Using Drilling Rig Formulas to Solve for the Unknown

by
Douglas S. Taylor

Derricks to Desks Lesson Plan

Subject: Mathematics, Algebra 1

Grade levels: 8-12

Objectives: Students will be able to:

1. Substitute numbers in for variables.
2. Solve for the missing variable using different problem-solving techniques.

Prerequisite Knowledge: Students should recognize equivalent formulas such as d=rt and t=$\frac{d}{r}$.

Introduction:

Employees entering the drilling industry need the ability to use simple arithmetic as a part of their everyday duties. Many new workers will find themselves unprepared to handle the arithmetic their work requires.

Routine operations account for most situations on the drilling rig where arithmetic is important. Standard procedures are followed for everyday situations. This places the responsibility for finding the correct answer squarely on the one who is doing the counting, measuring, calculating, or recording.

Emergency situations require special training in procedures and supervision. The success or failure of this training depends on the rig worker's ability to read gauges accurately and to record correctly the various pressures, weights and dimensions. Lives are at stake. **Answers must be correct!**

Teacher Guided Instruction:

In order to effectively solve for an unknown variable, formulas must be written in a sequence that will yield the desired answer after the applicable numbers and operation signs have been evaluated.

Using a formula for Hydrostatic Pressure Relationships, three other equivalent formulas can be found.

Example: $C \times Wt \times TVD = P$ where C =constant,
Wt = mud weight
TVD = true vertical depth
P = hydrostatic pressure

Three equivalent ways to rewrite this equation are:

$$\frac{P}{TVD \times C} = Wt \ , \quad \frac{P}{Wt \times C} = TVD \text{ , and } \frac{P}{Wt \times TVD} = C$$

Suppose we are trying to find the true vertical depth, which formula would we choose to use if the other variable were known? (Hopefully, the students will respond with the one solved for TVD.)

Problem: Find the TVD if C=.052, Wt=11.2, and P=2,329.6

$TVD = \frac{2369.6}{11.2 \times .052} = 4{,}000$ ft (Students will have to trust that the units are in feet.)

Based upon the TVD, a rig operator can decide if drilling should continue or stop.

Guided Practice:
The critical surface pressure is the maximum pressure that can be tolerated without risking some downhole failure such as formation breakdown or fracture. This critical surface pressure is calculated using the formula:

$$(CST_{Eq} - Wt_{Orig}) \times CD \times C = SICP_{Crit}$$

where CST= Casing seat test equivalent
Wt = 0riginal mud weight
CD= Casing depth
C = .052
SICP = Critical Pressure

If CST = 12.3, Wt = 9.5, CD = 3,000, find the critical pressure.

$$SICP_{Crit} = (12.3 - 9.5) \times 3{,}000 \times .052 = 436.8\, psi$$

How would the formula look if you were finding the casing depth?

$$CD = \frac{SICP_{Crit}}{(CST_{Eq} - Wt_{Orig} \times C}$$

Assessment:
1. Find the hydrostatic pressure produced by a vertical column of 14.3 ppg mud, 7,800 ft in length.
2. A mud column of 3,000 ft produces a pressure of 1,560 psi. Express mud weight in ppg.
3. Casing seat test equivalent is 11.8 ppg, original mud weight is 10 ppg, and casing depth is 2,800 ft. What is the critical surface pressure at which downhole failure of the formation may occur when casing is filled with mud weighing 10 ppg?

Answers:
1. 5,800 psi
2. 10 ppg
3. 262 psi