Warning Signs of Kicks

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Learning Objectives

- You will learn the and warning signs that indicate the well may be kicking:
  - Warning signs of kicks
  - False kick indicators
- You will also learn flow check procedures and that a positive flow show is a definitive sign of a kick.

Warning Signs of Kicks

Overview

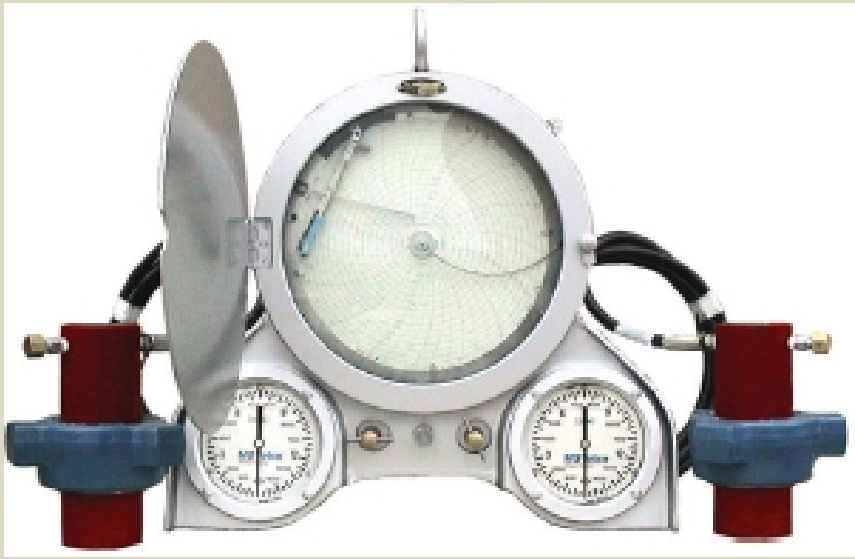
- Changes from established “trends” usually indicate downhole problems. Commonly monitored parameters are:
  - Flow Indicator:
    - Flow rate at given pump speed
    - Flow with pump shut down
  - Pumps:
    - Pump pressure changes
    - Pump Speed

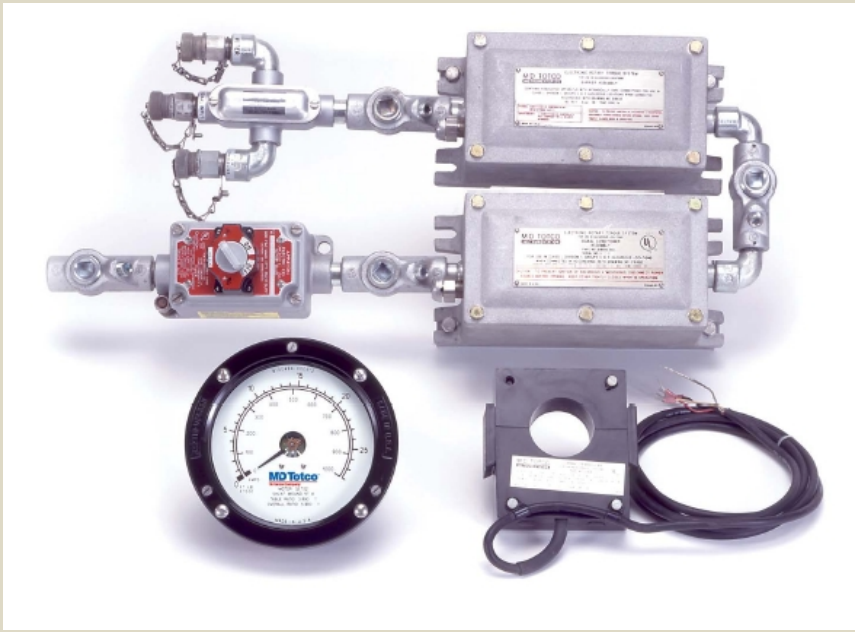
Warning Signs of Kicks

- Rotary:
  - Rate of Penetration whether a formation or milling
  - Torque/drag
  - String weight
  - Fill
- Pits:
  - Changes in Pit Level during any activity
  - Hole fill during trip in
  - Displacement during trip out

♦ Changes in any of the above can indicate pressure changes in the well and potentially that the well may be kicking.

Warning Signs of Kicks





Warning Signs of Kicks

- Monitored parameters can indicate downhole pressure changes include:
  - Mud/Fluid:
    - Density changes/weight
    - Viscosity and flocculation
    - Salinity
  - Flowline/Shakers:
    - Change in background gas
    - Change in shape and size of cuttings
    - Temperature

Warning Signs of Kicks

- Mud Logging:
  - Formation type
  - Drilling exponent
  - Shale Density
  - Type of gas in returns
- MWD/LWD tools:
  - Shale resistivity
  - Acoustic travel time
  - Conductivity
  - Radioactivity

♦ We must learn to react quickly and properly if one or more of these signs are noticed!

Warning Signs of Kicks

Penetration Rate Change

- *Penetration rate* is the distance in a period of time that the drill bit deepens the wellbore.
- A penetration rate change is a sign of a formation change or that a downhole obstruction has been milled through.

Penetration Rate Change

- Reasons for changes in the rate of penetration:
  - Pore pressure
  - Formation changes or environment
  - Hydraulics rotary speed
  - Fluid properties
  - Bit type
  - Weight on bit
  - Bit condition

Which of the above reasons can change rapidly?

Penetration Rate Change

- The "*drilling break*" is usually one of the first signs noted that downhole formations and/or pressures have changed.
  - May be a sudden increase in penetration.
  - Depending on bit and formation, ROP may decrease. This is referred to as a "reverse break" such as experienced in the Black Warrior basin in Alabama or when using PDC bits.
- A flowcheck should be performed whenever a new formation is encountered or a change in the rate of penetration occurs.

Increase in Flow of Fluid from the Well

- A fixed amount of fluid is displaced into the well every minute as long as the pump is running at a constant rate.
- So, the rate of fluid returns should be constant.
- Changes in the rate of returns can indicate formation flow adding to returns, increasing flow out. (Decrease in rate may indicate leakage to formation.)
- When possible, *always* set high and low flow alarms.

Flow Checks and Flow

- When any of the established trends change, a flowcheck is warranted.
- The most definitive sign that a well is kicking is flow from the well with the pumps shut down.
- **Flow check while on bottom:** *Notify Company Man*
  - Stop rotating
  - Pick up off bottom
  - Shut down pump(s)
  - Observe well carefully
  - If the flow slows and stops, then it is usually ok to continue activities. However, if the flow does not stop a kick may be occurring and the well must be shut in.

Flow Checks and Flow

- **Flow check on trips:** *Notify Company Man*
  - Not as definitive as when on bottom.
    - Stop pipe movement
    - Observer well carefully
      - if flowing the well must be shut in.

Trip Logs

The use of trip sheets are the best way to keep track of fluid to fill-up the well during a trip out of the well.

- Tracks actual amount to fill vs theoretical.
- *Theoretical fill* is based on pipe displacement and length pulled prior to check point (i.e. 5 stds DP, 3 stds HW, 1 std collar).
- Must account for displacement of all different types of tubulars in the well (work string, tubing, tools, drill pipe, collars, hevi-wate, etc.).

Trip Logs

- *Actual fill* is determined by recording barrels to fill using re-circulating tanks, trip tank or strokes to fill using pump strokes.
- Deviation from theoretical should be checked out by monitoring the well closely for flow. If flowing, shut the well in and decide on best course of action to take.

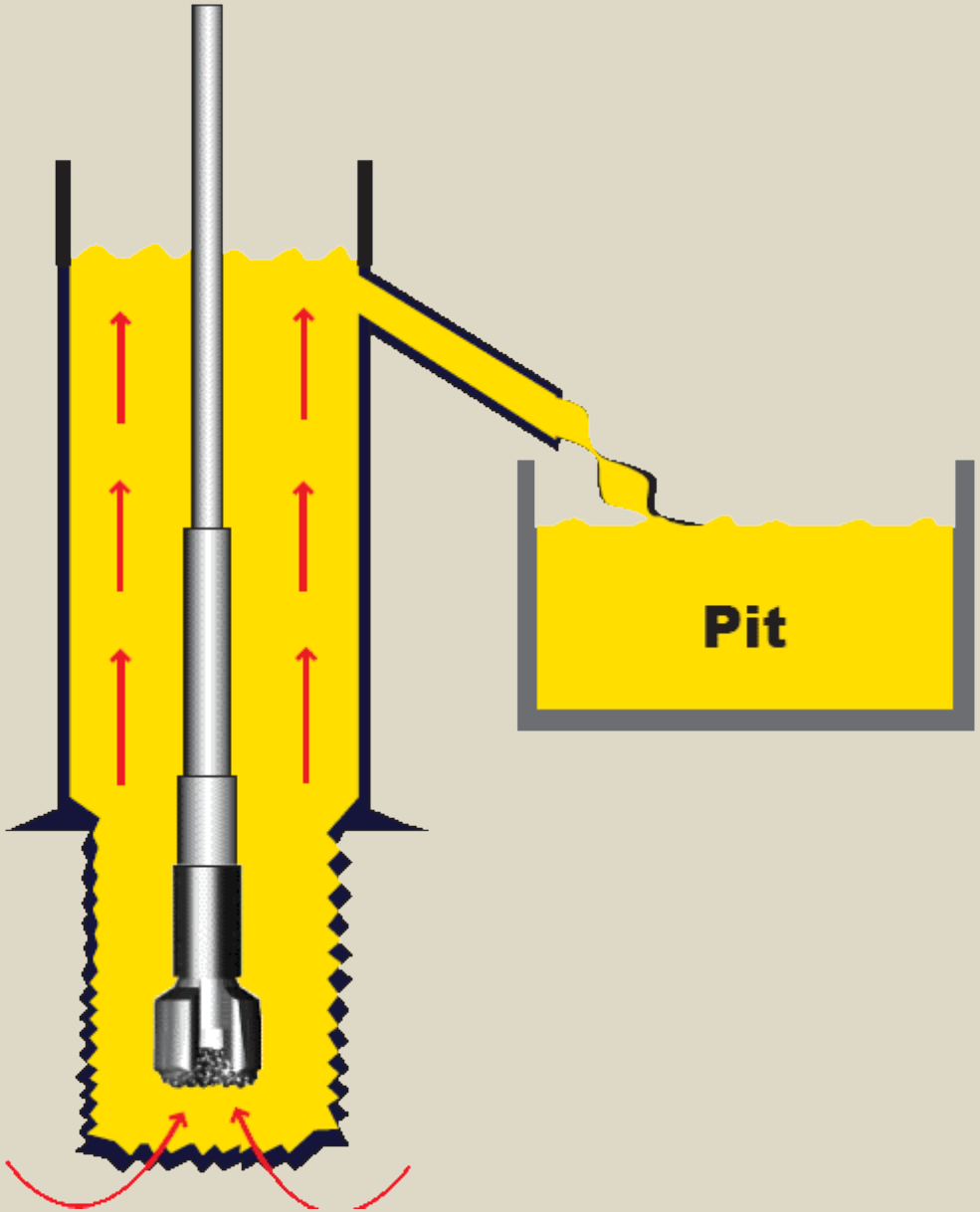
Pit Gain or Losses

- A **gain** in pit volume occurs when formation fluid entering the well displaces fluid out of the hole.
  - This is a sign that a kick is occurring.
  - Perform flow check, and shut well in if flowing.
  - Communication between pits, operational and rig floor personnel is critical.

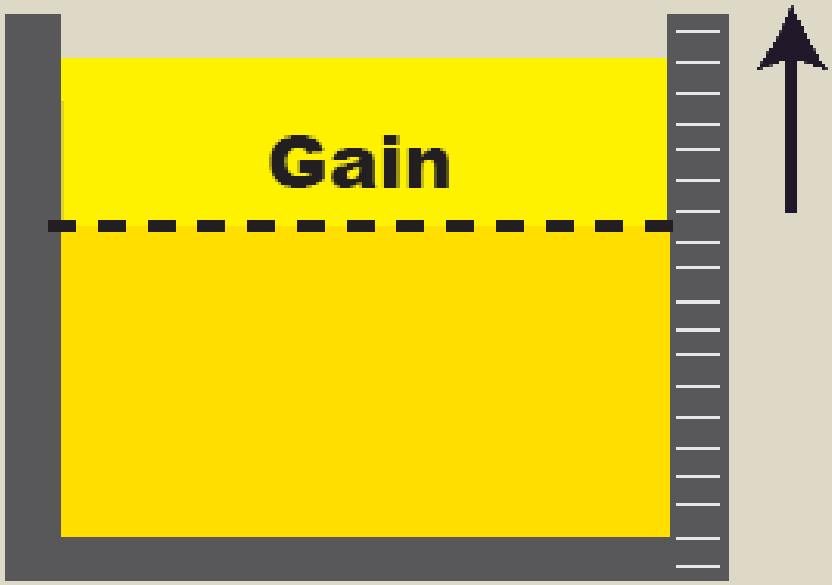
Pit Gain or Losses

- A **loss** in pit volume occurs when leakage or fluid loss to the formation occurs.
  - If severe enough results in loss of HP column height. Decrease in HP may allow the well to kick.
- *Always* set high and low pit alarms with close tolerances

Pit Gain or Losses



Pit Gain or Losses



Pump Speed/Pressure Change

- An influx of formation fluid provides for a decrease in density of the fluid column and hydrostatic pressure exerted by the fluid column decreases.
- The decreased hydrostatic of the fluid column requires less force to move it and can result in pump pressure and/or pump rate changes.
- Where downhole clearances are very small any influx will elongate greatly and may cause pump rate to decrease and circulating pressures increase to get past the restrictions.

Torque/Drag Increase and Hole Fill

- As a result of the string coming in contact with the well, rotary torque slowly increases as the well gets deeper.
- If the formation is soft and the HP column to formation pressure differential increases, some formation may close in after drilled.
- An increase in cuttings also may occur as the bit's teeth take larger bites into the formation
- Both can result in an increase in torque.

Hole Fill/Sloughing Shale

- When formation pressure gets to be greater than the fluid column pressure, the column to become less effective in holding up the walls of the hole.
  - This results in shale beginning to slough off the sides of the wellbore.
  - This is sometimes referred to as spalling, popping or heaving shale.

Hole Fill/Sloughing Shale

- Sloughing shale may cause tight hole, fill on bottom between connections and on trips, and may cause the string and other tools to get stuck.
- Sloughing shale has a long, splintery, and curvy (convex shaped) appearance compared to drilled shale.
- If severe enough may register as increase in pump pressure, as it increases the volume of cuttings in annulus.
- Abnormal pressure is not always the cause of sloughing shale.

Changes in Cuttings Size and Volume

- *Cuttings* are rock segments that are chipped or broken away from a formation from the drill bit.
- If the bit begins to dull while drilling and if the weight on the bit, formation type, and pressure differential remain constant, then the size of cuttings begin to decrease.
- If the formation pressure increases, the size, shape, and amount of cuttings could increase because the drill bit was able to cut better with a greater pressure differential.

Changes in Cuttings Size and Volume

Changes in String Weight

- Fluid provides buoyancy to objects in the fluid.
  - This is primarily a function of fluid density.
  - The greater the density the greater the buoyant effect.
- Kicks are usually less dense than the fluid in use.
  - An influx of formation fluid decreases the density in the fluid surrounding the pipe, which in turn, reduces buoyancy.
    - This results in an increase of weight at surface.
    - Could show jump in the string weight indicator.

Gas/Oil Shows - Circulating

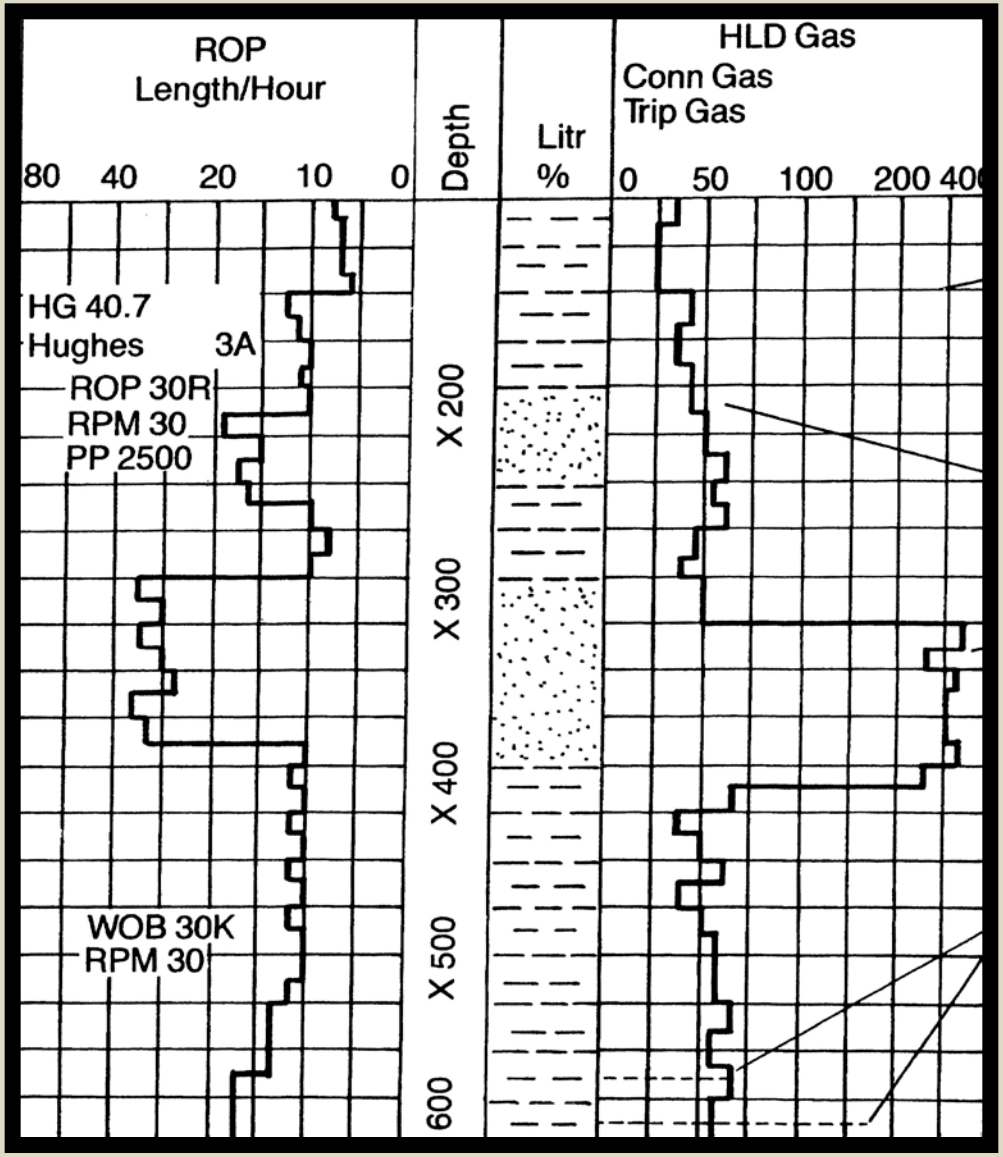
- Gas content increase in the returns fluid is a good sign of an abnormally pressure zone and should be monitored carefully.
  - *Drill Gas* – If porous formations containing gas are drilled, cuttings containing gas are moved up the hole and the gas expands. As it returns to surface it may cause the fluid weight to be cut. If severe or shallow enough, gas-cut mud may cause a decrease in hydrostatic pressure.

Gas/Oil Shows - Circulating

- *Connection or Trip Gas* – Trip gas *or* connection gas is the accumulation of gas that enters the hole during a connection or trip. Consistent Increases in these types of gas may indicate the fluid to formation pressure differential is changing.
- *Background Gas* – background gas changes are regarded as a warning that pore pressure is also changing.

♦ *Ceasing operations and circulating bottoms should clear most of the gas from the well. If gas levels remain elevated an increase in fluid weight may be warranted.*

Gas/Oil Shows - Circulating



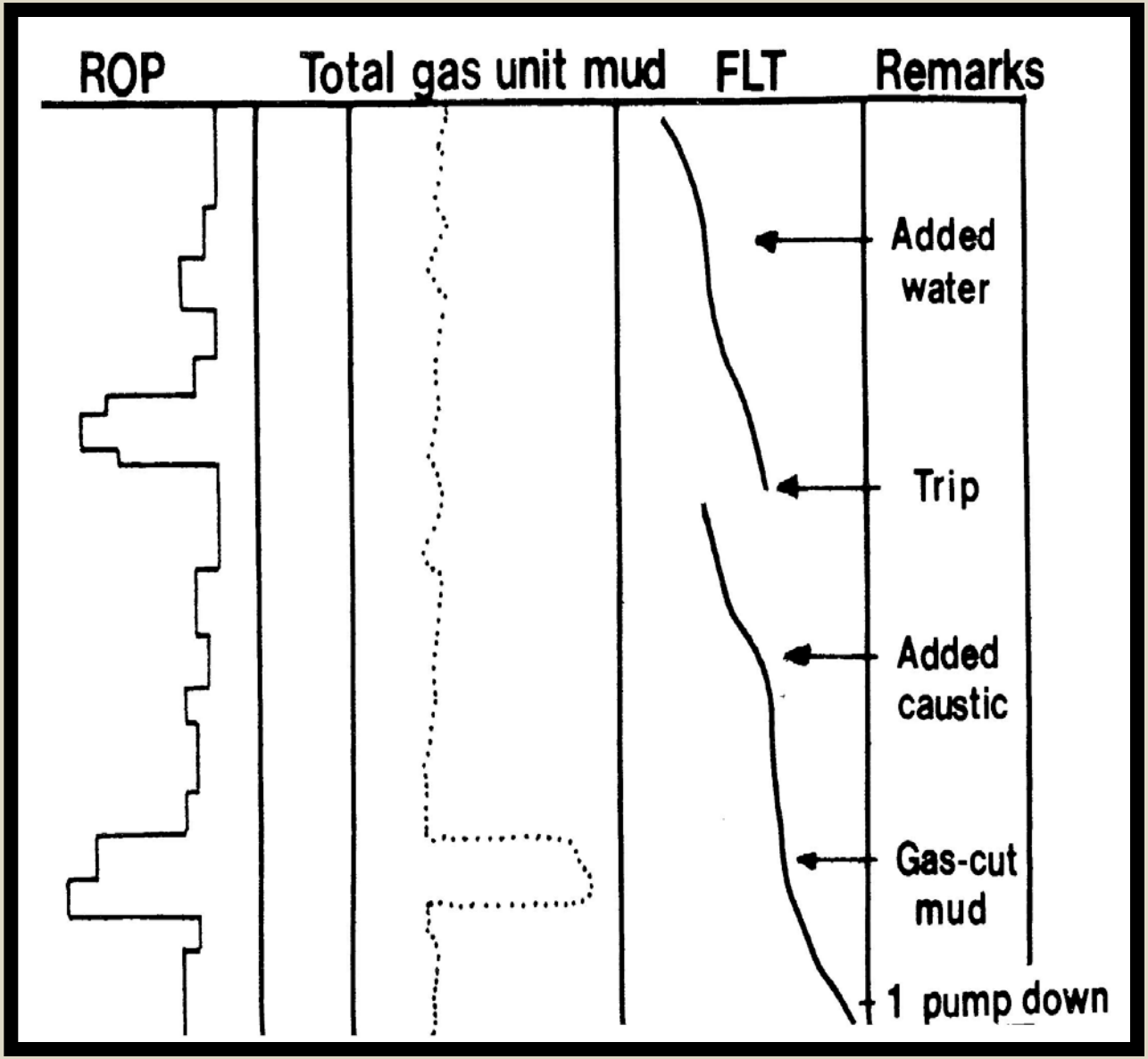
Change in Chloride Content

- If there is insufficient pressure, formation fluid may enter the wellbore and mingle with the circulating fluid, causing the chloride content of the fluid to change.
  - This change in chloride content is a valid indicator of a change in pressure.
  - Though changes occur, they must be measured over hundreds of feet and may not be a good indicator of an immediate situation.

Flow Line Temperature Increase

- Extreme temperature can occur in both the transition zone and in the zone of higher pressure below.
  - Flowline temperature can also be a result of a change in:
    - Circulation rate
    - Solid content of mud
    - The chemistry of the mud
    - Drilling practices
- When used with other indicators, flowline temperature can help identify transition zones. This should be plotted over distance of drilling.

Flow Line Temperature Increase



Shale Density Decrease

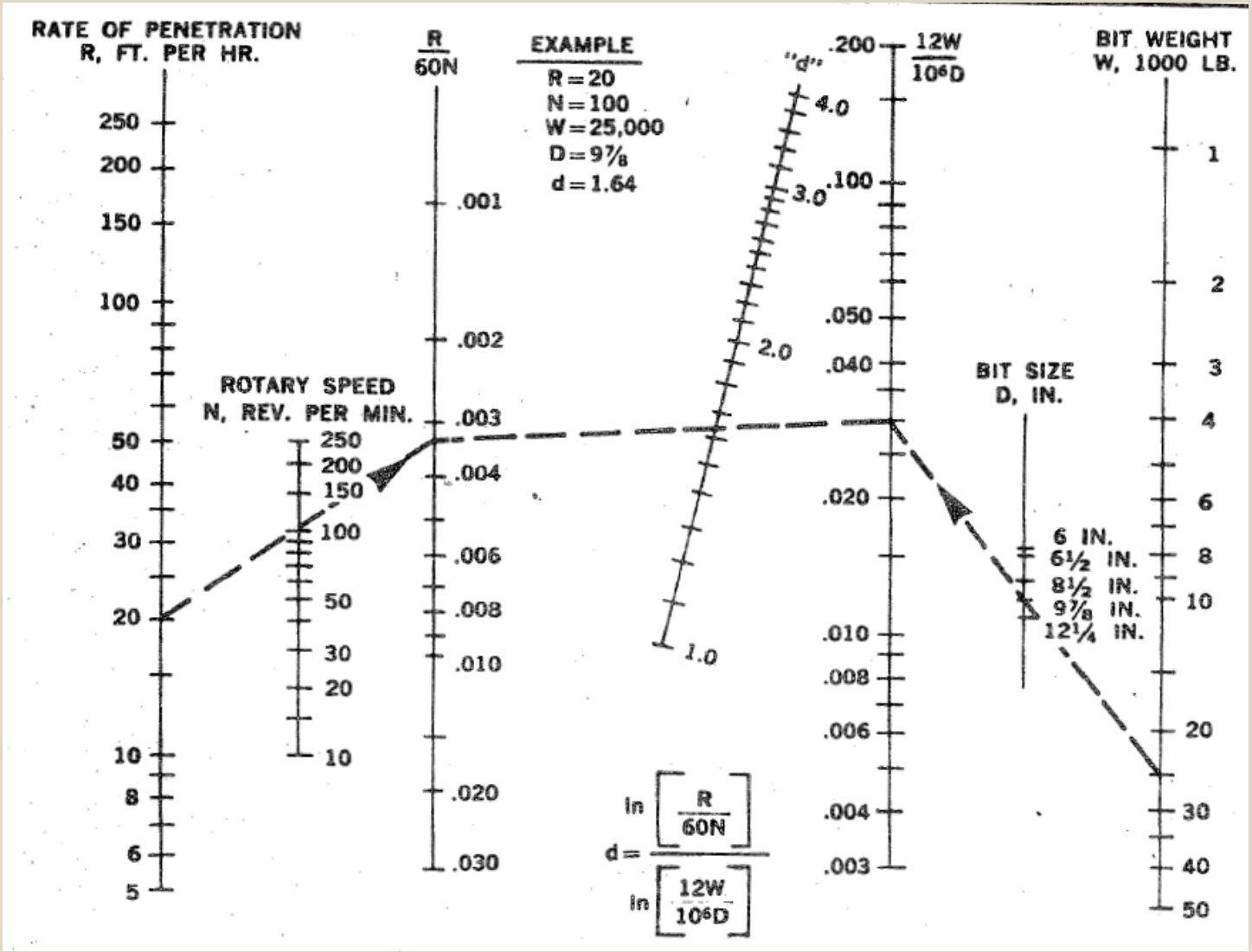
- Normally pressured shale have gone through normal compaction.
- In addition, the shale density increases consistently with depth in most cases, allowing the density to be predicted.
- Changes from expected trends can indicate changes in pressure.
- Changes in shale density is often hard to measure and is done over several hundred feet of drilling.

Shale Density Decrease

Variations From "d_c" Exponent

- The "d_c" exponent method is used sometimes to predict abnormal pressure zones.
- In order to utilize this method you need to know:
  - The penetration rate
  - Rotary rpm's
  - Weight on bit
  - Hole diameter
- Modified "d_c" exponent calculations are also used, based on formation and area.

“D” Exponent Nomograph



MWD/LWD and Logging

- Once a formation has been drilled, the pore pressure can be determined using electric logs.
- Typically this is done prior to running casing.
- MWD, PWD and LWD tools developed to gather this information sooner, while drilling. Can collect data that can be used to detect and predict formation pressure, and has been useful in kick detection.

Kicks – Out of the Hole

- A kick out of the hole generally occurs during the early stages of the trip out, probably when the hole was not filled sufficiently enough towards the latter part of the trip or while pulling the collars.
- Other times that kicks may occur out of the hole are during extensive logging, wirleine or fishing operations.
  - These operations may cause swab formation fluids into the well, resulting in a kick.

Displacement – Trip In

- If no floats are in use, pipe run into the well should displace a fluid amount equivalent to pipe's displacement.
- If the pipe is lowered down too quickly, surge pressures will force fluid into the formation ahead of the pipe.
  - This can cause a reduction in hydrostatic pressure, and if decreased below that of the formation pressure the well may being to flow.

Displacement – Trip In

- With an influx in the hole, gas expansion causes additional volume, more than the pipe's displacement, to be displaced out of the hole.
- The fluid displaced out of the hole and the pipe's displacement should always be carefully monitored and measured to be balanced. If they are not equal, there is a problem.

Kicks While Running Casing

- The problem with kick detection while running casing is that the operation is not focused on kick detection or shutting in the well.
- Once a kick is detected, the well should be shut in using casing rams or the annular preventer (closing pressure may have to be modified).
- A crossover back to a circulating swage should be made up prior to the casing run both for circulating and in case the casing float fails.

False Kick Indicators

- The kick indicators that we examined in this section should not be taken lightly. A pit gain may simply be the transfer of fluid from one pit to another. *What happens if a kick occurs during this process?*
- So, while you may be able to explain other reasons for a particular warning sign that is other than a kick, well control should always come first.
- Always suspect a kick when one or more of these warning signs are present.