Section 5
Unexpected Increases in Water Production

- Sources
- Methods to identify
- Remedial actions

Sources

- Mechanical problems (casing leaks)
  - Holes caused by corrosion or wear
  - Splits caused by flaws, excessive pressure or formation deformation
  - Casing leaks can result in pump failure or stuck pump
  - Typically occurs above top of cement
  - Invasion of drilling mud
  - After repairing
    - Check PBTD
    - May require re-stimulation to remove formation damage

Sources (cont.)

- Communication problems
  - Channels behind casing
  - Barrier breakdowns
  - Completion into or near water
  - Coning and cresting
  - Channeling through high perm zones or fractures
  - Fracturing out of zone

Methods to Identify Sources

- Chloride/TDS tests
- Production logging
  - Radioactive tracer or fluid travel survey
  - Differential fluid survey
  - Spinner (flowmeter) survey
  - Cased hole formation resistivity (CHFR) tool
- Mechanical integrity test (MIT)
  - Pressure testing
  - Casing inspection log

Chloride/TDS tests

- Production water sampling and testing on a regular basis for each producing well
- Establishing baseline is valuable if production or well conditions change
- Lower than normal chlorides could indicate shallow casing leak
- Iron concentrations can predict iron oxide precipitation
- pH can indicate metal oxide precipitation
- Knowing specific gravity useful in determining bottomhole hydrostatic pressure

Production Logging

- Injection profile tests in waterfloods
- Finding tubing/casing leaks
- Detecting lost circulation zones
- Determining if packer or bridge plugs are leaking
- Detecting fluid channels behind casing
- Developing production profiles
- Locating gas-oil-water contacts
- Tracing frac fluids
- Others

Radioactive Tracer Surveys

- Provides accurate information on fluid flow paths and rates
- Two types of methods
  - Velocity shot
    - Two detector method preferred
    - Tool is stationary and log a function of time
    - Main application in injection wells
  - Timed run
    - Qualitatively detects flow of fluids up or down hole, either in casing or annulus
    - Primary use to detect unwanted movement of injected water in casing annulus

Differential Temperature Survey

- Measures temperature of the wellbore fluid under static (shut-in) or dynamic (flowing) conditions
- Can monitor temperature in casing or casing annulus
- Common application in waterfloods
- Temperature response is function of depth, temperature of injected fluid, injection rate, time of injection, formation and fluid thermal properties and geothermal profile in the well
- After long period of injection, well is shut in and numerous logs run over a period of time to observe temperature profile as it returns to geothermal values
- Can detect behind pipe communication problems

Spinner Surveys

- Used to meter fluid flow rates in cased or uncased wells
- Generally made with tool being withdrawn from hole
- Stop a various depths to record total volume flow
- Type of fluid influences operation
  - Dirty fluids foul impeller movement
  - Gaseous fluid overspin impeller
  - High viscosity fluids result in optimistic flow volume values
  - Low viscosity fluids result in pessimistic flow volume values
- Some spinners limited to certain ranges of flow rates

Cased Hole Formation Resistivity Tool

- Measuring formation resistivity through casing allows measurement of water saturation away from from the wellbore
- Main purpose of CHFR is reservoir monitoring
- Understand fluid flow and recovery processes during production life of the reservoir by
  - Evaluate saturation changes with time can help identify swept zones, flow barriers and bypassed oil
  - Monitoring movement in oil/water contacts
  - Identification of take-ff rate induced water coning
  - Estimating residual oil saturation to a waterflood or WAG flood

Cased Hole Formation Resistivity Tool (cont.)

- Measures formation resistivity further away from wellbore than open hole logs
- Can be used for primary evaluation of reservoirs where
  - Where no logs were acquired in open hole
  - Operational problems made open hole logging too risky
  - Wells with old or faulty logs can be re-examined
- Uses caliper-like arms that open and contact casing
- Good contact essential
- Scale or corrosion inside casing creates problems
- Double cased intervals read only cement resistivy between casings

Mechanical Integrity Tests

- Can be determined by pressure testing or casing inspection logs
- In some instances a fluid level shot assists in locating casing leak
- Pressure testing
  - Required on injection and disposal wells by State regulatory agencies
  - Isolate leaks using leaks using RBP and packer
    - Majority of leaks occur where no cement behind casing
    - Use compatible fluid with producing formation
    - Can cause further damage in bad casing

Mechanical Integrity Tests (cont.)

- Casing inspection logs
  - Multi-fingered caliper logs
  - Electrical potential logs
  - Electromagnetic inspection devices
  - Borehole televiewers
  - Most measures extent to which corrosion has occurred
  - EP log indicates where corrosion is currently occurring

Remedial Actions

- Cement squeeze
- Polymer squeeze
- Combination squeeze
- Liner/casing patches

Cement Squeezing

- Basically a filtration process
- Cement slurries subject to differential pressure against a filter of permeable rock lose part of their mix water, leaving a cake of partially dehydrated cement particles
- Rate of cake buildup is function of
  - Formation permeability
  - Differential pressure applied
  - Time
  - Capacity of slurry to lose fluid
- Ideal slurry controls rate of cake growth so uniform filter cake builds over all permeable surfaces

Cement Squeezing (cont.)

- Dehydration of cement requires intermittent application of pressure, separated by period of pressure leakoff caused by loss of filtrate to formation, referred to *hesitation squeeze*
- Low pressure squeezing
  - Below fracturing pressure, near wellbore, low volume
  - In depleted formations, spot cement at perfs to prevent fracturing due to hydrostatic pressure
- High pressure squeezing
  - Breaks down formation, fills fractures or microannuli
  - Location and orientation cannot be controlled
  - Properly performed leaves cement close to wellbore

Cement Squeezing (Placement Techniques)

- Packer or bradenhead squeeze
  - Packer squeeze
    - Isolate casing and wellhead from high pressure
    - Retrievable packers and bridge plugs (by-pass values)
    - 1-2 sacks of sand on RBP
    - Cement retainers (mechanical or wireline set)
    - CIBP (mechanicalor wireline set)
- Bradenhead squeeze
  - Same as above with no packer
  - Typically low pressure, no doubt of casings ability to withstand squeeze pressures

Polymer Squeezes

- Used as alternative or in combination with cement
- Type of polymer and process depends on
  - Location and severity of leak
  - Whether squeeze required to hold pressure or block encroachment of water
- Advantages
  - Wash out of wellbore after squeeze
  - Lower hydrostatic pressure
- Four basic gel systems
  - Acrylic monomer grout
  - High concentration low molecular-weight polymer
  - High molecular-weight polymer
  - Cement/polymer combination

Polymer Squeezes (cont.)

- Acrylic monomer grout
  - Most effective in tight leaks or pressure leak-off
  - Excellent application for disposal or injection wells that fail MIT due to slight pressure leakoff
- High concentration low molecular-weight polymers
  - Used in tight to moderate leaks
  - Organic crosslinker can be used in environmentally sensitive area
- High molecular-weight polymers
  - Effective in large leaks, channeling or lost circulation
  - Can completely block flow
- Cement/polymer combination
  - Severe leaks

Liner/Casing Patches

- Permanently installed in casing or incorporated as part of tubing string
- Available in different lengths
- Many restrict internal diameter of casing
- Some patches incorporate sealing elements attached to tubing string (may or may not have vent tubes)
- Consider future uses or operations of the well and how these tools could have an effect