Kiefner & Associates, Inc.

September 10, 2011

Ms. Jane Yura
Vice President, Gas Operations, Standards: Policies
Pacific Gas & Electric Company
77 Beale Street
San Francisco, CA 94105

Re: Hydrostatic pressure "spike" test

Dear Ms. Yura:

You have requested a clarification of the concept of the hydrostatic pressure "spike" test for natural gas pipelines. Specifically, you asked under what circumstances the spike test is appropriate.

A standard hydrostatic pressure strength or proof test is held at a more-or-less constant pressure level that is greater than the maximum allowable operating pressure (MAOP) by a minimum ratio that is specified by regulations or standards for the pipeline construction and operation. The minimum test pressure must be maintained for a specified period of time, usually 8 hours as specified by 49 CFR Part 192, Subpart J. During the test period, the pressure is usually allowed to vary within a range above the minimum test pressure to allow for the effects of thermal expansion of the test fluid. Decades of industry operating experience and scientific analysis has shown that the standard hydrostatic pressure test, without a pressure spike, is a reliable and proven technique for demonstrating the strength of the pipe and components installed in a natural gas pipeline and for establishing their MAOP.

The spike test involves subjecting the piping system to a maximum pressure level that is held for a short duration at the beginning of the test, followed by a longer-duration hold period at a reduced pressure. The pressure during the spike interval corresponds to a hoop stress in the pipe that may be near or above the specified minimum yield strength (SMYS) of the pipe. The purpose of the spike test is two-fold: the very high pressure interval will induce pipe failure where significant defects such as potential cracks are suspected to be present, while the subsequent pressure relaxation allows any surviving cracks to stabilize and avoid subcritical crack growth during the following 8-hour hold period to detect significant leaks. To be effective, the duration of the spike test interval only needs to be a few minutes but is often held for as long as 30 minutes. The subsequent pressure reduction must be at least 5% of the spike test pressure level in order to stop flaw extension at the highest test pressure. A reduction of 10% appears to prevent most flaw growth during the test, and most spike testing plans reduce the pressure 10% accordingly.

Current natural gas pipeline regulations in Part 192, Subpart J require that the minimum ratio of test

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pressure to operating pressure be held for a full 8 hours. A spike test is not required by Subpart J to establish the MAOP of the pipe. A spike test where the high level equals the minimum required test pressure and then the pressure is reduced for the hold period would not meet the requirements of Subpart J. In order to comply with present regulations the spike interval of a spike test must therefore be at a higher pressure than the minimum test level required by regulations by at least 5%, and more typically 10%.

The spike test was initially developed as a mitigation technique for stress-corrosion cracking (SCC). In that application, the spike pressure level is generally in the range of 105% to 110% of SMYS, while the hold for leaks is between 90% and 100% of SMYS. The spike test used to prove the integrity of some older vintage ERW seams that have exhibited a tendency to fail at levels above the mill test pressure is usually limited to around 90% to 95% SMYS (if a successful test at that level can be achieved) while the hold period to check for leaks is reduced 5% to 10% from that level. The final MAOP is established by the minimum required test pressure ratio with respect to the hold period in accordance with the regulations.

It is possible to consider three categories for the appropriateness of a spike test: (1) advisable, (2) unnecessary or discretionary, and (3) undesirable. These are described below.

1. Spike testing is beneficial and therefore recommended in certain specific circumstances, namely:
    a. Where crack-like defects such as SCC, selective corrosion of ERW seams, bond line defects in older vintage ERW seams, and seam fatigue cracks are expected to exist based on evidence from inspections or failures; or
    b. Where it is desired to increase the retest interval for time-dependent flaws; or
    c. Where documentation is unable to confirm the attributes of the pipe and also unable to confirm that a prior hydrostatic test has occurred.
2. Spike testing is unnecessary though not harmful, and is therefore discretionary, in the following situations:
    a. Where the purpose of the test is to demonstrate the strength of the pipe where crack-like defects are not expected to be present;
    b. Where the standard test margin is 1.4 or greater; or
    c. Where the pipe being tested is new.
3. Spike testing would be undesirable in certain specific circumstances, including:
    a. Where the spike pressure above the minimum required standard test level could damage pipe;
    b. Where the spike pressure level would exceed the recommended maximum test pressure levels of components such as flanges or valves; or
    c. Where the margin above the spike pressure level could be insufficient to prevent damage to the pipe due to a pressure increase caused by fluid thermal expansion effects during the test, which could be the case where the test encompasses a large elevation spread, the test section is very short, or the test temperatures are high.

The NTSB has recommended conducting a spike test followed by a standard hydrostatic strength test

specifically in high-consequence area pipeline segments where records are unable to confirm the pipe attributes and also unable to confirm that a prior hydrostatic pressure test took place, as listed in (1)(c) above. The NTSB's recommendation to conduct spike testing is reasonable within the suggested scope, but it cannot be generalized to all testing situations. A spike test should be considered unnecessary in many conventional testing situations, such as those listed in category (2) above. Note that this includes situations where the standard test margin is 1.4 or greater, as listed in (2)(b) above. The rationale for (2)(b) is that pressure reversals as large as 30% of the test pressure have been shown to be statistically exceedingly improbable. Therefore, a reduction in pressure for the leak test from the high pressure is unnecessary, so whether the test is performed in a spike format is irrelevant. Finally, there are situations listed above in category (3) where a spike test could be harmful and is therefore not recommended.

With respect to the recently completed hydrostatic tests at Topock Compressor Station, it is noted that the operating stress levels range from 14% to 47% of SMYS depending on pipe size, the pressure test ratio is at least 1.5, and the pipe installed at Topock is of known type. What is important to establishing the MAOP in this case is the ratio of test pressure to operating pressure. Whether the test is conducted in the spike test format is unimportant to establishing the MAOP of the pipe and the absence of a spike test level in this case does not cause the test to be deficient. Furthermore, the facility contains components having recommended maximum test pressure limits. A spike test that encroaches on those limits could cause damage and is not recommended.

If you have further questions on this matter, please feel free to contact me.

Sincerely,

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President

cc:
Michelle Cooke, CPUC
Julie Halligan, CPUC
Sunil Shori, CPUC