Agenda Item 620-VACCUM

Title: Vacuum Testing while Substantially Empty

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Revision: **0**

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Purpose: Clarify vacuum testing of Low Temp and Cryogenic Tanks in Annexes R and Q.

Source: Brian Wiese (CB&I) emails beginning on July 22, 2022

Impact: Clarification of the vacuum testing rules

Discussion: The initial question raised by Mr. Wiese was about leaving some water in a LOX/LIN tank when standard speaks of such tests with the tank "empty" or "substantially empty". In the main body of the standard §7.18.5.4 speaks of the tank *"substantially empty"* at a time when the design vacuum is applied. In this case (a single wall tank), we know that some water needs to be left in the tank to prevent bottom uplift. But how low must the water level be to qualify as "*substantially empty*"? The subject comes up again in Q.6.6.6 and R.6.5.7. There the word "*substantially*" is absent but that is a not a vacuum context.

In working the above questions I noted that application of design vacuum on the empty tank is absent in Annex R and Q. R and Q tanks need a vacuum test with tank nominally empty same as required for 620-basic tanks. It is an important structural test. And in that vacuum case with tank empty, again it should be at some defined state of substantially empty to prevent bottom uplift. That this test is required for Q and R tanks by its presence in 620-base document has actually been established via below noted inquiry in 1996. But we have several pages of detailed steps on hydro and pneumatic testing. A reader has good reason to believe that ALL the required steps are shown within Q and R and so we should include the design vacuum test directly in Q and R.

Edition	Section	Inquiry No.	Questions	Reply
9th - Feb. 1996	R.8.4		Is a tank designed and fabricated in accordance with API 620 Appendix R to be vacuum tested per Section R.8.4.4 or Section 5.18.5?	Testing meeting requirements of both sections is required.

Note that I have shown the full vacuum test in different subsections for the varying types of systems since the container to which vacuum is applied varies.

Proposed Changes in API 620 (changes from current published 12th ed, Add. 3)

7.18.5 Partial-vacuum Tests

7.18.5.1 Following the tests specified in 7.18.3 (or in 7.18.4) where this latter procedure has been used), the pressure in the vapor space of the tank shall be released and a manometer shall be connected to this space. The ability of the upper part of the tank to withstand the partial vacuum for which it is designed and the operation of the vacuum-relief valve or valves on the tank shall then be checked by withdrawing water from the tank or using an ejector or vacuum pump to create vacuum, with all vents closed, until the design partial vacuum is developed at the top of the tank and by observing the differential pressure at which the valve or valves start to open. The vacuum-relief valve or valves must be of a size and be set to open at a partial vacuum closer to the external atmospheric pressure than the partial vacuum for which the tank is designed. The partial vacuum in the tank should never exceed the design value (see Annex K).

7.18.5.4 The water remaining in the tank shall then be withdrawn and when the tank is substantially empty (up to 2 feet of water may be left in the tank to prevent bottom uplift), a vacuum test comparable to that specified in 7.18.5.1, except with regard to the level of water in tank, shall be applied to the tank. After this, air shall again be injected into the tank until the pressure in the tank equals the pressure, Pg, for which the vapor space at the top of the tank is designed. Observations shall be made, both with the specified partial vacuum and with the vapor space design pressure above the surface of the water, to determine whether any appreciable changes in the shape of the tank occur under either condition of loading. In the case of a tank whose dished bottom rests directly on the tank grade, if the bottom rises slightly off the foundation during the pressure test, sand shall be tamped firmly under the bottom to fill the gap formed while the tank is under pressure (see 7.18.2.6 and 7.18.8).

Q.6.6 Pneumatic Pressure and Vacuum

Q.6.6.5 The opening pressure or vacuum of the pressure relief and vacuum relief valves shall be checked by pumping air above the water level and releasing the pressure and then either partially withdrawing water from the tank or using an ejector or vacuum pump to create vacuum. Refer to 7.18.5.1 for measures to prevent accidental damage during vacuum testing.

Q.6.6.6 After the tank has been substantially emptied of water and is at atmospheric pressure, the anchorage, if provided, shall be rechecked for tightness. Substantially empty means that no more than 2 feet of water may be left in the tank.

Q.6.6.7 In the case of a double-wall-double-roof tank, or a single wall tank, a vacuum test at the design vacuum shall be performed on the primary liquid container with the container substantially empty of water as defined in Q.6.6.6 to prevent bottom uplift.

Q.6.6.8 In the case of a warm vapor container, purge gas container, secondary liquid container, or membrane tank outer container, a vacuum test at the design vacuum shall be performed with sufficient bearing pressure by means of water level or uniform insulation weight to prevent bottom uplift.

Q.6.6.9 Then, for all tank configurations, air pressure equal to the design pressure shall be applied to the empty or substantially empty tank, and the anchorage, if provided, and the foundation shall be checked for uplift.

Existing Q.6.6.8 to be renumbered as Q.6.6.10

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R.6.5.6 The opening pressure or vacuum of the pressure relief and vacuum relief valves shall be checked by pumping air above the water level and releasing the pressure, then either partially withdrawing water from the tank or using an ejector or vacuum pump to create vacuum. Refer to 7.18.5.1 for measures to prevent accidental damage during vacuum testing.

R.6.5.7 After the tank has been substantially emptied of water and is at atmospheric pressure, the anchorage, if provided, shall be rechecked for tightness. Substantially empty means that no more than 2 feet of water may be left in the tank.

R.6.5.8 In the case of a double-wall-double-roof tank, or a single wall tank, a vacuum test at the design vacuum shall be performed on the primary liquid container with the container substantially empty of water as defined in R.6.5.7 to prevent bottom uplift.

R.6.5.9 In the case of a warm vapor container, purge gas container, secondary liquid container, or a membrane tank outer container, a vacuum test at the design vacuum pressure shall be performed with sufficient bearing pressure by means of water level or uniform insulation weight to prevent bottom uplift.
R.6.5.10 Then, for all tank configurations, air pressure equal to the design pressure shall be applied to the empty or substantially empty tank, and the anchorage, if provided, and the foundation shall be checked for uplift.