Section 1. Filled-in kill sheet exercises – Gauge problem exercises

Gauge problem exercises are created from a pre-completed kill sheet containing all relevant volume and pressure calculations.

Each question is based on strokes, pump rate, drillpipe and casing gauge readings at a specific point in time during well kill operation. Any one or a combination of these readings could indicate the action required. Options are shown in the multiple-choice answers.

The casing and/or drillpipe pressures will only be relevant to the action if:

- The casing and/or drillpipe pressures given in the question are below the expected pressures.

or

- The casing and/or drillpipe pressures given in the question are 70 psi or more above the expected pressures.

Section 2. Calculation formula

Abbreviation	Term
0.052	constant factor
bbl	barrels (us)
bbl/ft	barrels (us) per foot
bbl/min	barrels (us) per minute
bbl/stroke	barrels (us) per stroke
BHP	bottomhole pressure
BOP	blowout preventer
ft	feet
ft/hr	feet per hour
ft/min	feet per minute
lb/bbl	pounds per barrel
LOT	leak-off test
MAASP	maximum allowable annular surface pressure
ppg	pounds per gallon
psi	pounds per square inch (pressure)
psi/ft	pounds per square inch per foot
psi/hr	pounds per square inch per hour
SICP	shut-in casing pressure
SIDPP	shut-in drillpipe pressure
SPM	strokes per minute
TVD	true vertical depth

1. Hydrostatic pressure (psi)

fluid density (ppg) × 0.052 × TVD (ft)

2. Pressure gradient (psi/ft)

fluid density (ppg) × 0.052

3. Fluid density (ppg)

hydrostatic pressure (psi) ÷ TVD (ft) ÷ 0.052

or

$$\frac{\text{hydrostatic pressure (psi)}}{\text{TVD (ft)} \times 0.052}$$

4. Formation pressure (psi)

hydrostatic pressure in drillstring (psi) + SIDPP (psi)

5. Pump output (bbl/min)

pump displacement (bbl/stroke) × pump rate (SPM)

6. Equivalent circulating density (ppg)

fluid density (ppg) + (annular pressure loss (psi) ÷ TVD (ft) ÷ 0.052)

or

$$\text{fluid density (ppg)} + \left(\frac{\text{annular pressure loss (psi)}}{\text{TVD (ft)} \times 0.052}\right)$$

7. Fluid density (ppg) with trip margin (psi) included

fluid density (ppg) + (trip margin (psi) ÷ TVD (ft) ÷ 0.052)

or

$$\text{fluid density (ppg)} + \left(\frac{\text{trip margin (psi)}}{\text{TVD (ft)} \times 0.052}\right)$$

8. New pump pressure (psi) with new pump rate (SPM) (approximate)

$$\text{current pump pressure (psi)} \times \left(\frac{\text{new pump rate (SPM)}}{\text{current pump rate (SPM)}}\right)^2$$

9. New pump pressure (psi) with new fluid density (ppg) (approximate)

$$\text{current pump pressure (psi)} \times \left(\frac{\text{new fluid density (ppg)}}{\text{current fluid density (ppg)}}\right)$$

10. Maximum allowable fluid density (ppg)

LOT fluid density (ppg) + (surface LOT pressure (psi) ÷ casing shoe TVD (ft) ÷ 0.052)

or

$$\text{LOT fluid density (ppg)} + \left(\frac{\text{surface LOT pressure (psi)}}{\text{casing shoe TVD (ft)} \times 0.052}\right)$$

11. MAASP (psi)

(maximum allowable fluid density (ppg) - current fluid density (ppg)) × casing shoe TVD (ft) × 0.052

12. Kill fluid density (ppg)

current fluid density (ppg) + (SIDPP (psi) ÷ TVD (ft) ÷ 0.052)

or

$$\text{current fluid density (ppg)} + \left(\frac{\text{SIDPP (psi)}}{\text{TVD (ft)} \times 0.052}\right)$$

13. Initial circulating pressure (psi)

circulating pressure at kill rate (psi) + SIDPP (psi)

14. Final circulating pressure (psi)

$$\left(\frac{\text{kill fluid density (ppg)}}{\text{current fluid density (ppg)}}\right) \times \text{circulating pressure at kill rate (psi)}$$

15. Gas migration rate (ft/hr)

rate of increase in surface pressure (psi/hr) ÷ fluid density (ppg) ÷ 0.052

or

$$\frac{\text{rate of increase in surface pressure (psi/hr)}}{\text{fluid density (ppg)} \times 0.052}$$

16. Gas laws

$$P_1 \times V_1 = P_2 \times V_2$$

$$P_1 = \frac{P_2 \times V_2}{V_1} \qquad V_1 = \frac{P_2 \times V_2}{P_1}$$

$$P_2 = \frac{P_1 \times V_1}{V_2} \qquad V_2 = \frac{P_1 \times V_1}{P_2}$$

17. Pressure drop per foot tripping dry pipe (psi/ft)

$$\frac{\text{fluid density (ppg)} \times 0.052 \times \text{metal displacement (bbl/ft)}}{\text{riser or casing capacity (bbl/ft)} - \text{metal displacement (bblft)}}$$

18. Pressure drop per foot tripping wet pipe (psi/ft)

$$\frac{\text{fluid density (ppg)} \times 0.052 \times \text{closed end displacement (bbl/ft)}}{\text{riser or casing capacity (bbl/ft)} - \text{closed end displacement (bbl/ft)}}$$

19. Level drop pulling remaining collars out of well dry (ft)

$$\frac{\text{length of collars (ft)} \times \text{metal displacement (bbl/ft)}}{\text{riser or casing capacity (bbl/ft)}}$$

20. Level drop pulling remaining collars out of well wet (ft)

$$\frac{\text{length of collars (ft)} \times \text{closed end displacement (bbl/ft)}}{\text{riser or casing capacity (bbl/ft)}}$$

21. Length of tubulars to pull dry before overbalance is lost (ft)

$$\frac{\text{overbalance (psi)} \times \left(\text{riser or casing capacity (bbl/ft)} - \text{metal displacement (bbl/ft)}\right)}{\text{fluid gradient (psi/ft)} \times \text{metal displacement (bbl/ft)}}$$

or

$$\frac{\text{overbalance (psi)} \times \left(\text{riser or casing capacity (bbl/ft)} - \text{metal displacement (bbl/ft)}\right)}{\text{fluid density (ppg)} \times 0.052 \times \text{metal displacement (bbl/ft)}}$$

22. Length of tubulars to pull wet before overbalance is lost (ft)

$$\frac{\text{overbalance (psi)} \times \left(\text{riser or casing capacity (bbl/ft)} - \text{closed end displacement (bbl/ft)}\right)}{\text{fluid gradient (psi/ft)} \times \text{closed end displacement (bbl/ft)}}$$

or

$$\frac{\text{overbalance (psi)} \times \left(\text{riser or casing capacity (bbl/ft)} - \text{closed end displacement (bbl/ft)}\right)}{\text{fluid density (ppg)} \times 0.052 \times \text{closed end displacement (bbl/ft)}}$$

23. Volume to bleed due to gas migration in a vertical well (bbl)

$$\text{working pressure to bleed (psi)} \times \left(\frac{\text{annular capacity (bbl/ft)}}{\text{pressure gradient (psi/ft)}}\right)$$

or

$$\text{working pressure to bleed (psi)} \times \left(\frac{\text{annular capacity (bbl/ft)}}{\text{fluid density (ppg)} \times 0.052}\right)$$

24. Slug volume (bbl) for a given length of dry pipe

$$\frac{\text{length of dry pipe (ft)} \times \text{pipe capacity (bbl/ft)} \times \text{current fluid density (ppg)}}{\text{slug density (ppg)} - \text{current fluid density (ppg)}}$$

25. Pit gain due to slug U-tubing (bbl)

$$\text{slug volume (bbl)} \times \left(\frac{\text{slug density (ppg)}}{\text{current fluid density (ppg)}} - 1\right)$$

26. Riser margin (ppg)

$$\frac{\left(\left(\text{air gap (ft)} + \text{water depth (ft)}\right) \times \text{fluid density (ppg)} - \left(\text{water depth (ft)} \times \text{water density (ppg)}\right)\right)}{\text{TVD (ft)} - \text{air gap (ft)} - \text{water depth (ft)}}$$

27. Hydrostatic pressure loss if casing float fails (psi)

$$\frac{\text{fluid density (ppg)} \times 0.052 \times \text{casing capacity (bbl/ft)} \times \text{unfilled casing height (ft)}}{\text{casing capacity (bbl/ft)} + \text{annular capacity (bbl/ft)}}$$