MARCELLUS
SHALE COALITION™

RECOMMENDED PRACTICES:
Drilling and Completions

MSC RP 2013-3 September 24, 2013

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1.1 Purpose
The following recommended practices address relevant considerations and guidelines for drilling and completion of shale gas wells and they support the Marcellus Shale Coalition (MSC) guiding principles.

1.2 Nomenclature
The term "drilling" refers to the installation of the well bore including casing strings, cement and surface well control equipment. "Well completions" refers to various operations that may occur at a wellbore once the drilling operations are complete. Well completions encompass such activities as well stimulation or hydraulic fracturing, and other post-drilling wellbore activities associated with production. Workover operations are performed post-completion and may include well maintenance or enhancement techniques to continue production or prudent operations.

2.1 Planning
Regulatory requirements and local ordinances must be followed at all stages of well operations and are an integral part of the planning process. These requirements vary based on the location and applicable regulations and are not addressed in detail in this document.

Planning decisions are often influenced by the duration of the activity. Single well pad sites can be constructed, drilled, completed and put on production in a period of several months whereas a multi-well pad site can go from construction to production in less than one year. There are also sites where the drilling and completions activities are spaced apart over longer time frames.

Traffic related to shale development is highest during the drilling and completions phases. Operators should identify and consider available transportation routes with the goal of reducing traffic impact on communities. It is also advisable to work with local and regional road departments to learn about the condition and weight limit of roads on preferred routes and to coordinate maintenance and repairs, as necessary. Operators should maintain lease roads to minimize excessive dust around occupied structures and public road and should employ practices to mitigate mud tracked by vehicles from well pad sites or other facilities onto public roads.

Operators should evaluate potential water management options prior to the start of drilling. Consider preparing a water management plan in which the following are addressed:

- Maximizing efforts to recycle/reuse produced water as reasonably practicable.
- Working with local water boards and/or other appropriate regulatory agencies to identify suitable water sources. Consider use of alternative water sources (e.g. mine influenced water, saline ground water, industrial effluent, municipal effluent).
- Evaluating water transportation systems with a goal of minimizing truck traffic and encouraging use of pipelines (temporary or permanent), centralized storage (impoundments or tanks), and treatment facilities.
- Testing and monitoring water transfer systems prior to and during operations.

Consider developing a waste management strategy that addresses processes and procedures for minimizing waste as well as handling and disposal of all waste streams including drill cuttings and produced water.

Well pads should be designed to minimize erosion and to contain a spill or release. Operators should consider the following:

- Maximizing consolidation of operations on multi-well pads.
- Designing pads and erosion and sediment controls under the direction of an appropriately trained professional.
- Using a temporary impermeable material (natural or manmade) under critical well pad areas.
- Using secondary containment for tanks that contain fluids (excluding fresh water).
- Using "closed loop" fluids management systems (i.e. eliminating the need for lined earthen pits at the drilling site) where practicable.
- Using weather protection when storing dry additives.
- Using diversionary structures to manage storm water flow around a well pad.
- Providing appropriate sorbent materials (spill kits) and making them readily available at the well site.
- Developing fluid recovery systems for equipment disassembly.
- Minimizing the risk of accidental spillage during equipment refueling. Consider using portable containment equipment, developing methods to utilize and maintain equipment (e.g. hoses and hose/nozzle covers) and monitoring fuel transfers.

When selecting additives for use in drilling and completion fluids, operators should consider their environmental characteristics, balanced with the operational needs of the project. Consider developing and using more environmentally benign ingredients in fluids and minimizing the volume of additives used, to the extent practicable.

Consider preparing a regional spill and emergency response plan that includes the ability to access key equipment and material in a timely manner. Response plans should identify the operator's internal reporting processes and contacts, along with applicable external processes and contacts. Where appropriate, operators should also consider the creation of regional spill response co-operative agreements. Emergency contact phone number(s) should be displayed at the well site.

Consider evaluating and implementing site security controls on a case specific basis in cooperation with local authorities and landowners.

Operators should have procedures to identify subsurface pipelines and other equipment prior to any ground disturbance that could reasonably be expected to impact buried equipment. This may include internal processes for sites that are within the control of the operator and utilizing One Call programs on sites that involve multiple users.

Consider strategies for addressing air emissions, noise and visual impacts (including illumination at night) with particular attention paid near congested settings, potentially sensitive receptors, or occupied buildings. Well operations have phases that must be continued on a 24-hour basis and therefore lighting is required for the safety of site workers. Efforts should be made to direct lighting so that it does not shine into occupied buildings.

3.1 General Health and Safety Considerations

Operators should ensure that all personnel have appropriate health and safety training in addition to specific training on the use of equipment for their job description and function. All operating personnel should receive training regarding the need for, use of, and expectations regarding appropriate Personal Protective Equipment.

An operator representative should be present throughout all active phases of drilling and completion operations. There should be procedures in place to monitor critical parameters for any significant deviations or abnormal conditions. The operator representative should be authorized to take appropriate action including shutting down operations if warranted, based on operator policies.

3.2 Well Control

Well control is an industry term to describe the management of flow and pressure in the wellbore such that the operator maintains control of the wellbore fluids at all times. In order to achieve this, it is recommended that two mechanical barriers in the flow path be maintained, when feasible, during all drilling and completions operations. The mechanical barrier equipment includes specialized valves known as Blowout Preventers (BOPs). Each operator should develop specifications, testing, inspection and maintenance requirements for all BOPs and associated equipment.

Operators should implement a comprehensive well control training and competency assurance program for well engineers, rig foremen and service contractors. The operator's representative and critical contractor supervisory representatives on site should have current International Association of Drilling Contractors or International Well Control Forum well control certification.

3.3 High Pressure Equipment

Operators should implement methods and procedures to routinely test the integrity of all high pressure surface equipment (e.g., wellhead, flow lines, manifolds, piping, and pump equipment). Considerations are as follows:

- Testing and inspecting all high pressure equipment and piping on a regular basis.
- Winterizing equipment for cold weather operations.
- Designing pressure relief and control systems for maximum anticipated flow rates and proper containment of fluids.
- Using restraint and/or anchoring systems on all temporary piping as needed.
- Testing the emergency shut down and/or pressure safety valve system prior to commencing key operations (e.g., prior to the start of the first stage in a hydraulic fracturing operation).

3.4 Drilling Operations

The following section applies specifically to drilling activities.

Prior to drilling, operators should seek to identify the following information:

- The existence of coal mines or workable coal seams.
- Depths of groundwater.
- Oil or gas wells (active, idle, or plugged) within 1,000 feet of the surface location and those where the depth is known or reasonably expected to be within a 500 foot vertical depth of the horizontal portion of the planned wellbore.

Operators should drill through fresh ground water only with air, water, or water based drilling fluids, to the extent reasonably practicable. The surface (or shallowest) casing string should be installed at sufficient depth to protect fresh groundwater and be in compliance with regulations.

Operators should develop and implement procedures to centralize casing, and use a cementing program that is designed to meet the anticipated conditions of the well, in order to protect fresh groundwater and to provide effective isolation between fluid bearing zones.

Operators should seek opportunities for collaboration on improved well construction practices and standards.

3.5 Hydraulic Fracturing and Flow Back Operations

Fracturing fluids recovered from the wellbore are often referred to as "flow back". The following section applies specifically to hydraulic fracturing and subsequent flow back activities. The longer term production of natural gas, water and in some cases, liquid hydrocarbons, from the well bore is called "production". The production phase is not addressed in this document.

Operators should commit to transparency in their operations by disclosing the composition of hydraulic fracturing fluid additives to the extent permitted by suppliers, while respecting related intellectual property rights, and proprietary and confidential business information.

To the extent practicable, operators should monitor adjacent oil and gas wells during hydraulic fracturing. Particular attention should be paid to the wells identified in Section 3.4.

Initial flow back should be designed to minimize the release of produced gases and to contain produced liquids. The preferred method of reducing emissions is "capture" (production into tanks or pipelines) or temporary flaring. Venting is discouraged.

If flaring is planned, consider notifying local authorities (e.g., the fire department) so that they are aware of the activity and can address inquiries from others.

When operating in liquid hydrocarbon or "wet gas" areas, operators should prepare a liquid hydrocarbon management plan designed to facilitate safe operations. Operators should implement procedures that require a comprehensive review of equipment placement and spacing, designation of safe loading areas, location of potential ignition sources, and safe handling procedures.

This document provides general guidance on recommended practices for the subject(s) addressed. It is offered as a reference aid and is designed to assist industry professionals in improving their effectiveness. It is not intended to establish or impose binding requirements. Nothing herein constitutes, is intended to constitute, or shall be deemed to constitute the setting or determination of legal standards of care in the performance of the subject activities. The foregoing disclaimers apply to this document notwithstanding any expressions or terms in the text that may conflict or appear to conflict with the foregoing.

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