



### 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 5 kg/cm<sup>2</sup> or more above the expected pressures.

### Section 2. Calculation formula

Abbreviation	Term
10	constant factor
l	litres
l/m	litres per minute
l/min	litres per minute
l/stroke	litres per stroke
BHP	bottomhole pressure
BOP	blowout preventer
m	metres
m/hr	metres per hour
m/min	metres per minute
kg/l	kilogramme per litre
LOT	leak-off test
MAASP	maximum allowable annular surface pressure
kg/cm <sup>2</sup>	kilogram per square centimetre (pressure)
kg/cm <sup>2</sup> /m	kilogram per square centimetre per metre
kg/cm <sup>2</sup> /hr	kilogram per square centimetre per hour
SICP	shut-in casing pressure
SIDPP	shut-in drillpipe pressure
SPM	strokes per minute
TVD	true vertical depth

**1. Hydrostatic pressure (kg/cm<sup>2</sup>)**

$$\frac{\text{fluid density (kg/l)} \times \text{TVD (m)}}{10}$$

**2. Pressure gradient (kg/cm<sup>2</sup>/m)**

$$\frac{\text{fluid density (kg/l)}}{10}$$

**3. Fluid density (kg/l)**

$$\text{hydrostatic pressure (kg/cm}^2\text{)} \div \text{TVD (m)} \times 10$$

or

$$\frac{\text{hydrostatic pressure (kg/cm}^2\text{)} \times 10}{\text{TVD (m)}}$$

**4. Formation pressure (kg/cm<sup>2</sup>)**

$$\text{hydrostatic pressure in drillstring (kg/cm}^2\text{)} + \text{SIDPP (kg/cm}^2\text{)}$$

**5. Pump output (l/min)**

$$\text{pump displacement (l/stroke)} \times \text{pump rate (SPM)}$$

**6. Equivalent circulating density (kg/l)**

$$\text{fluid density (kg/l)} + (\text{annular pressure loss (kg/cm}^2\text{)} \div \text{TVD (m)} \times 10)$$

or

$$\text{fluid density (kg/l)} + \left( \frac{\text{annular pressure loss (kg/cm}^2\text{)} \times 10}{\text{TVD (m)}} \right)$$

**7. Fluid density (kg/l) with trip margin (kg/cm<sup>2</sup>) included**

$$\text{fluid density (kg/l)} + (\text{trip margin (kg/cm}^2\text{)} \div \text{TVD (m)} \times 10)$$

or

$$\text{fluid density (kg/l)} + \left( \frac{\text{trip margin (kg/cm}^2\text{)} \times 10}{\text{TVD (m)}} \right)$$

**8. New pump pressure (kg/cm<sup>2</sup>) with new pump rate (SPM) (approximate)**

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

**9. New pump pressure (kg/cm<sup>2</sup>) with new fluid density (kg/l) (approximate)**

$$\text{current pump pressure (kg/cm}^2\text{)} \times \left( \frac{\text{new fluid density (kg/l)}}{\text{current fluid density (kg/l)}} \right)$$

**10. Maximum allowable fluid density (kg/l)**

$$\text{LOT fluid density (kg/l)} + (\text{surface LOT pressure (kg/cm}^2\text{)} \div \text{casing shoe TVD (m)} \times 10)$$

or

$$\text{LOT fluid density (kg/l)} + \left( \frac{\text{surface LOT pressure (kg/cm}^2\text{)} \times 10}{\text{casing shoe TVD (m)}} \right)$$

**11. MAASP (kg/cm<sup>2</sup>)**

$$\frac{(\text{maximum allowable fluid density (kg/l)} - \text{current fluid density (kg/l)}) \times \text{casing shoe TVD (m)}}{10}$$

**12. Kill fluid density (kg/l)**

$$\text{current fluid density (kg/l)} + (\text{SIDPP (kg/cm}^2\text{)} \div \text{TVD(m)} \times 10)$$

or

$$\text{current fluid density (kg/l)} + \left( \frac{\text{SIDPP (kg/cm}^2\text{)} \times 10}{\text{TVD (m)}} \right)$$

**13. Initial circulating pressure (kg/cm<sup>2</sup>)**

$$\text{circulating pressure at kill rate (kg/cm}^2\text{)} + \text{SIDPP (kg/cm}^2\text{)}$$

**14. Final circulating pressure (kg/cm<sup>2</sup>)**

$$\left( \frac{\text{kill fluid density (kg/l)}}{\text{current fluid density (kg/l)}} \right) \times \text{circulating pressure at kill rate (kg/cm}^2\text{)}$$

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

rate of increase in surface pressure (kg/cm<sup>2</sup>/hr) ÷ fluid density (kg/l) × 10

or

$$\frac{\text{rate of increase in surface pressure (kg/cm}^2\text{/hr)} \times 10}{\text{fluid density (kg/l)}}$$

**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 (kg/cm<sup>2</sup>/m)**

$$\frac{\text{fluid density (kg/l)} \times \text{metal displacement (l/m)}}{(\text{riser or casing capacity (l/m)} - \text{metal displacement (l/m)})} \times 10$$

**18. Pressure drop per metre tripping wet pipe (kg/cm<sup>2</sup>/m)**

$$\frac{\text{fluid density (kg/l)} \times \text{closed end displacement (l/m)}}{(\text{riser or casing capacity (l/m)} - \text{closed end displacement (l/m)})} \times 10$$

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

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

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

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

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

$$\frac{\text{overbalance (kg/cm}^2\text{)} \times (\text{riser or casing capacity (l/m)} - \text{metal displacement (l/m)})}{\text{fluid gradient (kg/cm}^2\text{/m)} \times \text{metal displacement (l/m)}}$$

or

$$\frac{\text{overbalance (kg/cm}^2\text{)} \times 10 \times (\text{riser or casing capacity (l/m)} - \text{metal displacement (l/m)})}{\text{fluid density (kg/l)} \times \text{metal displacement (l/m)}}$$

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

$$\frac{\text{overbalance (kg/cm}^2\text{)} \times (\text{riser or casing capacity (l/m)} - \text{closed end displacement (l/m)})}{\text{fluid gradient (kg/cm}^2\text{/m)} \times \text{closed end displacement (l/m)}}$$

or

$$\frac{\text{overbalance (kg/cm}^2\text{)} \times 10 \times (\text{riser or casing capacity (l/m)} - \text{closed end displacement (l/m)})}{\text{fluid density (kg/l)} \times \text{closed end displacement (l/m)}}$$

**23. Volume to bleed due to gas migration (l)**

$$\text{working pressure to bleed (kg/cm}^2\text{)} \times \left( \frac{\text{annular capacity (l/m)}}{\text{pressure gradient (kg/cm}^2\text{/m)}} \right)$$

or

$$\text{working pressure to bleed (kg/cm}^2\text{)} \times \left( \frac{\text{annular capacity (l/m)} \times 10}{\text{fluid density (kg/l)}} \right)$$

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

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

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

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

**26. Riser margin (kg/l)**

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

**27. Hydrostatic pressure loss if casing float fails (kg/cm<sup>2</sup>)**

$$\frac{\text{fluid density (kg/l)} \times \text{casing capacity (l/m)} \times \text{unfilled casing height (m)}}{(\text{casing capacity (l/m)} + \text{annular capacity (l/m)}) \times 10}$$