



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 500 kPa or more above the expected pressures.

Section 2. Calculation formula

Abbreviation	Term
0.00981	constant factor
m ³	cubic metres
m ³ /m	cubic metres per metre
m ³ /min	cubic metres per minute
m ³ /stroke	cubic metres per stroke
BHP	bottomhole pressure
BOP	blowout preventer
m	metres
m/hr	metres per hour
m/min	metres per minute
LOT	leak-off test
MAASP	maximum allowable annular surface pressure
kg/m ³	kilogram per cubic metre
kPa	kilopascal (pressure)
kPa/m	kilopascal per metre
kPa/hr	kilopascal per hour
SICP	shut-in casing pressure
SIDPP	shut-in drillpipe pressure
SPM	strokes per minute
TVD	true vertical depth



1. Hydrostatic pressure (kPa)

$$\text{fluid density (kg/m}^3\text{)} \times 0.00981 \times \text{TVD (m)}$$

2. Pressure gradient (kPa/m)

$$\text{fluid density (kg/m}^3\text{)} \times 0.00981$$

3. Fluid density (kg/m³)

$$\text{hydrostatic pressure (kPa)} \div \text{TVD (m)} \div 0.00981$$

or

$$\frac{\text{hydrostatic pressure (kPa)}}{\text{TVD (m)} \times 0.00981}$$

4. Formation pressure (kPa)

$$\text{hydrostatic pressure in drillstring (kPa)} + \text{SIDPP (kPa)}$$

5. Pump output (m³/min)

$$\text{pump displacement (m}^3\text{/stroke)} \times \text{pump rate (SPM)}$$

6. Equivalent circulating density (kg/m³)

$$\text{fluid density (kg/m}^3\text{)} + (\text{annular pressure loss (kPa)} \div \text{TVD (m)} \div 0.00981)$$

or

$$\text{fluid density (kg/m}^3\text{)} + \left(\frac{\text{annular pressure loss (kPa)}}{\text{TVD (m)} \times 0.00981} \right)$$

7. Fluid density (kg/m³) with trip margin (kPa) included

$$\text{fluid density (kg/m}^3\text{)} + (\text{trip margin (kPa)} \div \text{TVD (m)} \div 0.00981)$$

or

$$\text{fluid density (kg/m}^3\text{)} + \left(\frac{\text{trip margin (kPa)}}{\text{TVD (m)} \times 0.00981} \right)$$

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

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

9. New pump pressure (kPa) with new fluid density (kg/m³) (approximate)

$$\text{current pump pressure (kPa)} \times \left(\frac{\text{new fluid density (kg/m}^3\text{)}}{\text{current fluid density (kg/m}^3\text{)}} \right)$$

10. Maximum allowable fluid density (kg/m³)

$$\text{LOT fluid density (kg/m}^3\text{)} + (\text{surface LOT pressure (kPa)} \div \text{casing shoe TVD (m)} \div 0.00981)$$

or

$$\text{LOT fluid density (kg/m}^3\text{)} + \left(\frac{\text{surface LOT pressure (kPa)}}{\text{casing shoe TVD (m)} \times 0.00981} \right)$$

11. MAASP (kPa)

$$(\text{maximum allowable fluid density (kg/m}^3\text{)} - \text{current fluid density (kg/m}^3\text{)}) \times 0.00981 \times \text{casing shoe TVD (m)}$$

12. Kill fluid density (kg/m³)

$$\text{current fluid density (kg/m}^3\text{)} + (\text{SIDPP (kPa)} \div \text{TVD (m)} \div 0.00981)$$

or

$$\text{current fluid density (kg/m}^3\text{)} + \left(\frac{\text{SIDPP (kPa)}}{\text{TVD (m)} \times 0.00981} \right)$$

13. Initial circulating pressure (kPa)

$$\text{circulating pressure at kill rate (kPa)} + \text{SIDPP (kPa)}$$

14. Final circulating pressure (kPa)

$$\left(\frac{\text{kill fluid density (kg/m}^3\text{)}}{\text{current fluid density (kg/m}^3\text{)}} \right) \times \text{circulating pressure at kill rate (kPa)}$$

**15. Gas migration rate (m/hr)**

rate of increase in surface pressure (kPa/hr) \div fluid density (kg/m³) \div 0.00981

or

$$\frac{\text{rate of increase in surface pressure (kPa/hr)}}{\text{fluid density (kg/m}^3\text{)} \times 0.00981}$$

16. Gas laws

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

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

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

17. Pressure drop per metre tripping dry pipe (kPa/m)

$$\frac{\text{fluid density (kg/m}^3\text{)} \times 0.00981 \times \text{metal displacement (m}^3\text{/m)}}{\text{riser or casing capacity (m}^3\text{/m)} - \text{metal displacement (m}^3\text{/m)}}$$

18. Pressure drop per metre tripping wet pipe (kPa/m)

$$\frac{\text{fluid density (kg/m}^3\text{)} \times 0.00981 \times \text{closed end displacement (m}^3\text{/m)}}{\text{riser or casing capacity (m}^3\text{/m)} - \text{closed end displacement (m}^3\text{/m)}}$$

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

$$\frac{\text{length of collars (m)} \times \text{metal displacement (m}^3\text{/m)}}{\text{riser or casing capacity (m}^3\text{/m)}}$$

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

$$\frac{\text{length of collars (m)} \times \text{closed end displacement (m}^3\text{/m)}}{\text{riser or casing capacity (m}^3\text{/m)}}$$

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

$$\frac{\text{overbalance (kPa)} \times (\text{riser or casing capacity (m}^3/\text{m)} - \text{metal displacement (m}^3/\text{m)})}{\text{fluid gradient (kPa/m)} \times \text{metal displacement (m}^3/\text{m)}}$$

or

$$\frac{\text{overbalance (kPa)} \times (\text{riser or casing capacity (m}^3/\text{m)} - \text{metal displacement (m}^3/\text{m)})}{\text{fluid density (kg/m}^3) \times 0.00981 \times \text{metal displacement (m}^3/\text{m)}}$$

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

$$\frac{\text{overbalance (kPa)} \times (\text{riser or casing capacity (m}^3/\text{m)} - \text{closed end displacement (m}^3/\text{m)})}{\text{fluid gradient (kPa/m)} \times \text{closed end displacement (m}^3/\text{m)}}$$

or

$$\frac{\text{overbalance (kPa)} \times (\text{riser or casing capacity (m}^3/\text{m)} - \text{closed end displacement (m}^3/\text{m)})}{\text{fluid density (kg/m}^3) \times 0.00981 \times \text{closed end displacement (m}^3/\text{m)}}$$

23. Volume to bleed due to gas migration in a vertical well (m³)

$$\text{working pressure to bleed (kPa)} \times \left(\frac{\text{annular capacity (m}^3/\text{m)}}{\text{pressure gradient (kPa/m)}} \right)$$

or

$$\text{working pressure to bleed (kPa)} \times \left(\frac{\text{annular capacity (m}^3/\text{m)}}{\text{fluid density (kg/m}^3) \times 0.00981} \right)$$

24. Slug volume for a given length of dry pipe (m³)

$$\frac{\text{length of dry pipe (m)} \times \text{pipe capacity (m}^3/\text{m)} \times \text{current fluid density (kg/m}^3)}{\text{slug density (kg/m}^3) - \text{current fluid density (kg/m}^3)}$$

25. Pit gain due to slug U-tubing (m³)

$$\text{slug volume (m}^3) \times \left(\frac{\text{slug density (kg/m}^3)}{\text{current fluid density (kg/m}^3)} - 1 \right)$$

26. Riser margin (kg/m³)

$$\frac{((\text{air gap (m)} + \text{water depth (m)}) \times \text{fluid density (kg/m}^3)) - (\text{water depth (m)} \times \text{water density (kg/m}^3))}{\text{TVD (m)} - \text{air gap (m)} - \text{water depth (m)}}$$



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

$$\frac{\text{fluid density (kg/m}^3\text{)} \times 0.00981 \times \text{casing capacity (m}^3\text{/m)} \times \text{unfilled casing height (m)}}{\text{casing capacity (m}^3\text{/m)} + \text{annular capacity (m}^3\text{/m)}}$$