Cold Weather Hazards and Winterizing Operating Considerations for U.S. Onshore Upstream Facilities and Pipeline Systems

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Introduction

Raw natural gas[1] across the onshore United States is produced, separated, treated, and transported from just over 900,000 wells and hundreds of thousands of facilities and millions of miles of gas pipelines. More than half of the nation's states produce raw natural gas. Each well and facility has its own specific operating structures, equipment, configurations, and unique operating environments.

Freezing weather can affect a spectrum of upstream and midstream onshore operations. Facilities that operate in areas with recurrent and sustained seasonal freezing weather typically have winterization programs in place. Cold weather is part of the geographical culture. Facilities located in moderate climates can encounter freezing weather infrequently and in short intervals.

Facilities that do not often experience freezing weather can be the most difficult to weatherize. Facilities located where freezing weather is uncommon can be more prone to freeze-offs as winterization practices are not necessarily a part of the work culture and staff may not be familiar with those practices. Also, most oil and natural gas production depletes the stored reservoir pressure over time. This often results in a decline in production at each individual well, causing wells and facilities to be operated differently from season to season as production rates and equipment needs change. These compounding elements contribute to the uniqueness of each production facility.

[1] Gas produced from the well still contains natural gas liquids (propane, butane, pentane, hexane, and heptane), water, and some other impurities. The raw gas is processed in a gas processing plant to make the gas commercial (see SLB Energy Glossary).

Cold Weather Hazards and Winterizing Operating Considerations for U.S. Onshore Upstream Facilities and Pipeline Systems

1 Scope

This document is intended to address the issues encountered by infrequent freezing events that can occur in moderate climates, and encourages upstream onshore and midstream operators to review winterizing programs and integrate appropriate considerations into written facility operating and emergency programs and procedures.

2 Oil and Natural Gas Reliability Overview

Annually, U.S. natural gas production remains relatively constant while the volume of gas consumed is cyclical. In the summer months, operators tend to produce more than is consumed, while in the winter, more product is consumed than is produced.

Maintaining continuous operation is a key to reliable upstream onshore production. Access to consistent utility power is the most crucial factor for continuous operations of oil and natural gas production. Forced shut-ins during cold weather due to loss of power are operationally crippling. As the industry has grown, it has become more interdependent on multiple facets. Electrical controls, electrical pumps, emission controls, midstream compression, processing plants, gas treatment, NGL transport, residue gas transport, oil transportation, product storage, water transportation, and water disposal all depend on some form of reliable utility power. Any failure of one of the components can cause a chain-reaction shutdown of upstream production. Restarts of facilities are particularly difficult in freezing temperatures when compressors and internal combustion engines—which are part of the process or tank batteries—have been stagnant for hours.

3 Piping Freeze Basics

Overall, the freezing points of hydrocarbons are quite low and are generally not considered a significant freezing risk. Additionally, higher salinity produced water (salt water) has a lower freezing point than fresh water. However, small volumes of water that condense out of natural gas can become a freeze concern.

Since piping failures could play a part in some freeze-related incidents, a review of pipe basics provides a useful background. Like most materials, metal contracts (decreases in volume) as its temperature decreases; by contrast, when liquid fresh water in a pipe freezes to become solid ice at 32 °F (0 °C), it increases in volume by 9 % (liquids other than water shrink when they freeze). The specific heat of ice is one half that of water, and thus is easier to cool further. If an ice “freeze plug” results in liquid blockage in a pipe, the 9 % expansion tries to compress the liquid, resulting in very high pressures. If this high pressure exceeds the strength of the piping material, a release can result. The consequences of the release depend on the nature and quantity of the liquid released and the characteristics of the environment. Similar breakage can occur where water freezes when confined in valves. A critical time can be when the temperature rises above freezing and the ice melts.

4 Freezing Weather Hazards

Freezing weather can bring on unique operating concerns for each of the millions of onshore sites, most of which are remote and are not continually staffed. Some common problems encountered with infrequent freezing weather incidents include:

a) hazardous working conditions for personnel requiring shut-ins;

b) failure of heat-generating equipment;

c) instrument malfunction;

d) communications interruption;