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AN AID FOR REDUCING WIND SPEEDS OVER WATER TO A STANDARD LEVEL

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1. INTRODUCTION

The wind near the sea surface is an important variable to marine forecasters for determining wave conditions and for preparing offshore and coastal forecasts. In the Gulf of Mexico there are wind observations available from oil drilling platforms. However, these wind observations are normally quite high above the sea surface. There is a requirement for an easy to use aid for reducing wind speeds measured on the platforms to lower, more standard, levels.

2. THE METHOD

The determination of the wind as a function of height over the sea is not completely solved. Papers showing the wide variation of results of investigators have been written, among others, by Wilson (1960), Deacon and Webb (1962), and Pierson (1964).

Pierson (1964) shows the relation for the logarithmic wind profile with height as:

$$U_z = U_{10}\left[1 + (C_{10})^{1/2}/k\right] \ln \frac{z}{10} \qquad (1)$$

where U_Z is wind speed at height Z,
U_{10} is wind speed at 10 meters,
C_{10} is drag coefficient at 10 meters, and
k is a constant equal to 0.4.

The problem is what values to use for the drag coefficient (C_D), as there are many values available. For example, Wilson (1960) shows the results of 47 authorities in the determination of drag coefficients.

For the present use, drag coefficients determined by DeLeonibus (1971) in a study of momentum flux and wave spectra observations at Argus Island Tower are used. Drag coefficients for the 7.5 meter level for neutral and unstable stratifications were averaged for wind speeds of 3.0 m/sec to 14.5 m/sec (5.8 to 28.2 knots). A total of 232 observations were used. Observations for neutral and unstable conditions were averaged because there isn't much difference in the drag coefficients in these data. A smooth curve was fit by eye to these values and then the curve was extrapolated to wind speed values of 21 m/sec (40.8 knots). These values of drag coefficient ($C_{7.5}$) were then used in the relationship:

$$U_z = U_{7.5}\left[1 + (C_{7.5})^{1/2}/k\right] \ln \frac{z}{7.5} \qquad (2)$$

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This is similar to equation (1) except that the wind and drag coefficients are for the 10-meter level in equation (1). Calculations were made for U_Z at levels of 10, 15, 20, 25, 30, 35, 40, 45, and 50 meters for 7.5 meter winds of 3, 5, 7, 9, 11, 13, 15, 17, 19, and 21 m/sec. A display of these calculations is shown in figure 1. Quite obvious is the effect of larger drag coefficients at the higher wind speeds.

We were quite hesitant to present similar wind profiles for stable conditions as the values of drag coefficient for stable conditions are much more irregular than for unstable and neutral conditions. However, because of the importance of having such wind profiles, they have been constructed. There were 137 observations made during stable conditions with 7.5 meter wind speeds ranging from 3.5 to 13 m/sec (6.8 to 25.3 knots). It was felt unwise to extrapolate this curve further because of the irregular nature of the data. Profiles were then determined in the same manner as for the unstable and neutral conditions. These are plotted in figure 2.

3. USE OF THE NOMOGRAMS

To determine the wind speed at some level, simply enter the proper nomogram with the wind speed, U_Z, at the elevation Z and then come down to the desired level by interpolating between the available curves and read the wind speed on the X-axis. For example, if there is a wind observation at 50 meters of 20 knots in unstable conditions and the wind speed at 10 meters is desired, enter the nomogram of Figure 1 at 50 meters and 20 knots and follow downward between the curves to about 17 knots at 10 meters.

4. SUMMARY

The derived nomograms for reducing wind speed from a high level to a lower level are based on the calculation of drag coefficients for the Argus Island experiments of 1964, 1967, and 1969 (DeLeonibus, 1971). Two nomograms were prepared--one for neutral and unstable conditions and one for stable conditions. The preparation of the nomograms is a quick approach to the problem, using available data, and by no means are the nomograms the ultimate solution to this complicated problem. The authors view these nomograms as a preliminary aid for reducing wind speeds to lower levels and expect that more sophisticated methods will be developed as more experimental work is carried out.

Some caution should be taken in using the nomograms initially and an effort should be made to determine their validity in cases where there are wind observations available at different levels at the same location or at nearby locations.

5. REFERENCES

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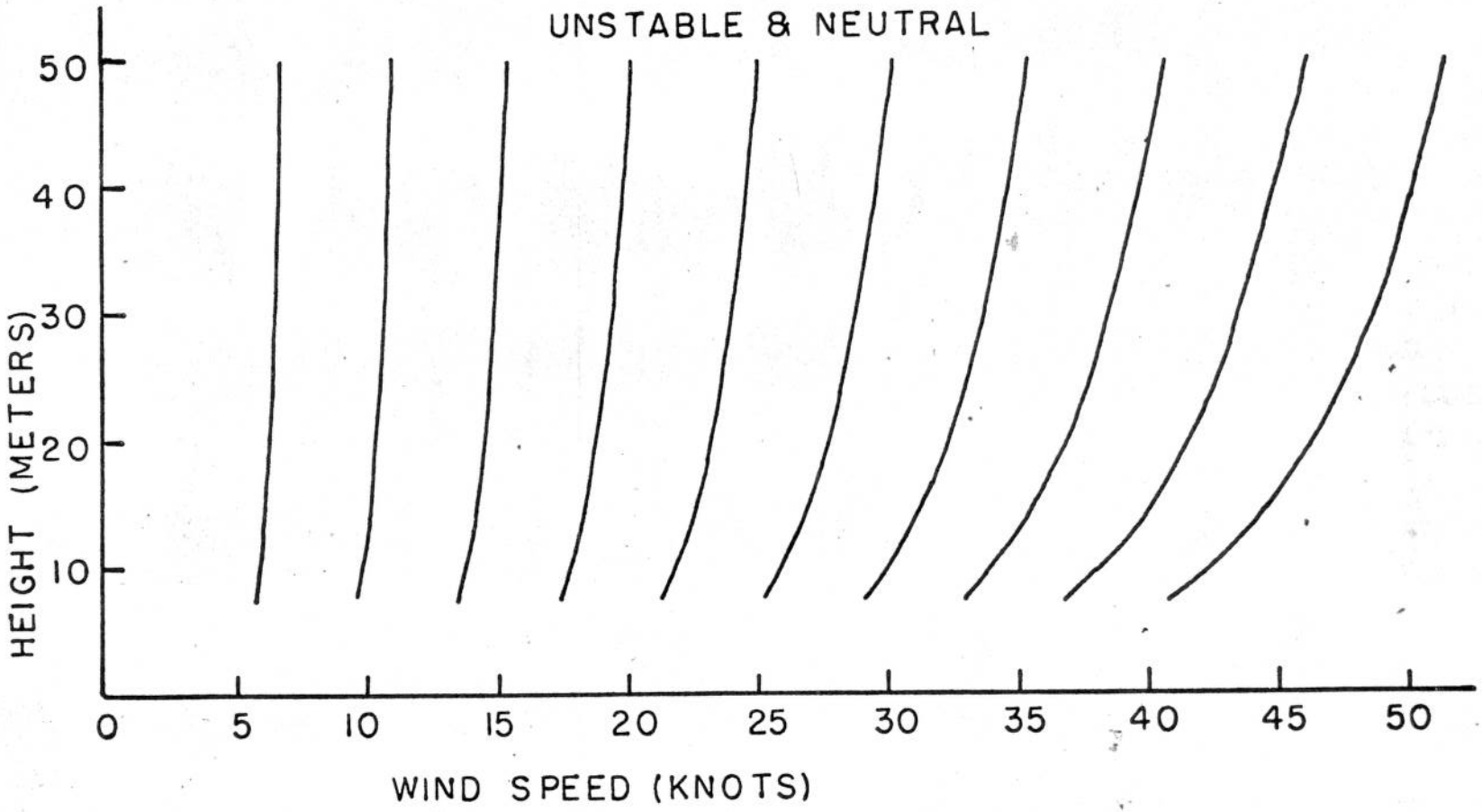

Figure 1. Calculated wind profiles using drag coefficients determined in the Argus Island experiments for unstable and neutral conditions.

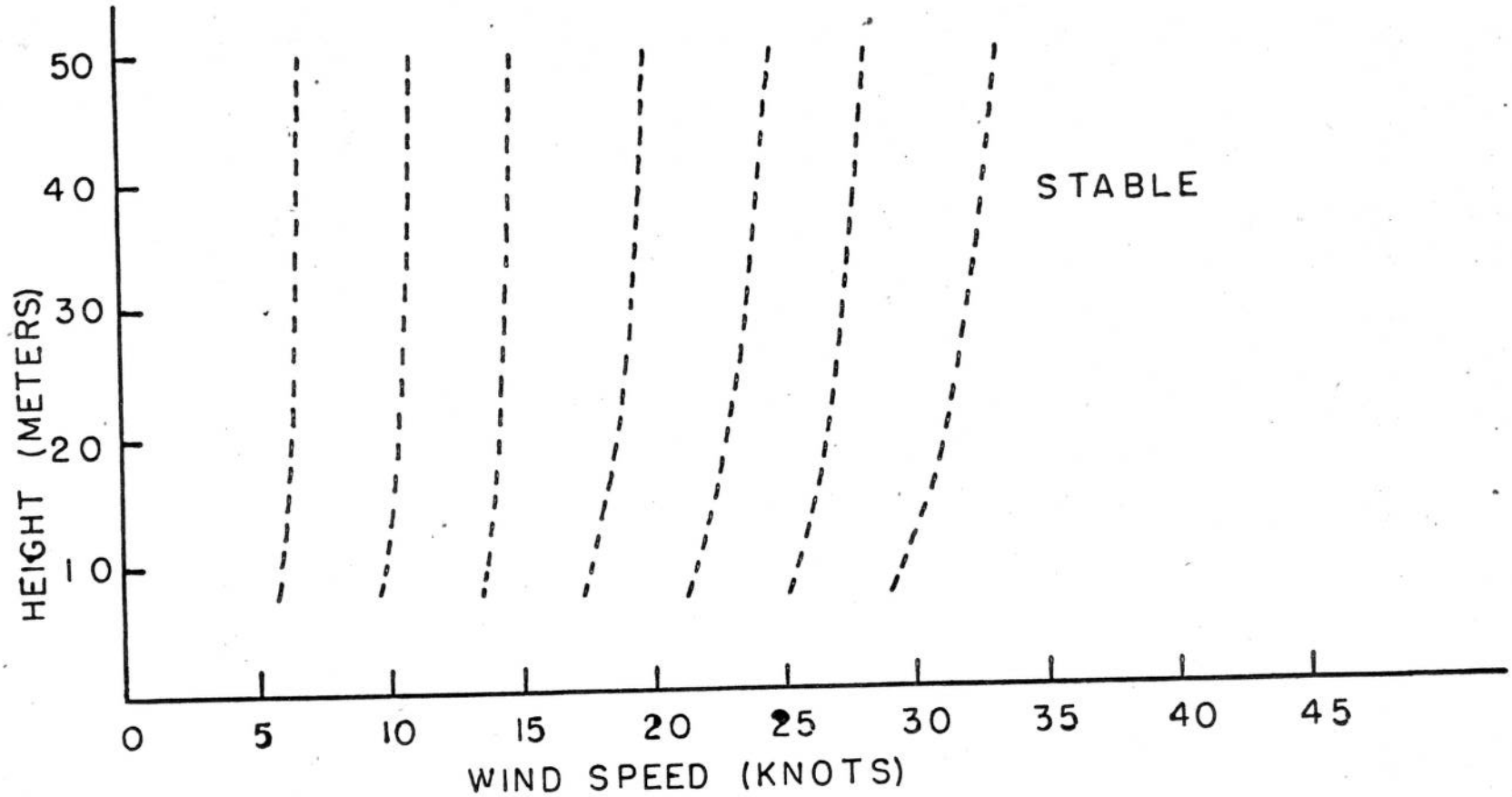

Figure 2. Calculated wind profiles using drag coefficients determined in the Argus Island experiments for stable conditions.