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WEST OF SHETLAND DATA BUOY PROJECT - SECOND REPORT

December 1976 - March 1977

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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Internal Document No 16

Institute of Oceanographic Sciences
Crossway
Taunton

October 1977

<u>Report from the Institute of Oceanographic Sciences to the United Kingdom Offshore Operators Association on the conduct of the West of Shetland data buoy project from the first deployment of the buoy on 4 December 1976 to its stranding on 11 March 1977</u>

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INTRODUCTION

This is the second in a series of documents which reports on the conduct of the UKOOA West of Shetland data buoy project. A brief description of this project was included in the first report, and for the sake of completeness this appears again in the present report, this time as an appendix. The first report described events up to and including deployment of the buoy on 4 December 1976.

The organisational aspects of the project have remained the same, that is, UKOOA has contracted with the Natural Environment Research Council, Institute of Oceanographic Sciences, to make measurements to the West of Shetland, and has nominated Marex Ltd as the major sub-contractor, to be responsible for the supply and operation of a data buoy.

This report describes the first three months of the first commercial data gathering project in UK waters to use a data buoy. It was a rather eventful three months, but the data recovery from the project as a whole, particularly for the waves, was very high and moreover was higher than had previously been achieved on UKOOA projects.

Scope and organisation of the report

The report covers the period from the deployment of the buoy on 4 December 1976 up to its stranding on Shetland on 11 March 1977.

As in the first report, the narrative describing the sequence of events is divided into two parts: Part 1 deals with the Marex operation and Part 2 with the receiving station on Foula. The data from both sources are considered in Part 3.

Part 1 is preceded by a schedule of the main events which occurred during the period (Table 1). There are a number of appendices:

Appendix A - Brief description of the project (reproduced from the first report)

Appendices B1 to B8 - Comparisons of wave data in spectral form from the waverider and the data buoy.

Table 1 - Schedule of main events

4 December 1976	-	Marex data buoy deployed
6 December 1976	-	Receiving station on Foula reinstated
14 December 1976	-	Receiving station failed
16 December 1976	-	Interim measures taken to try to keep Foula station operating
to		
12 January 1977	-	IOS visit Foula and install modified power supply
13 January 1977	-	Data buoy module change; mooring found to have dragged $\frac{1}{2}$ mile
8 February 1977	-	Data buoy module change; buoy remoored with heavier anchor; waverider transmit frequency changed.
9 March 1977	-	Data buoy broke away
11 March 1977	-	Data buoy reported ashore on Shetland.

Part 1 - Marex data buoy

The buoy was deployed on 4 December 1976, and signals received on Foula during the following month indicated that the buoy was operating normally.

During the period covered by this report neither a back-up buoy nor an exchange processor module were available. Thus, during a 'module exchange visit', although the battery modules were exchanged, the processor module was simply removed, its magnetic tapes replaced by new ones and the same processor put back into the buoy. While the servicing boat was in the vicinity of the buoy spot readings of air and sea temperatures, wind speed and direction and barometric pressure were taken.

The first such visit was made on 13 January 1977, and the exchange of batteries and tapes successfully accomplished. It was found however that the buoy had moved about ½ NM from its original position.

On the 9 February the second module exchange was made and during the same visit the data buoy mooring was recovered and a heavier anchor fitted. The buoy was towed to the original location and re-anchored. In addition, the waverider was recovered and the crystal changed to give a transmission frequency of 27.065 MHz and so comply with the (just received) Home Office allocation.

The stranding of the buoy:

On 10 March IOS informed Marex that the buoy signal was no longer being received on Foula, although the waverider signal was present. Later that day the buoy was reported ashore at Watts Ness on the west coast of the mainland of Shetland.

The modules were removed from the buoy by Marex's Shetland agent and subsequently the hull and all salvageable components were shipped back to Cowes.

Subsequent examination of the buoy magnetic tape revealed that the processor/recorder had failed 13 days after the previous module change. The cause of the failure was a faulty power supply, but fortunately the transmitted data were not affected.

Neither the mast, the meteorological instruments nor the mooring were recovered, these having been lost during the stranding or subsequently removed by local people.

The loss of the mooring components was particularly serious as very little evidence was available from which the cause of the breakaway could be determined. IOS decided that in the circumstances they should investigate the mooring design and make some recommendations to Marex. Marex were asked to submit a drawing of the buoy mooring to the Mechanical Engineering Group at IOS, and on the 19 April the Group's observations and recommendations were sent to Marex.

Part 2 - The receiving station on Foula

An IOS party visited Foula as soon after deployment as the weather would permit. The object of the visit was to reinstate the system which had failed earlier, apparently because of a faulty battery. It was also necessary to check that the data buoy and waverider signals were being received. The receiving/recording system was reinstated on 6 December 1976 and it was confirmed that good signals were being received from both sources. There was however some evidence of voice channel interference especially on the data buoy frequency.

On the 14 December our agent informed IOS that the system had again failed, and on the 16th a new logger was sent airfreight to Foula, arriving on the 22nd.

In the meantime laboratory tests were carried out to try to reproduce the fault. As a result of these it proved possible to keep the system running until a visit to Foula could be arranged to install a modified power supply system. This visit was made on the 12 January and the party stayed on the island until the 19th. During that time the system operated satisfactorily and a number of spectral comparisons between the data buoy and the waverider were made.

The difficulties described above resulted in the loss of 70% of the transmitted data during the first five weeks. Fortunately the buoy system performed well during this period and very little recorded data was lost.

After the installation of the modified power supply the system continued to operate without incident for the remainder of the period covered by this report.

A persistent problem has been interference by voice and sometimes music signals which appear to originate from Eastern Europe. The data loss due to this cause averaged about 10% for the period of this report. Some improvement would probably be obtained by modifications to the beam pattern of the aerial array, and the use of a more selective receiver, and these options are being considered at IOS.

On the afternoon of 9 March our agent on Foula visited the receiving station and found that the data buoy signal was no longer being received although the waverider signal was present. He phoned IOS the following morning (10 March) and was instructed to switch over to the waverider channel. IOS then informed Marex.

Part 3 - The Data

Scrutiny of the data by IOS

In order to operate the 'continuity of operations' clauses in the contract, it was necessary for IOS to develop a checking procedure to be used on all the data buoy results. As well as having purely contractual use, this work was important in that the performance of the buoy, which was a comparatively untried system, was monitored closely and recommendations regarding specific aspects of its performance could be made as necessary.

Briefly, the checking scheme used was as follows. A copy of each buoy data tape was sent to IOS by Marex. This was checked by a computer program to determine how much of the data was retrievable, and how much of the retrievable data passed some simple checks for reasonableness. These we refer to as 'Group 1 checks' - see ref (1).

In addition comparisons were made:

(a) between the wave data recorded on the buoy, and the wave data recorded on Foula; and

(b) between the meteorological data recorded on the buoy and estimates of the meteorological conditions at the buoy site prepared by the Meteorological Office (London Weather Centre) using the appropriate synoptic charts.

These comparisons we refer to as 'Group 2 checks' - ref (1).

The results of these procedures were used in the following way:

(1) We used the Group 2 checks to assess the general performance of the buoy. In particular we could detect any systematic errors. If there

were errors, depending on the nature of these, we either disqualified the data (for payment) or accepted it, but in any case asked that Marex qualify the data as being erroneous or suspect.

(2) If we considered that as a result of the Group 2 checks the data were useful, then the results of the Group 1 checks were used to determine the data return figures to be used contractually.

The results of this procedure are shown in Table 2. An explanation of Table 2 is now given.

The table shows the percentage data loss for each element recorded, and for each of the three module periods. The periods covered by the modules are as follows:

Module No	Period covered
1	4 Dec 76 - 13 Jan 77
2	13 Jan 77 - 8 Feb 77
3	8 Feb 77 - 21 Feb 77

In addition, the table is subdivided into errors detected by Group 1 checks and those detected by Group 2 checks. The letters A, B, C, D are cross-referenced to the detailed comments about the data listed below the table.

Table 2 (for explanation see text)

	GROUP 1			GROUP 2		
Module No	1	2	3	1	2	3
RMS	1	14	54D	0	0	0D
Hmax	1	16	52D	0	0	0D
H1	1	14	51D	0	0	0D
Tz	1	14	54D	0A	0A	0A,D
Wind speed	1	6	52D	0	0	0
Wind direction	0	4	48D	0	0	0
Barometric pressure	2	11	55D	0B	0B	0B
Air temp	2	12	55D	0C	0C	0C
Sea temp	2	11	55D	0C	0C	0C

Comments on the Data

A - The values of Tz recorded on the buoy did not correlate well with those calculated from the transmitted data. The cause of the discrepancies is being investigated by both IOS and Marex

B - A mean difference between the data buoy and the Met Office pressures of approximately $\frac{1}{2}$ mb was noted

C - Both air and sea temperatures exhibited excessive hour to hour variability. This data will be flagged as suspect. Marex were advised to modify the sample scheme for these elements (see First Report (Ref 2) Appendix E6).

D - The on-buoy data processing and recording system failed after 13 days, due to a faulty power supply. The transmitted data was not interrupted, however. Overall, wave data was available for more than 95% of module period 3.

Group 1 Failures:

These were almost entirely due to random errors on the magnetic tape or to completely missing data records. Approximately 4% of the total possible number of records were lost due to the latter cause during module period 2.

Group 2 Failures:

It will be noted that no data were disqualified for payment during the period covered by this report as a result of Group 2 checks. Although certain questions about the validity of some of the data were raised, it was felt that they nevertheless constituted valuable or potentially valuable data.

Raw data recording:

The on-buoy raw wave data recorder did not operate during the period of this report.

Foula Data

Table 3 shows the percentage of data lost during each of the three periods between magnetic tape changes.

Table 3

Period	% data lost
6 Dec 76 - 12 Jan 77	70
12 Jan 77 - 11 Feb 77	8
11 Feb 77 - 14 Mar 77	19

The losses in the first period were due to system failure caused by a faulty power supply (see Part 2). The third period covered the buoy break-away, and some data was lost before the receiver could be switched over to the waverider channel. Other causes of data loss were radio interference and data recorder formatting errors.

Spectral comparisons

Appendices B2 - B8 show 7 spectral comparisons between the data buoy and the waverider. These were obtained during the January visit to the island. They show fair agreement although many more would be needed before a reliable assessment of the relative responses of the buoy and the waverider could be made. Appendix B1 gives an explanation of the spectra.

REFERENCES

(1) PITT, E.G., 'The Quality Control of Data from an Offshore Station'. Symposium on Offshore Data Acquisition Systems. Southampton. Sept 74. SUT.

(2) Institute of Oceanographic Sciences. 'West of Shetland Data Buoy Project - First Report'. IOS Internal Document No 11. Confidential to UKOOA Oceanographic Committee participants. NB This report is part of the IOS Internal Document series and should not be cited in any other paper or report except as 'personal communication'.

APPENDIX A

Brief description of the Foula Data Buoy Project

The project is based on the use of the Marex data buoy which is moored at a site chosen to be in the same general area as the Fitzroy location and in a comparable depth of water, but close enough to land to enable the telemetry of wave data from the buoy.

The buoy makes hourly recordings of the following parameters:

- Wave height
- Wave period
- Wind speed
- Wind direction
- Atmospheric pressure
- Air temperature
- Sea temperature

The computations involved are carried out by an onboard microprocessor and the results are recorded using a cassette type digital magnetic tape recorder.

The microprocessor and the tape recorder are housed in one of four replaceable waterproof modules, the batteries are housed in two others, and the Datawell heave sensor in the fourth.

The changing of the magnetic tapes and batteries is accomplished by simply exchanging the self-contained modules. This is done at approximately monthly intervals by Marex staff using a chartered fishing boat.

As well as being processed and recorded on the buoy, the wave data is transmitted continuously using a standard waverider modulator and transmitter. A receiving station has been set up on the island of Foula which is switched on for 25 minutes once every 3 hours and during this time the signal is received and samples of the wave data are recorded using both analogue and digital tape recorders.

The receiving station is visited every few days by IOS's agent who is resident on the island, to check that the buoy signal is still being received. Battery charging is necessary once per week and the tapes are changed once per month. If for any reason the buoy signal is not received, our agent telephones IOS to discuss the problem and IOS in turn informs Marex. At the end of each month the tapes are transported to the mainland of Shetland for onward transmission to IOS.

As a back-up to the data buoy measurement of waves, Marex deployed a waverider close to the buoy position. In the event of a failure of the data buoy transmission the waverider can be received and recorded on Foula by selecting the appropriate channel on the receiver. In normal circumstances the waverider signal is checked once every few days but is not sampled.

APPENDIX B1

Spectral Comparisons

The spectra shown in Appendices B2 to B8 have been included to give an indication of the results obtainable from the data buoy and the waverider.

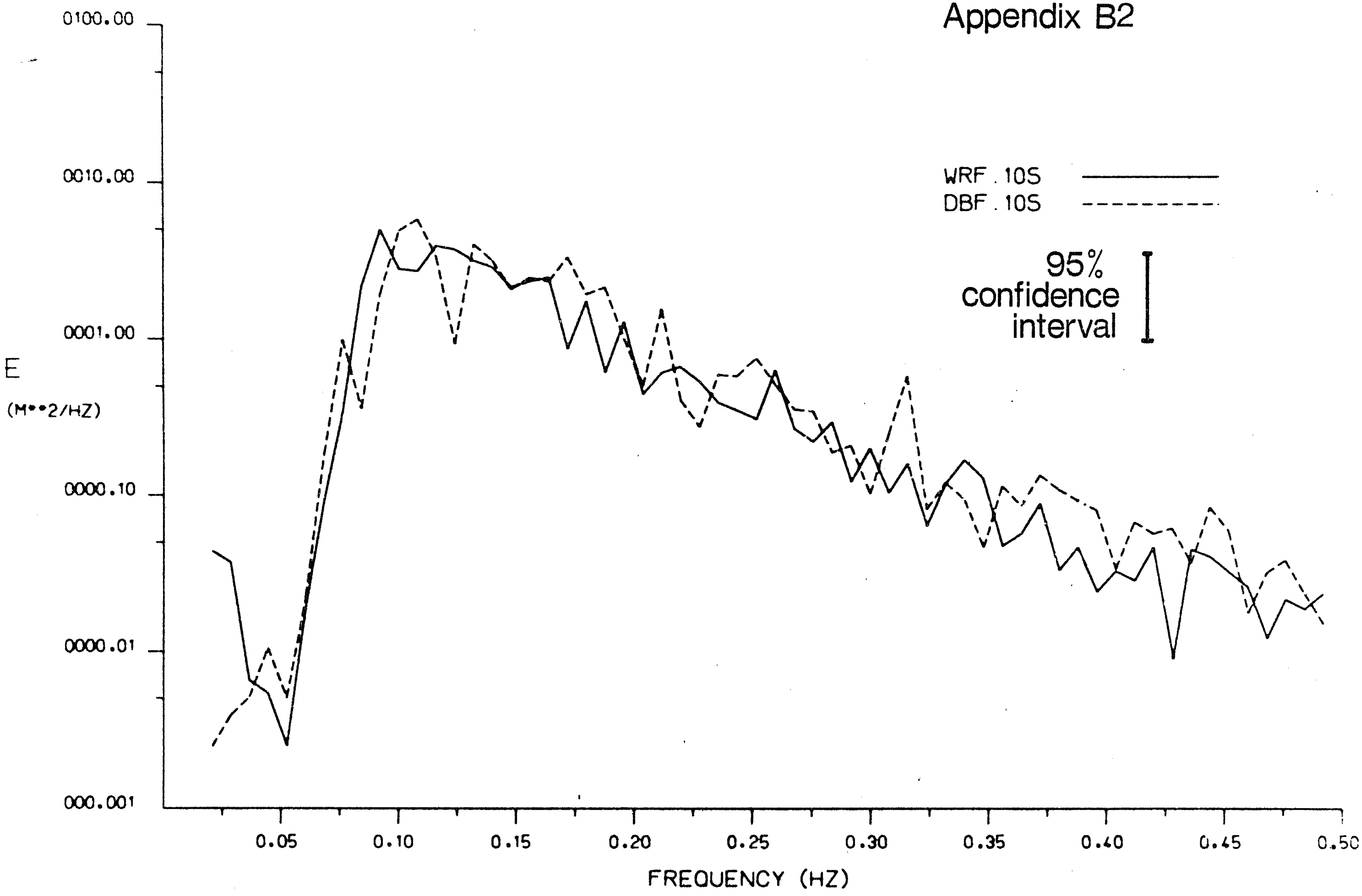
The instruments were moored 0.5 miles apart and the data pairs were not taken simultaneously, but during consecutive 17 minute periods.

The sampling process introduces large random sampling errors (confidence limits for individual spectral estimates are marked on the spectra). Thus, the results cannot be taken as a definitive measure of the relative response of the two equipments - in order to do this a much more carefully controlled experiment would be required, and many more pairs of spectra.

Values of Hs and Tz computed from the spectra are shown below. Taking account of the poor statistics of the comparison, the agreement between the two can be considered as satisfactory.

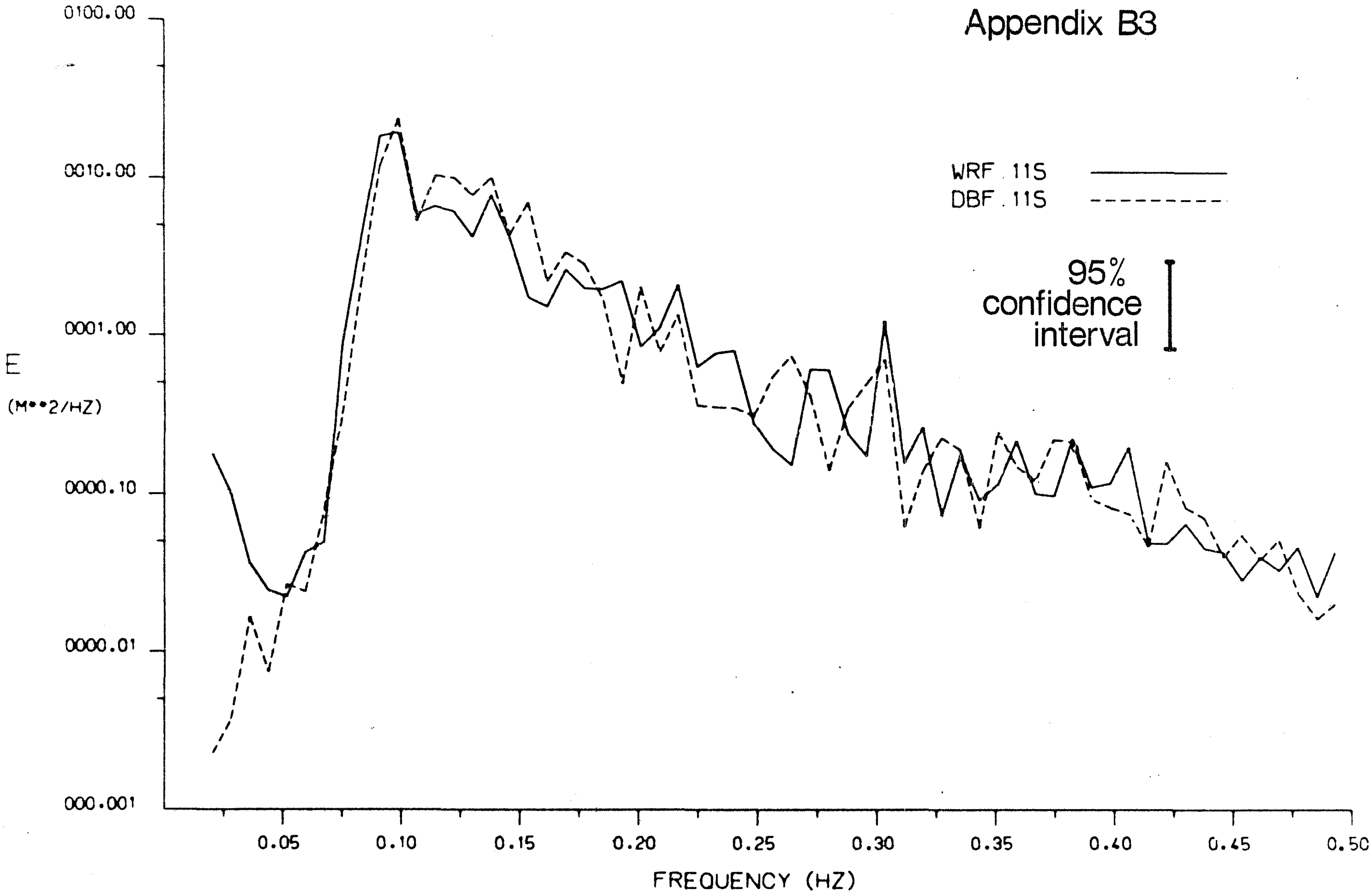
	W/R		MDB	
Appendix	Hs	Tz	Hs	Tz
B2	2.39	6.19	2.52	5.81
B3	3.59	6.73	3.82	6.78
B4	3.52	6.64	3.54	6.03
B5	2.34	6.27	2.57	6.01
B6	2.48	6.08	2.57	6.32
B7	2.45	7.56	2.35	6.42
B8	2.18	6.28	2.45	6.86
Means of Hs and Tz	2.71	6.54	2.83	6.32

Appendix B2

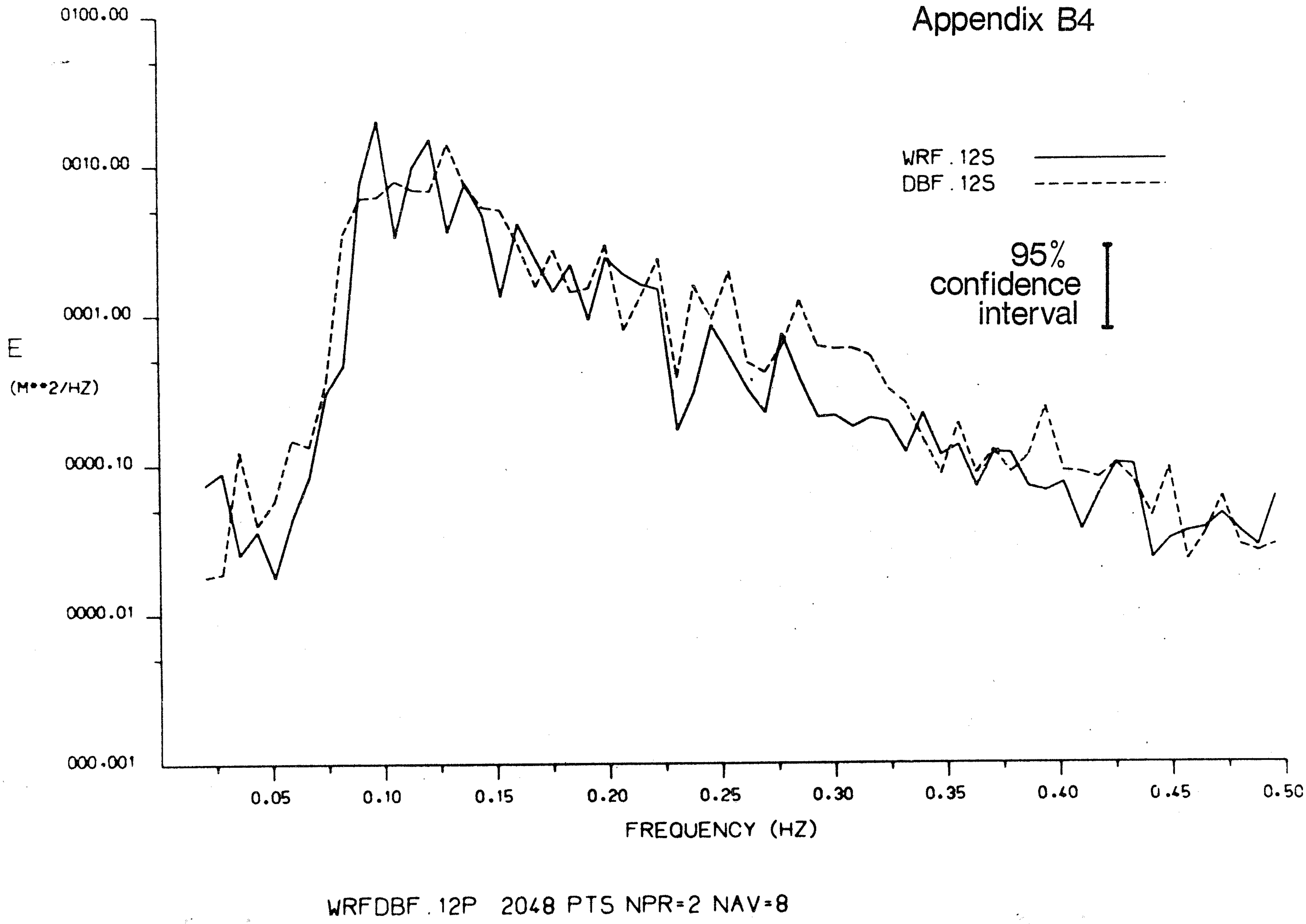


WRFDBF 10P 2000 PTS NPR=2 NAV=8

Appendix B3

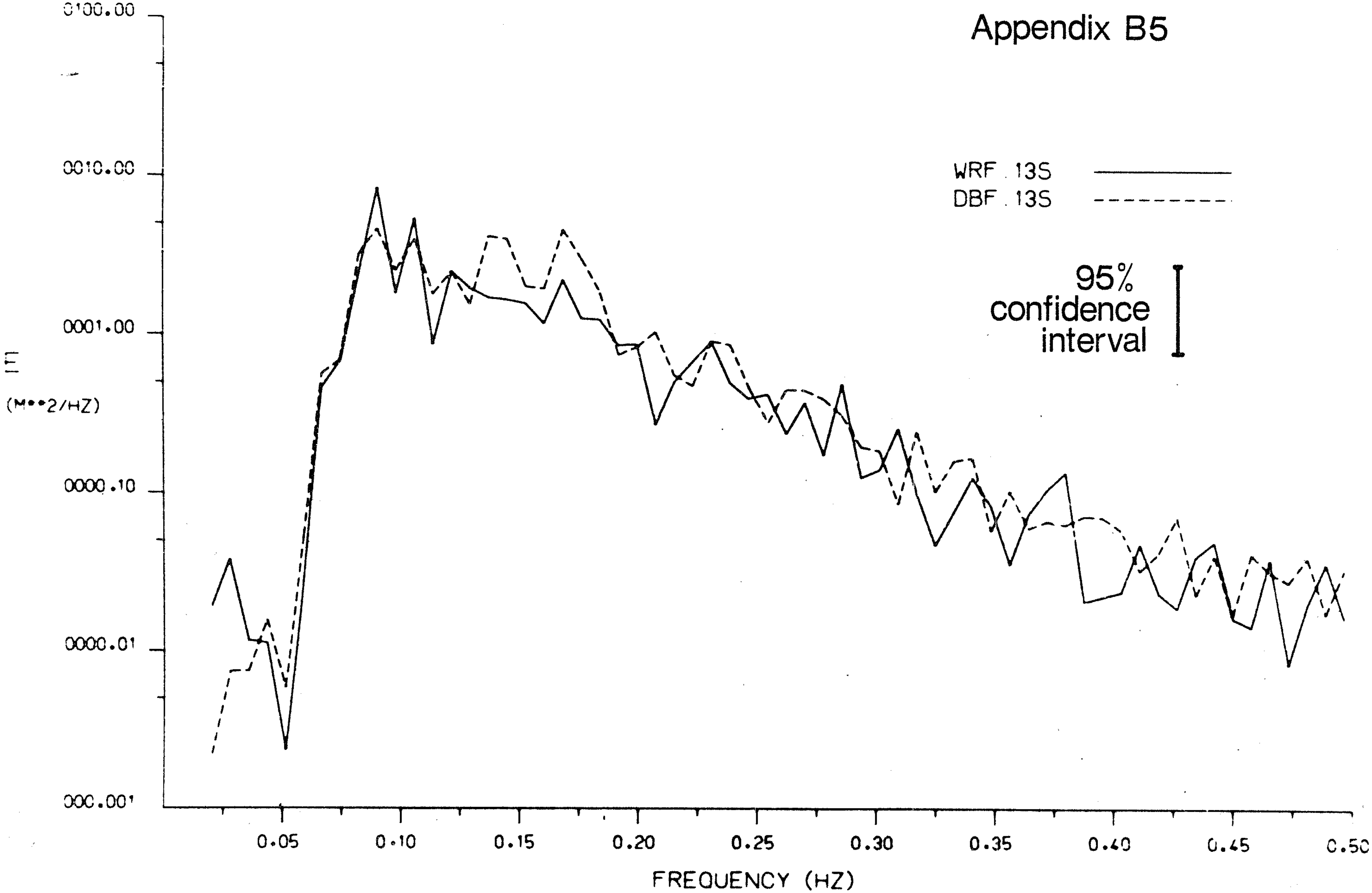


WRFDBF 11P 2028 PTS NPR=2 NAV=8



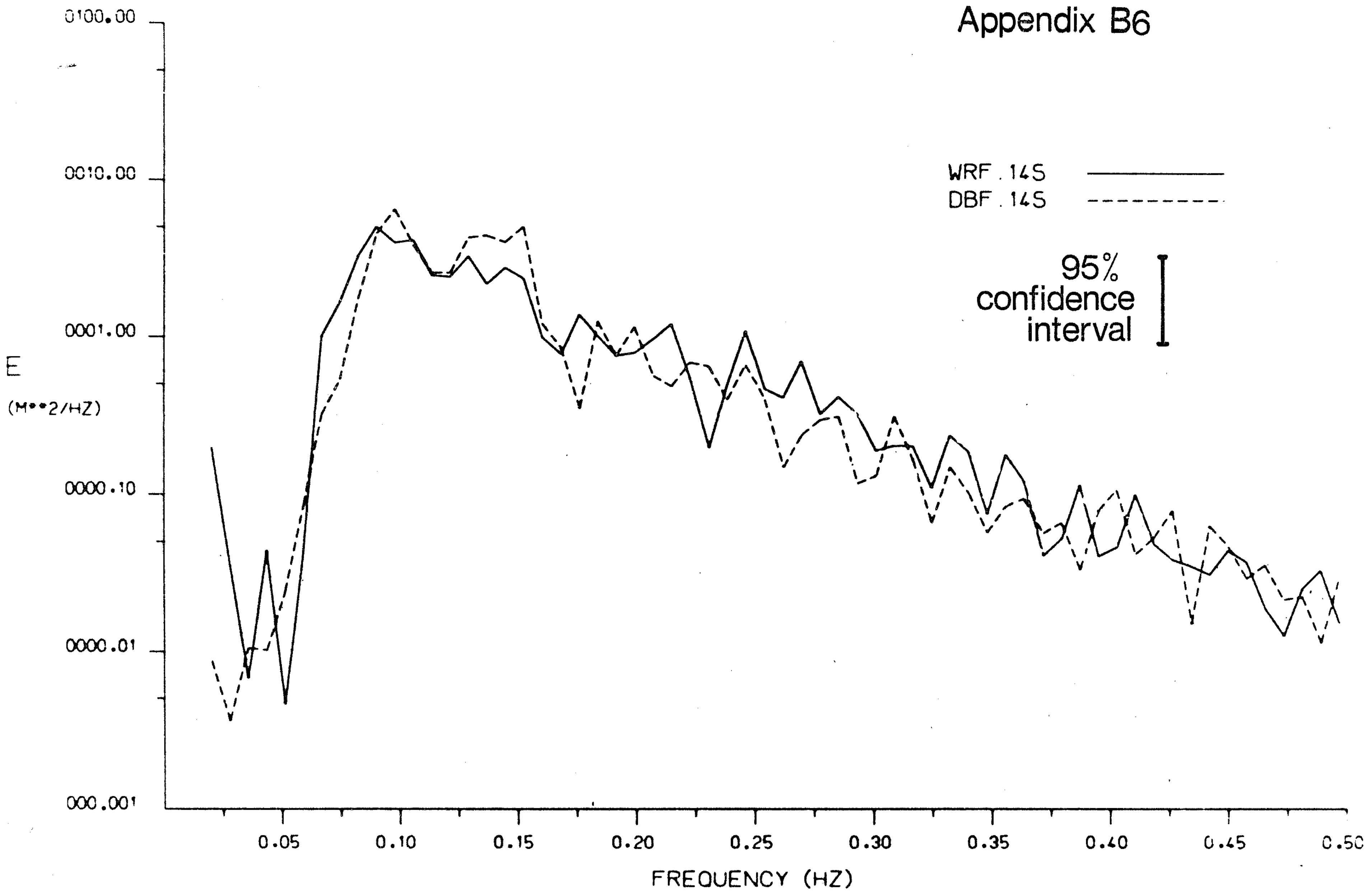
Appendix B4
WRF . 12S
DBF . 12S
95% confidence interval
0100.00
0010.00
0001.00
0000.10
0000.01
000.001
E
(M**2/HZ)
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
FREQUENCY (HZ)
WRFDBF . 12P 2048 PTS NPR=2 NAV=8

Appendix B5

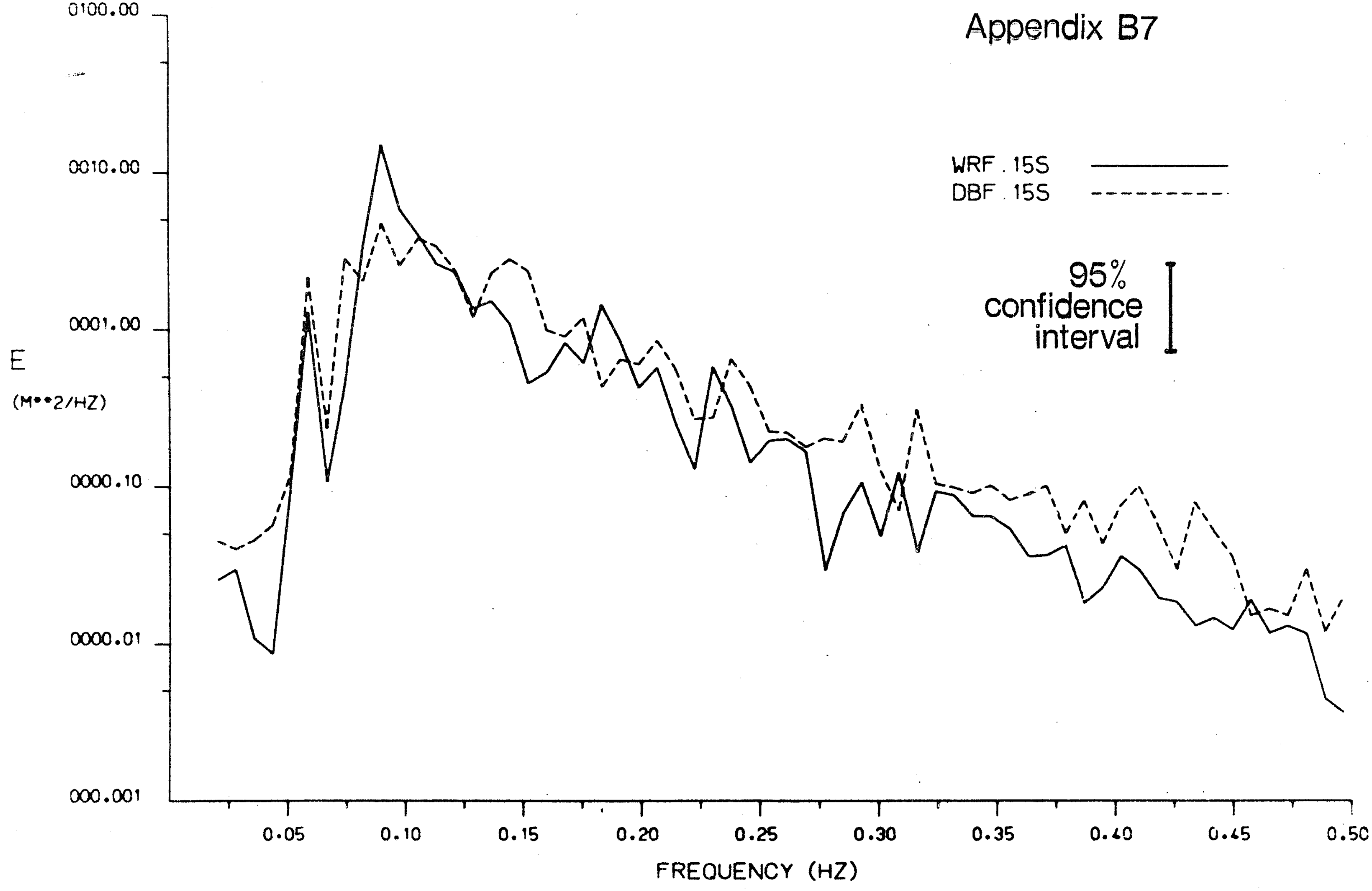


WRFDBF 13P 2048 PTS NPR=2 NAV=8

Appendix B6

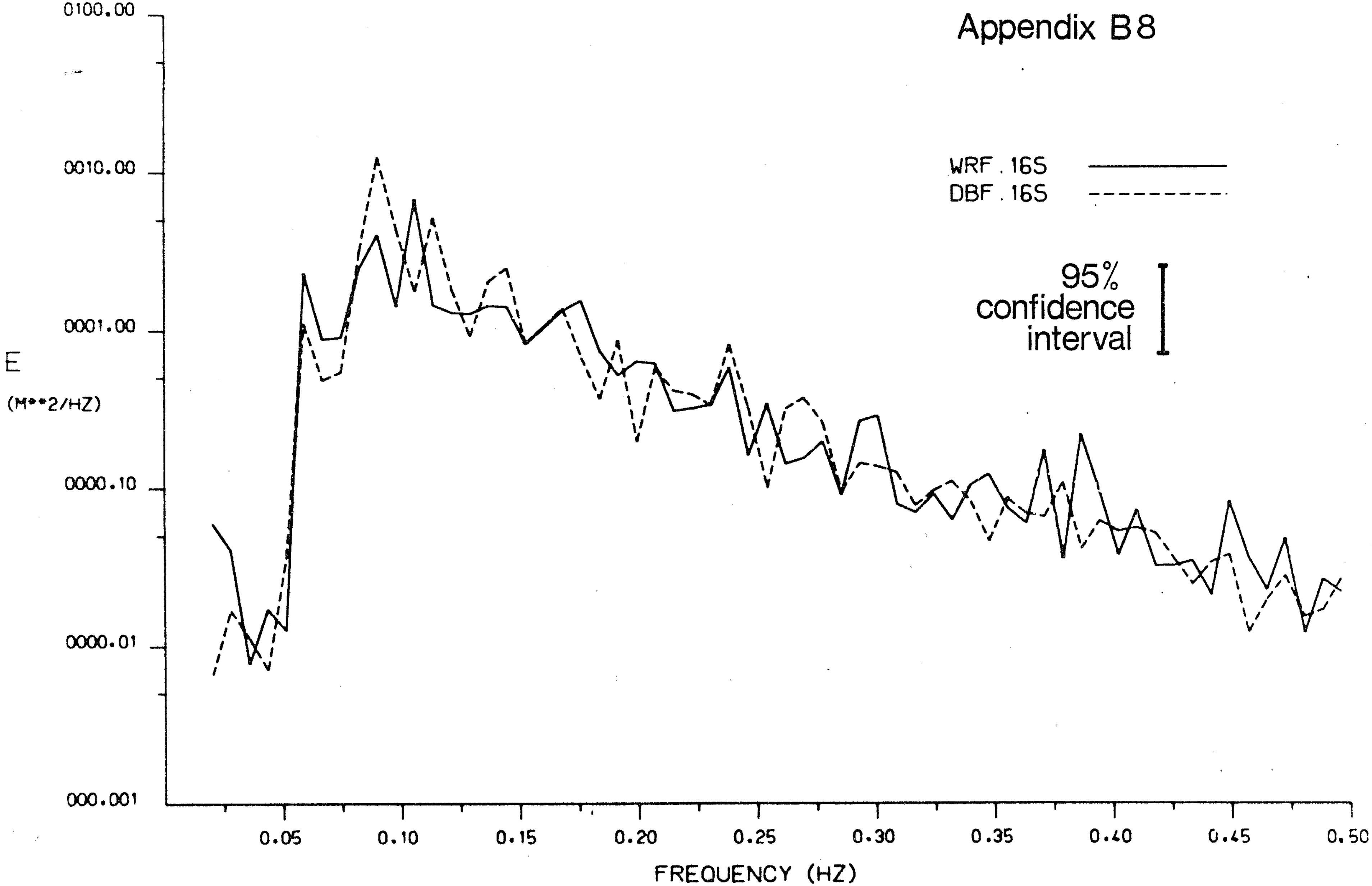


WRFDBF 14P 2048 PTS NPR=2 NAV=8



WRFDBF . 15P 2048 PTS NPR=2 NAV=8

Appendix B8



WRFDBF.16P 2048 PTS NPR=2 NAV=8