



D33 Propane Explosions: The Result of Failed Water Heater Gas Control Valves—Manufacturing Flaws Brought on by Design Changes by an Outsourcer

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Learning Overview: After attending this presentation, attendees will be familiar with some basic principles on the safety features of gas control valves, as well as how changes in valve component, by a third-party vendor, can lead to gas fires and explosions.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by demonstrating how unilateral design changes by outsourcing vendors of critical subcomponent parts, unknown to the control valve manufacturer, can affect the product's overall safety.

Following two propane explosions, it was concluded that the source of the fugitive gas was the failure of water heater control valves. Additional incidents came to light during these investigations. All shared these common threads: (1) out of gas conditions or a pilot outage. The victims were burned while trying to relight the appliance pilot; (2) same brand water heater control valves; (3) the failure of the valve's internal safety magnet to properly close off flow following the gas outages; (4) the same basic safety magnets used with gas appliance control valves since the 1930s; and (5) a common mode of failure: a peeling off of the rubber seat from the top mount on the valve's safety magnet, such that once off, the seat would not provide closure. The consequence being that on the occasions of an interruption of gas service or pilot flame outage, this insidious failure would permit raw (unburned) gas flow—absent a lit pilot light—to the constant (or standby pilot), and when called on (i.e., tank water temperature dropped below the desired set point), a much larger discharge of fugitive gas through the main burner.

In recent years, the safety magnet had been supplied to the valve manufacturer by an outsourcing (third-party) vendor: unbeknownst to the valve manufacturer at the time, this third-party vendor had changed (reduced) the dimensions of the magnet's top metal tip (referred to as a nesting button), where the donut-shaped rubber seat was nested, thus leaving the seat susceptible to being peeled off.

Even as more incidents occurred, the valve manufacturer maintained inexplicably that the separation (peeling off) of the seat from its magnet mount was a direct result of overpressure conditions. However, testing of the subject (incident) pressure regulators and later, high pressure testing in lab conditions, disproved this failure mode.

Residing within the valve's inlet chamber, the primary purpose of this safety magnet is to shut down gas flow to both pilot and main burners in the event of pilot flame outage. A failure of this safety magnet will allow unburned or raw gas to flow to the appliance burners in absence of a lit pilot. A thermocouple, with its head impinging upon the pilot flame, will feed a small (millivolt) electrical current into the safety magnet, sufficient to energize the magnet. Following the pilot lighting steps, the valve's reset button is manually depressed, which draws the safety magnet's rubber seal down and away from its metal closure opening, which in turn pushes the attached spring-loaded stem so that its mating plate bottoms-out against the magnet; once the pilot flame is established and the thermocouple is generating current, the energized magnet should hold the mating plate down, thus permitting gas (or gas flow) into the other valve chambers.

In these incidents, the peeling off of the rubber seat would have occurred during previous pilot lightings, when the control valve was operated as described: while properly aligned and in place, the affinity (or sticking) of the closed rubber seat to its metal closure was the cause of the failure. This failure only occurred in the more recently manufacture valves, specifically magnets provided by the third-party vendor with reduced-sized top (nesting) buttons.

Review of the valve manufacturer's documents and drawings of the safety magnet assembly reflected an inexplicable change in dimension of the top (nesting) button. The 10/20/94-dated drawing depicts a 0.472-inch diameter button, while the 2/23/02 drawing reflects a 0.421-inch diameter, with no engineering change order. Again, measurements of the failed control valves revealed safety magnets with 0.42-inch diameter top buttons. Related to the alleged overpressure theory, in the drawing, the rubber seats are flush against the base metal disk: in other words, there is no excess rubber hanging off the base disk and exposed to the directional gas flow, whether it is nominal or high pressure.

In deposition testimony, the valve manufacturer's senior principal engineer explained that in previous drawings, the diameter of the top (nesting) button was incorrect: the outsourcer had always supplied safety magnets with a 0.421-inch diameter top (nesting) button.

The relevant section of deposition testimony follows: Question: Why? Answer: We were told by the outsourcing vendor that was not (1) correct; that the dimension had never been 472. It had (2) always been 421. So, it was to update our drawing, and, (3) correct it to what it should have been. Question: Okay. So ... so, in other words, the .472 never existed. Answer: That's correct. That's correct.

In contradiction to this testimony, notwithstanding previous drawings, the earlier vintage of same brand control valves, both had top (nesting) buttons with the larger (0.472) diameters. An unmarked magnet (possibly not from this outsourcer) with a red rubber seat has a date code 9427, while the other, safety magnet (supplied by the same third-party vendor) has a date code 9405.

This presentation will briefly discuss the basic design of appliance gas valves, the critical role that safety magnets play, relevant aspects of the incident investigations and testing, as well as the conclusions reached.

After this presentation, attendees will be familiar with how subtle changes in the design of a subcomponent can affect the integrity of a key component of a pilot-ignited gas appliance.

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