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OPERATING MANUAL FOR SOIL DENSITY AND MOISTURE MEASUREMENTS BY NUCLEAR METHODS

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INTRODUCTION

This is an interim report prepared by the Research Laboratory's Isotopes Section, covering the results of research carried out during the past two years on the determination of soil density and moisture content by nuclear methods.

This report consists primarily of an operating manual for the nuclear gages involved and their accessory apparatus. It is intended as a practical field guide and includes step-by-step procedures for determination of soil density and moisture content and instructions for proper care of the equipment concerned.

The manual contains all essential up-to-date information available at this time pertaining to the nuclear methods under discussion, and includes density and moisture curves based on actual field operations calibrated against conventional determinations (Figures 1 and 2).

Although the curves are considered accurate on the basis of the limited number of experiments performed, it is realized that either curve or both may have to be adjusted slightly as additional field determinations may indicate. Laboratory evidence indicates that the upper range of the moisture curve may go either way as drawn. A comprehensive program designed to furnish this additional information has already been initiated, and a later report will present the results of the field tests.

EQUIPMENT REQUIRED

1. Portable Scaler
2. Density Gage
3. Moisture Gage
4. Density Gage Standard
5. Moisture Gage Standard
6. Calibration Curve for Density
7. Calibration Curve for Moisture

OPERATING INSTRUCTIONS

Safety Precautions

The greatest source of radiation is from the front of the gage; therefore, when the gage is handled, it should always point away from the user. The safe distance behind the gage for minimum radiation exposure is approximately one foot. Closer distances should be employed for brief periods of time for handling purposes only. Film badges may be worn if required.

Gages: Controls and Connectors

1. Output connector: supplies high voltage to the gages.
2. Switch on density gage: turns on battery contained in gage.

Scaler: Controls and Connectors

1. Master Switch: Selects either battery or a-c power. Battery charging is automatic when connected to 110-v a-c line, regardless of switch position.
2. Battery Test: Light comes on brightly when spring switch is depressed, and the battery is charged whether plugged into a-c line or not. Dim light will be seen when the unit is connected to the a-c line and has been fully charged with switch in "off" position.
3. HV Control: Adjusts the high voltage on the gage. This setting should not be changed except by Laboratory personnel.
4. Moisture-Density Switch: Selects proper voltage for each gage. This switch position should be changed only when the scaler is off. Switch positions:

   "Moisture" applies 1540 v to gage, for moisture determinations.

   "Density" applies 900 v to gage, for density determinations.
5. Test-Use Switch: In test positions, pulses from the gage are stopped. The scaler will count the frequency of the power supply, either battery or a-c line. Frequency on battery is approximately 115 cps. Frequency on a-c line is exactly 60 cps. For precise checks on counter or timer, the a-c line is used.
6. Time-Count Switch: The counting is stopped or started by means of the toggle switch on the timer. If the timer is not being used,

this switch is adjusted to either the "count" or "off" position. When the timer is to be used, the timer knob is adjusted to the desired count-time interval. To start the count, the toggle switch is set to the "count" position, then back to "off" position. When the time interval has elapsed, the count will be stopped automatically.

7. Reset Button: Resets all glow-tube counters to zero position. The count switch should be in the "off" position.

Fuses

1. 6-amp: Battery protection fuse. Unit will operate on a-c line with this fuse out.
2. 0.3-amp: Protects battery charger and counting circuits.
3. 0.15-amp: Separate circuit protection. Charger alone will work on ac with this fuse out.

Input

Supplies all voltages necessary to operate gages.

OPERATING PROCEDURE

Connecting Gages to Scaler

The gage to be used is connected to the input of the scaler.

BE SURE THE SCALER IS "OFF" WHEN CHANGING GAGES.

Care should be taken to see that the cable is connected securely to the gage and the scaler.

The moisture-density switch is set to the position corresponding to the gage being used. This switch should be operated only when the scaler is off.

> THE DENSITY GAGE WILL BE PERMANENTLY DAMAGED IF THE SCALER IS TURNED ON WITH THE GAGE CONNECTED AND SWITCH LEFT IN THE "MOISTURE" POSITION. DOUBLE-CHECK THIS SWITCH POSITION BEFORE TURNING ON THE SCALER.

The switch on the density gage should be turned on before the scaler is turned on when using the density gage. (Be sure to turn off when through.)

Taking a Standard Count

The density gage, connected to the scaler, is placed on its standard in the designated position. A one-minute count is taken.[1] The moisture gage is then connected to the scaler and the gage is placed in position on its standard. A one minute count is taken.[1] The count rate per minute

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[1] A longer count may be taken for greater accuracy.

is calculated for each gage, and these figures are compared with the following corrected standard count rate:

Density - 5900 counts per minute
Moisture - 1220 counts per minute.

The difference between the standard counts per minute just taken and the corrected standard count rate is the correction factor for all measurements made during the next three or four hours. If the standard count taken is greater than the corrected standard, the correction factor must be subtracted from the count rate per minute taken on the soil. If the standard count is less than the corrected standard, the correction factor must be added to the count rate. The result is the corrected count rate per minute. Usually a standard should be run on each gage at the beginning of the work day and another shortly after mid-day.

Soil Measurements

Sites for density and moisture determinations should be selected where density and moisture are as uniform as possible. These locations shouldbe leveled off when necessary, so that the entire bottom of the gage is in contact with the soil; the area within a two-foot radius of the gage should be as level as possible, with no small piles of dirt nearby higher than half the height of the gage edge.

WHEN MAKING A DENSITY MEASUREMENT, BE SURE THE MOISTURE GAGE IS PLACED IN THE LEAD BOX SHIELD AND IS AT A SUFFICIENT DISTANCE FROM THE DENSITY GAGE SO AS NOT TO AFFECT THE DENSITY COUNT.

Keeping the truck door closed with the moisture gage and shield inside will also help reduce radiation from that source. The presence of the density gage when making a moisture count will not affect the moisture measurement.

A one-minute count is taken with each gage.[2] It is recommended that the density test be made before the moisture test. After each measurement has been made, the count rate per minute should be calculated. To correct this count rate, add or subtract the correction factor. The density (wet basis) and moisture are then determined from their respective master curves (Figures 1 and 2). To determine the density on the dry basis, use the graph (Figure 3) or the formula,

$$\text{Density}_{(\text{dry})} = \frac{\text{Density}_{(\text{wet basis})}\ \text{lb/ft}^3}{\text{Percent moisture}_{(\text{dry basis})} + 100} \times 100$$

This yields the density (dry basis) in pounds per cubic foot.

Be sure to shut off the switch on the density gage if it is to be out of operation longer than a half-hour.

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[2] If greater accuracy is required, one or more three-minute counts may be taken as desired, the results averaged, and this average expressed as count rate per minute; or the gage may be moved two inches to one side and rotated several degrees between each three-minute count. Do not bear down on the gage, as this will tend to compact the soil.

Care of the Scaler and Gages

When equipment is going to be out of operation 12 hours or longer, the operator should be certain that:

1. The master switch on the scaler is off, and
2. The switch on the density gage is off.

The scaler should then be plugged into a 110-v a-c line to recharge the batteries.

Important: The battery should be examined periodically to see that all filling caps are tight and the vent tube is in place and clear.

The battery should be examined weekly for proper electrolyte level. All the specific gravity balls should be above the level line.

ADD ONLY DISTILLED WATER.

The scaler should not be stored for more than 30 hours without trickle charging; a complete recharge can be obtained over a 36-hour period.

Laboratory personnel should be notified if the scaler shows any sign of faulty operation; if the timer shows signs of improper operation, such as considerable difference in count rates made on a single point or on the standard, the scaler may be timed manually with a stopwatch.

Laboratory personnel should be contacted if the scaler has been charging for more than 30 hours and the battery test light has not come on dim.

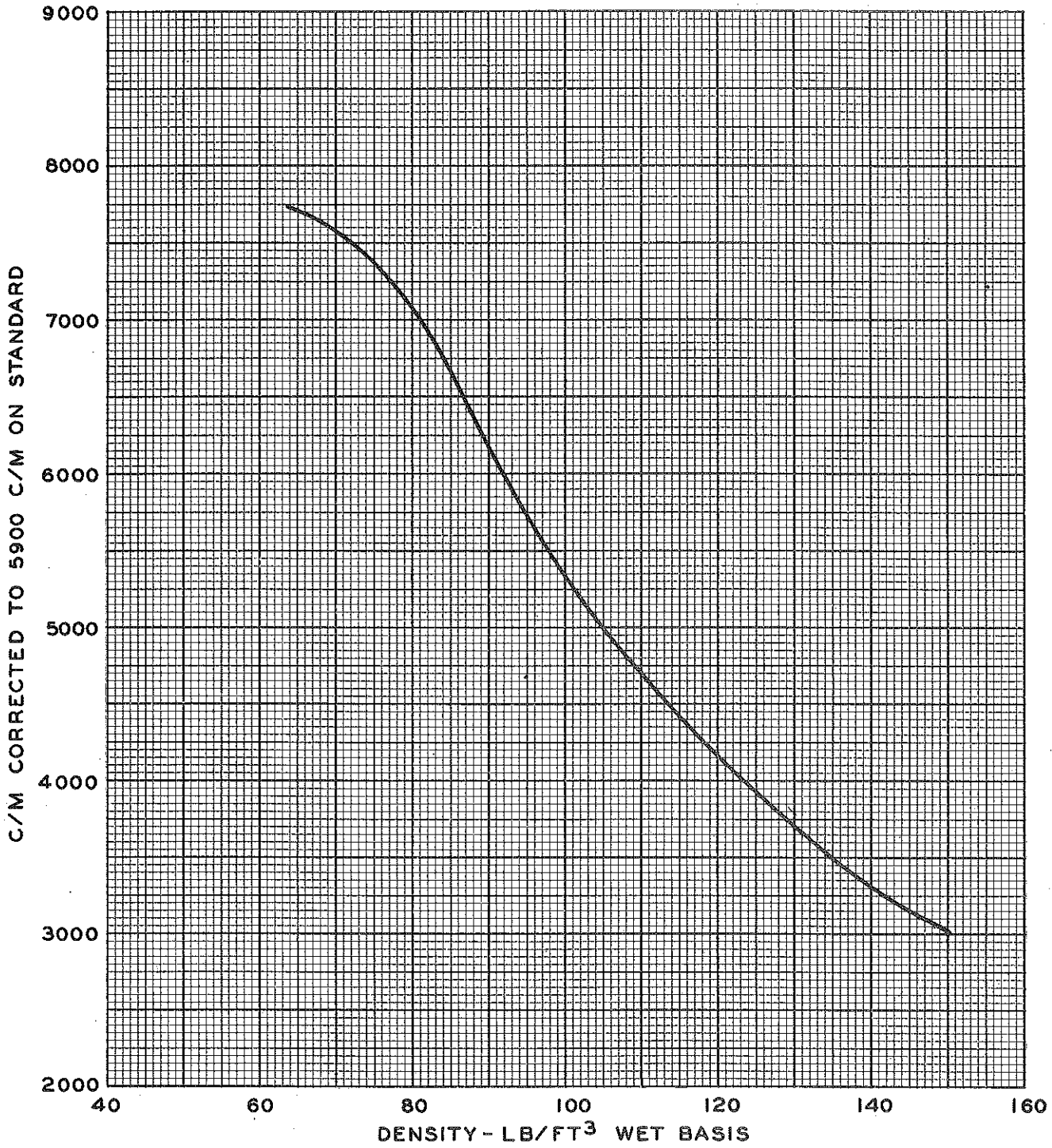

Figure 1. Density Curve

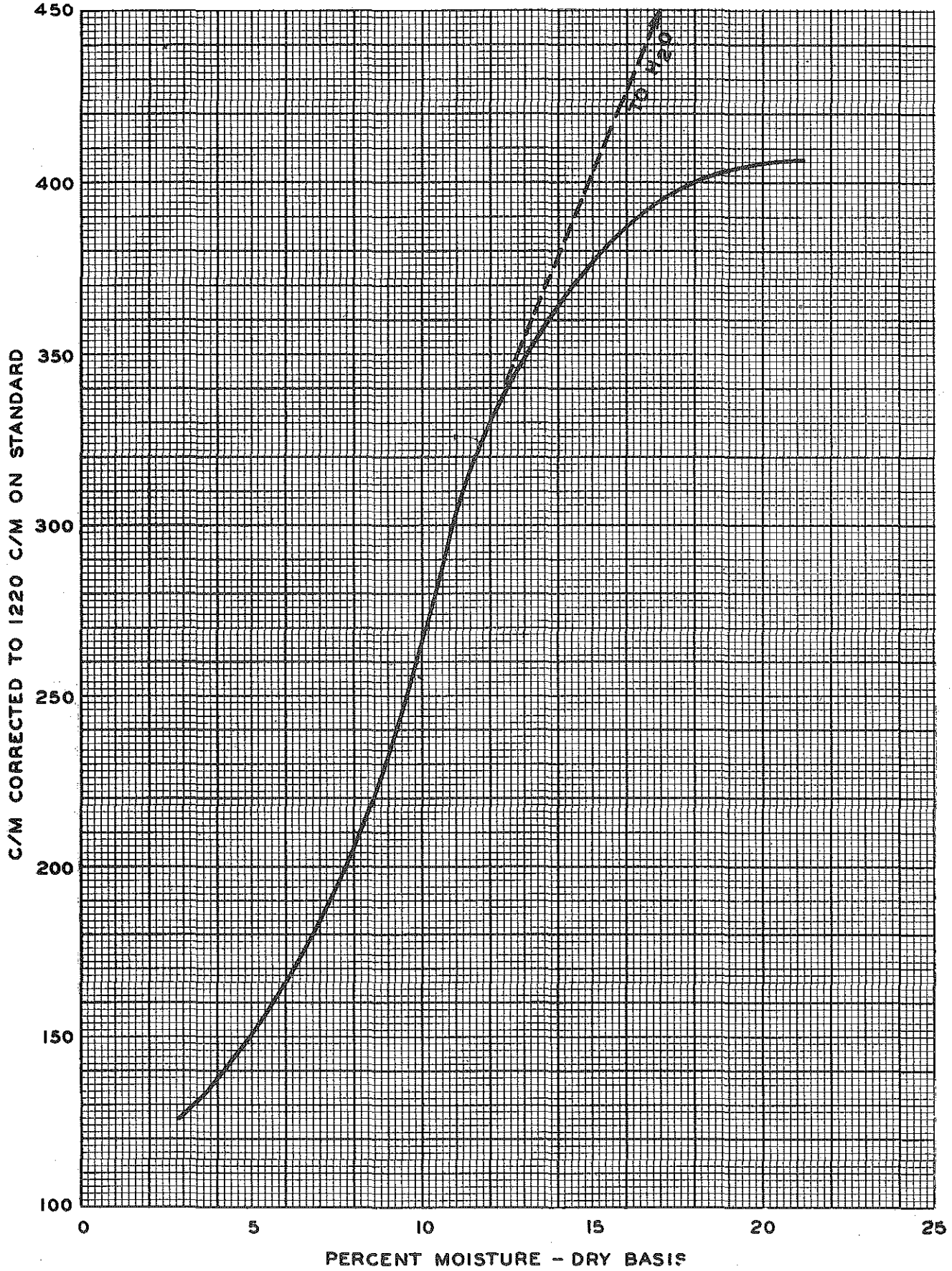

Figure 2. Moisture Curve

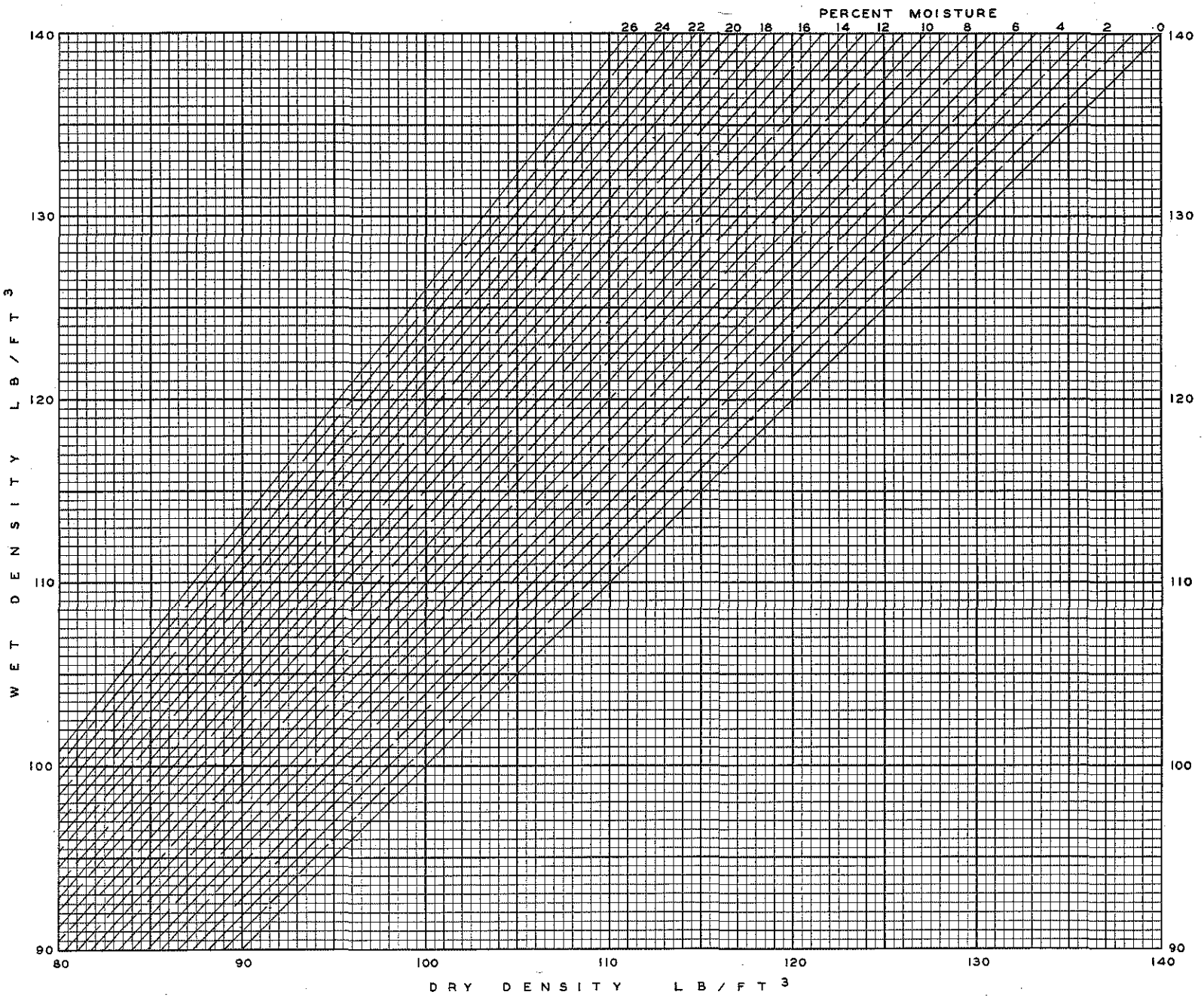

Figure 3. Wet Density-Dry Density Conversion Graph