Chapter 57
Risk Analysis in the Process of Hydraulic Fracturing

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ABSTRACT

This chapter focuses on risk to the environment from hydraulic fracturing operations, starting with transport of materials and ending when the well is routed to the production facilities. The initial assumption for the fracturing risk analysis is that the well is new and was constructed correctly so that all producible formations are securely isolated behind the barriers of casing and competent cement. The justification for this assumption is that the vast majority of fracturing is the first major stimulation in a well and occurs immediately after completing a new well. Although many well development problems are blamed on fracturing, there are only excluded problems that are real and worthy of the discussion to help define boundaries of the fracturing risk (King, 2012).

INTRODUCTION

While hydraulic fracturing is a well-developed technology that has been used for more than 60 years in petroleum engineering, its wide-spread use for coal-bed natural gas and shale gas development has raised questions about the appropriate regulatory approach to ensure that groundwater resources and surface water are protected (Arthur, 2011). Millions of fracs have been pumped (SPE - Society of Petroleum Engineers estimate 2.5 million fracs world-wide). The technical literature on hydraulic fracturing is extensive, addressing nearly every aspect of oil and gas development, with over 550 papers in shale fracturing. The shale papers in the past several years alone are from more over 70 universities, over a dozen state, federal and international agencies and more then a hundred energy and service companies (King, 2010; Arthur, 2009).

However, recent exposure of the general public to this technology, particularly as practiced with large volume of water, has resulted in considerable fear and misunderstanding of what is occurring downhole. Fortunately, the industry has been studied the problem of fracture height growth

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for several decades and has been monitoring fractures with tiltmeters for two decades and with microseismics for over one decade. All data of investigation has shown that hydraulic fracturing in typical reservoirs is not threat to fracture into and contaminate or otherwise disturb groundwater (Warpinski, 2011). In engineering terms, fracturing concerns a precise stimulation activity, limited to the fluid action in initiating and extending cracks in the rock; while, for many concerned citizens, bloggers and environmentalists, fracturing has come to represent nearly every phase of the well development cycle from drilling to production.

First, scale drawings of the distance from the surface and near-surface fresh water supplies (nearly all fresh water formations are within the first 300 meters from the surface) are needed to show the physical distance between the surface and the completion interval of interest (pay zone).

Fracture height, predicted by computer models and confirmed by microseismics monitoring during fracturing, post-frac tracer flows, temperature logs and even by mine-back experiments (Warpinski, 1985), show most vertical effective fracture growth at 100 meters or less. Fracture height growth in most formations is known to be effectively limited by barriers and fluid leakoff (loss of fluid to the rock). Fracture heights limited by these physical and active barriers will simply not reach into fresh water sands.

Although the fracturing process is more than thousand meters away from the water table, methane is showing up in residential water wells, but this contamination in water wells is caused by other natural and manmade causes. Part of the reason is the natural occurrence with biogenic methane forming from shallow decay of organic materials and natural seeps of thermogenic methane (gas formed deep in the earth) that have been coming to the surface for millions of years, particularly in regions with shale and coal outcrops or shallow formations that share the water table with fresh water wells.

However, part of the increasing methane content in water well may be coming from nearby improperly constructed gas or oil well. These older wells predate the invention of hydraulic fracturing and most predate any significant well construction regulations. Deeper formations are at higher pressures and exposure of these zones without sufficient cementing isolation will allow gas seepage that will build up a higher pressure that was customary at shallower depths. This type of methane leak is usually low volume and is made possible by poor or incomplete cementing practices. The incident can be noticed soon after drilling and can start before the well is fractured.

In a fracturing risk analysis, that is main focus of the chapter, any local conditions will influence the conclusions. For regional or area studies the impact and the occurrence information, from traffic accidents to fractured well incidents should be from the area, but wider studies of other factors may be necessary for purposes of well population and incident review. Estimating risk at both regional and area levels allows identification of risk areas and refinement of that risk through knowledge of local conditions. Different companies operating in different areas of the country may use the same risk estimation approach but reach different values in roads, well construction requirements, infrastructure, engineering experience, local geology, regulations and other factors.

The level of permeability in a rock holding oil and gas dictates whether the reservoir must be hydraulically fractured (Figure 1). At lower permeabilities or where oil viscosity is high or reservoir pressure is low, the flow of fluids toward the wellbore can be assisted by fracturing, which creates a flow path of much higher permeability. Stable fractures offer a flow path with average permeability of 100 to over 1000 times the permeability of the formation (Gaskari, 2006). At lower permeabilities, such as shale, most wells will not flow economic quantities of fluids without extensive hydraulic fracturing.