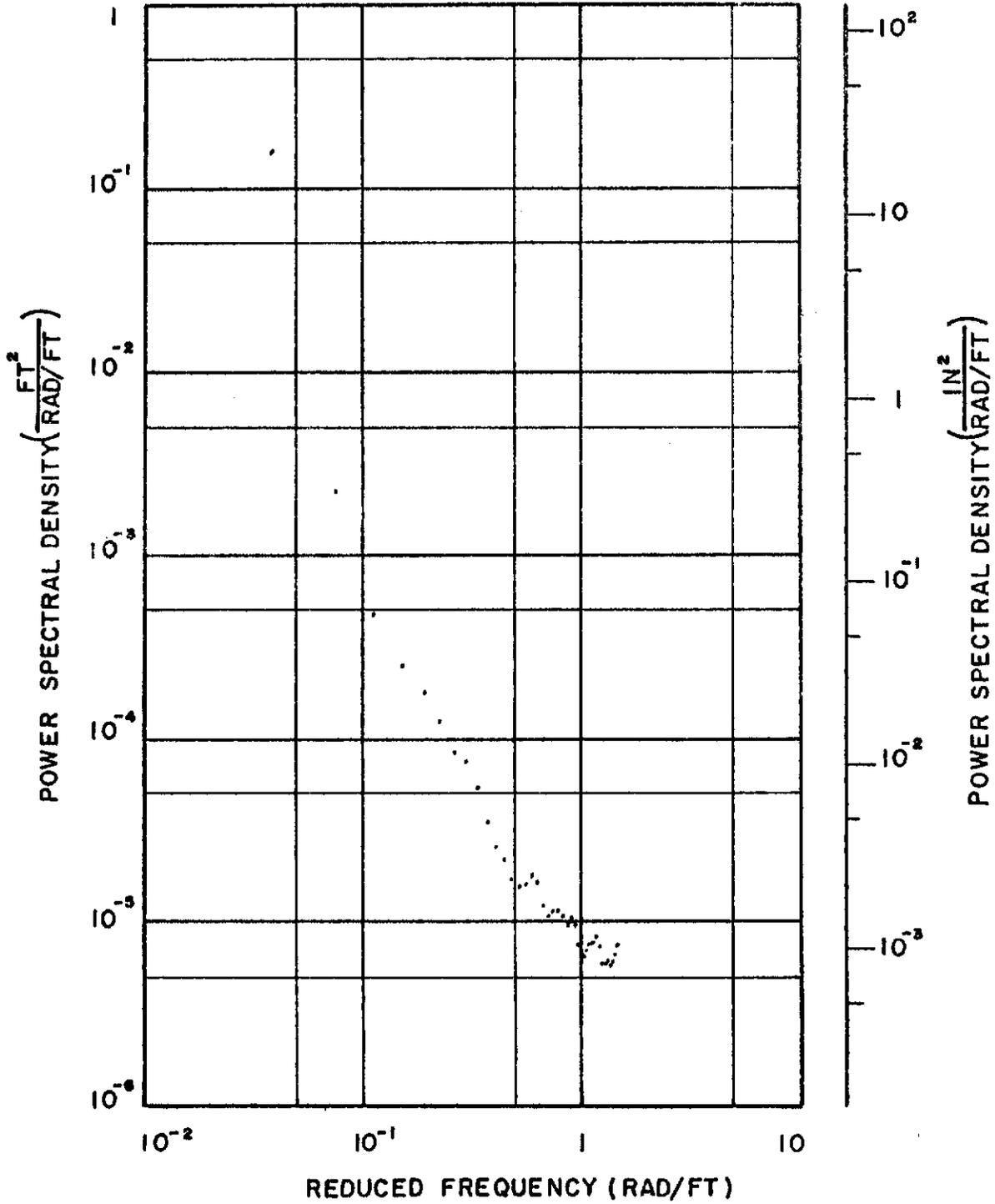
Runway 74

Contrails



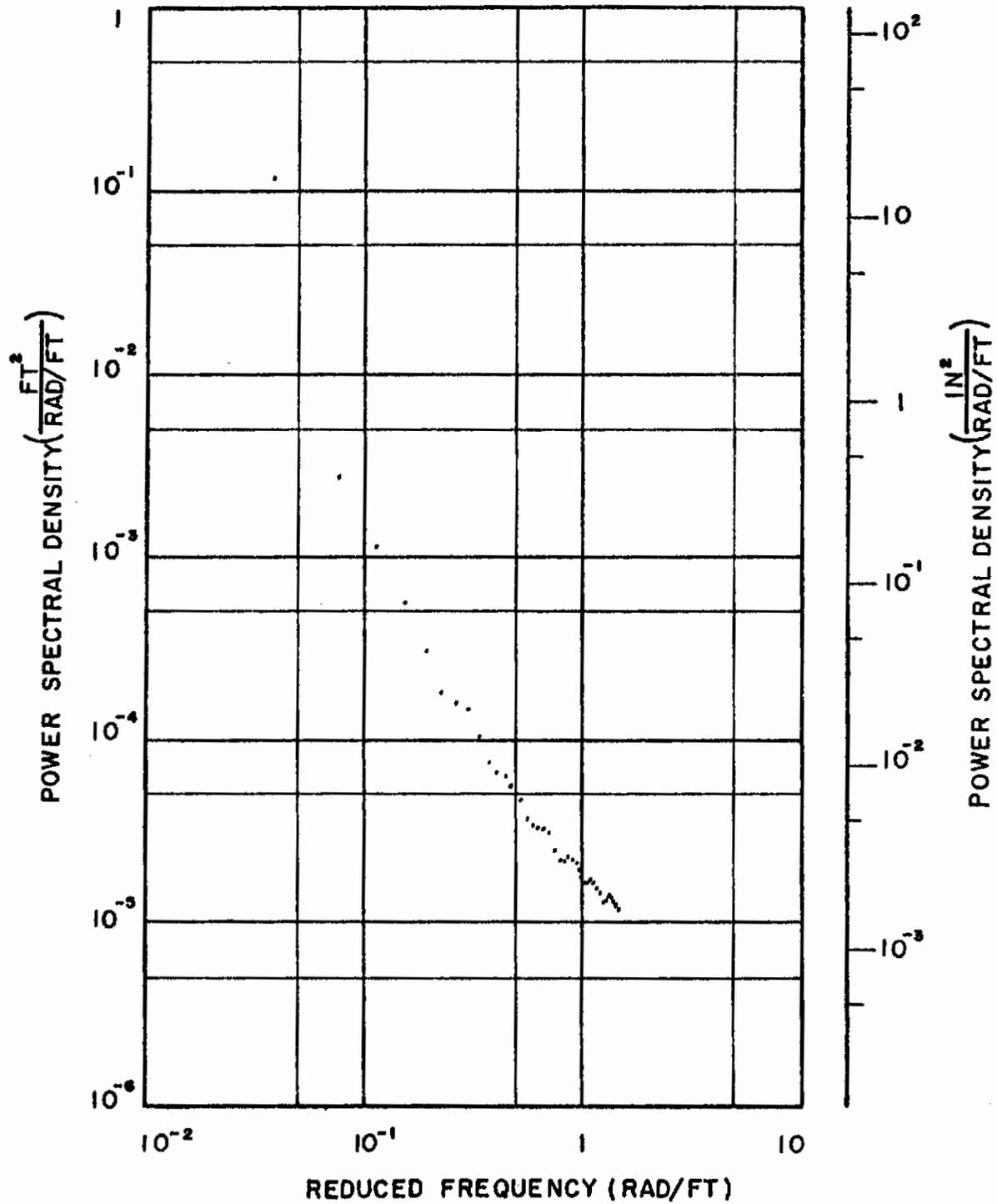
Runway 75

Contrails



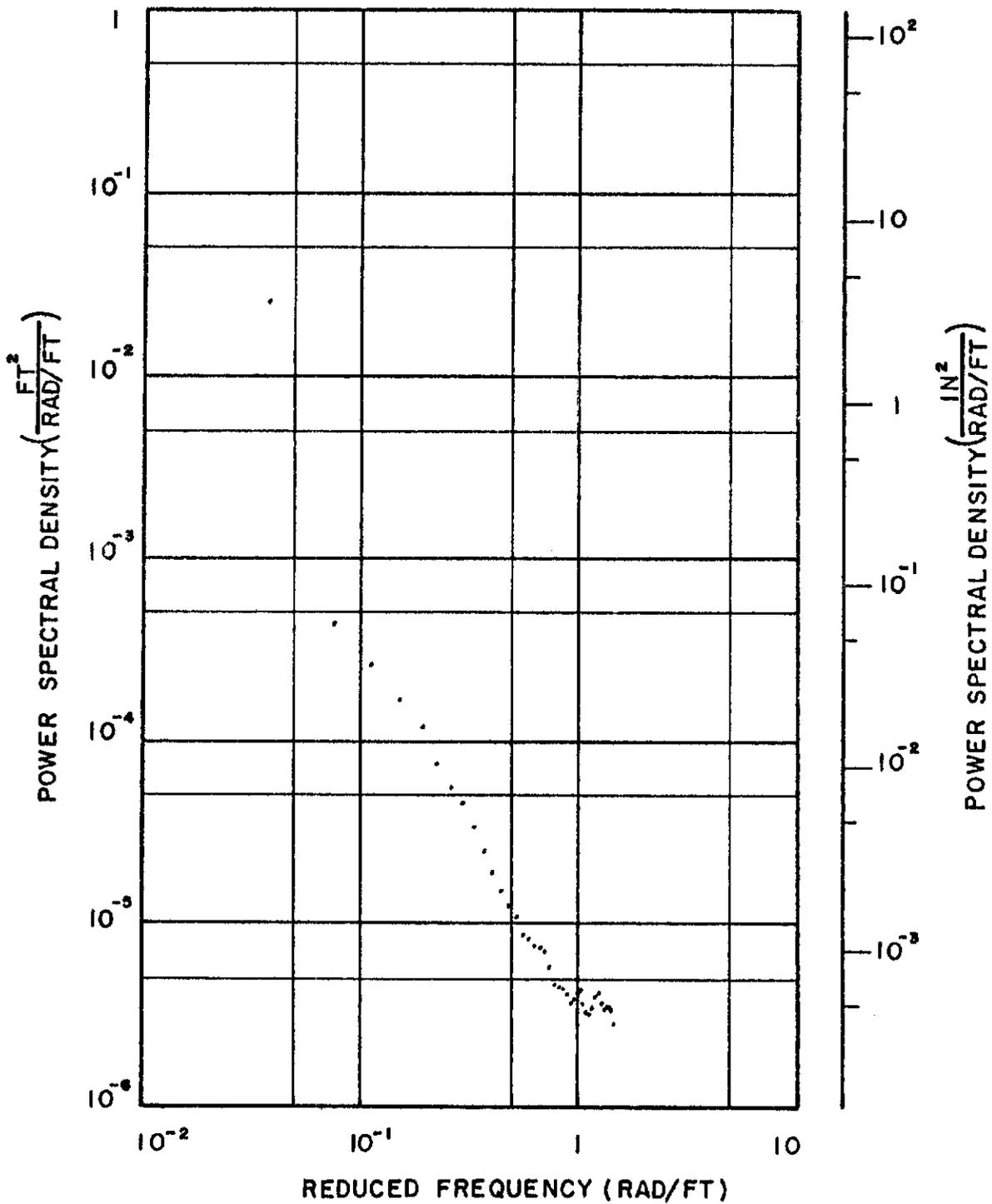
Runway 76

Contrails



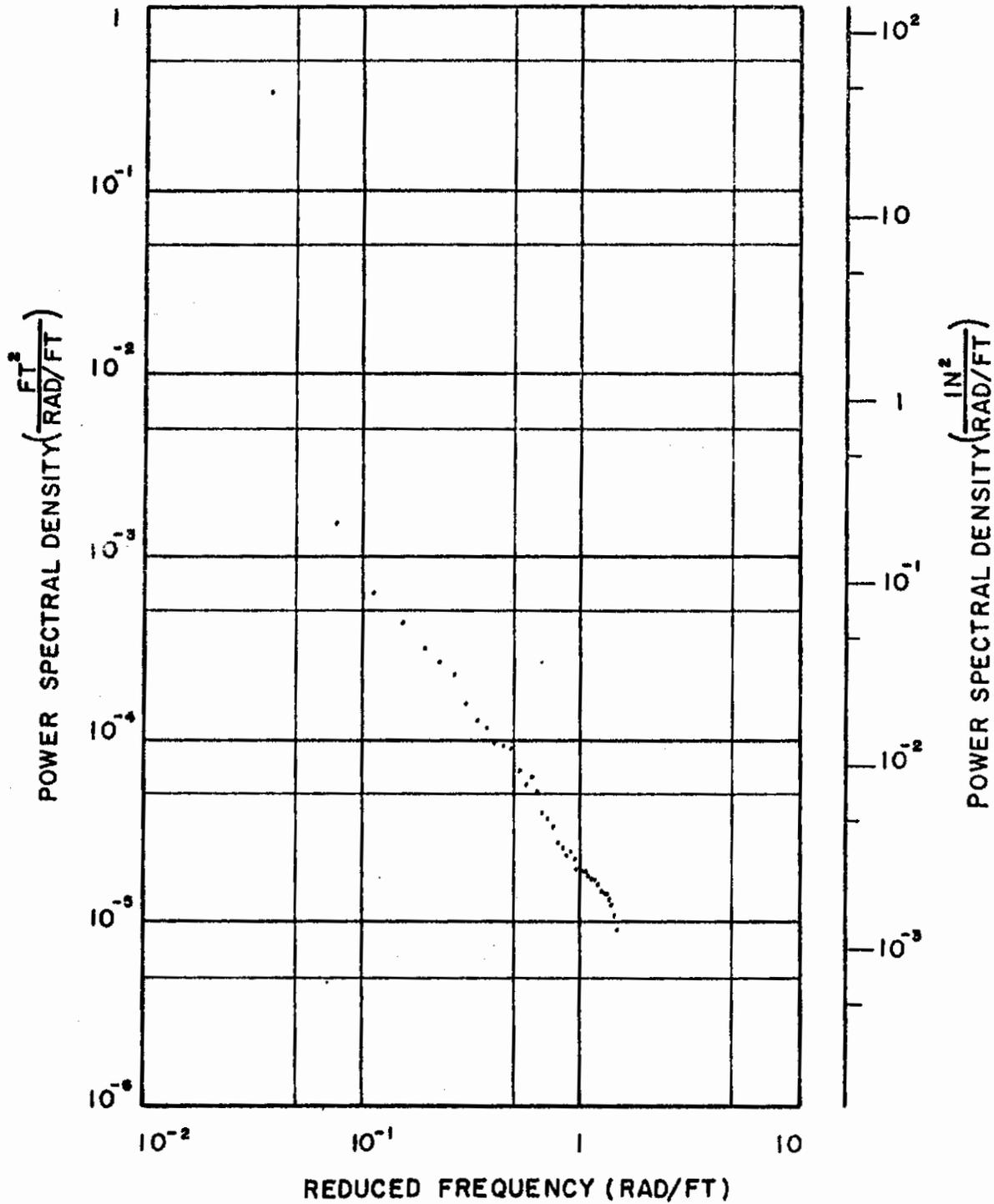
Runway 77

Contrails



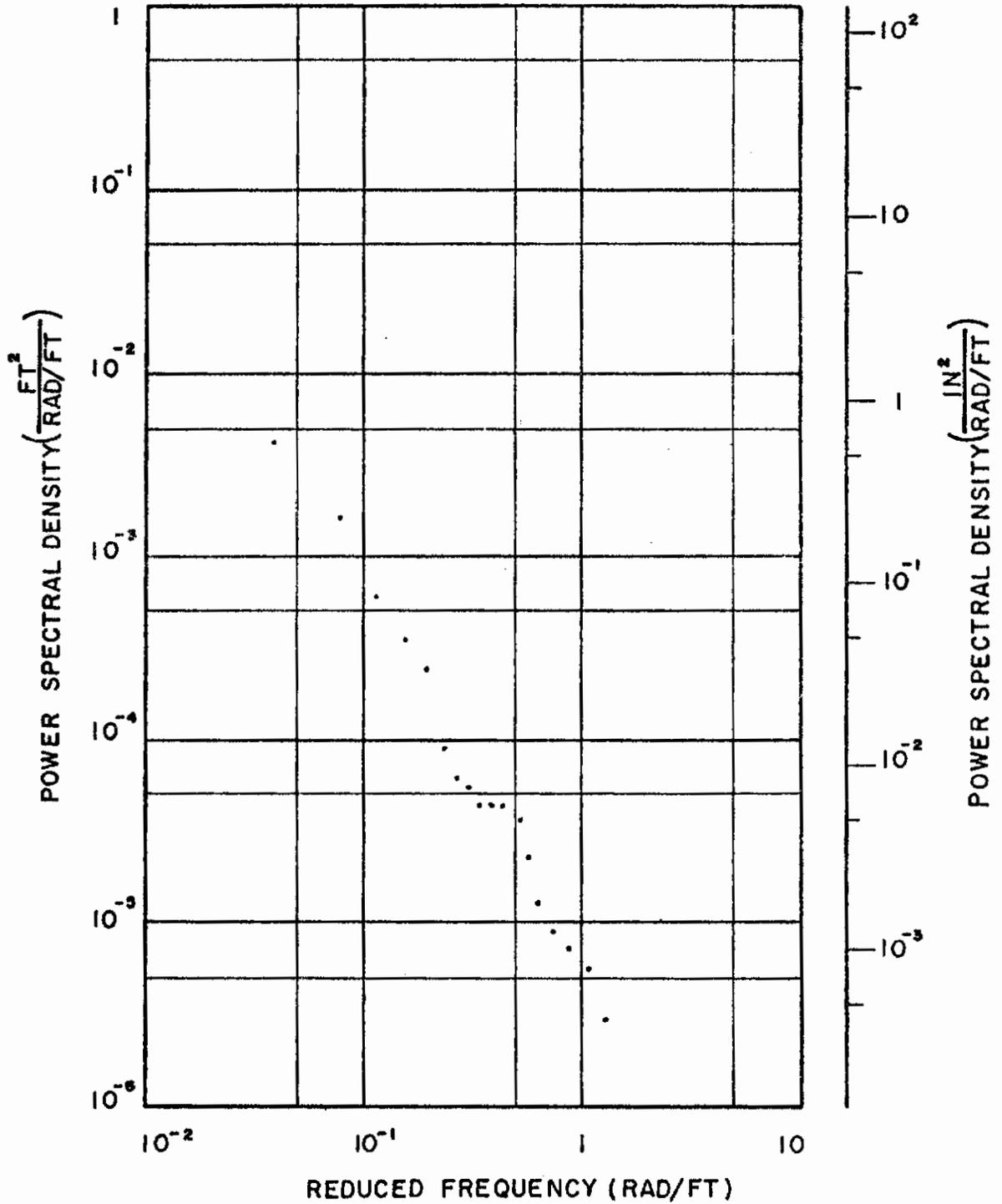
Runway 78

Contrails



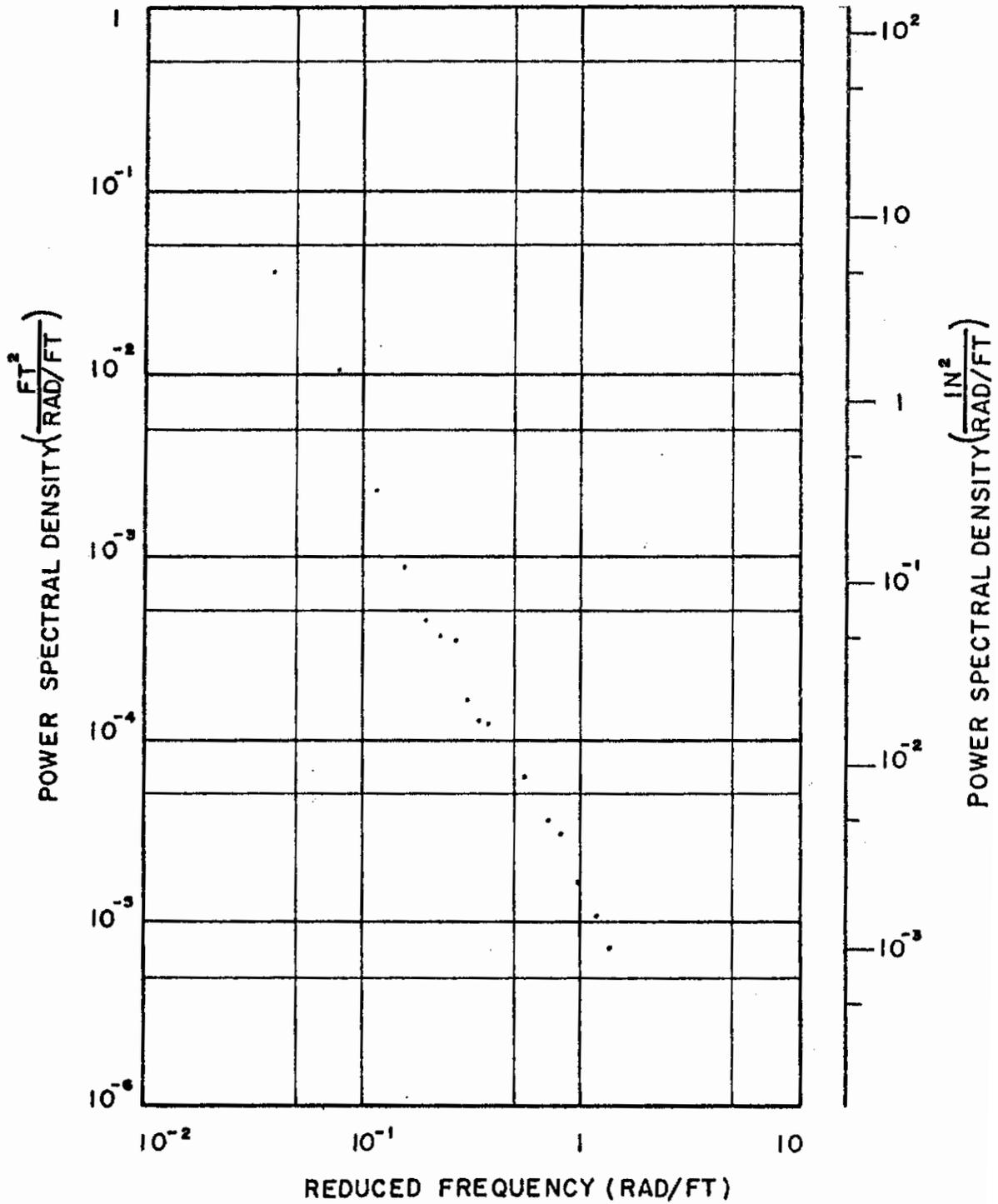
Runway 79

Contrails



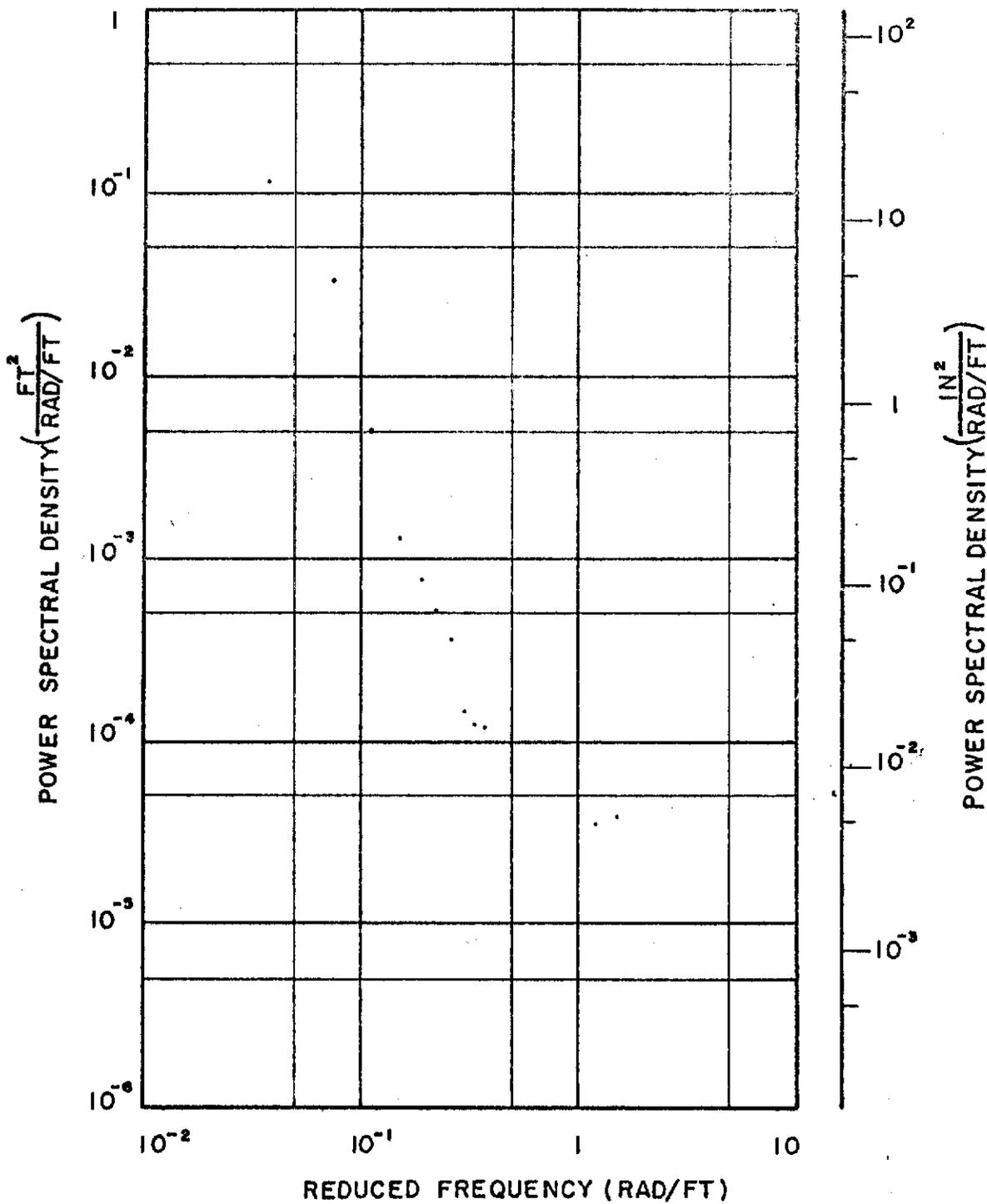
Runway 81

Contrails



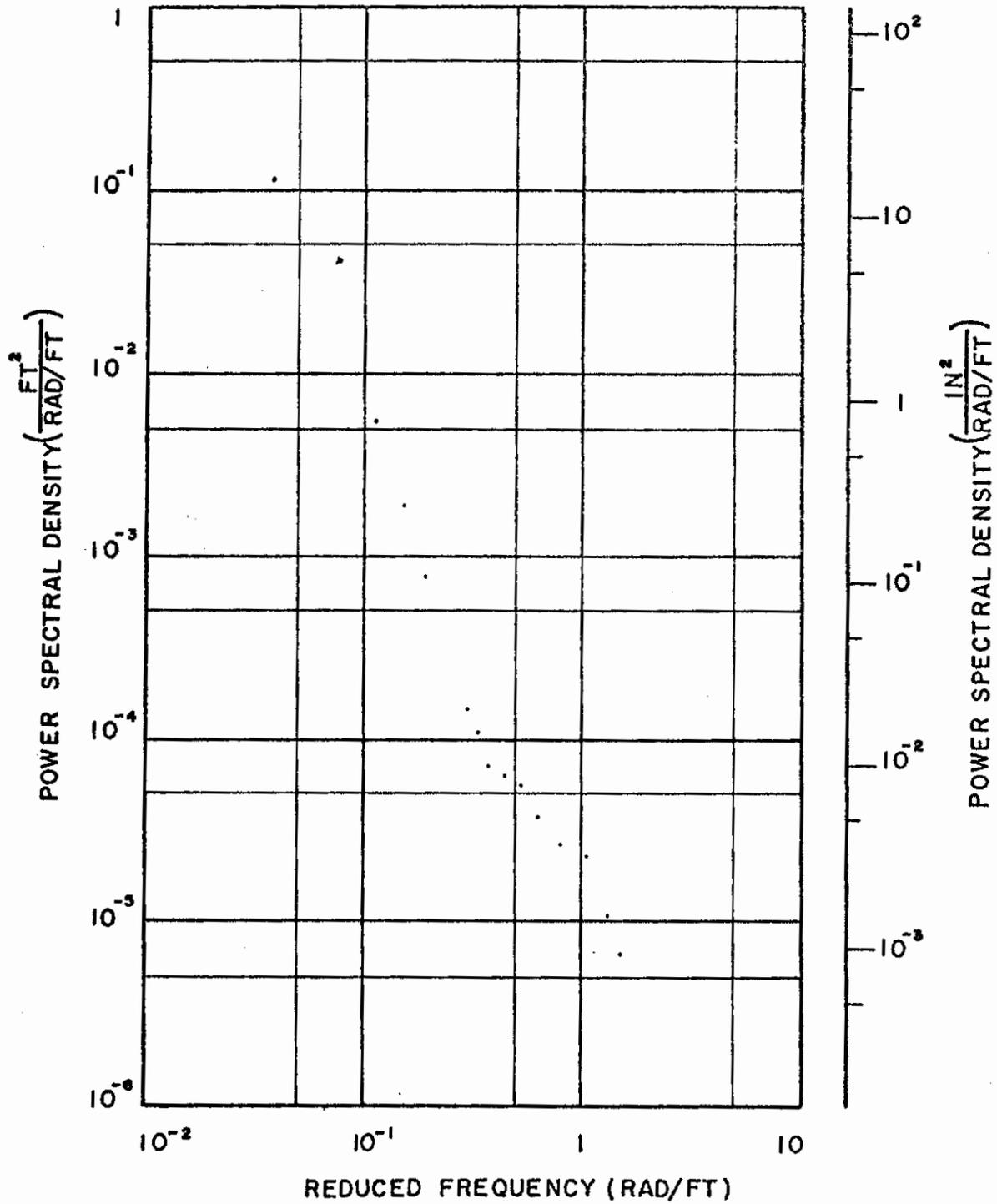
Runway 82

Contrails



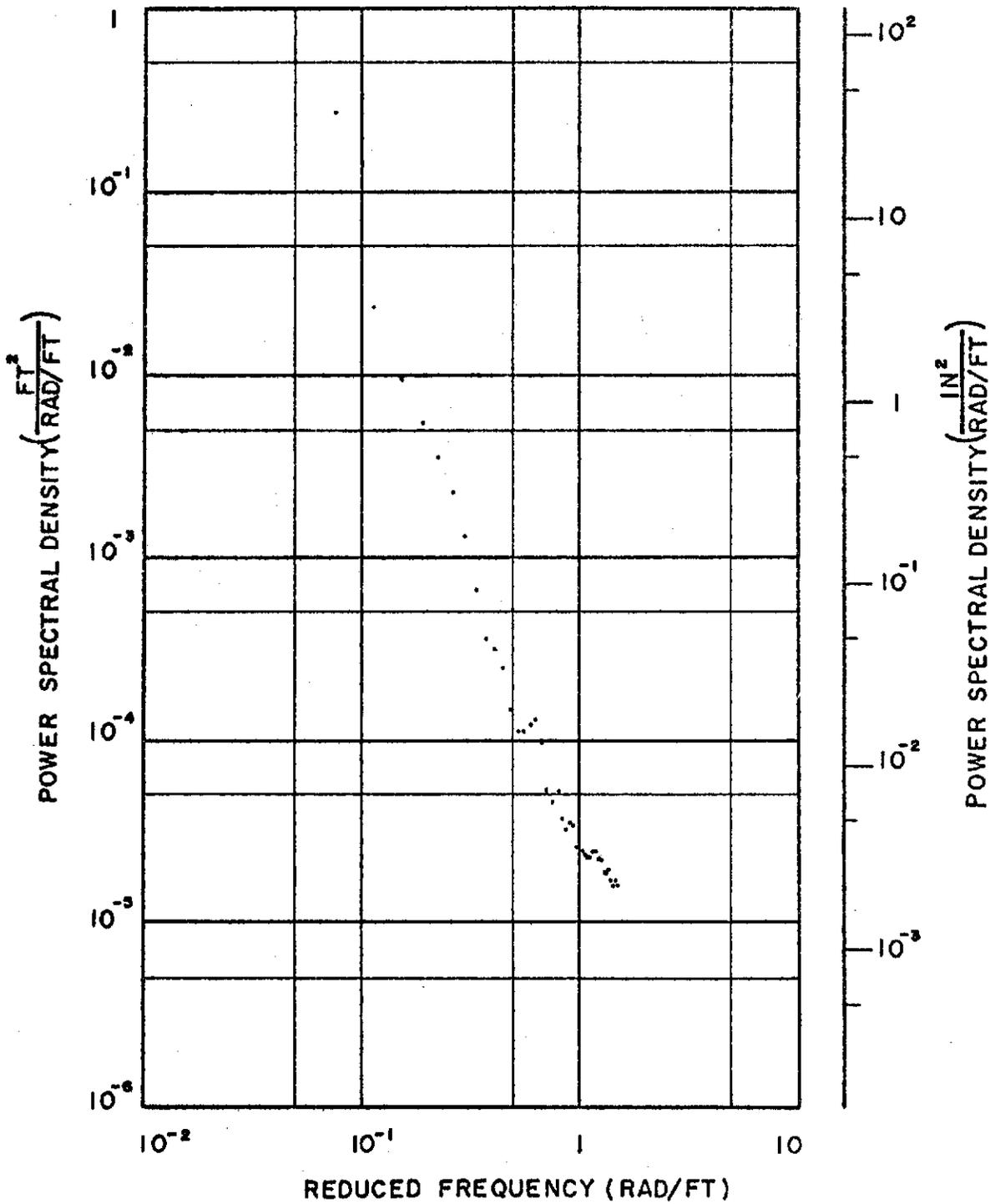
Runway 84
(Computed by Boeing)

Contrails



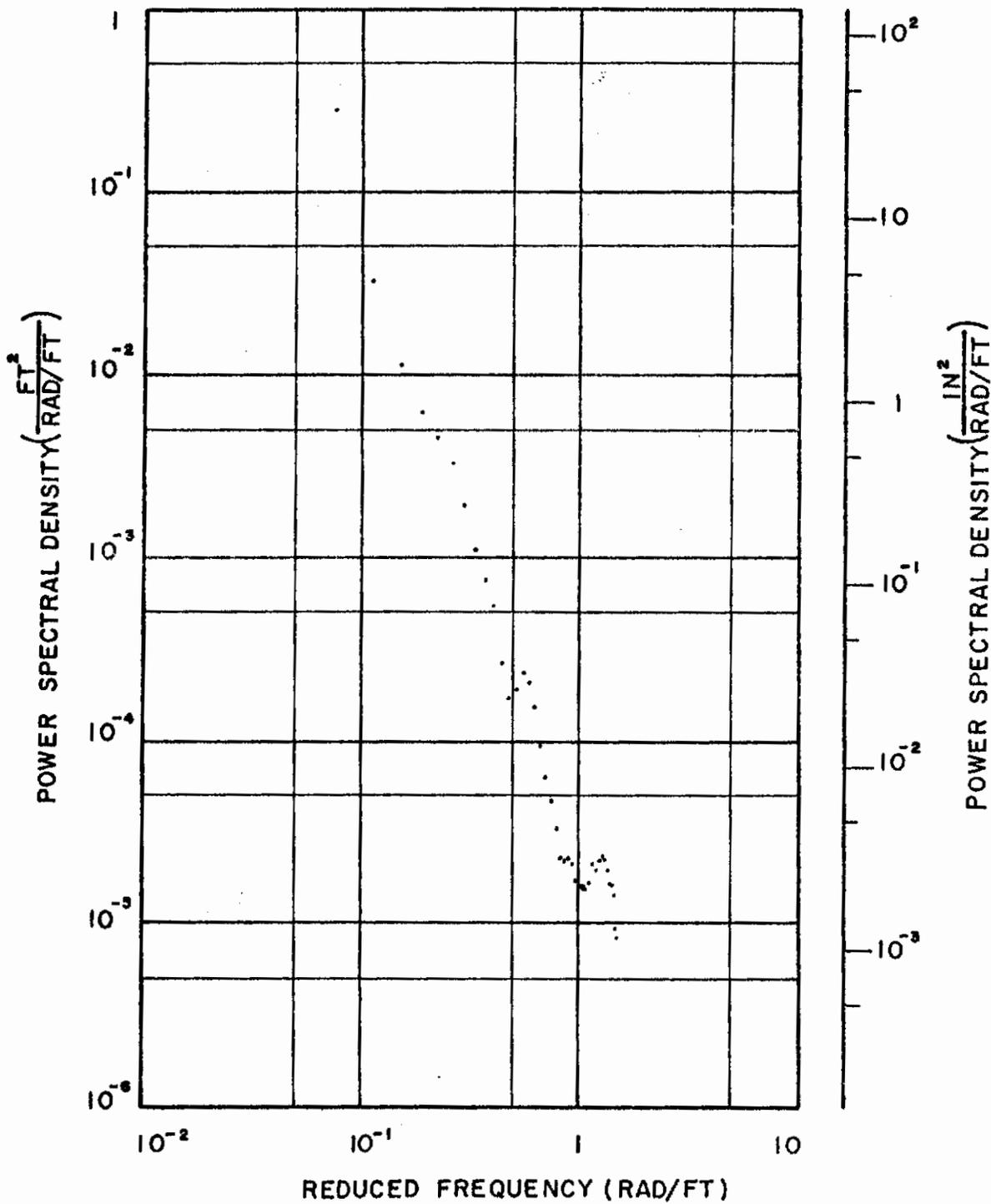
Runway 84
(Computed by NACA)

Contrails



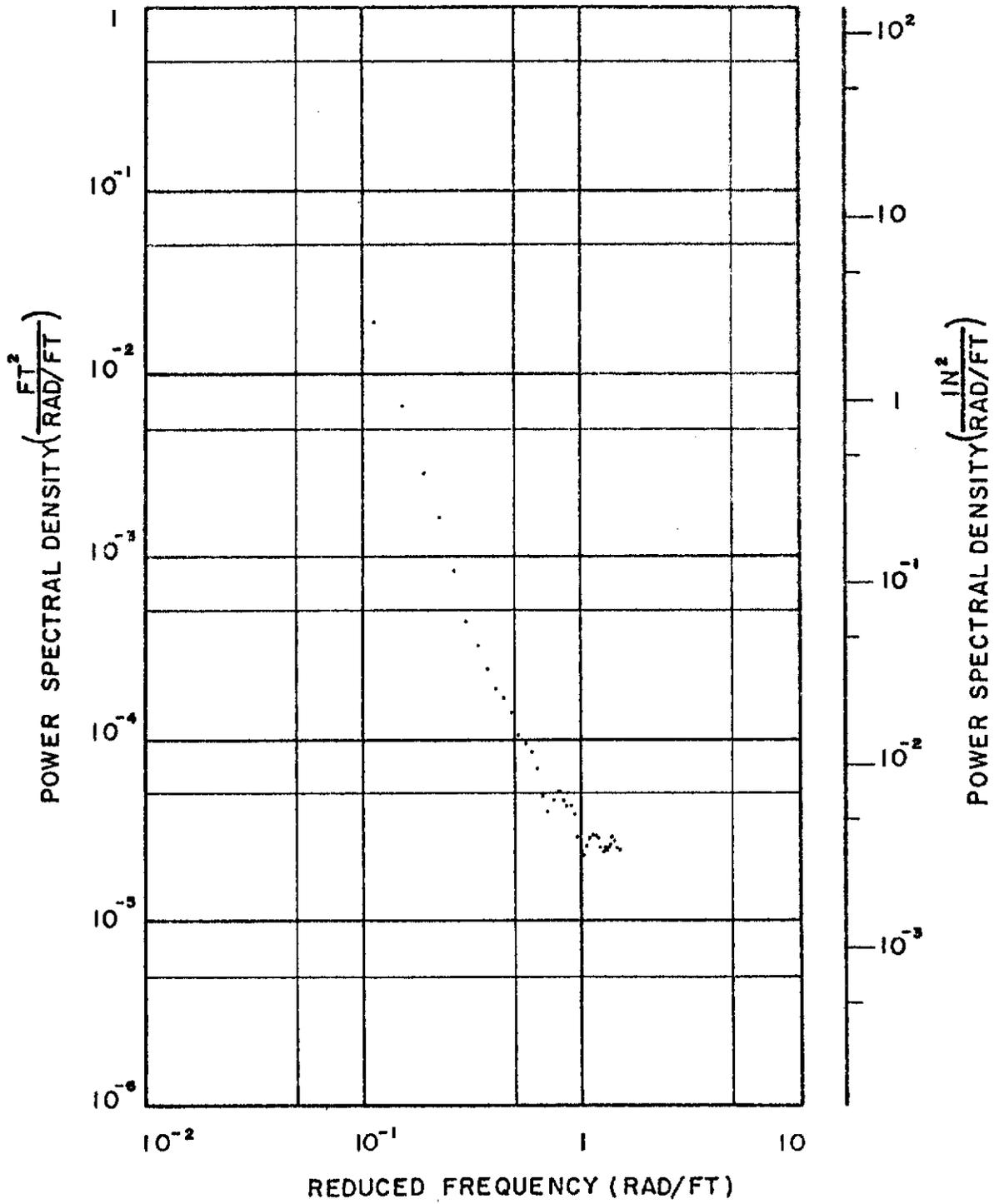
Runway 86

Contrails



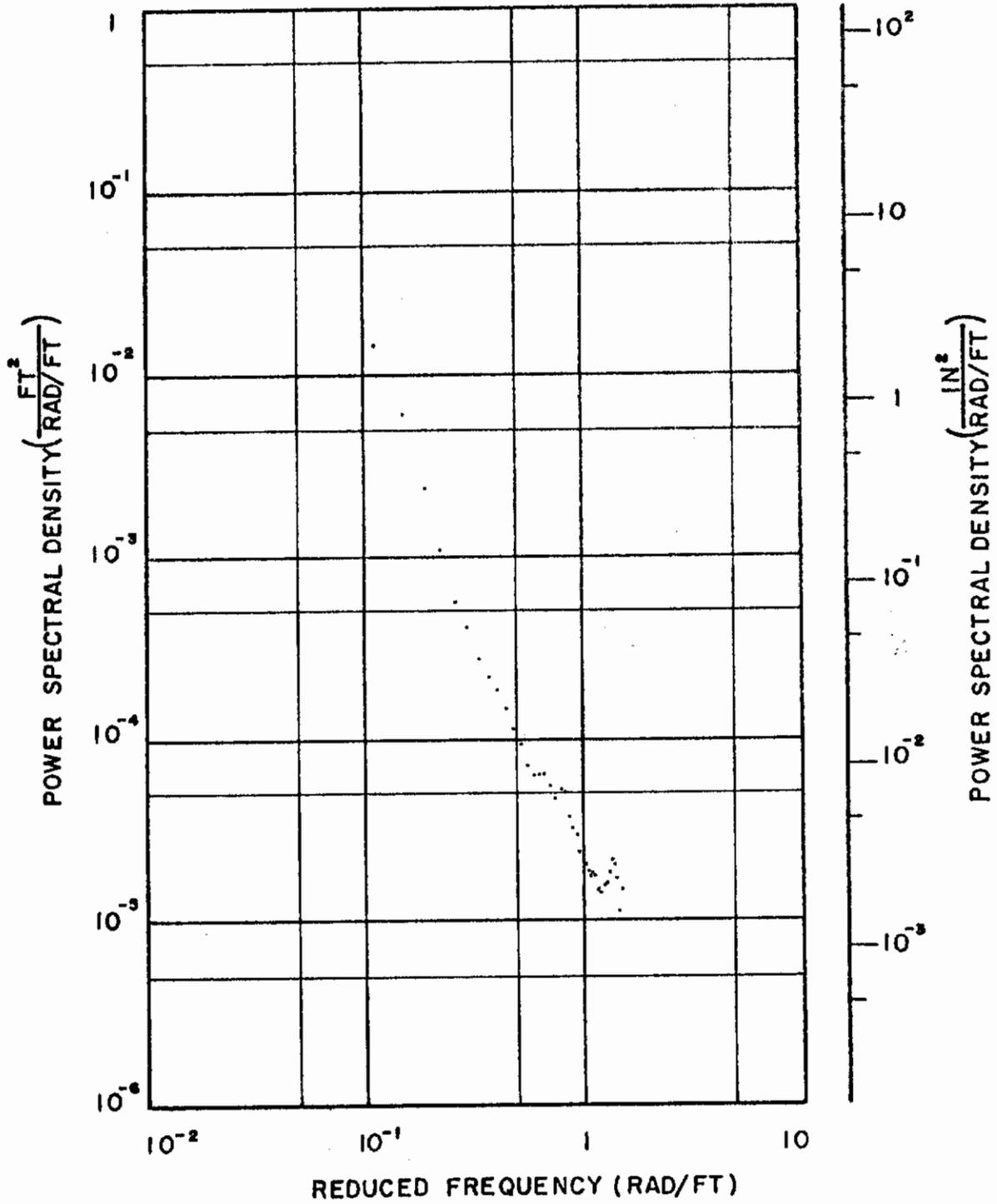
Runway 87

Contrails



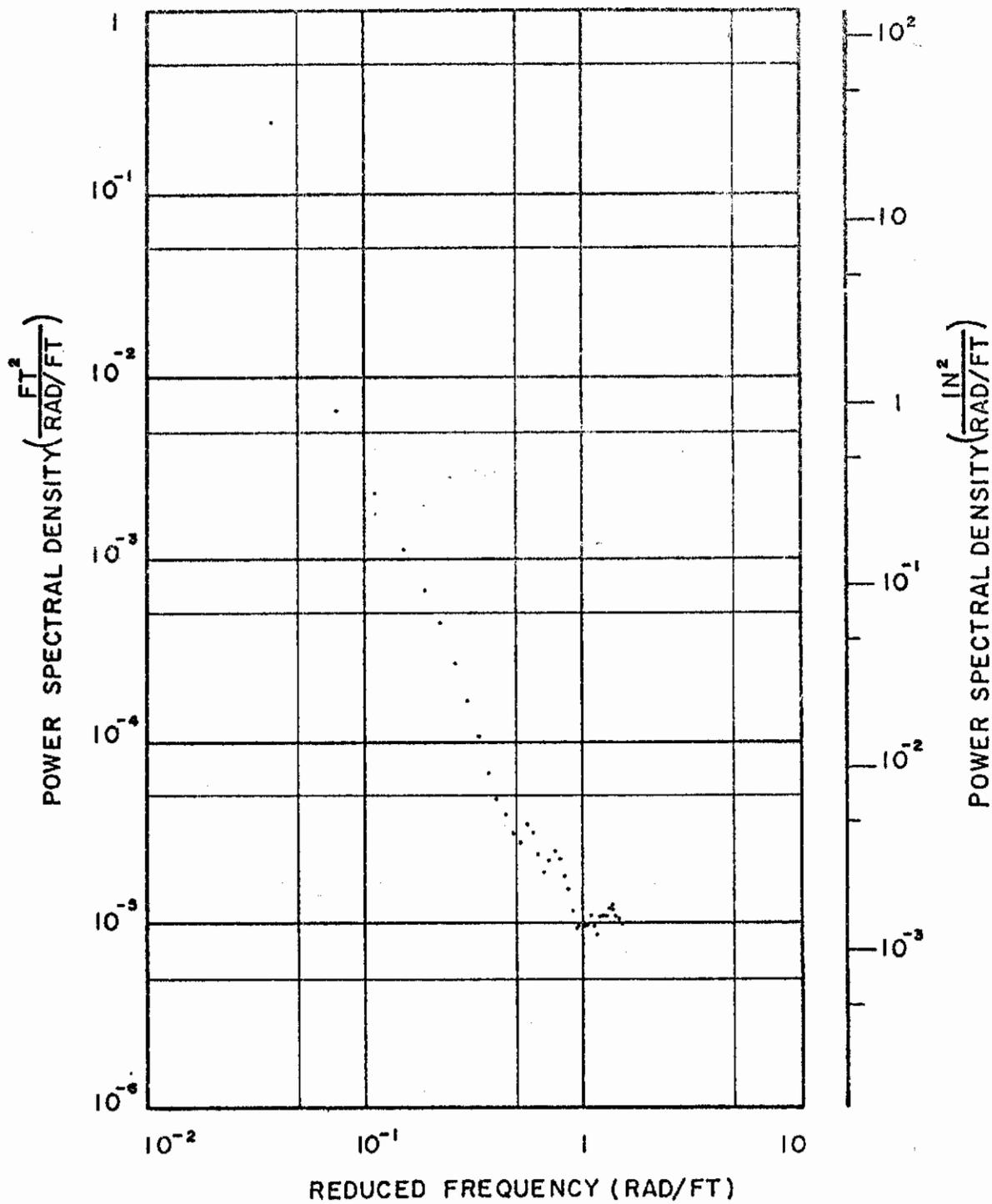
Runway 88

Contrails



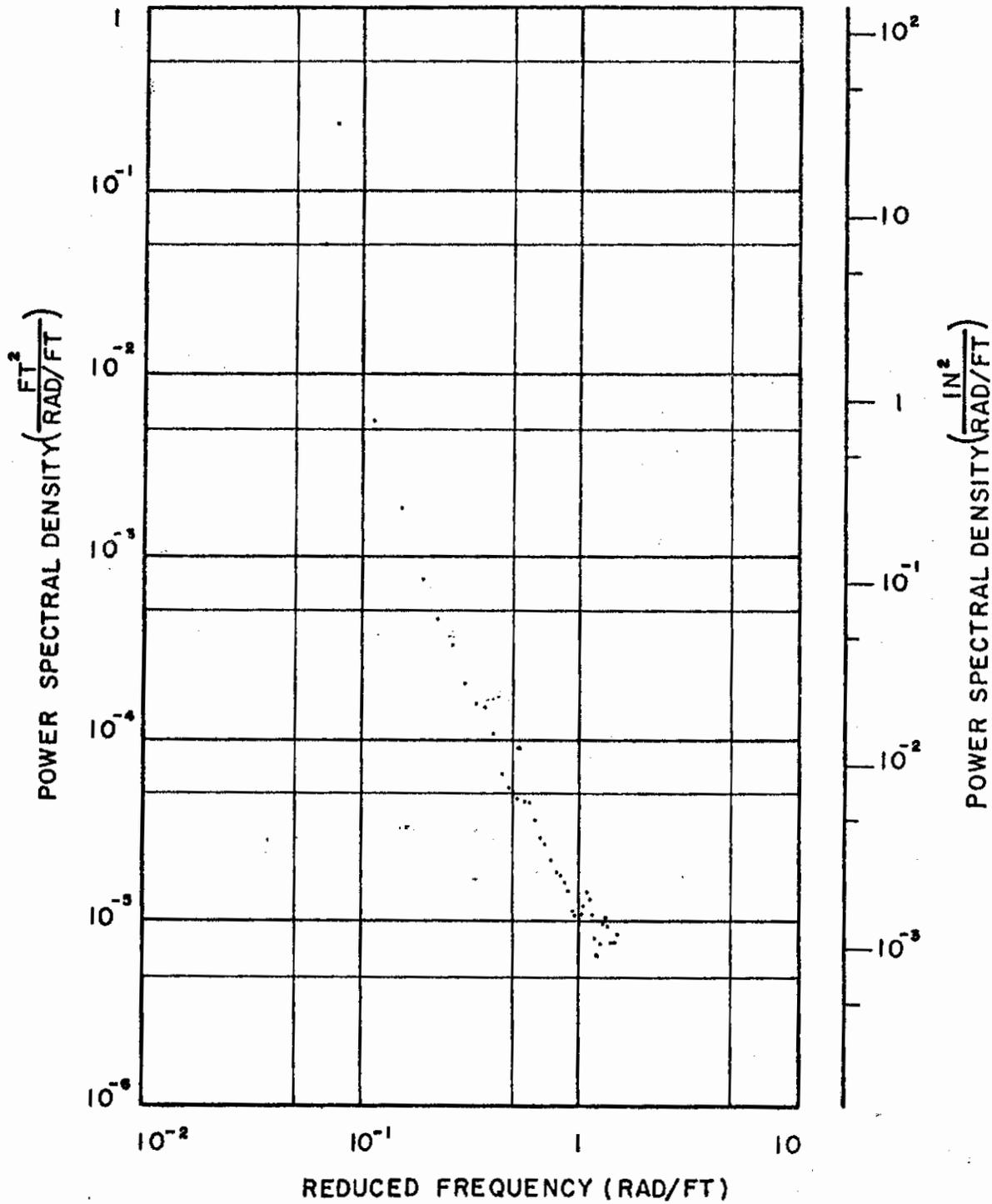
Runway 89

Contrails



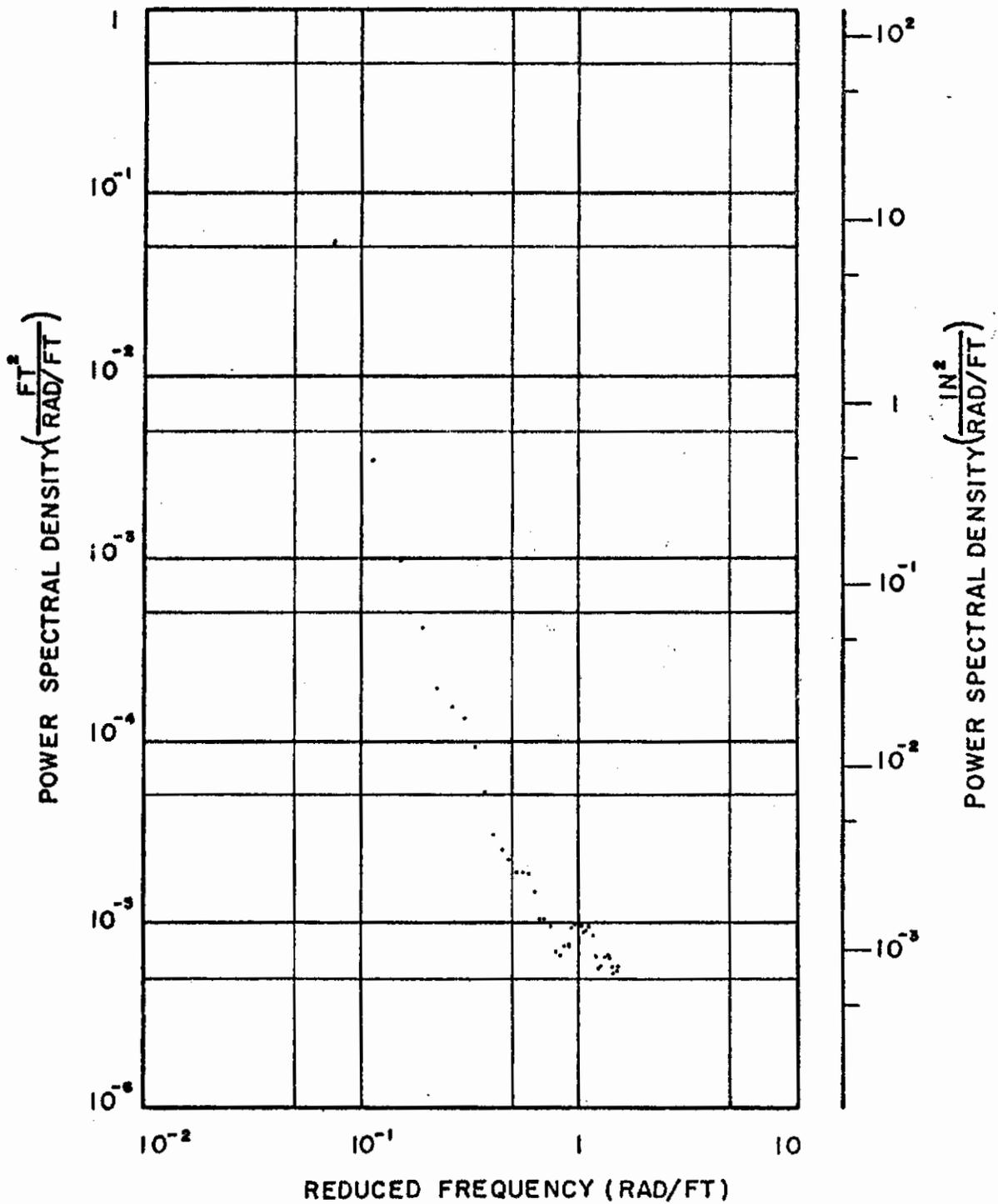
Runway 90

Contrails



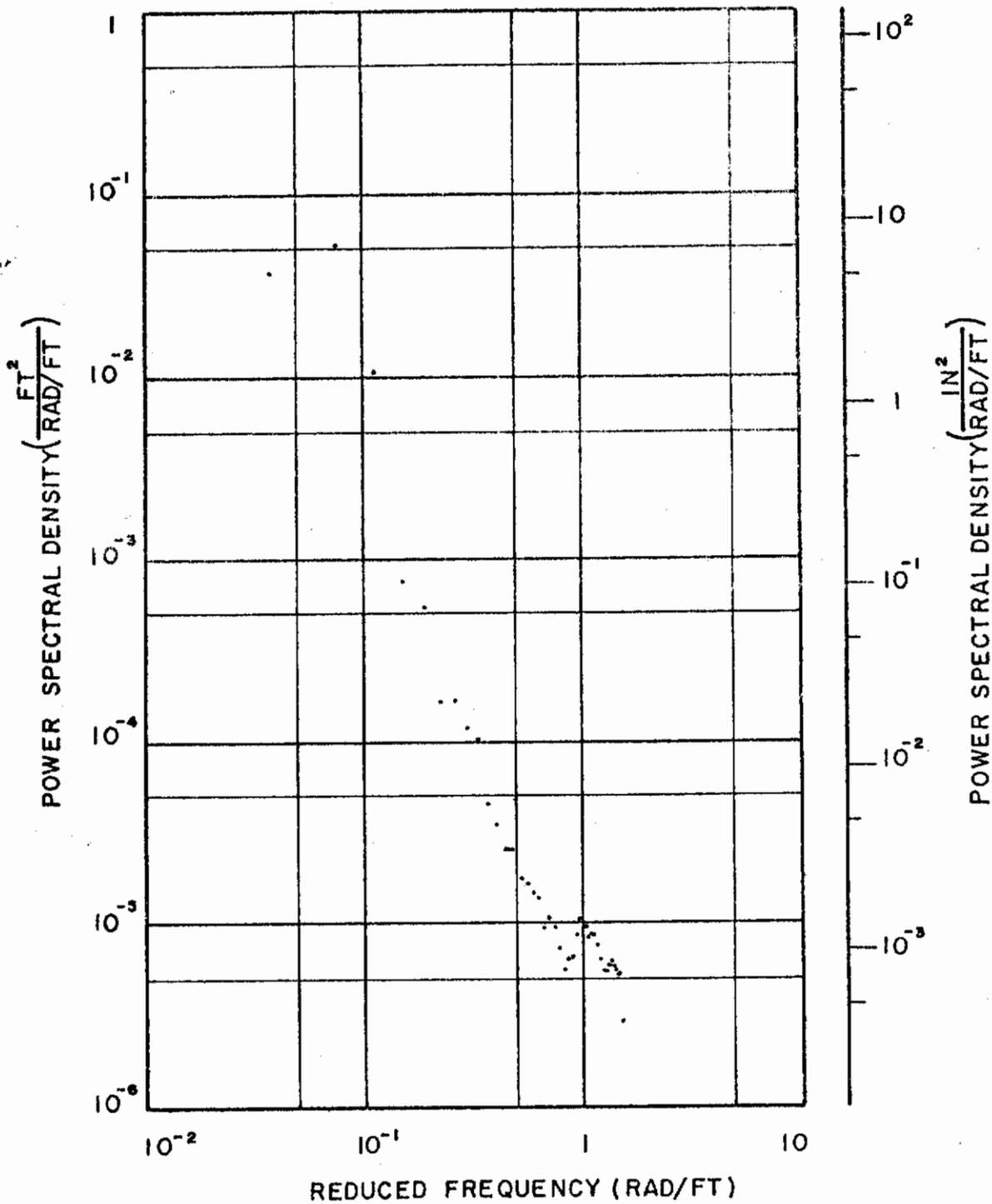
Runway 91

Contrails

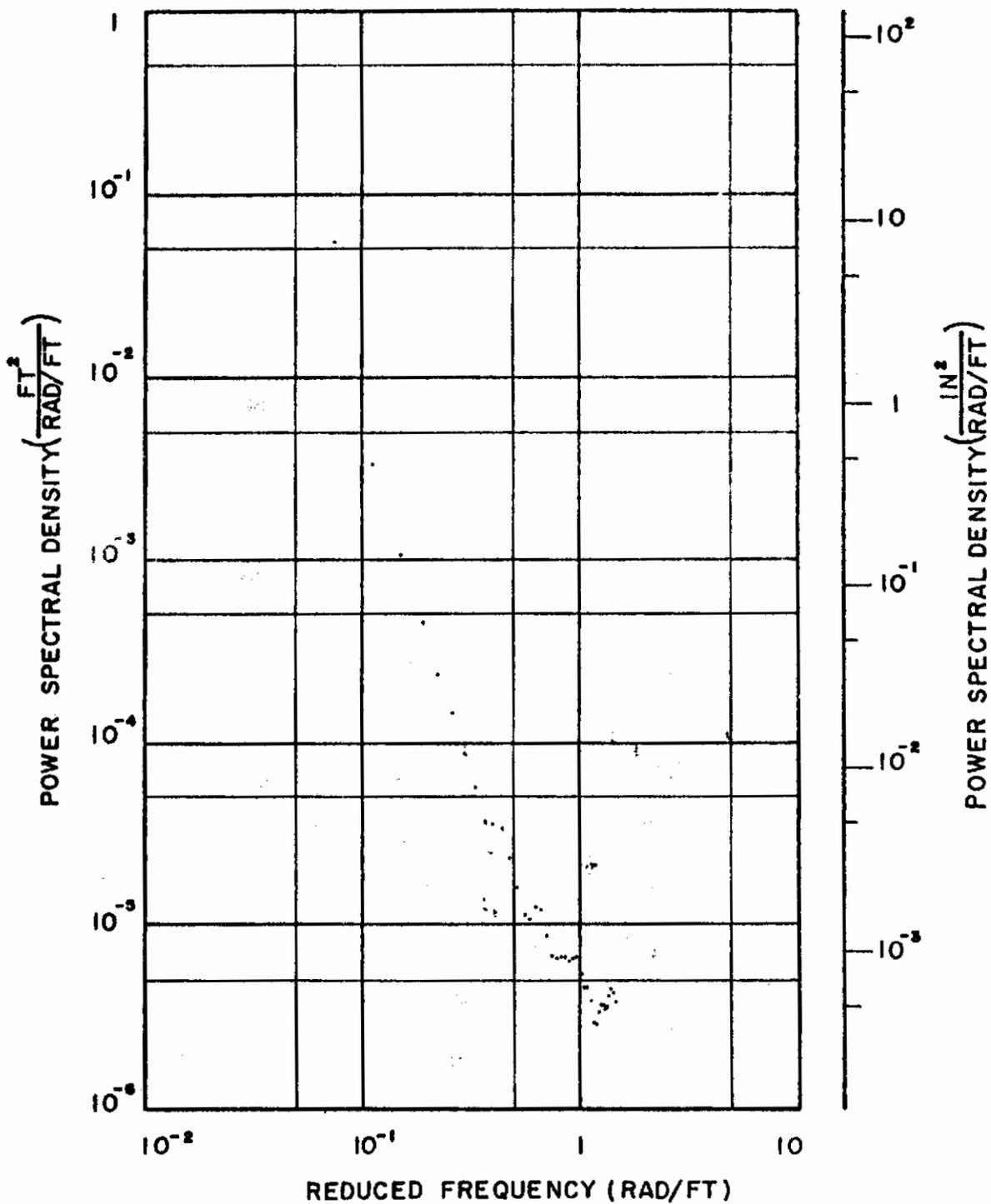


Runway 92
(Computed Using a Prewhitener)

Contrails

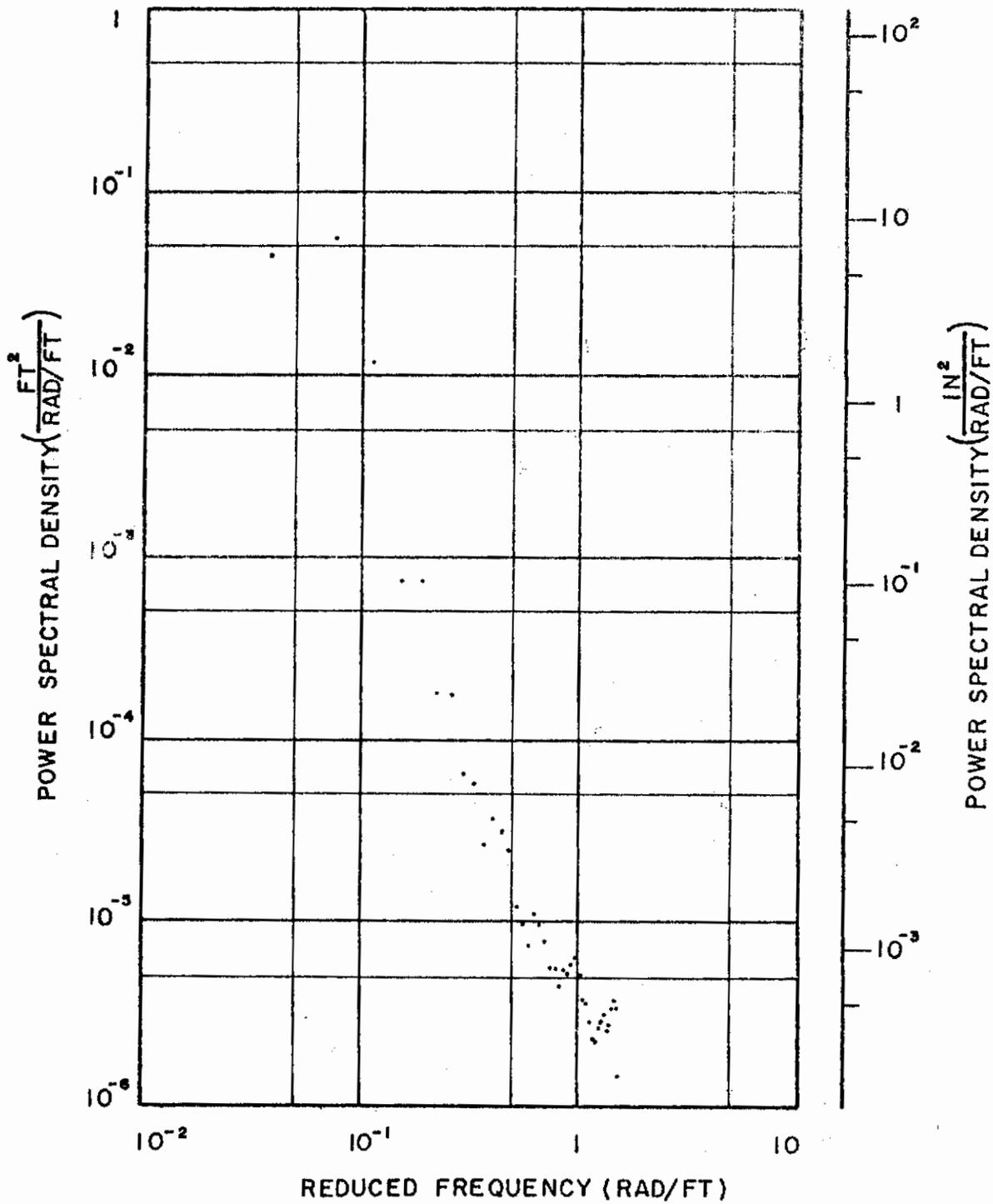


Runway 92
(Computed Using a 300 ft Moving Average)



Runway 93
(Computed Using a Prewhitener)

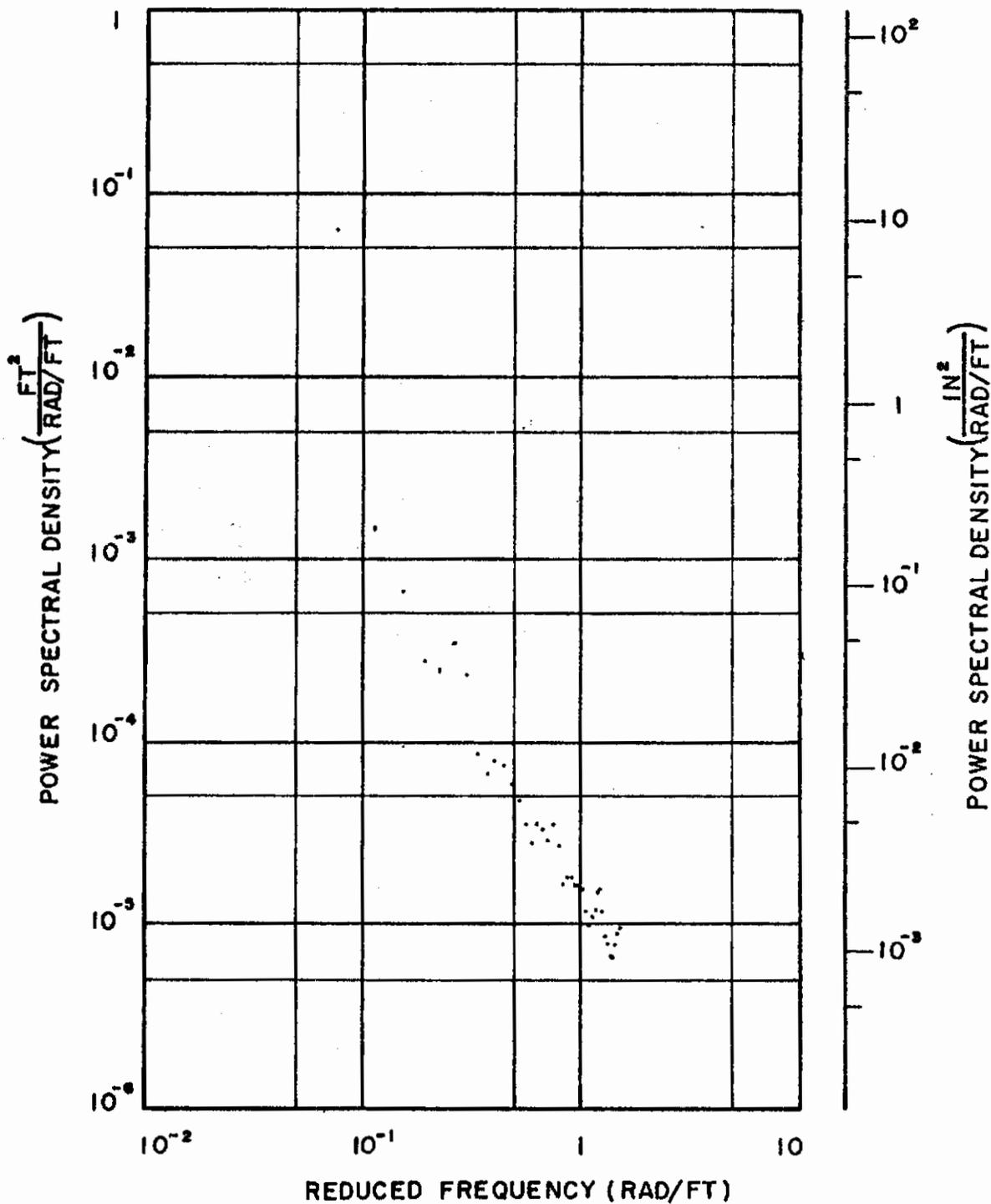
Contrails



Runway 93

(Computed Using a 300 ft Moving Average)

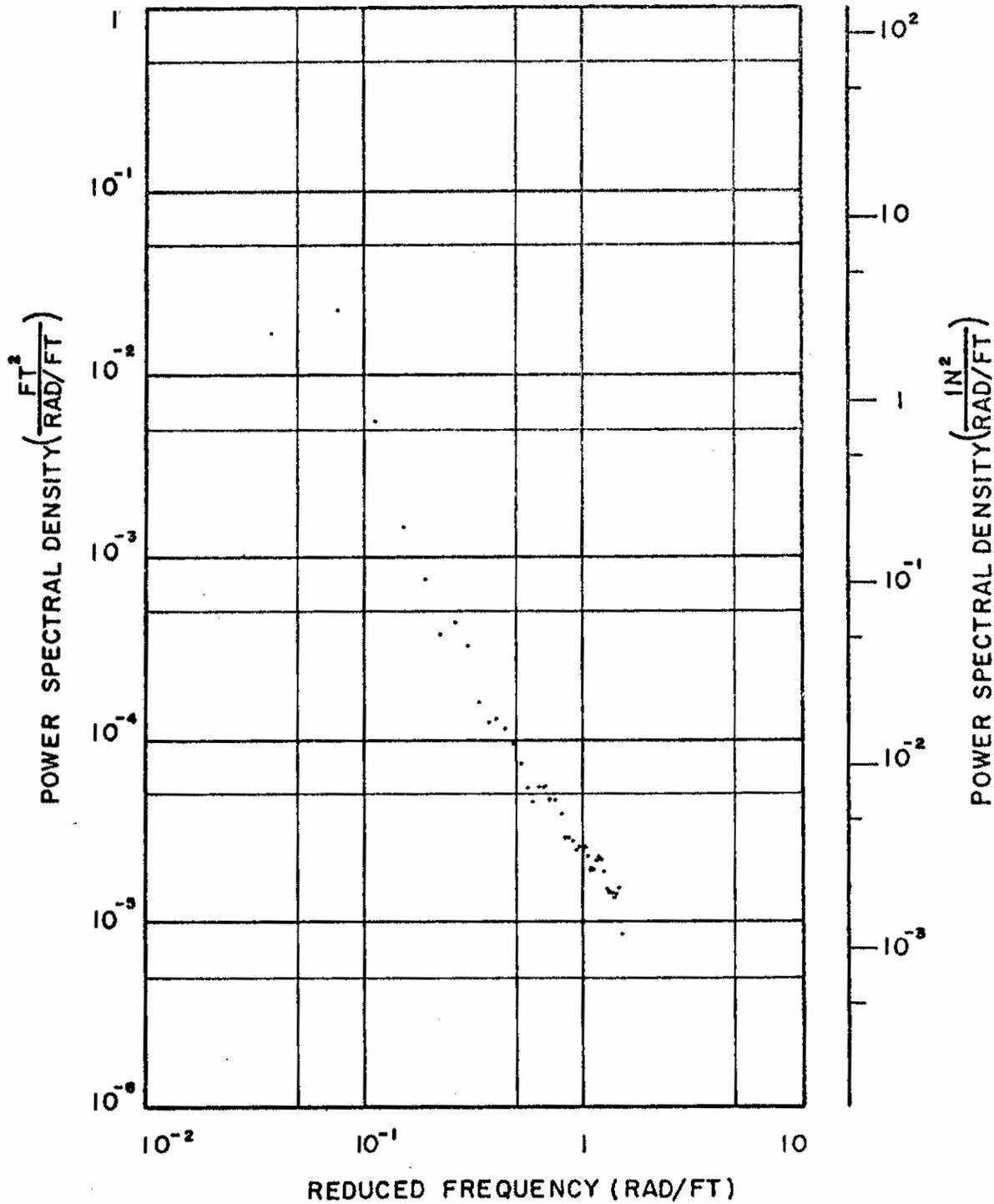
Contrails



Runway 94

(Computed Using a Prewhitener)

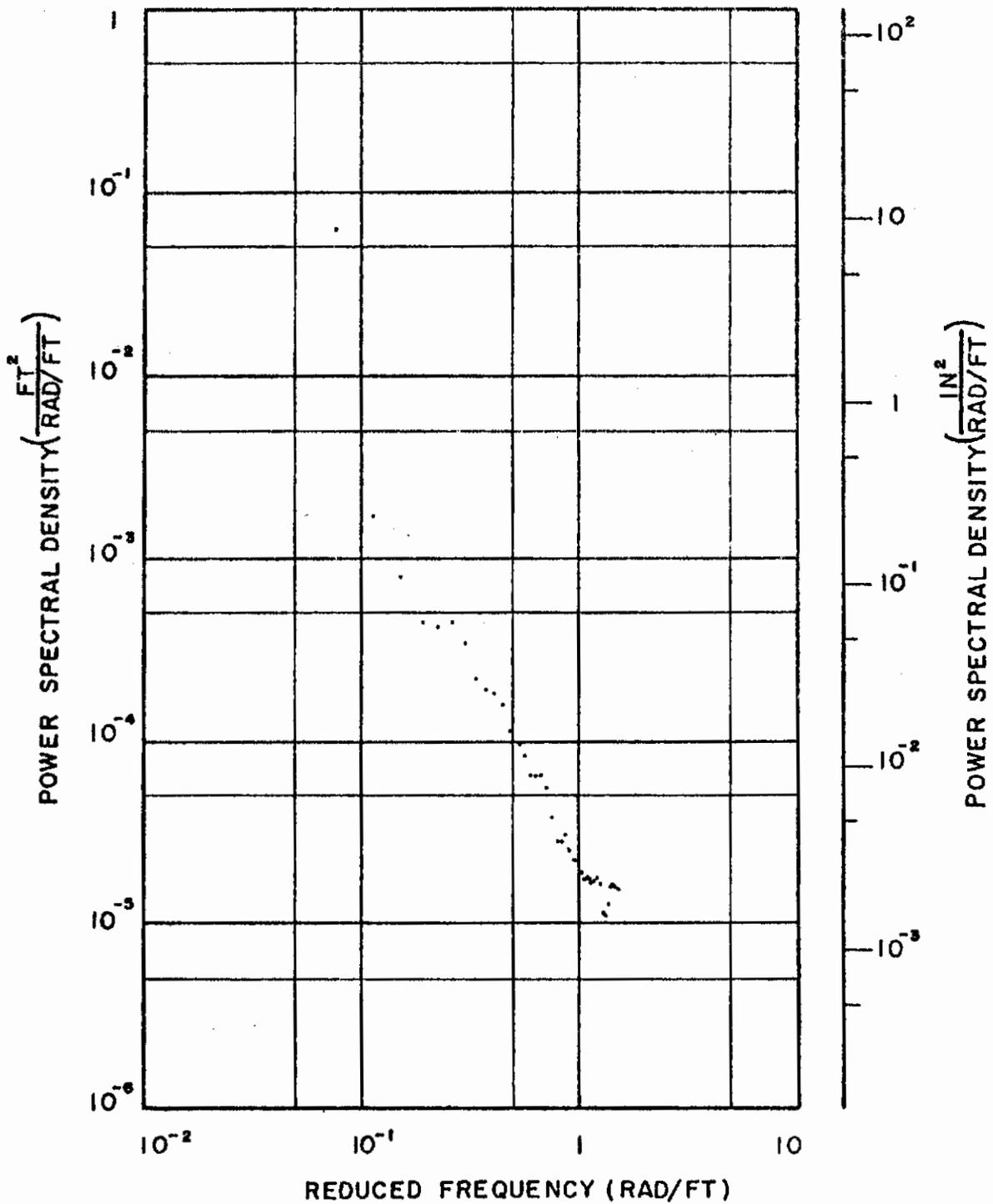
Contrails



Runway 94

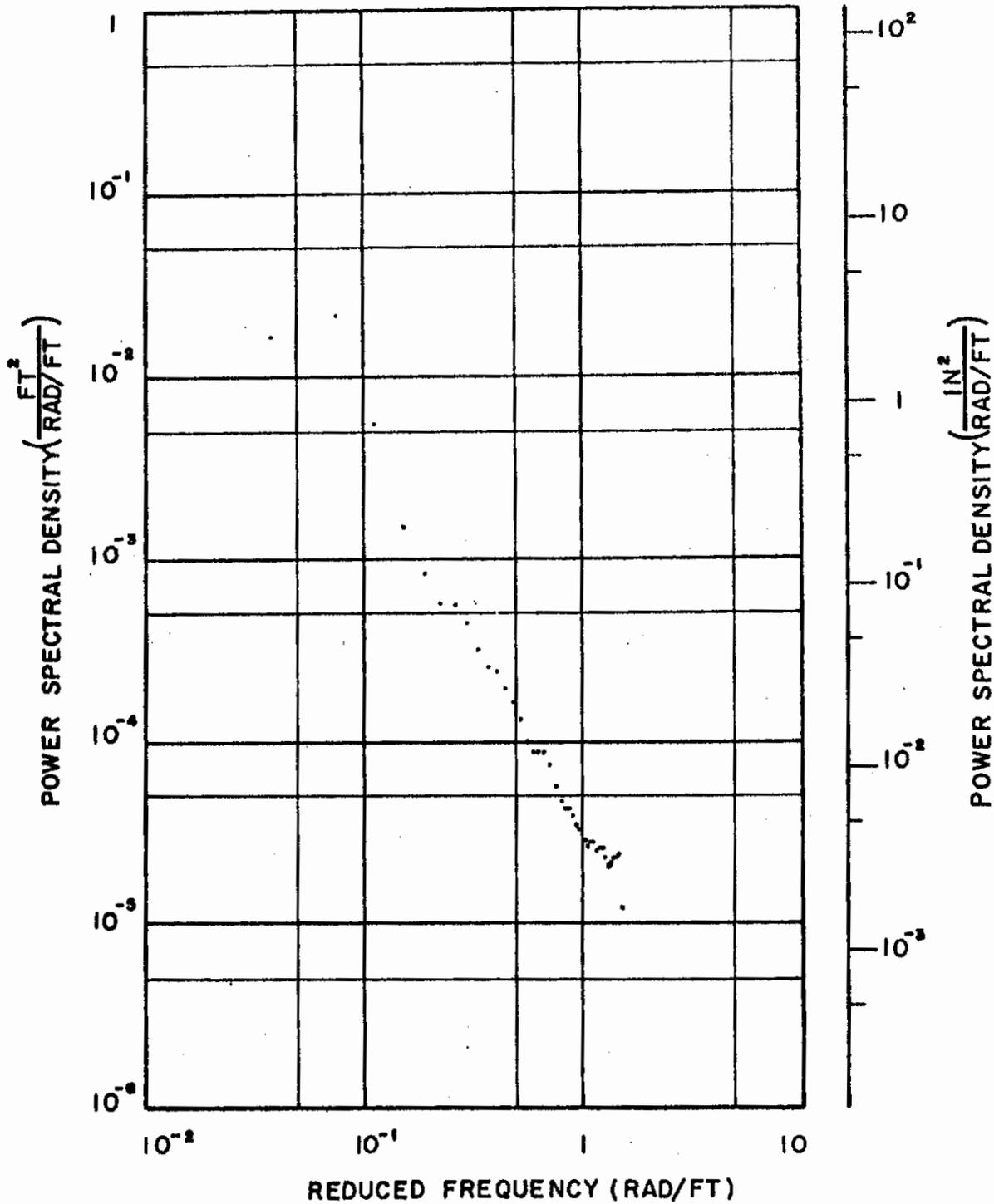
(Computed Using a 300 ft Moving Average)

Contrails



Runway 95
(Computed Using a Prewhitener)

Contrails



Runway 95
(Computed Using a 300 ft Moving Average)

Contrails

APPENDIX III

DISCRETE BUMP MEASUREMENTS

APPENDIX III

DISCRETE BUMP MEASUREMENTS

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg.
T-1025	270	0.65				
T-1025	100	0.40				
T-1025			40	0.10		
T-1028	40	0.05				
T-1028			40	0.05		
T-1028	30	0.05				
T-1028	90	0.15				
T-1028			80	0.10		
T-1028			40	0.05		
T-1028			40	0.10		
T-1028	30	0.05				
T-1028	20	0.05				
T-1028	20	0.05				
T-1028	20	0.05				
T-1028			60	0.10		
T-1028	60	0.10				
T-1028	50	0.05				
T-1028	20	0.05				
T-1028	60	0.10				
T-1028			60	0.15		
T-1028			40	0.05		
T-1028			40	0.10		
T-1028			60	0.05		
T-1028	90	0.05				
T-1028			40	0.05		
T-1028			130	0.10		
T-1028	40	0.10				
T-1028	50	0.05				
T-1028	70	0.05				
T-1028			50	0.05		
T-1028			40	0.05		

T	-	Taxiway
Rn	-	Runway
Ra	-	Ramp

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
T-1030	20	0.05				
T-1030	60	0.10				
T-1030			50	0.05		
T-1030	40	0.10				
T-1030	80	0.15				
T-1030	30	0.10				
T-1030	30	0.10				
T-1030	50	0.05				
T-1030	30	0.05				
T-1030	50	0.10				
T-1030	30	0.05				
T-1030	30	0.05				
T-1030			30	0.05		
T-1030			30	0.05		
T-1030	80	0.05				
T-1030	100	0.15				
T-1030			60	0.10		
T-1030			60	0.10		
T-1030			80	0.10		
T-1030			60	0.10		
T-1030	20	0.05				
T-1030	40	0.05				
T-1030			70	0.10		
T-1030	60	0.10				
T-1030	70	0.10				
T-1030	70	0.05				
T-1030			80	0.10		
T-1030	70	0.10				
T-1030	90	0.10				
T-1030			30	0.05		
T-1030			60	0.10		
T-1030	50	0.10				
T-1030			80	0.05		
T-1030			100	0.05		
T-1030	50	0.05				

Contrails

Project Identification Number	BUMP		DIP		ANGLE(deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
T-1036	20	0.05				
T-1036	20	0.05				
T-1036			30	0.05		
T-1036	20	0.05				
T-1036			60	0.05		
T-1036			30	0.05		
T-1036			30	0.05		
T-1036			30	0.10		
T-1036	20	0.10				
T-1036	30	0.10				
T-1036	50	0.15				
T-1036	30	0.10				
T-1036	80	0.15				
T-1036			60	0.10		
T-1036	70	0.20				
T-1036	30	0.10				
T-1036	30	0.05				
T-1036	40	0.20				
T-1036			160	0.20		
T-1036			20	0.05		
T-1036			20	0.05		
T-1036	70	0.15				
Ra-1042			50	0.05		
Ra-1042			70	0.05		
Ra-1042			40	0.05		
Ra-1042	30	0.05				
Ra-1042	20	0.05				
Ra-1042			60	0.05		
Ra-1042			30	0.05		
Ra-1042			30	0.05		
Ra-1051			50	0.20		
Ra-1051	30	0.15				
Ra-1071	80	0.30				
Ra-1071			100	0.15		
Ra-1071	90	0.10				
Ra-1071	130	0.20				
Ra-1071	130	0.15				
T-1080						

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
T-1085	70	0.05				
T-1085	70	0.05				
T-1085	80	0.05				
T-1085			30	0.05		
T-1085			60	0.05		
T-1085	50	0.05				
T-1085			70	0.05		
T-1085	140	0.10				
T-1085	240	0.15				
T-1085	130	0.05				
T-1085	30	0.05				
T-1085	40	0.05				
T-1085			80	0.05		
T-1085			50	0.05		
T-1085	100	0.05				
T-1085			120	0.05		
T-1085	80	0.05				
T-1085			60	0.05		
T-1085	40	0.05				
Rn-1090	40	0.05				
Rn-1090	60	0.05				
Rn-1090			50	0.10		
Rn-1090	50	0.05				
Rn-1090	30	0.05				
Rn-1090	60	0.05				
Rn-1090	100	0.10				
Rn-1090	150	0.10				
Rn-1090	100	0.10				
Rn-1090	90	0.10				
Rn-1090	120	0.10				
Rn-1090	60	0.05				
Rn-1090	80	0.10				
Rn-1090	70	0.10				
Rn-1090	100	0.10				
Rn-1090	160	0.10				
Rn-1090	110	0.10				
Rn-1090	80	0.05				
Rn-1090			80	0.15		

Contrails

Project Identification Number	BUMP		DIP		ANGLE(deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
Rn-1090	160	0.15				
Rn-1090	60	0.10				
Rn-1090	100	0.15				
Rn-1090	90	0.10				
Rn-1090	70	0.10				
T-1100			90	0.25		
T-1100	230	0.55				
T-1100	30	0.30				
T-1100			70	0.10		
T-1100	140	0.15				
T-1100	90	0.10				
T-1100	50	0.05				
T-1100	40	0.05				
T-1100	160	0.10				
T-1100	30	0.10				
T-1100	70	0.10				
T-1100	40	0.05				
T-1100	80	0.10				
T-1100	90	0.10				
T-1100	70	0.15				
T-1100			50	0.10		
T-1100	40	0.10				
T-1100	20	0.10				
T-1100			20	0.10		
T-1100	140	0.20				
T-1100			60	0.05		
T-1100	80	0.10				
T-1100			90	0.10		
T-1100			80	0.10		
T-1100	40	0.10				
T-1100			30	0.05		
T-1100	110	0.10				
T-1100			80	0.10		
T-1100			50	0.05		
T-1100	120	0.25				
T-1100			100	0.20		

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
T-1100			30	.05		
T-1100	60	0.15				
T-1100	40	0.05				
T-1100	90	0.10				
T-1100			40	0.10		
T-1100			70	0.10		
T-1100			70	0.10		
T-1100			60	0.05		
T-1100			50	0.10		
T-1100			60	0.05		
T-1101	510	1.15				
T-1101	500	0.90				
T-1101			20	0.15		
T-1101	80	0.20				
T-1101			30	0.10		
T-1101	120	0.10				
T-1101	50	0.05				
T-1101					179.53	0.47
T-1101	110	0.15				
T-1101					180.73	0.73
T-1101			110	0.15		
T-1101					179.47	0.53
T-1101					180.48	0.48
T-1101			20	0.10		
T-1101			40	0.10		
T-1101					179.48	0.52
T-1101	100	0.20				
T-1101			50	0.10		
T-1101	20	0.05				
T-1101			60	0.05		
T-1101			30	0.05		
T-1101	170	0.15				
T-1101	60	0.10				
T-1101	110	0.15				
T-1101	260	0.10				

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual(ft)	Deviation From 180 deg
T-1101	140	0.15				
T-1101	140	0.10				
T-1101	120	0.10				
T-1101	40	0.10				
T-1101	70	0.10				
T-1101	40	0.05				
T-1101	50	0.10				
T-1101	80	0.10				
T-1101			140	0.15		
T-1101	290	0.20				
T-1101	80	0.10				
Ra-1103	110	0.25				
Ra-1103	40	0.15				
Ra-1103	30	0.05				
Ra-1103	50	0.15				
Ra-1103	30	0.15				
Ra-1103	40	0.10				
Ra-1103					180.95	0.95
Ra-1103					179.02	0.98
Ra-1103					180.80	0.80
Ra-1103					177.58	2.42
Ra-1103					181.25	1.25
Ra-1104	30	0.15				
Ra-1104	30	0.15				
Ra-1104	20	0.10				
Ra-1104	40	0.10				
Ra-1104	30	0.05				
Ra-1104			20	0.15		
Ra-1104					180.93	0.93
Ra-1104					179.07	0.93
Ra-1104					181.23	1.23
Ra-1104					178.33	0.67
Ra-1104					181.28	1.28

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
Rn-1110			70	0.15		
Rn-1110	70	0.15				
Rn-1110	70	0.10				
Rn-1110	40	0.10				
Rn-1110	80	0.15				
Rn-1110	60	0.15				
Rn-1110	390	0.80				
Rn-1110	30	0.10				
Rn-1110	40	0.10				
Rn-1110	50	0.10				
Rn-1110	70	0.15				
Rn-1110	80	0.10				
Rn-1110	390	0.80				
Rn-1110			80	0.20		
Rn-1110	110	0.30				
Rn-1110			70	0.10		
Rn-1110	110	0.20				
Rn-1110			350	0.25		
Rn-1110	160	0.25				
Rn-1110	80	0.20				
Rn-1110	330	0.35				
Rn-1110	50	0.10				
Rn-1110	30	0.10				
Rn-1110	60	0.10				
Rn-1110	40	0.10				
Rn-1110	100	0.15				
Rn-1110	60	0.10				
Rn-1110	80	0.20				
Rn-1110	50	0.15				
Rn-1110	30	0.05				
Rn-1110	50	0.05				
Rn-1110	40	0.15				
Rn-1110	30	0.10				
Rn-1110	50	0.10				
Rn-1110	30	0.10				
Rn-1110	40	0.15				
Rn-1110	50	0.05				

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
Rn-1110	70	0.10				
Rn-1110	90	0.20				
Rn-1110	80	0.10				
Rn-1110	30	0.05				
Rn-1110	70	0.15				
Rn-1110	160	0.40				
Rn-1110	100	0.15				
Rn-1110	40	0.10				
Rn-1110	80	0.10				
Rn-1110	70	0.10				
Rn-1110			30	0.05		
Rn-1110			60	0.10		
Rn-1110	30	0.05				
Rn-1110	30	0.05				
Rn-1110	80	0.05				
Rn-1110	80	0.10				
Rn-1110	70	0.05				
Rn-1110	70	0.10				
Rn-1110	30	0.05				
Rn-1110	70	0.10				
Rn-1110	80	0.10				
Rn-1110	50	0.05				
Rn-1114	80	0.10				
Rn-1114	80	0.10				
Rn-1114	30	0.05				
Rn-1114	40	0.05				
Rn-1114			30	0.05		
Rn-1114	40	0.10				
Rn-1114			80	0.05		
Rn-1114	40	0.05				
Rn-1114	80	0.10				
Rn-1114	20	0.05				
Rn-1114	30	0.05				
Rn-1114	30	0.05				
Rn-1114	40	0.05				
Rn-1114	30	0.05				

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth (ft)	Actual	Deviation From 180 deg
Rn-1114		40		0.05		
Rn-1114	20	0.05				
Rn-1114	40	0.05				
Rn-1114			40	0.05		
Rn-1114			30	0.05		
Rn-1114	60	0.05				
Rn-1114			90	0.10		
Rn-1114			120	0.15		
Rn-1114	30	0.05				
Rn-1114	50	0.05				
Rn-1114			20	0.10		
Rn-1114			40	0.05		
Rn-1114	60	0.10				
Rn-1114	40	0.05				
Rn-1114			20	0.05		
Rn-1114			40	0.05		
Rn-1114	40	0.05				
Rn-1114	40	0.05				
Rn-1114			50	0.05		
Rn-1114	50	0.05				
Rn-1114			30	0.05		
Rn-1114	60	0.05				
Rn-1114	90	0.05				
Rn-1114	40	0.05				
T-1120	60	0.15				
T-1120	30	0.100				
T-1120	70	0.05				
T-1120			20	0.05		
T-1120	220	1.00				
T-1120	320	1.10				
T-1120	30	0.10				
T-1121					179.08	0.92
T-1122					179.10	0.90

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
T-1129	20	0.05				
T-1129	60	0.05				
T-1129			40	0.10		
T-1129	40	0.10				
T-1129					179.58	0.42
T-1129					180.46	0.54
T-1129	20	0.05				
T-1129					179.40	0.60
T-1129					180.77	0.77
T-1129	30	0.05				
T-1129			40	0.15		
T-1129			50	0.20		
T-1129					181.17	1.17
T-1129	30	0.10				
T-1129			40	0.10		
T-1129			30	0.05		
T-1129					179.08	0.92
T-1129	170	0.20	50	0.10		
T-1131	30	0.05				
T-1131					178.98	1.02
T-1131	50	0.05				
T-1131					180.90	0.90
T-1131	20	0.05				
T-1131	30	0.10				
T-1131					179.33	0.67
T-1131	40	0.10				
T-1131	50	0.10				
T-1131					180.92	0.92
T-1131	60	0.10				
T-1131			30	0.10		
T-1131					179.37	0.63
T-1131			30	0.10		
T-1131					181.33	1.33
T-1131			50	0.10		
T-1131			30	0.05		
T-1131					179.08	0.92

Contrails

Project Identification Number	EUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
T-1131	60	0.10				
T-1131			30	0.10		
T-1131	60	0.15				
Rn-1133	170	0.15				
Rn-1133	40	0.10				
Rn-1133	110	0.10				
Rn-1133			150	0.20		
Rn-1133	150	0.20				
Rn-1133					179.80	0.20
Rn-1133	40	0.05				
Rn-1133			30	0.05		
Rn-1133	30	0.10				
Rn-1133			80	0.10		
Rn-1133			30	0.10		
Rn-1133	290	0.50				
Rn-1133					179.87	0.13
Rn-1133	60	0.10				
Rn-1133			70	0.05		
Rn-1133	30	0.05				
Rn-1135			40	.05		
Rn-1135	20	0.05				
Rn-1135			40	0.10		
Rn-1135			20	0.05		
Rn-1135			70	0.10		
Rn-1135			40	0.20		
Rn-1135			40	0.15		
Rn-1135			30	0.10		
Rn-1135			70	0.15		
Rn-1135			60	0.10		
Rn-1135			30	0.10		
Rn-1135			110	0.30		
Rn-1135	20	0.05				
Rn-1135	20	0.05				
Rn-1135	30	0.10				

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
Rn-1135			30	0.05		
Rn-1135			40	0.05		
Rn-1135			20	0.05		
Rn-1135			30	0.05		
Rn-1135			30	0.05		
Rn-1135			30	0.20		
Rn-1135	40	0.05				
Rn-1135	20	0.05				
Rn-1135	30	0.10				
Rn-1135			40	0.10		
Rn-1135	40	0.05				
Rn-1135	90	0.10				
Rn-1135			40	0.05		
Rn-1135			70	0.10		
Rn-1135	80	0.10				
Rn-1135	50	0.10				
Rn-1135			70	0.10		
Rn-1135			40	0.10		
Rn-1135			40	0.05		
Rn-1135			70	0.10		
Rn-1135			30	0.05		
Rn-1135	30	0.05				
T-1143			20	0.10		
T-1143			70	0.05		
T-1143	30	0.05				
T-1143			40	0.15		
T-1143	50	0.05				
Rn-1178			60	0.10		
Rn-1178			100	0.10		
Rn-1178	70	0.10				
Rn-1178			80	0.10		
Rn-1178			50	0.05		
Rn-1178			40	0.05		
Rn-1178			50	0.10		
Rn-1178			20	0.05		
Rn-1178			80	0.10		
Rn-1178			40	0.10		

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
Rn-1178	40	0.05				
Rn-1178	50	0.10				
Rn-1178	60	0.10				
Rn-1178	40	0.10				
Rn-1178			70	0.10		
Rn-1178			40	0.05		
Rn-1178	90	0.10				
Rn-1178	40	0.10				
Rn-1178	90	0.05				
Rn-1180			30	0.05		
Rn-1180			30	0.05		
Rn-1180			40	0.10		
Rn-1180			120	0.10		
Rn-1180			100	0.10		
Rn-1180			470	0.20		
Rn-1180			40	0.05		
Rn-1180	100	0.10				
Rn-1180	100	0.10				
Rn-1180			30	0.05		
Rn-1180			40	0.05		
Rn-1180	20	0.05				
Rn-1180	60	0.05				
Rn-1180	30	0.05				
Rn-1180	40	0.05				
Rn-1180	30	0.05				
Rn-1180	30	0.05				
Rn-1180	30	0.10				
Rn-1180	40	0.05				
Rn-1180	65	0.05				
Rn-1180	90	0.10				
Rn-1180	60	0.05				
Rn-1180	50	0.05				
Rn-1180	70	0.05				

Contrails

Project Identification Number	BUMP		DIP		ANGLE (deg)	
	Length(ft)	Height(ft)	Length(ft)	Depth(ft)	Actual	Deviation From 180 deg
Rn-1180	30	0.05				
Rn-1180	100	0.05				
Rn-1180	20	0.05				
Rn-1180	70	0.10				
Rn-1180	30	0.05				
Rn-1180			30	0.05		
Rn-1180			40	0.05		

APPENDIX IV

PROFILE RECORD BOOK

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1	NACA TN 4303 Runway 7	5010	AGARD Airport 1	March 1959	AGARD Research Memo 1	AGARD Research Memo 1	4494	2 ft
2	NACA TN 4303	5013	AGARD Airport 2	March 1959	AGARD Research Memo 2	AGARD Research Memo 2	5083	0.6 meter
3		5001	AGARD Airport 3 Runway 1	December 1956	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
4	NASA Runway Code 3	3	AGARD Airport 3 Runway 1	January 1957	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
5		5002	AGARD Airport 3 Runway 1	February 1957	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
6		5003	AGARD Airport 3 Runway 1	March 1959	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
7		5004	AGARD Airport 3 Runway 1	April 1957	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
8	NASA Runway Code 13	13	AGARD Airport 3 Runway 1	May 1957	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
9	NASA Runway Code 14	14	AGARD Airport 3 Runway 1	June 1957	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
10	NASA Runway Code 27	27	AGARD Airport 3 Runway 1	July 1957	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
11	NASA Runway Code 28	28	AGARD Airport 3 Runway 1	August 1957	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
12	NASA Runway Code 301	301	AGARD Airport 3 Runway 1	September 1957	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
13	NASA Runway Code 302	302	AGARD Airport 3 Runway 1	October 1957	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
14	NASA Runway Code 303	303	AGARD Airport 3 Runway 1	November 1957	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
15		5005	AGARD Airport 3 Runway 2	December 1956	AGARD Research Memo 3	AGARD Research Memo 3	2255	2 ft
16	NASA Runway Code 4	4	AGARD Airport 3 Runway 2	January 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
17		5006	AGARD Airport 3 Runway 2	February 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
18		5007	AGARD Airport 3 Runway 2	March 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
19		5008	AGARD Airport 3 Runway 2	April 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
20	NASA Runway Code 15	15	AGARD Airport 3 Runway 2	May 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
21	NASA Runway Code 17	17	AGARD Airport 3 Runway 2	June 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
22	NASA Runway Code 26	26	AGARD Airport 3 Runway 2	July 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
23	NASA Runway Code 30	30	AGARD Airport 3 Runway 2	August 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
24	NASA Runway Code 304	304	AGARD Airport 3 Runway 2	September 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
25	NASA Runway Code 305	305	AGARD Airport 3 Runway 2	October 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
26	NASA Runway Code 306	306	AGARD Airport 3 Runway 2	November 1957	AGARD Research Memo 3	AGARD Research Memo 3	2254	2 ft
27		5012	AGARD Airport 4 Runway 1 Section 1	July 1959	AGARD Research Memo 4	AGARD Research Memo 4	533	2 ft
28	NACA TN 4303	5012	AGARD Airport 4 Runway 1 Section 2	July 1959	AGARD Research Memo 4	AGARD Research Memo 4	1401	2 ft

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
29	NASA Runway Code 6 NACA TN 4303 Runway 10	6	AGARD Airport 4 Runway 2	July 1959	AGARD Research Memo 4	AGARD Research Memo 4	1182	2 ft
30	NASA Runway Code 5 NACA TN 4303 Runway 11	5	AGARD Airport 4 Runway 3	July 1959	AGARD Research Memo 4	AGARD Research Memo 4	1729	2 ft
31	NASA Runway Code 8 NACA TN 4303 Runway 12	8	AGARD Airport 5 Runway 1	August 1959	AGARD Research Memo 5	AGARD Research Memo 5	1801	2 ft
32	NASA Runway Code 9 NACA TN 4303 Runway 13	9	AGARD Airport 5 Runway 2	August 1959	AGARD Research Memo 5	AGARD Research Memo 5	1901	2 ft
33	NASA Runway Code 11 NACA TN 4303 Runway 14	11	AGARD Airport 6 Runway 1	September 1959	AGARD Research Memo 6	AGARD Research Memo 6	1801	2 ft
34	NASA Runway Code 10 NACA TN 4303 Runway 15	10	AGARD Airport 6 Runway 2	September 1959	AGARD Research Memo 6	AGARD Research Memo 6	3301	2 ft
35	NASA Runway Code 1965 NACA TN 4303 Runway 16	1965	AGARD Airport 7 Runway 1	September 1959	AGARD Research Memo 6	AGARD Research Memo 6	2201	2 ft
36	NACA TN 4303 Runway 17	5011	AGARD Airport 7 Runway 2	September 1959	AGARD Research Memo 7	AGARD Research Memo 7	2201	2 ft
37	NASA Runway Code 20 NACA TN 4303 Runway	20	AGARD Airport 8 Runway 1	September 1959	AGARD Research Memo 8	AGARD Research Memo 8	3201	2 ft
38	NASA Runway Code 21 NACA TN 4303 Runway 19	21	AGARD Airport 8 Runway 2	September 1959	AGARD Research Memo 8	AGARD Research Memo 8	1201	2 ft
39	NASA Runway Code 22 NACA TN 4303 Runway 20	22	AGARD Airport 9 Runway 1	October 1959	AGARD Research Memo 9	AGARD Research Memo 9	701	2 ft

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
40	NASA Runway Code 23 NACA TN 4303 Runway 21	23	AGARD Airport 9 Runway 2	October 1959	AGARD Research Memo 9	AGARD Research Memo 9	1201	2 ft
41	NASA Runway Code 24 NACA TN 4303 Runway 22	24	AGARD Airport 9 Runway 3 Section 1	October 1959	AGARD Research Memo 9	AGARD Research Memo 9	1201	2 ft
42	NACA TN 4303 Runway 22	5009	AGARD Airport 9 Runway 3 Section 2	October 1959	AGARD Research Memo 9	AGARD Research Memo 9	3001	2 ft
43	NASA Runway Code 31 NACA TN 4303 Runway 23	31	AGARD Airport 10 Runway 1	October 1959	AGARD Research Memo 10	AGARD Research Memo 10	2701	2 ft
44	NASA Runway Code 32	32	AGARD Airport 10 Runway 2	October 1959	AGARD Research Memo 10	AGARD Research Memo 10	2501	2 ft
45	NASA Runway Code 34 NACA TN 4303 Runway 25	34	AGARD Airport 11 Runway 1	November 1959	AGARD Research Memo 11	AGARD Research Memo 11	6101	2 ft
46	NASA Runway Code 33 NACA TN 4303 Runway 26	33	AGARD Airport 11 Runway 2	November 1959	AGARD Research Memo 11	AGARD Research Memo 11	2851	2 ft
47	NASA Runway Code 37 NACA TN 4303 Runway 27	37	AGARD Airport 12 Runway 1	November 1959	AGARD Research Memo 12	AGARD Research Memo 12	3501	2 ft
48	NASA Runway Code 36 NACA TN 4303 Runway 28	36	AGARD Airport 12 Runway 2	November 1959	AGARD Research Memo 12	AGARD Research Memo 12	1501	2 ft
49	NASA Runway Code 38 NACA TN 4303 Runway 29	38	AGARD Airport 13 Runway 1	December 1959	AGARD Research Memo 13	AGARD Research Memo 13	2701	2 ft
50	NASA Runway Code 39 NACA TN 4303 Runway 30	39	AGARD Airport 13 Runway 2	December 1959	AGARD Research Memo 13	AGARD Research Memo 13	2501	2 ft

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
51	NASA Runway Code 40 NACA TN #303 Runway 31	40	AGARD Airport 14 Runway 1	December 1959	AGARD Research Memo 14	AGARD Research Memo 14	3501	2 ft
52	NASA Runway Code 41 NACA TN #303 Runway 32	41	AGARD Airport 14 Runway 2	December 1959	AGARD Research Memo 14	AGARD Research Memo 14	2601	2 ft
53	NASA Runway Code 7	7			NASA	NASA	1182	2 ft
54	Nasa Runway Code 14	14			NASA		2255	2 ft
55	NASA Runway Code 16	16	Williamsburg, Va. Sod Runway		NASA	NASA	501	2 ft
56	NASA Runway Code 19-L	19-L			NASA	NASA	4911	2 ft
57	NASA Runway Code 25	25			NASA		3001	2 ft
58	NASA Runway Code 42	42	Washington National		NASA	NASA	2605	2 ft
59	NASA Runway Code 43	43	Idlewild		NASA	NASA	4743	2 ft
60	NASA Runway Code 44	44	La Guardia		NASA	NASA	993	2 ft
61	NASA Runway Code 45	45	La Guardia		NASA	NASA	2493	2 ft
62	NASA Runway Code 46	46	Logan		NASA	NASA	5020	2 ft
63	NASA Runway Code 50	50	Langley Landing Loads Track		NASA	NASA	999	2 ft
64	NASA Runway Code 115	115			NASA	NASA	4015	2 ft
65	NASA Runway Code 116	116			NASA	NASA	8008	2 ft
66	NASA Runway Code 117	117			NASA	NASA	4170	2 ft
67	NASA Runway Code 118	118			NASA	NASA	3000	2 ft
68	NASA Runway Code 123	123			NASA	NASA	4002	2 ft

Contrails

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Date	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
69	NASA Runway Code 124	124			NASA	NASA	3998	2 ft
70	NASA Runway Code 125	125			NASA	NASA	2500	2 ft
71	NASA Runway Code 126	126			NASA	NASA	4909	2 ft
72	NASA Runway Code 127	127			NASA	NASA	4491	2 ft
73	NASA Runway Code 128	128			NASA	NASA	4005	2 ft
74	NASA Runway Code 133				NASA	NASA		
75	NASA Runway Code 215	215			NASA	NASA	4015	2 ft
76	NASA Runway Code 216	216			NASA	NASA	4005	2 ft
77	NASA Runway Code 217	217			NASA	NASA	4170	2 ft
78	NASA Runway Code 218	218			NASA	NASA	5998	2 ft
79	NASA Runway Code 226	226			NASA	NASA	4000	2 ft
80	NASA Runway Code B	5025	Logan		NASA		5020	2 ft
81	NACA TN 3305 Runway a	5000	Langley Field Runway 35	November 1954	NACA	NACA	701	2 ft
82	NACA TN 3305 Runway b	5001	Langley Field Runway 12	November 1954	NACA	NACA	1501	2 ft
83		2546	Boeing Field Runway 4	March 1954	Boeing Co.		501	2 ft
84		2526	Boeing Field Runway 4	March 1954	Boeing Co.	NACA Boeing Co.	501	2 ft
85		2554	Boeing Field Runway 4	March 1954	Boeing Co.		501	2 ft
86	Lockheed Report No. 15679, page A-1	4601	Lockheed Air Terminal E-W Taxiway South Track	August 1961	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	751	2 ft

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval Between Measurements
87	Lockheed Report No. 15679, page A-9	4602	Lockheed Air Terminal E-W Taxiway North Track	August 1961	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	751	2 ft
88	Lockheed Report No. 15679, page A-17	4603	Lockheed Air Terminal N-S Taxiway East Track	August 1961	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	1501	2 ft
89	Lockheed Report No. 15679, page A-32	4604	Lockheed Air Terminal N-S Taxiway West Track	August 1961	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	1501	2 ft
90	Lockheed Report No. 15679, page A-47	4605	Lockheed Air Terminal E-W Runway North Track	August 1961	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	1501	2 ft
91	Lockheed Report No. 15679, page A-62	4606	Lockheed Air Terminal E-W Runway South Track	August 1961	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	1501	2 ft
92	Lockheed Report No. 14700, page B-2	4607	Hamilton Air Force Base Runway 14 71.5-ft Right Side	December 1959	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	1501	2 ft
93	Lockheed Report No. 14700, page B-17	4608	Hamilton Air Force Base Runway 14 62.5-ft Right Side	December 1959	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	1501	2 ft
94	Lockheed Report No. 14700, page B-62	4609	Palmdale Air Force Base Runway 25 4.5-ft Right Side	December 1959	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	1501	2 ft
95	Lockheed Report No. 14700, page B-77	4610	Palmdale Air Force Base Runway 25 4.5-ft Left Side	December 1959	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	1501	2 ft
96	Lockheed Report No. 10809, Profile A		Lockheed Air Terminal E-W Runway 14-ft Left Side	June 1954	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	351	2 ft

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Date	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
97	Lockheed Report No. 10809 Profile B		Lockheed Air Terminal E-W Runway Centerline	June 1954	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	351	2 ft
98	Lockheed Report No. 10809 Profile C		Lockheed Air Terminal E-W Runway 14-ft Right Side	June 1954	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	351	2 ft
99	Lockheed Report No. 10809 Profile D		Lockheed Air Terminal E-W Taxiway 42-ft Left Side	June 1954	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	401	2 ft
100	Lockheed Report No. 10809 Profile E		Lockheed Air Terminal E-W Taxiway 14-ft Left Side	June 1954	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	401	2 ft
101	Lockheed Report No. 10809 Profile F		Lockheed Air Terminal E-W Taxiway 14-ft Right Side	June 1954	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	401	2 ft
102	Lockheed Report No. 10809 Profile G		Lockheed Air Terminal E-W Taxiway 42-ft Right Side	June 1954	Lockheed Aircraft Corporation	Lockheed Aircraft Corporation	401	2 ft
1001	ASD Tape 1		Altus Air Force Base Ramp Run 1	February 1962	WADD TR 60-470 Part III	WADD TR 60-470 Part III	2000	6 in.
1002	ASD Tape 2		Altus Air Force Base Ramp Run 2	February 1962	WADD TR 60-470 Part III	WADD TR 60-470 Part III	2000	6 in.
1003	ASD Tape 6		Altus Air Force Base Taxiway 5, Centerline	February 1962	WADD TR 60-470 Part III	WADD TR 60-470 Part III	25,529	6 in.
1004	ASD Tape 7		Altus Air Force Base Taxiway 5 25-ft Left Side	February 1962	WADD TR 60-470 Part III	WADD TR 60-470 Part III	25,560	6 in.
1005	ASD Tape 8		Altus Air Force Base Taxiway 5 25-ft Right Side	February 1962	WADD TR 60-470 Part III	WADD TR 60-470 Part III	25,544	6 in.

Contrails

Project Identification Number	Order Identification Number	IDM Card Description Number	Airport and Runway or Taxiway Identification	Date Profile Measure	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1006	ASD Tape 4		Altus Air Force Base Runway 35, Centerline	February 1962	WADD TR 60-470 Part II	WADD TR 60-470 Part II	40,817	6 in.
1007	ASD Tape 0		Altus Air Force Base Runway 35 75-ft Left Side	February 1962	WADD TR 60-470 Part II	WADD TR 60-470 Part III	26,526	6 in.
1008	ASD Tape 10		Altus Air Force Base Runway 35 75-ft Right Side	February 1962	WADD TR 60-470 Part II	WADD TR 60-470 Part III	26,816	6 in.
1009	ASD Tape 21		Bakalar Air Force Base Parking Ramp 1	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	2,000	6 in.
1010	ASD Tape 11		Bakalar Air Force Base Parking Ramp 1	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	2,000	6 in.
1011	ASD Tape 18		Bakalar Air Force Base Taxiway 3, Centerline	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	3,011	6 in.
1012	ASD Tape 19		Bakalar Air Force Base Taxiway 3 30-ft Left Side	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	2,991	6 in.
1013	ASD Tape 20		Bakalar Air Force Base Taxiway 3 30-ft Right Side	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	3,002	6 in.
1014	ASD Tape 2		Bakalar Air Force Base Runway 15, Centerline	June 1961	WADD TR 60-470 Part II	WADD TR 60-470 Part III	10,019	6 in.
1015	ASD Tape 3		Bakalar Air Force Base Runway 13 50-ft Left Side	June 1961	WADD TR 60-470 Part II	WADD TR 60-470 Part III	10,014	6 in.
1016	ASD Tape 4		Bakalar Air Force Base Runway 13 50-ft Right Side	July 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	10,006	6 in.

Contrails

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1017	ASD Tape 6		Bakalar Air Force Base Runway 18 Centerline	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	10,018	6 in.
1018	ASD Tape 7		Bakalar Air Force Base Runway 18 50-ft Left Side	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	10,015	6 in.
1019	ASD Tape 8		Bakalar Air Force Base Runway 18 50-ft Right Side	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	10,007	6 in.
1020	ASD Tape 10		Bakalar Air Force Base Runway 22 Centerline	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	10,009	6 in.
1021	ASD Tape 11		Bakalar Air Force Base Runway 22 50-ft Left Side	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	9,990	6 in.
1022	ASD Tape 12		Bakalar Air Force Base Runway 22 50-ft Right Side	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	10,003	6 in.
1023	ASD Tape 14		Bakalar Air Force Base Taxiway 27 Centerline	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	7,943	6 in.
1024	ASD Tape 15		Bakalar Air Force Base Taxiway 27 30-ft Left Side	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	7,941	6 in.
1025	ASD Tape		Bakalar Air Force Base Taxiway 27 30-ft Right Side	June 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	7,927	6 in.
1026	ASD Tape 6		Castle Air Force Base Ramp Run 1	November 1961	WADD TR 60-470 Part III	WADD TR 60-470 Part III	2,000	6 in.

Contrails

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1027	ASD Tape 14		Castle Air Force Base Ramp Run 2	November 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	2,000	6 in.
1028	ASD Tape 7		Castle Air Force Base Taxiway 9, Centerline	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	14,662	6 in.
1029	ASD Tape 9		Castle Air Force Base Taxiway 9 50-ft Left Side	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	14,684	6 in.
1030	ASD Tape 10		Castle Air Force Base Taxiway 9 50-ft Right Side	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	14,676	6 in.
1031	ASD Tape 2		Castle Air Force Base Runway 30, Centerline	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	23,606	6 in.
1032	ASD Tape 5		Castle Air Force Base Runway 30, Centerline	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	23,636	6 in.
1033	ASD Tape 4		Castle Air Force Base Runway 30 75-ft Right Side	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	23,647	6 in.
1034	ASD Tape 1		Dobbins Air Force Base Ramp Run 1	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1035	ASD Tape 10		Dobbins Air Force Base Ramp Run 1	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1036			Dobbins Air Force Base Taxiway 10, Centerline	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	19,226	6 in.
1037			Dobbins Air Force Base Taxiway 10 31-ft Left Side	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	19,235	6 in.
1038			Dobbins Air Force Base Taxiway 10 31-ft Right Side	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	19,228	6 in.

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1039			Dobbins Air Force Base Runway 10, Centerline	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,046	6 in.
1040			Dobbins Air Force Base Runway 10 75-ft Left Side	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,062	6 in.
1041			Dobbins Air Force Base Runway 10 75-ft Right Side	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,048	6 in.
1042	ASD Tape 2		Edwards Air Force Base Ramp Run 1	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1043	ASD Tape 3		Edwards Air Force Base Ramp Run 2	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1044	ASD Tape 5		Edwards Air Force Base West Taxiway, Centerline	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	10,045	6 in.
1045	ASD Tape 6		Edwards Air Force Base West Taxiway 50-ft Left Side	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	10,046	6 in.
1046	ASD Tape 10		Edwards Air Force Base West Taxiway 50-ft Right Side	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	10,047	6 in.
1047	ASD Tape 7		Edwards Air Force Base Runway 4, Centerline	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	30,020	6 in.
1048	ASD Tape 8		Edwards Air Force Base Runway 4 75-ft Left Side	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	30,015	6 in.
1049	ASD Tape 9		Edwards Air Force Base Runway 4 75-ft Right Side	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	30,037	6 in.
1050	ASD Tape 3		Ellsworth Air Force Base Ramp Run 1	September 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1051	ASD Tape 4		Ellsworth Air Force Base Ramp Run 2	September 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1052	ASD Tape 2		Ellsworth Air Force Base Runway 30, Centerline	September 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	24,607	6 in.
1053	ASD Tape 2		George Air Force Base Ramp Run 1	January 1962	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1054	ASD Tape 3		George Air Force Base Ramp Run 2	January 1962	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1055	ASD Tape 8		George Air Force Base Runway 3, Centerline	January 1962	WADD TR-60-470 Part III	WADD TR-60-470 Part III	18,275	6 in.
1056	ASD Tape 9		George Air Force Base Runway 3 50-ft Left Side	January 1962	WADD TR-60-470 Part III	WADD TR-60-470 Part III	18,280	6 in.
1057	ASD Tape 10		George Air Force Base Runway 3 50-ft Right Side	January 1962	WADD TR-60-470 Part III	WADD TR-60-470 Part III	18,292	6 in.
1058	ASD Tape 11		George Air Force Base Taxiway 5, Centerline	January 1962	WADD TR-60-470 Part III	WADD TR-60-470 Part III	10,641	6 in.
1059	ASD Tape 13		George Air Force Base Taxiway 5 25-ft Left Side	January 1962	WADD TR-60-470 Part III	WADD TR-60-470 Part III	10,630	6 in.
1060	ASD Tape 14		George Air Force Base Taxiway 5 25-ft Right Side	January 1962	WADD TR-60-470 Part III	WADD TR-60-470 Part III	10,241	6 in.
1061	ASD Tape 4		George Air Force Base Runway 16, Centerline	January 1962	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,134	6 in.
1062	ASD Tape 6		George Air Force Base Runway 16 50-ft Right Side	January 1962	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,128	6 in.

Contrails

Project Identification Number	Other Identification Number	ISM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1063	ASD Tape 2		Glasgow Air Force Base Ramp Run 1	October 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1064	ASD		Glasgow Air Force Base Ramp Run 2	October 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1065	ASD Tape 4		Glasgow Air Force Base Runway 10, Centerline	October 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	26,990	6 in.
1066	ASD Tape 5		Glasgow Air Force Base Runway 10, 75-ft Left Side	October 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	26,950	6 in.
1067	ASD Tape 8		Glasgow Air Force Base Taxiway 10, Centerline	October 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	26,112	6 in.
1068	ASD Tape 9		Glasgow Air Force Base Taxiway 10, 35-ft Left Side	October 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	22,142	6 in.
1069	ASD Tape 10		Glasgow Air Force Base Taxiway 10, 35-ft Right Side	October 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	22,140	6 in.
1070	ASD Tape 9		Langley Air Force Base Ramp Run 1	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1071	ASD Tape 10		Langley Air Force Base Ramp Run 2	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1072	ASD Tape 2		Langley Air Force Base Runway 7, Centerline	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,031	6 in.
1073	ASD Tape 3		Langley Air Force Base Runway 7, 50-ft Left Side	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,021	6 in.
1074	ASD Tape 4		Langley Air Force Base Runway 7, 50-ft Right Side	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	18,988	6 in.

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1075	ASD Tape 6		Langley Air Force Base Runway 35, Centerline	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	10,008	6 in.
1076	ASD Tape 8		Langley Air Force Base Runway 35 50-ft Left Side	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	9,990	6 in.
1077	ASD Tape 7		Langley Air Force Base Runway 35 50-ft Right Side	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	9,993	6 in.
1078	ASD Tape 9		Larson Air Force Base Ramp Run 1	October 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1079	ASD Tape 10		Larson Air Force Base Ramp Run 2	October 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1080	ASD Tape 2		Larson Air Force Base Taxiway 4, Centerline	October 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	6,126	6 in.
1081	ASD Tape 3		Larson Air Force Base Taxiway 4 35-ft Left Side	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	6,123	6 in.
1082	ASD Tape 4		Larson Air Force Base Taxiway 4 35-ft Right Side	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	6,124	6 in.
1083	ASD Tape 6		Larson Air Force Base Taxiway 3, Centerline	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	13,946	6 in.
1084	ASD Tape 7		Larson Air Force Base Taxiway 3 37-ft Left Side	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	13,955	6 in.
1085	ASD Tape 8		Larson Air Force Base Taxiway 3 37-ft Right Side	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	13,962	6 in.

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1086	ASD Tape 12		Larson Air Force Base Runway 32, Centerline	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	27,002	6 in.
1087	ASD Tape 13		Larson Air Force Base Runway 32 75-ft Left Side	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	27,033	6 in.
1088	ASD Tape 14		Larson Air Force Base Runway 32 75-ft Right Side	August 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	27,046	6 in.
1089	ASD Tape 4		Mather Air Force Base Runway 22 Left Centerline	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	22,634	
1090	ASD Tape 5		Mather Air Force Base Runway 22 Left 5-ft Left Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	11,400	6 in.
1091	ASD Tape 6		Mather Air Force Base Runway 22 Left 5-ft Right Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	11,400	6 in.
1092	ASD Tape 7		Mather Air Force Base Runway 22 Left 25-ft Left Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	11,400	6 in.
1093	ASD Tape 8		Mather Air Force Base Runway 22L 25-ft Right Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	11,400	6 in.
1094	ASD Tape 9		Mather Air Force Base Runway 22L 45-ft Left Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	11,400	6 in.
1095	ASD Tape 10		Mather Air Force Base Runway 22 Left 45-ft Right Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	11,400	6 in.
1096	ASD Tape 11		Mather Air Force Base Runway 22 Left 60-ft Left Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	11,400	6 in.

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1097	ASD Tape 12		Mather Air Force Base Runway 22 Left 60-ft Right Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	11,400	6 in.
1098	ASD Tape 3		Mather Air Force Base Runway 22 Left 75-ft Right Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	22,641	6 in.
1099	ASD Tape 14		Mather Air Force Base Taxiway 22, Centerline	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	19,486	6 in.
1100	ASD Tape 15		Mather Air Force Base Taxiway 22, 75-ft Left Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	19,480	6 in.
1101	ASD Tape 16		Mather Air Force Base Taxiway 22, 75-ft Right Side	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	19,490	6 in.
1102	ASD Tape 17 Paper Tape 1		Mather Air Force Base Parking Ramp	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1103	ASD Paper Tape 2		Mather Air Force Base Parking Ramp	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1104	ASD Paper Tape 3		Mather Air Force Base Parking Ramp	May 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1105	ASD Tape 9		McGuire Air Force Base Ramp Run 1		WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1106	ASD Tape 10		McGuire Air Force Base Ramp Run 2		WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1107	ASD Tape 11		McGuire Air Force Base Runway 6, Centerline		WADD TR-60-470 Part III	WADD TR-60-470 Part III	18,000	6 in.
1108	ASD Tape 2		McGuire Air Force Base Runway 12, Centerline		WADD TR-60-470 Part III	WADD TR-60-470 Part III	15,054	6 in.

Contrails

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1109	ASD Tape 3		McGuire Air Force Base Runway 12 75-ft Left Side		WADD TR-60-470 Part III	WADD TR-60-470 Part III	14,930	6 in.
1110	ASD Tape 4		McGuire Air Force Base Runway 12 75-ft Right Side		WADD TR-60-470 Part III	WADD TR-60-470 Part III	14,930	6 in.
1111	ASD Tape 6		McGuire Air Force Base Taxiway 5, Centerline		WADD TR-60-470 Part III	WADD TR-60-470 Part III	12,754	6 in.
1112	ASD Tape 7		McGuire Air Force Base Taxiway 5 31-ft Left Side		WADD TR-60-470 Part III	WADD TR-60-470 Part III	12,757	6 in.
1113	ASD Tape 8		McGuire Air Force Base Taxiway 5 31-ft Right Side		WADD TR-60-470 Part III	WADD TR-60-470 Part III	12,761	6 in.
1114	ASD Tape 42		USAF Plant No. 42 Palmdale Runway 7, Centerline	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	24,022	6 in.
1115	ASD Tape 14		USAF Plant No. 42 Palmdale Runway 7 50-ft Left Side	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	24,024	6 in.
1116	ASD Tape 15		USAF Plant No. 42 Palmdale Runway 7 50-ft Right Side	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	24,027	6 in.
1117	ASD Tape 3		USAF Plant No. 42 Palmdale Taxiway P(16)	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1118	ASD Tape 4		USAF Plant No. 42 Palmdale Taxiway L(12)	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	1,600	6 in.
1119	ASD Tape 5		USAF Plant No. 42 Palmdale Taxiway N(14)	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	4,002	6 in.
1120	ASD Tape 6		USAF Plant No. 42 Palmdale Taxiway N(14)	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	1,000	6 in.

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Data Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1121	ASD Tape 7		USAF Plant No. 42 Palmdale Taxiway H(8)	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	1,600	6 in.
1122	ASD Tape 8		USAF Plant No. 42 Palmdale Taxiway J(10)	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	1,600	6 in.
1123	ASD Tape 9		USAF Plant No. 42 Palmdale Taxiway E(5)	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,400	6 in.
1124	ASD Tape 11		USAF Plant No. 42 Palmdale Runway 22	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	24,000	6 in.
1125	ASD Tape 12		USAF Plant No. 42 Palmdale Taxiway B(2), Centerline	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	23,347	6 in.
1126	ASD Tape 16		USAF Plant No. 42 Palmdale Taxiway B(2), 35-ft Left Side	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	23,357	6 in.
1127	ASD Tape 17		USAF Plant No. 42 Palmdale Taxiway B(2), 35-ft Right Side	December 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	23,365	6 in.
1128			Sewart Air Force Base Ramp Run	June 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	4,000	6 in.
1129			Sewart Air Force Base Taxiway 2, Centerline	June 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	8,039	6 in.
1130			Sewart Air Force Base Taxiway 2, 35-ft Left Side	June 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	8,022	6 in.
1131			Sewart Air Force Base Taxiway 2, 35-ft Right Side	June 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	8,026	6 in.
1132			Sewart Air Force Base Runway 14, Centerline	June 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	15,931	6 in.
1133			Sewart Air Force Base Runway 14, 75-ft Left Side	June 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	15,873	6 in.

Contrails

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1134			Sewart Air Force Base Runway 14 75-ft Right Side	June 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	15,855	6 in.
1135			Sewart Air Force Base Runway 18, Centerline	June 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	10,011	6 in.
1136			Sewart Air Force Base Runway 18 75-ft Left Side	June 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	10,019	6 in.
1137			Sewart Air Force Base Runway 18 75-ft Right Side	June 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	10,017	6 in.
1138	ASD Tape 9		Shaw Air Force Base Ramp Run 1	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1139	ASD Tape 10		Shaw Air Force Base Ramp Run 2	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1140	ASD Tape 2		Shaw Air Force Base Runway 4, Centerline	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,044	6 in.
1141	ASD Tape 3		Shaw Air Force Base Runway 4 50-ft Left Side	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,054	6 in.
1142	ASD Tape 4		Shaw Air Force Base Runway 4 50-ft Right Side	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	20,055	6 in.
1143	ASD Tape 6		Shaw Air Force Base Taxiway, Centerline	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	5,716	6 in.
1144	ASD Tape 7		Shaw Air Force Base Taxiway 35-ft Left Side	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	5,703	6 in.

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Runway or Taxiway Identification	Airport and Runway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1145	ASD Tape 8		Shaw Air Force Base Taxiway 35-ft Right Side	Shaw Air Force Base Taxiway 35-ft Right Side	July 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	5,735	6 in.
1146	ASD Tape 1		Travis Air Force Base Ramp Run 1	Travis Air Force Base Ramp Run 1	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1147	ASD Tape 2		Travis Air Force Base Ramp Run 2	Travis Air Force Base Ramp Run 2	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.
1148	ASD Tape 4		Travis Air Force Base Runway 21 R, Centerline	Travis Air Force Base Runway 21 R, Centerline	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	22,040	6 in.
1149	ASD Tape 5		Travis Air Force Base Runway 21 R, 75-ft Left Side	Travis Air Force Base Runway 21 R, 75-ft Left Side	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	22,060	6 in.
1150	ASD Tape 6		Travis Air Force Base Runway 21 R, 75-ft Right Side	Travis Air Force Base Runway 21 R, 75-ft Right Side	November 1961	WADD TR-60-470 Part III	WADD TR-60-470 Part III	22,946	6 in.
1151	ASD File 1		Wright Field Runway 27, Centerline	Wright Field Runway 27, Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	13,200	6 in.
1152	ASD File 2		Wright Field Runway 27, Centerline	Wright Field Runway 27, Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	11,800	6 in.
1153	ASD File 3		Wright Field Runway 05, Right Side	Wright Field Runway 05, Right Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	11,600	6 in.
1154	ASD File 4		Wright Field Runway 23, Right Side	Wright Field Runway 23, Right Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	11,000	6 in.
1155	ASD File 5		Wright Field Taxiway 05, Right Side	Wright Field Taxiway 05, Right Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	11,200	6 in.
1156	ASD File 6		Wright Field Taxiway 05, Right Side	Wright Field Taxiway 05, Right Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	11,000	6 in.
1157	ASD File 8		Wright Field Runway 16, Centerline	Wright Field Runway 16, Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	9,000	6 in.
1158	ASD File 9		Wright Field Runway 16, Left Side	Wright Field Runway 16, Left Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	9,000	6 in.

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Data	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1159	ASD File 10		Wright Field Runway 16, Right Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	9,000	6 in.
1160	ASD File 12		Wright Field Taxiway 05, Left Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	9,000	6 in.
1161	ASD File 13		Patterson Field Taxiway 12, Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	8,400	6 in.
1162	ASD File 14		Patterson Field Taxiway 12, Right Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	8,400	6 in.
1163	ASD File 15		Patterson Field Taxiway 12, Left Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	7,800	6 in.
1164	ASD File 16A		Patterson Field Taxiway 17, Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	11,800	6 in.
1165	ASD File 16B		Patterson Field Taxiway 16, Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	10,800	6 in.
1166	ASD File 30		Patterson Field Runway 5 Left Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	23,400	6 in.
1167	ASD File 31		Patterson Field Runway 5 Left Right Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	23,400	6 in.
1168	ASD File 32		Patterson Field Runway 5 Left Left Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	23,400	6 in.
1169	ASD File 56		Fairchild Air Force Base Runway 23, Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	23,800	6 in.
1170	ASD File 57		Fairchild Air Force Base Runway 23, Right Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	24,000	6 in.
1171	ASD File 58		Fairchild Air Force Base Runway 23, Left Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	24,600	6 in.

Contrails

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Date	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1172	ASD File 69		Fairchild Air Force Base Taxiway 1, Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	15,800	6 in.
1173	ASD File 70		Fairchild Air Force Base Taxiway 1, Left Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	15,800	6 in.
1174	ASD File 71		Fairchild Air Force Base Taxiway 1, Right Side	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	15,800	6 in.
1175	ASD File 72		McConnell Air Force Base Runway 36 Right Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	21,200	6 in.
1176	ASD File 79		Lincoln Air Force Base Runway 35, Centerline	October 1961	WADD TR-60-470 Part II	WADD TR-60-470 Part II	15,800	6 in.
1177			Carswell Air Force Base Runway 17 13-ft Left Side		WADD TR-60-470 Part III	WADD TR-60-470 Part III	24,037	6 in.
1178			Carswell Air Force Base Runway 17 13-ft Right Side		WADD TR-60-470 Part III	WADD TR-60-470 Part III	24,052	6 in.
1179			Carswell Air Force Base Runway 17 37-ft Left Side		WADD TR-60-470 Part III	WADD TR-60-470 Part III	24,043	6 in.
1180			Carswell Air Force Base Runway 17 37-ft Right Side		WADD TR-60-470 Part III	WADD TR-60-470 Part III	24,051	6 in.
1181			Carswell Air Force Base Runway 17 87-ft Left Side		WADD TR-60-470 Part III	WADD TR-60-470 Part III	24,068	6 in.
1182			Carswell Air Force Base Taxiway, Centerline		WADD TR-60-470 Part III	WADD TR-60-470 Part III	18,500	6 in.

Project Identification Number	Other Identification Number	IBM Card Deck Identification Number	Airport and Runway or Taxiway Identification	Date Profile Measured	Source of Profile Date	Source of Power Spectral Density Data	Total Number of Measurements	Interval between Measurements
1183			Carswell Air Force Base Ramp Run 1	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.	
1184			Carswell Air Force Base Ramp Run 2	WADD TR-60-470 Part III	WADD TR-60-470 Part III	2,000	6 in.	

Contrails