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Forensic Engineering Investigation of a Furnace Oil Supply Line Fitting Leak

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Abstract

A basement oil leak was reported to a service company, which immediately replaced a supply line SAE 37° fitting body while leaving the flared copper lines in place. An environmental remediation claim was later made against this service company, alleging improper installation of new supply lines within the prior year. Fuel delivery records and heating degree day records were analyzed, revealing a consumption rate discrepancy versus the homeowner's narrative. An experimental apparatus was designed to evaluate leak rates for flared fittings in tightened and partially loosened states. The modeled expected consumption rate results inferred tampering with the fittings several days prior to the leak report. The experimental technique and consumption rate analysis withstood a Daubert challenge for relevance at the mediation conference.

Keywords

Oil furnace, leak rates, consumption rates, SAE 37° flare, Daubert, forensic engineering

Introduction

The case involved a reported leak of heating oil from a union fitting in a copper line connecting an indoor storage tank to a furnace in the basement of a home in rural southwestern Ontario. The plaintiff alleged that the leak was discovered on or about December 19, 2005, by Mr. A (all names of persons and firms have been coded to respect confidentiality requirements), the home owner, who called the burner service company (hereafter referred to as "BURSCO") personnel and requested that they perform a repair to the line. BURSCO's own records documented an attendance on January 7, 2006, and a report to its insurer on January 9, 2006. An environmental remediation claim was later made by the homeowner's insurer against BURSCO, alleging improper and negligent installation of new supply lines in May 2005.

The author was engaged to investigate the circumstances of the development of the fuel oil line leak using forensic engineering techniques.

Neither the site nor the involved components were available for inspection in part because the forensic engineer's involvement began at a late stage in the litigation proceedings — about five years after the incident. The components were not retained by BURSCO, for unknown reasons, even though they were important. Spoliation of evidence was not raised as an issue by other parties. A detailed study and review was made of the transcript of the Examination for Discovery of Mr. A (in the Canadian common law system, an Examination for Discovery or EfD is equivalent to counsel deposing one of the parties in a litigation proceeding, under oath); responses to Undertakings and Refusals by the various parties, incorporating sketches of the site and records of maintenance and fuel delivery to the home; and historical weather data from Environment Canada for Georgetown, ON.

Background

The home was built in the 1970s (**Figure 1** on page 2), and its basement area measured approximately 35 feet by 75 feet (11 meters by 23 meters), and was comprised of two bedrooms, a living area with woodstove heater, laundry room, and utility area. Within this utility area was a furnace, a 240-gallon (910-liter) fuel oil tank with a copper supply line attached to the cement slab floor, and two sump pits. The fuel line was located by the perimeter wall and had a single union a few feet away from the point where it supplied the furnace. There were some furniture items (such as bookshelves and boxes of books) in the furnace area. These site details are found in an unscaled sketch reproduced as **Figure 2** (on page 2), with the tank, fitting, and furnace highlighted in red ovals.

The copper line was $^{3}/_{8}$ inch (9.5 mm) nominal diameter, and was coated with red polymer. The line reportedly

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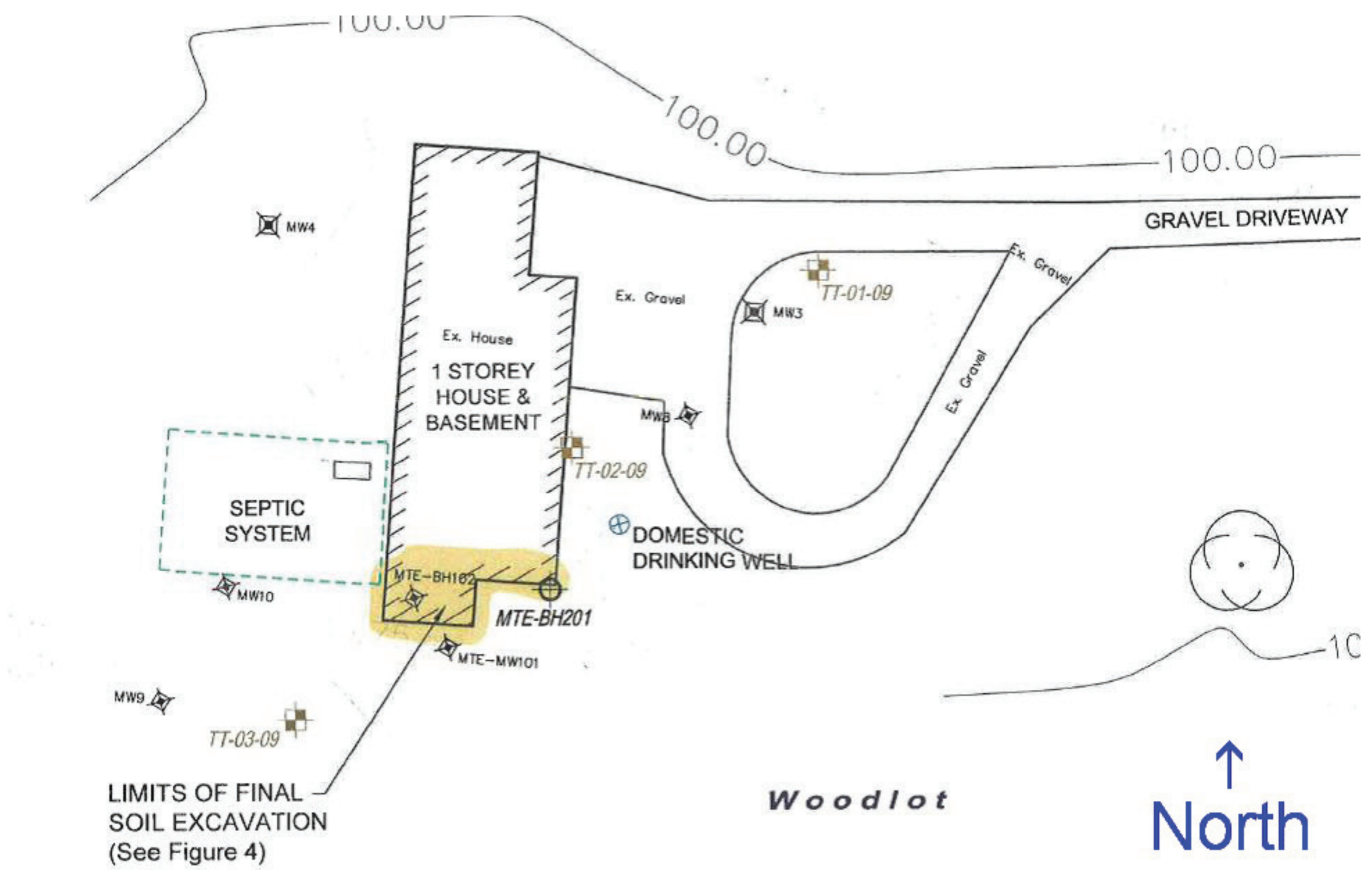

Figure 1
Excerpt from the remediation site plan.

ran from a tank adjacent to the east wall, south along the wall to the south wall, and then along a loop north toward the furnace. The line was kept in place with anchor clips at 6 inches from the wall. A union joint had been made with a flared fitting along the south wall. This fitting was the reported location of the leak. The basement floor slab had a crack running parallel to the walls, at about 10 inches (25 cm) away, according to Mr. A.

Reported Circumstances and Timeline of Events

Mr. A had engaged BURSCO to remove two used 240-gallon (910-liter) capacity tanks and replace them with a new 240-gallon indoor tank on May 27, 2005 (Julian Day 513 elapsed since January 1, 2004) — the Julian Calendar numbers the days of a year in succession, making it simple to measure time between two events. The reference period begins on January 1, 2004, and is counted in Julian Days (abbreviated as JD###) elapsed since then, to provide a clear way to show days between events in the case timeline. The supply line was changed by BURSCO. The work orders and invoices found in the records support the narrative about this activity.

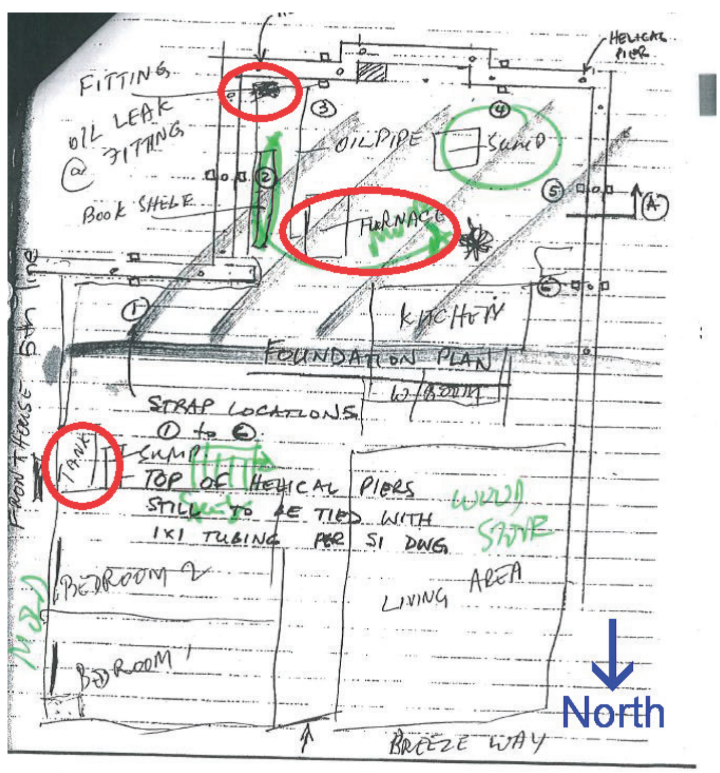

Figure 2
Scanned sketch of the basement configuration by others.

During his Examination for Discovery, Mr. A reported that since the time of the tank removal, fuel oil smell had gradually increased. The smell had become offensive to his son-in-law during the start of the heating season. Other family members had complained about the smell, but Mr. A stated that none of them had attempted to locate the source.

Mr. A called his regular service company (hereafter referred to as "RESCO") for the seasonal furnace tune-up, which was performed by RESCO on December 19, 2005, (JD 718), according to that company's records. Mr. A said that he instructed his wife to ask the technician about the smell and where the source was located. His wife noted that the technician stated he couldn't find a leak, and the homeowner stated:

> *"Because the technician couldn't find the smell when he came to service the furnace, we knew the smell was still then strong. That's when I decided to look around. That's when I noticed a leak."*

After RESCO's visit, Mr. A found the leaking fitting himself the next day, describing how he did so just by touching it.

Mr. L and Mr. W attended on behalf of BURSCO on January 7, 2006. They located a fast drip at perhaps one drip per second, at the union fitting and repaired it, but their observation was that the quantity fell below the minimum reporting threshold for the Ministry of Environment Spills Action Centre. During the repair, they removed the central union body, but kept the nuts and the flares on the tubing as they had been. Mr. L and Mr. W described the odor as unbearable. Subsequent statements by Mr. L and Mr. W did not include any observations with respect to tool marks on the nuts or other irregularities.

Over the course of a few months, Mr. A applied a cleaning fluid mixed with water in pail-sized quantities two to three times per week into the crack in the slab adjacent to the position of the union fitting, apparently to remove the grease and smell.

In the summer of 2006 (JD 900), Mr. A called in his insurance representatives regarding a mold and dampness problem in the basement rooms. According to Mr. A, the field adjuster, Mr. F, detected the smell of oil and noted presence of oil in the sump by the furnace. This adjuster set in motion a series of events that led to reclamation of the soil beneath the slab due to contamination by fuel oil. The remediation process lasted over several months, and the homeowner's insurer initiated the litigation against BURSCO for negligent installation of the fuel line in May 2005. **Figure 3** summarizes these important events.

Party	Activities	Julian Date of Activity
BURSCO	Replaced tanks, installed new lines and tank	JD 513 (May 2005)
Homeowner Mr. A	Complained to RESCO about smell in basement	JD 719 (Dec. 19, 2005)
RESCO	Attended home, did annual service on furnace	JD 719 (Dec. 19, 2005
BURSCO	Attended home after call from Mr. A, found drip at fitting	JD 738 (Jan. 7, 2006)
FUELCO	Filled the tank	JD 749 (Jan. 19, 2006)
HOME INSURER	While investigating other issues, found oil spill and initiated remediation	JD 900 (July 2006)

Figure 3
Timeline of activities at the site.

Questions to Address During the Forensic Investigation

Conducting the investigation without hard evidence required extra effort, such as looking at the historical information in the fuel delivery documents. These would provide context to allow estimation of the furnace consumption rate or burn rate. For example, did the burn rate change prior to and after the alleged intervention by BURSCO? The 200 days between the service and discovery posed the questions: Why would a bad fuel line connection take so long to be noticed as leaking? Additionally, wouldn't a leak in the fuel line cause the pump to draw air in and cause burner problems? There was nothing in the narrative about either the former or the latter.

The cause of the fuel leak and its rate of loss characteristics would be factors in the quantum of fuel released. As such, the amount of fuel found at the site would give insight into the cause and timing of the event. How fast was the leak from the fitting, and how much leaked in a given time? Answers to these questions could lead to insight into what really happened to create the drip in the basement.

Considerations of Fuel Supply and Consumption Data

According to records from the fuel supply company (hereafter referred to as "FUELCO"), the following amounts were delivered to the home on the dates in **Figure 4** on page 4. The heating degree days as measured at Georgetown, from the Environment Canada historical record for the same intervals, were compiled. The third

Date of Fuel Delivery	Julian Days Elapsed Since Jan. 1 2004	Quantity, Liters	Heating Degree-Days Since Last Delivery	Fuel Oil Consumption, Liters per Degree-Day
Oct. 28, 2004	302	915	—	—
Dec. 21, 2004	356	1270	849	1.5
Feb. 09, 2005	405	1245	1220	1.0
Mar. 30, 2005	454	500	1078	0.5
Oct. 06, 2005	644	684	671	1.0
Nov. 23, 2005	692	733	502	1.5
Dec. 19, 2005	718	791	597	1.3
Jan. 19, 2006	749	749	580	1.3
Feb. 21, 2006	782	814	649	1.3
Apr. 04, 2006	824	799	760	1.1
Oct. 18, 2006	1021	690	722	1.0
Nov. 21, 2006	1055	824	448	1.8
Dec. 18, 2006	1082	756	409	1.8
Jan. 12, 2007	1107	714	399	1.8

Figure 4
Table of fuel oil consumption rates for the furnace.

column shows the estimated consumption (burn rate) of the furnace calculated from the data, in liters per degree day.

A heating degree day is a commonly used measure of the requirement to keep a building at a base reference temperature (typically 18° Celsius) in the metric system in Canada. A similar concept is used in customary U.S. units based on Fahrenheit degrees. The present analysis was performed using the Canadian version of heating degree day.

This basement had supplemental woodstove heating, but the family lived primarily upstairs — and it was reported that the woodstove was used infrequently by visiting family members. It followed that heat was provided by the oil-fired furnace only. The homeowner stated that FUELCO used an automatic delivery system.

Historical heating season consumption rates were plotted against Julian Days elapsed since January 1, 2004 in **Figure 5**. They ranged from 1.0 to 1.5 liters per degree day in 2004, from 1.0 to 1.5 liters per degree day in 2005, and were steady at 1.8 liters per degree day in 2006. The off-season rate was no more than 0.8 liters per degree day in 2005 and 1 liter per degree day in 2006.

The consumption rates were effectively stable from the date of the installation of the new tank in May 2005 (Julian Day 513) until the beginning of the heating season. There was no increase after the reported discovery date by the homeowner in December 2005 (Julian Day 718) until the next fill date of January 19, 2006 (Julian Day 749), an interval that would have included the site visit by BURSCO personnel. The site excavation and remediation reportedly took place in the fall of 2006. There was a significant jump to 1.8 liters per degree day consumption rate in the 2007

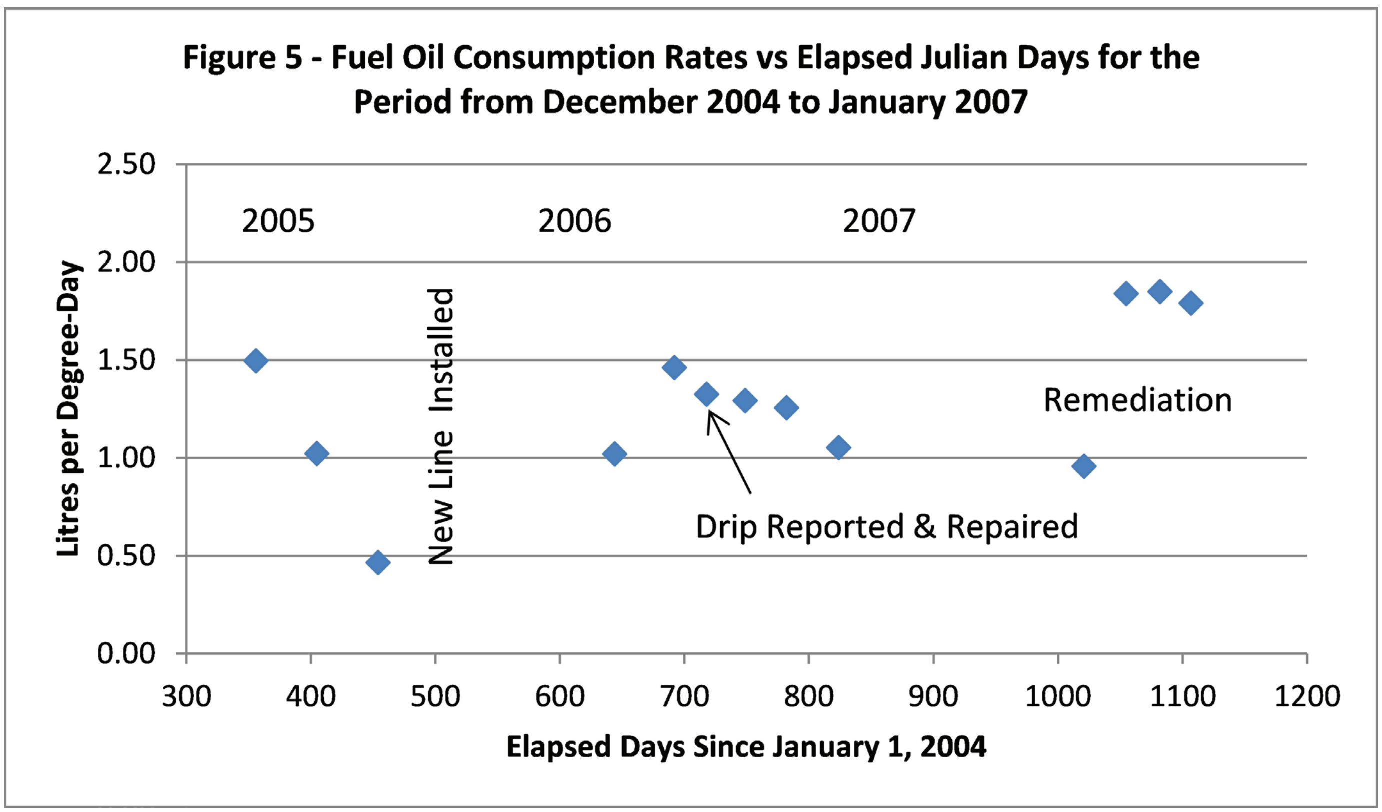

Figure 5
Fuel oil consumption rates vs elapsed Julian Days since January 1, 2004 for the period from December 2004 to January 2007.

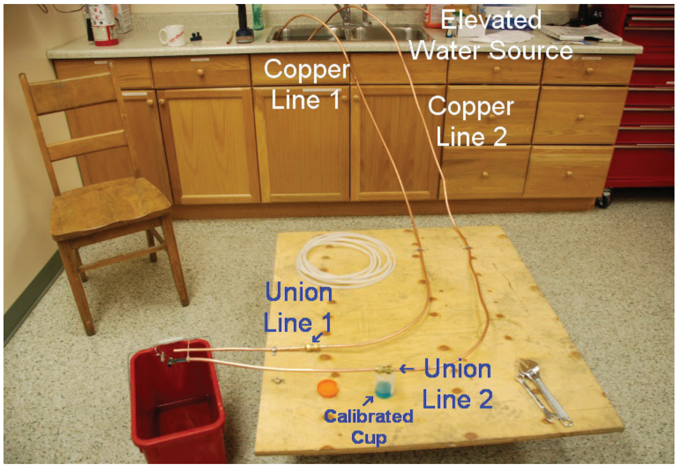

Figure 6
An overview of the experimental set-up, with collection bottle in the foreground. The effective head was 18 to 23 inches from the bottom of the sink full of water to the height of the plywood.

heating season.

Observations

Mr. A mentioned (EfD, Q&A 482) that "the oil line before the incident was buried," but no other specifics had been determined by others. However, this fact should not escape scrutiny in the analysis of the circumstances because of the potential historical significance — if the old oil line had been leaking into the ground, the plume analysis could have been confounded. Additionally, the actual dispersive effect of the cleaning solution (which contained isopropanol) being poured into the crack on any fuel oil — and whether this would mitigate or enhance the size of the plume — needed to be considered as part of the overall context of the assessment of liability.

The question in litigation was whether the supply line had been improperly installed by BURSCO in May 2005.

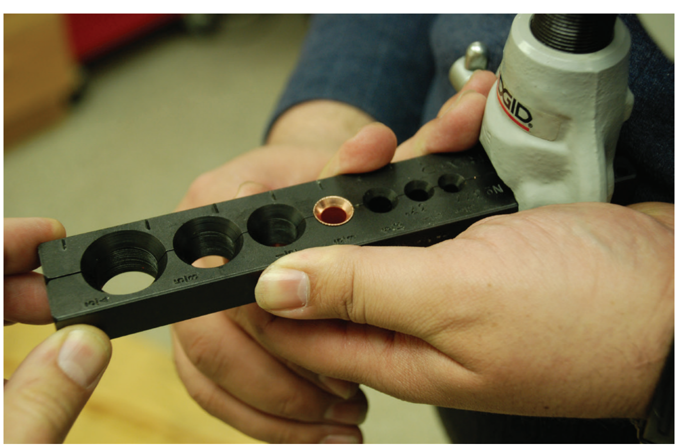

Figure 7
The flaring tool used on the copper lines.

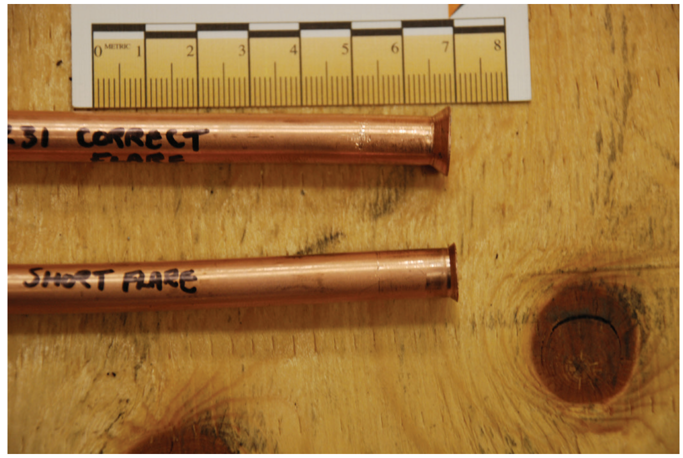

Figure 8
Correct and short flares in $^{3}/_{8}$-inch copper tubing.

To evaluate this hypothesis, the following conditions were postulated:

1. the flares on the copper tubes were incorrectly made;

2. the nuts on the union were not properly tightened; and

3. the nuts were tightened at installation but loosened while in service.

On April 15, 2011, a testing apparatus comprising a $^{3}/_{8}$ inch copper line, mounted on a plywood sheet was devised (see **Figure 6**). The line was attached to the sheet with an anchor clip, then bent around a 14-inch (35 cm) radius, followed by a straight section into a $^{3}/_{8}$ inch SAE 37 degree union fitting, and into another straight held in place by an anchor clip.

A set of experiments was designed to determine flow rates from the fitting in various settings, using a head of 18 to 23 inches (45 to 58 cm) of water (made blue with food coloring for better photographic visibility. This simulated the expected head from a typical 900-liter (240-gallon) storage tank raised on pipe stands filled to a third of capacity. This choice of fill level was derived from the estimated amount in the tank just prior to the events in the narrative. A full tank would have more head and may have given a different range of experimental results.

The tubing was flared with a professional quality swaging tool (**Figure 7**) similar to that used by BURSCO's employees, and both correct and short flares were made (**Figure 8** and **Figure 9**). The nuts (**Figure 10**) were

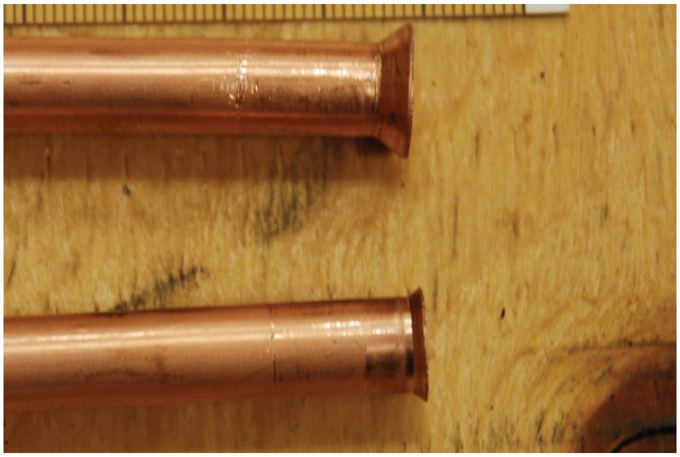

Figure 9
Correct and short flares – magnified view.

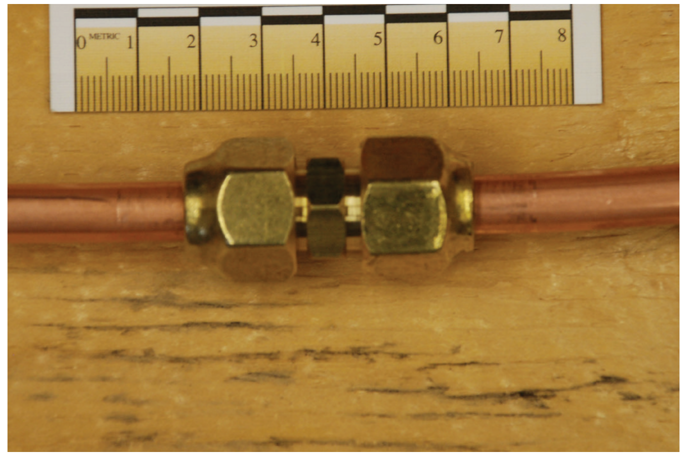

Figure 11
The union as assembled for testing.

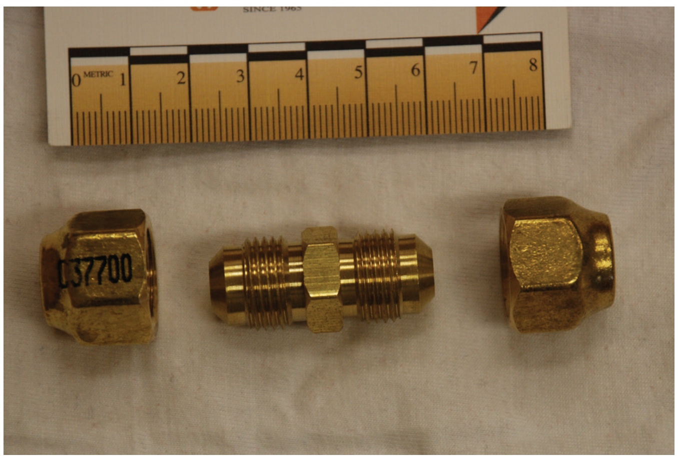

Figure 10
The exemplar SAE 37° union fitting and nuts.

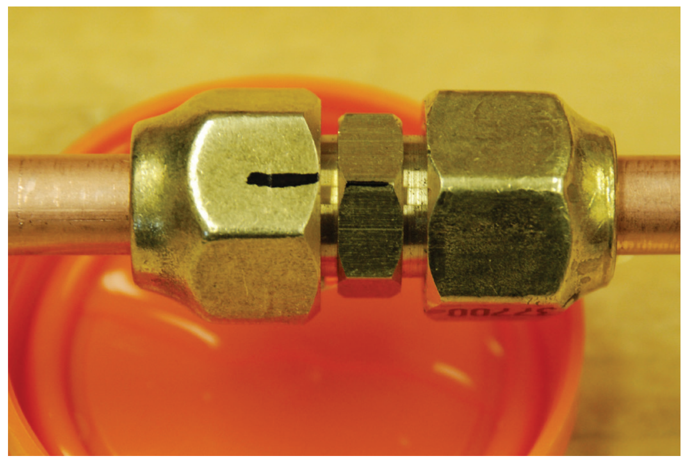

Figure 12
Minimal relative movement of 1 mm after the finger-tight assembly was repeatedly kicked.

tightened with a $^{7}/_{8}$-inch wrench, while the union hex face was tightened with a $^{5}/_{8}$ wrench, and the joint was ready for testing (**Figure 11**).

The experiment included an attempt to disrupt a tool-tightened union fitting by repeatedly kicking by a work-boot worn by a 250-lb technician with the strike force directed at pushing the nut, over a period of 3 minutes. We also considered whether the burner pump vibration, from a distance of 8 feet away, could have had an effect, but it was presumed to be insignificant. These actions were unable to dislodge the fitting or tubing to create a leak. The same actions were performed on a finger-tight union fitting, but these actions could only move the nut 1 millimeter, as seen in **Figure 12**. No droplets were formed from the fitting after this interaction.

The potential over-tightening scenario was not tested, due to the narrative describing the leak without broken components, and because the same flare was re-used after the event and could not have been re-used successfully if damaged.

An improper "short" flare was created with the flaring tool and connected to the union with the nut. The seal that was produced was unstable such that small movements of the tubing on the short flare side immediately produced drops on the underside as shown in **Figure 13** on page 7**.** There were 10 drops produced in 40 seconds, with a total volume of 2.5 milliliters, as measured with a calibrated syringe. On the correctly flared union, conditions were set to mimic the one drip per second described by Mr. L and Mr. W, by arranging the relative position of the hex head and the nut at 6 to 7 mm from the tool-tight position, shown in **Figure 14** on page 7.

A range around 10 drips in 10 seconds was obtained with this configuration. On a trial run, 40 drips were

Figure 13
Short flare tubing joint was unstable and leaked immediately.

Figure 15
Active dripping from the 7 mm nut offset configuration.

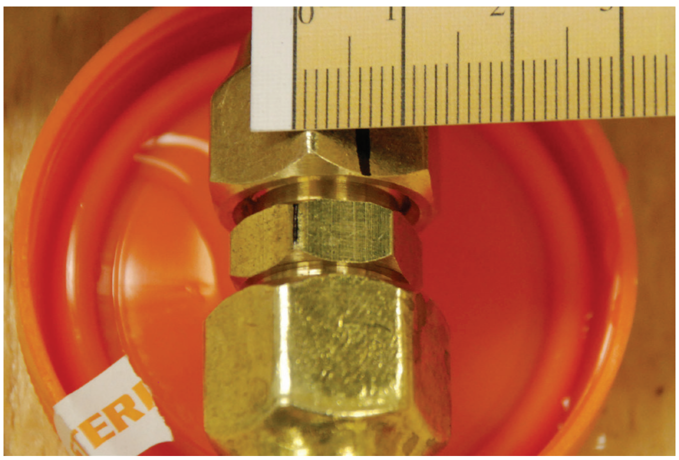

Figure 14
Relative rotations of the nut in the 7 mm test configuration.

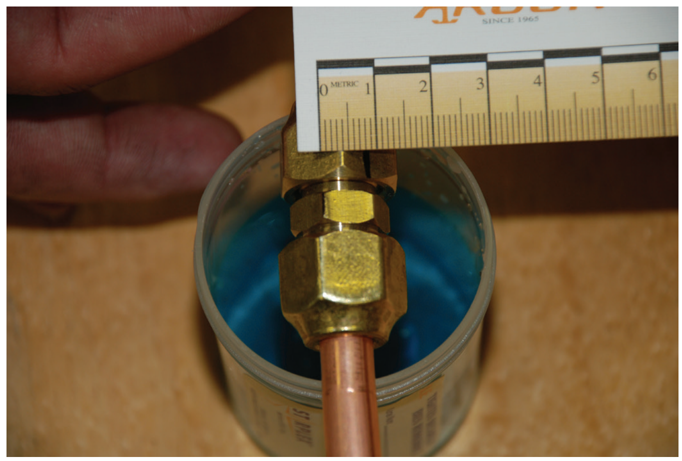

Figure 16
Nut offset for the 9 mm configuration during the test run.

observed in 60 seconds. A volume of 55 ml in a calibrated sample cup was produced in 10 minutes as seen in **Figure 15**.

The nut was rotated to the 9 mm relative position for the second run, yielding 73 drips per minute, with a slightly lower head of 15 to 20 inches of water. On this run, 66 ml were captured in 5 minutes, and the volume increased to a total of 100 ml in 9 minutes (**Figure 16** and **Figure 17**). As expected, the rate was most sensitive to the position of the tubing flare. The testing results are summarized in **Figure 18** and **Figure 19** on page 8.

Analysis & Discussion

Limitations to the Testing Protocol

Viscosity, density and surface tension were considered as factors and are different for water and fuel oil. We did not use fuel oil in the laboratory due to the fumes. Recognizing that water is not fuel oil, there will be an expected

Figure 17
Calibrated cup after 9 minutes with 100 ml of water.

Flare Type	Nut Position	Leak?	Head, cm of Water	Drip Rate per Time	Total Volume	ml per min	ml per hour
Regular	Finger tight	No	45 - 58	Nil	Nil		
Regular	Finger tight kicked 1 mm movement	No	45 - 58	Nil	Nil		
Regular	Tool tightened	No	45 - 58	Nil	Nil		
Regular	Loosened 7 mm rotation	Yes	45 - 58	10 in 10 secs	55 ml in 10 mins	5.5	330
Regular	Loosened 9 mm rotation	Yes	38 - 50	73 in 60 secs	100 ml in 9 mins	11	660
Short	Tool tightened		45 - 58	10 in 40 secs	2.5 ml	3.8	220

Figure 18
Summary of experimental rates for regular and short flare connections (metric units).

Flare Type	Nut Position	Leak?	Head, inches of Water	Drip Rate per Time	Total Volume	Fl oz per min	Fl oz per hour
Regular	Finger tight	No	18 - 23	Nil	Nil		
Regular	Finger tight kicked 0.040 inch movement	No	18 - 23	Nil	Nil		
Regular	Tool tightened	No	18 - 23	Nil	Nil		
Regular	Loosened 0.28 inch rotation	Yes	18 - 23	10 in 10 secs	1.9 fl oz in 10 mins	0.19	11
Regular	Loosened 0.35 inch rotation	Yes	15 - 20	73 in 60 secs	3.4 fl oz in 9 mins	0.37	22
Short	Tool tightened		18 - 23	10 in 40 secs	0.08 fl oz	0.13	7.5

Figure 19
Summary of experimental rates for regular and short flare connections (U.S. customary units).

variance between the testing results obtained and site data because of the density differences (1 gram/cm^3 for water versus 0.8 gram/cm^3 for #1 fuel oil) and the surface tension properties of fuel oil. For example, the drop size has a range dependent on these properties and was not fine-tunable in the experiments. Notwithstanding these conditions, the values yielded in the experiments provided insight and guidance for the basis of an opinion about the range of expected leak rates.

Mechanical Fitness of the Seal at the Union

The professional swaging fixture was designed to prevent oversized flares, which cannot be removed from the tool, and to minimize short flares swaged when the tube is not correctly inserted into the jig. There was no evidence in the file documents of incorrect flaring of the involved tubes. To the contrary, it was established that the same flares were successfully reused to redeploy the supply line to the furnace. Had there been an incorrect flare present, the joint seal would have been immediately unstable, according to the laboratory results.

There were two nuts for each union, and the tightness of nuts was a contributing factor to the success and longevity of the seal. The attempts to knock and roll the fitting demonstrated the secure nature of the tool-tightened seal on the union. There were no movements of the nuts or opening of the seal when either rotating and twisting or by standing on the connection. Torque wrenches were not used during the experimental trials because we would not have been able to compare with the field settings. Most oil-burner technicians do not use torque wrenches in the field during installation and repair activities.

The results of the testing indicated extremely low potential for disruption of a line by moving furniture and materials across the fitting, partly because of its anchored location adjacent to the wall, but mostly because even a finger-tight fitting will not move enough to create a leak. Once properly made, assembled, and tightened, these SAE 37° unions do not loosen and leak. This pattern of behaviour of the union fittings was in direct contradiction to the alleged existence of a poor mechanical seal at the union at the time of installation of the new tank by BURSCO in May 2005.

Tool-tightened nuts have limited potential to loosen over time, if at all, without external intervention. A relative rotation of 6 to 9 mm (0.2 to 0.35 inches) was required to create dripping.

Flow Rates from Disrupted Union Flare Seals

For the test runs, a range of 330 ml/ hour to 660 ml/ hour (11 to 22 fluid ounces per hour) was obtained for drip rates that matched those observed at the site by BURSCO personnel in January 2006, that is, one drip per second. There was inherent variability seen due to the size of the drops, which was uncontrolled.

This volume would range from 8 to 16 liters (about 2 to 4 gallons) per 24 hour period, rates which could drain a full 240 gallon (910-Liter) tank in anywhere from 50 to 100 days. A leak of this quantity would not only be visible once underway but also certainly have a potent unpleasant odor.

Over the time period from installation of the new tank in late May 2005 to the apparent discovery in December 2005 (or the documented discovery by BURSCO in January 2006), a period of seven months, the projected quantity of the spill would be from 260 to 520 gallons (1,000 to 2,000 liters), without any consumption by the furnace. Had such a drip sequence started in May, the fuel tank would have been completely empty well before the start of the heating season in October. Therefore, the possibility of a disrupted union having been installed in the furnace supply line was so remote as to be dismissed. We considered whether running the burner pump would reduce the leakage while it was operating, but concluded that both the burner and the leak would account for a proportion of the lost oil. The consumption would lessen the escaped fuel amount, so the burner pump does have an effect.

Steady Heating Season Fuel Consumption Rates

The analysis assumed that there were no major changes in the way the system was controlled or set by the occupants — and that Georgetown Station weather was adequately similar to that at Rockwood some 13 miles (22 km) away. The typical consumption rate for the furnace was calculated at between 1 and 1.5 liters per degree day during the heating season, and less than 1 liters per degree day during the off-season. The rates for the prior period of 2004 and the involved period of 2005 were essentially similar within the expected variance of calculations.

If the installation in May had been anything except ordinary, there would have been a direct effect on the fuel consumption rate between that time and December 2005. If the drip rate ranged from 8 liters to 16 liters per calendar day, the off-season consumption would have been from 2.5 to 4.1 liters per degree day, that is from 250% to 400% of the typical value, as shown at upper slow and lower slow rates in **Figure 20** on page 10. However, the base fuel oil consumption calculations showed that it was relatively constant over this period.

The actual consumption rates were not reflective of a drip forming at the union at any time from March through October. This supported an assertion that denied the existence of a fast drip in May, and qualified the possibility of an incorrect installation as very remote. Had the fast drip started on December 19 and been discovered only on January 7, 2006, the consumption rate would have risen to 1.8 liters per degree day (see the acute line in **Figure 20**), but it did not: It remained at 1.3 liters per degree day. The next fill of the tank on January 19 was unexceptional.

Intervention at the Union by Unknown Parties

Fully tightened unions can only be loosened by tools, such as a $^{7}/_{8}$-inch wrench, a $^{5}/_{8}$ wrench, or adjustable wrenches. These wrenches are not specialized and are typically available in every home. The possibility of an intervention at the union by an unknown party presented itself in light of the consumption data discrepancy.

The analysis converged on an intervention as the initiator for the leak at the union. This intervention would have occurred sometime after the service call by the RESCO on December 19, 2005 (JD 718), when there was no sign of dripping detected by the technician. This would bracket the frame of time of the active leak at no more than 19 days.

Only Mr. A and his family members had access to the basement during the period when the fittings were loosened enough to create the drip.

Conclusions

The testing exercise demonstrated that the mechanics of the flare seal under tool-tightened conditions are such that it cannot be disrupted by contact in the field, eliminating this as a potential causal factor for creation of a leak. About 7 to 9 mm of rotation of the nut is required to crease a dripping scenario for $^{3}/_{8}$-inch SAE 37° fittings at less than 30 inches of water head. During tests, flow rates of one drip per second were matched to conditions of the nuts and the union, and demonstrated that this rate was 2 to 4 gallons (8 to 16 liters) per day. Such rates would create substantial localized pooling of fuel oil in a short period, and would be immediately visible and noticeable from the pungent odor.

The invariance of the furnace's fuel consumption rates for the period prior to discovery of the drip in either December or January pointed directly to an acute event, and qualified a longer term configuration issue at the union as very remote.

The hypothesis of an external intervention, at the union joint with common wrenches one or two days before the event was reported by Mr. A to BURSCO, would be consistent with the physical evidence of the local extent of the spill. Confirmation of the external intervention hypothesis would follow if the amount of fuel oil relating to this event and found during remediation activity had been confirmed.

Daubert Challenge at Mediation

Under the Rules of Civil Procedure, Ontario, the case went to mandatory pre-trial mediation where the analysis and techniques were submitted in report form in the brief by counsel for BURSCO. Opposing counsel challenged the testing under Daubert, arguing that the reported results were not technically relevant.

Remember that the five Daubert factors considered in such a challenge include:

- Whether a method can or has been tested;
- The known or potential rate of error;
- Whether the methods have been subjected to peer review;
- Whether there are standards controlling the technique's operation; and
- The general acceptance of the method within the relevant community.

The seasoned mediator disagreed with the basis of the

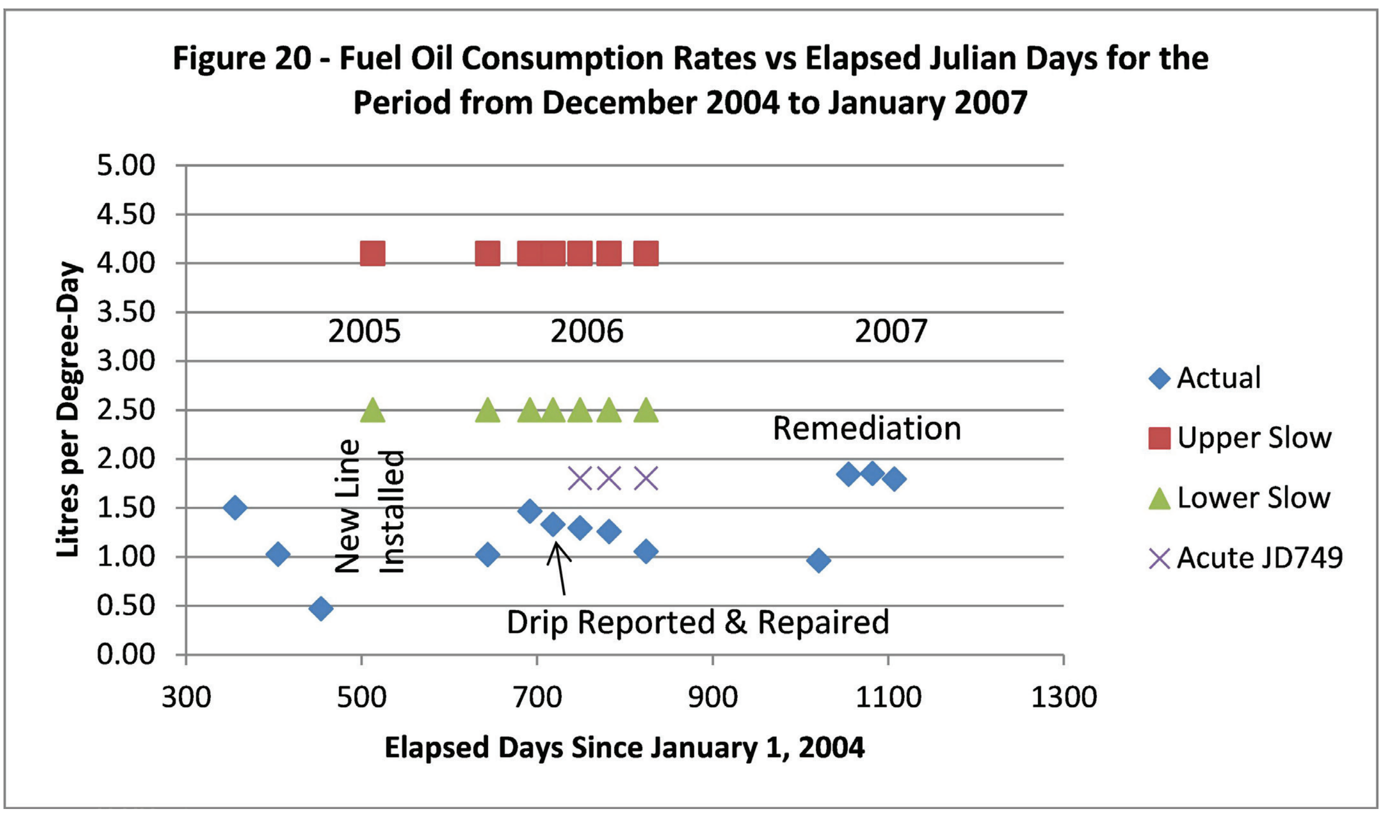

Figure 20
Theoretical rate upper and lower ranges for one drip per second starting at JD 513 and acute drip starting on JD 749.

challenge, and found that the analysis of historical consumption rates, the experimental testing in the laboratory, and the calculation of the rates of dripping were all acceptable and technically relevant to understanding the circumstances.

Had the author been required to mount a defence based on these factors, the patented Certuse Methodology as well as the 2008 and 2016 NAFE Journal articles with respect to burn rate calculations listed in the bibliography below would have been cited. The technical basis of the heating degree day method, used throughout the fuel oil industry to automatically calculate the fill dates for residential systems, is explained clearly in these peer-reviewed references.

The hypothesis of an external intervention by the homeowner was accepted as reasonable and found to have a higher probability than that of the incorrect or negligent installation hypothesis. The homeowner was found by the mediator to have poor credibility and was assigned two-thirds responsibility. The matter settled at mediation.

Bibliography

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