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Water Heater Connector Failures: An Engineering Assessment of Cause

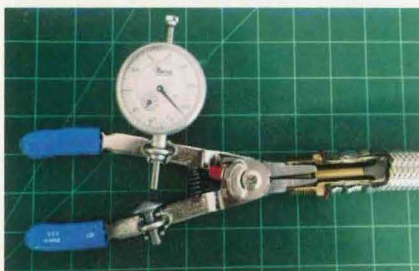
By Michael DeHarde, P.E. and Brian Darr, P.E., U.S. Forensic

NATIONAL FORENSIC ENGINEERING firm, U.S. Forensic, recently undertook a large project to investigate a large number of braided stainless steel water heater connector failures for one of the largest property carriers in the country. Michael DeHarde, P.E., and Brian Darr, P.E., worked on the months-long project to determine the cause of the leaks associated with the braided stainless steel brand water heater connectors commonly sold at the major big box hardware centers.

U.S. Forensic was one of several forensic engineering firms approached to work on the project, and was selected based in part on the proposal to actually test each unit and photograph the results of the test, rather than just visually inspect, as proposed by others. As NASA Rocket Scientist Wernher von Braun famously said, "One test result is worth 1,000 expert opinions."

The process began even before the subject connectors were received by acquiring several exemplar connectors to understand the as-supplied condition of the connector and to develop an inspection protocol. An exemplar connector was cross sectioned to understand the interior make up of the hose and to assist in the design and manufacture of a durometer that could measure the hardness of the plastic interior materials.

Fig. 1: The custom made durometer and cross sectioned exemplar connector.



The durometer was first tested in an exemplar connector. Then, each reportedly failed hose was visually inspected, measured and photographed both externally and internally to document the condition of the hose upon receipt. Once the received condition was documented, each connector was tested to confirm a leak existed in the connector. The location and cause of the leak was observed and then photographed internally using a high-end articulating borescope to document the failure region.

After analyzing multiple connectors of differing sizes, most being 12, 18 and 24 inches in length with 3/4-inch female fittings on either end, the findings were consistent. U.S. Forensic's testing verified that the leaks were present within the inner plastic tubes and were the result of their prematurely decomposing and flaking apart. This material defect led to a breach of the internal wall, which caused the water release and the resultant damages at the various properties across the country.

In some cases, U.S. Forensic was supplied with the other water heater connector, which had not failed. While the second connector showed some changes, this second connector did not have the extensive level of degradation found on the failed connector. This provided valuable information. While in most cases we were not provided the identity of whether the connector was either a hot or cold connector, U.S. Forensic believes that the failed connectors were primarily the hot water, or outgoing, connectors. A rule of thumb for dealing with plastic is for every 10 degrees Celsius of temperature rise, the chemical reaction rate doubles.



Fig. 2: Internal borescope images revealing the decomposition of the interior plastic tubing.

This manufacturing or design defect in many cases ultimately caused the braided stainless steel housing of the connectors to cave in, deform, and/or twist. It was determined that a chemical reaction caused the plastic tubing in the connectors to decompose, and this decomposition caused the connector to structurally deform.

U.S. Forensic understands that codes and industry standards don't always address the needs of a good scientific investigation to determine root cause failure analysis. While the ASME A112.18.6 Flexible Water Connectors 4.3 Hydrostatic Burst Test: Connector recommends the connectors should be pressurized at 250 psi at 180°F and held at that pressure and temperature for 0.5 hours, it does not address or test for long-term creep in plastic. U.S. Forensic is constantly developing new tools and procedures to push the envelope of product liability failure analysis. U.S. Forensic engineers now hold 3 patents, were responsible for 2 national manufacturer vehicle service campaigns, and helped author the new ASHRAE standard for air conditioning flexible duct installation procedure. Stay tuned for the results of U.S. Forensic testing on various plumbing connectors that more closely mimic real-world conditions of connectors and a laboratory recreation of these water connector failures.

