Engineered Safety and Environmental Aspects of Well Construction and Fracturing Design

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Surface Considerations

• Design Hydraulic Fracturing Treatment
• Determine Maximum Pressure and Injection Rate Requirements.
  – Location size equipment considerations.
    • Fluid heating units.
    • Fluid transfer pumps.
    • Fluid blending units.
    • High pressure slurry pumping equipment.
    • High pressure discharge manifold.
    • Treating line pressure relief valve and flowline.
    • Remote operated wellhead valve control station.
    • Wireline equipment staging area, if applicable.
    • Flowback manifold, sand trap, three phase separator, flare stack, and flowback tanks.
Surface Considerations

• Determine Fluid and Material Requirements.
  – Location size to accommodate fluid and material storage.
    • Water storage tanks.
      – Bulk tanks or pit storage.
      – Working tanks.
    • Proppant storage units.
    • Flowback storage tanks.
      – Oil
      – Water
  – Determine necessary spill berm volume.
    • Typically around 1.5 times fluid storage volume.
  – Determine logistics access requirements.
    • Sufficient lease road width.
    • Truck maneuvering, loading, and unloading area.
Methodology

• Determine Treatment Conductor Requirement
• Design Required Wellbore
  – Casing Size
    • Fracturing Treatment and Production Considerations.
  – Casing Grade
    • Hydrogen Sulfide present?
    • Corrosive fluids present?
  – Casing Weight
    • Determined by Pressure Rating Requirement.
  – Setting Depth
Wellbore Construction

– Surface Casing to cover deepest potable water source as per regulation.
  • Casing must be cemented to surface.
  • Perform top outside cement job, if cement not circulated to surface.
    – Prevents surface wellsite fluids from entering wellbore and contaminating groundwater.
  • Set and pressure test BOP.
  • Drill out and pressure test casing shoe to insure good seal.
  • May be set deeper than regulatory requirement for drilling considerations.
Wellbore Construction

– Intermediate Casing set to target formation.
  • Cemented as required for isolation of overlying formations.
    – Supports casing.
    – Protects casing.
  • Cement fill verified using appropriated cement evaluation logging tools.
    – Typically a Cement Bond Log and/or Ultrasonic Cement Evaluation Tool.
  • Casing inspection tool needed when used as treatment conductor.
    – Typically an internal caliper log coupled with magnetic thickness sensor.
    – Pressure rating must be certified.
  • Casing must be rated above maximum treating pressure, with regulatory stipulated safety factor applied, when used as treatment conductor.
Wellbore Construction

• Production Liner set through producing formation.
  – Cementing not required if wellbore confined to single regulatory producing interval.
  – Liner hanger packer required if production liner is not cemented.
    • Necessary to isolate upper wellbore from exposure to hydraulic fracturing pressure
    • Sometimes run as backup pressure isolation when production liner is cemented.
    • Swellable packers commonly used to provide additional pressure isolation between intermediate and production liner.
Wellbore Integrity

• Wellbore environmental safeguards.
  – First level is properly designed treatment conductor.
    » Cemented intermediate casing, inside cemented surface casing through production liner.
    • Provides two layers of steel pipe and one or two layers of cement between fracturing or produced fluids, and potable groundwater.
    » Tie-back liner, inside cemented intermediate casing, inside cemented surface casing through production liner.
    • Provides three layers of steel pipe and one or two layers of cement between fracturing or produced fluids, and potable groundwater.
Pressure Control

• Second level is properly rated surface wellhead and high pressure treating line.
  – Wellhead typically rated to greater than the maximum expected treatment pressure.
    » Minimum of two manual wellhead valves.
    » Lowest valve used as master valve.
    » Additional one or two hydraulic remote actuated valves.
  – High pressure treating line rated to greater than maximum expected treatment pressure.
  – Number of treatment lines run to wellhead determined by maximum anticipated injection rate and size of high pressure treating line.
    » High pressure treating line inspection and testing must be current.
    » Pressure test high pressure treating line to maximum treating pressure regularly during treatment.
Pressure Control

• Wellbore casing over-pressure protection.
  – First level is operator supervision during fracturing treatment.
  – Second level is individual fracturing unit electronic pressure limit shutdown.
    • Shuts down individual pump indicating over-pressure.
    • Unit shutdown settings commonly staggered from above expected working pressure to near maximum pressure limit.
  – Third level is global fracturing unit electronic pressure limit shutdown.
    • Shuts down all pumps when pressure setting value is exceeded.
    • Typically set below maximum pressure limit and above highest individual pump shutdown setting.
  – Fourth level is high pressure treating iron relief valve.
    • Opens pressure relief valve or rupture disk located on high pressure surface treating line, and vents fluid stream to surface tank.
    • Typically a single use item, but some relief valves are resettable, if actuated while pumping proppant free fluid.
    • Must have functional check valves in the surface high pressure treating line, between the pressure relief valve and the wellhead, to prevent uncontrolled well flowback.
    • Remote actuated wellhead typically shut if immediate resumption of pumping is not possible.
Pressure Control

• Additional wellbore pressure control measures.
  – Pressure relief valve on annulus between intermediated casing and tie-back liner.
    • Set at or below the maximum allowable pressure limit for the annulus determined by applying safety factor to lowest pressure rated component.
    • Flowline routed to surface tank to contain fluid if pressure relief valve actuated.
  – Valve between surface and intermediate casing opened.
    • Flowline routed to surface tank to contain fluid, if intermediate casing fails and surface casing exposed to wellbore pressure.
    • Prevents over-pressure failure of surface casing wellhead flange and possible loss of wellhead.
Fluid Safety

- Common household materials utilized whenever possible and practical.
  - Acetic acid – vinegar
  - Potassium Chloride – muriate of Potash – fertilizer
  - Guar gum – food thickener
  - Sodium hydroxide – lye - oven and drain cleaner
  - Sodium chloride – table salt
  - Mineral oil - baby oil – cosmetic remover
  - Sodium borate - borax – laundry cleaning aid
  - Boric acid – antiseptic – insecticide – flame retardant
  - Ammonium hydroxide – ammonia cleaner
  - Sodium bicarbonate – baking soda
  - Sodium hypochlorite – laundry bleach
  - Hydrochloric acid – Muriatic acid – pool additive – stomach acid
  - Silicon dioxide – silica sand – very clean sandbox sand – sand proppant
  - Isopropyl alcohol – rubbing alcohol – gas tank anti-freeze
  - Citric acid – citrus fruit acid – beverage acidifier
  - Limonene – citrus fruit rind extract– solvent – cleaning aid – fragrance
  - Ethyl alcohol – beer - wine – whisker - vodka
Fluid Safety

• Lots of Dihydrogen Monoxide.

• Or......
Fluid Safety

• H2O – Water
The End

• Questions?