CNG 235
REV 2/96

CASCADE NATURAL GAS CORPORATION

INTEROFFICE MEMO

To: Tina Beach From: Mike Hardesty

RE: Icing Evaluation Date: 6/21/12

Cascade evaluated all district regulator stations across the company (both Washington and Oregon) for icing threats over the 2011/2012 winter. This includes all regulator stations feeding main and larger service line regulators (SLRs). The evaluation consisted of site visits during the coldest weather period of the year (late December for most districts) in conjunction with institutional knowledge from maintenance crews and inspectors.

Of the approximately 797 stations evaluated, 132 stations have experienced some level of icing under their current operating conditions. Of these stations, 35 had icing that was judged to be significant, which was determined by a thick, persistent layer of ice that affected operation of the regulator block valve and continued underground to cause frost heaving concerns.

The primary determinate of icing was found to be the average pressure cut across the regulator over its typical operation during the cold weather season. High flow rates did amplify the icing level in many cases, but it was found that under the largest pressure cuts (400 psi and greater) significant icing is possible even under low flow conditions. During the warmer months, icing was generally found only to occur at stations with a combination of a high flow and a high pressure cut.

The minimum differential required for icing was generally found to be around 250 psi, although minor icing was found to form under the right conditions with as little as a 200 psi differential. Significant icing typically requires 300 psi differential minimum. There is evidence that the pressure differential required for icing increases as the absolute pressure of the inlet/outlet gas increases (i.e. a station that cuts from 400 psig to 100 psig would have more icing than a station that cuts from 800 psig to 500 psig)

The number of pressure cuts at a regulator station did not reduce or otherwise affect the level of icing. This is due to the limited length of piping for the gas to recover heat. In fact, it was found that cumulative pressure cuts at regulator stations up to a mile apart would cause icing at the second regulator, where icing would otherwise not be expected. At least five of the stations with significant icing were due to this affect.

The make, model, size, or restriction (capacity plate, orifice, etc) of the regulator or pilot does not appear to affect icing in any way.

Icing affects were found to vary slightly around Cascade's various climate zones. The prevailing factor appeared to be mean ambient temperature, which (during the winter months) is lower in Eastern Washington and Oregon, particularly in areas of high elevation. There is little evidence that enclosures such as buildings or vaults reduced the icing potential, despite the air temperatures being slightly milder in these spaces.

While only limited research was conducted on the timing, it was found that significant ice forms relatively slowly, taking several weeks on occasion. The speed of melting is determined by factors such as ambient temperature and humidity.

There is little evidence that external icing has directly caused any malfunctions of pressure control equipment. The primary concerns with ice are operation of the downstream block valve and frost heaving

at the outlet pipe header, putting undue stress on the pipe. Typically frost heaving potential requires both a high flow rate and large pressure cut. On rare occasions,

In order to address these concerns, Cascade is proposing the following steps:

For all stations with significant icing, Engineering has determined if the pressure cuts can be reduced by altering delivery pressure in either the upstream or downstream pipeline. This review determined that 13 of the 35 stations have a good potential to significantly reduce or eliminate the icing threat by changing operating pressures. It should be noted that some of these would require an uprate which requires an extensive study of the pipeline and WUTC approval before it may occur.

Of the 35 stations with significant icing, 19 use pilot operated regulators. Due to the potential of hydrates forming in the control lines, it is proposed that pilot heaters be installed on all these stations where they are not currently, which will reduce or eliminate the need for additional tubing on the vent. It is also proposed that Cascade perform weekly monitoring of these stations during the months of November through March, taking advantage of the dual runs on each of the stations as necessary. Although Cascade has not yet been able to perform field testing, it is believed that switching the runs on a weekly basis may significantly reduce the icing at stations where the ice takes a long time to form.

Three stations were affected by a upstream pressure cut performed by Northwest Pipeline. Cascade will be discussing these with NWP in hopes of reaching a solution.

Of the 16 stations without pilots, as well as the 65 stations found to have moderate icing, Cascade will monitor these stations in late December to determine if further action need to be taken. At these stations with pilots, crews will insure that the pilot vents are not covered, and add tubing as necessary. If any significant icing concerns are found during this check, the stations will be added to the weekly monitoring list.

Cascade Engineers will consider the affects of icing in design of new regulator stations, and will avoid, whenever possible, installing new stations where is it anticipated icing will be a significant concern.