Incident Summary (Reference #5605195)

SUPPORTING INFORMATION	Incident Date			September 13, 2016
	Location			White Rock
	Regulated industry sector			Natural gas system and low voltage electrical system (30V to 750V)
	Impact	Injury	Qty injuries	1
			Injury description	A furnace installer received first and second degree burns to the left side of his face and his left arm.
			Injury rating	Moderate
		Damage	Damage description	Fire damage to the gas piping system, new furnace, and fire and arcing damage to a receptacle and cover plate. Extensive fire and smoke damage to the basement of a house.
			Damage rating	Major
	Incident rating			Major
	Incident overview			A fire occurred during a furnace replacement installation for a house. A heating contractor's installer was performing gas and electrical work at the time of the incident. Natural gas entered the basement area and was ignited by an electrical arc causing the fire and resulting injuries to the installer.
INVESTIGATION CONCLUSIONS	Site, system and components			The gas furnace was a typical furnace that is installed in residential applications. The furnace is designed to have electrical and gas connections enter the side of the furnace to supply power for the furnace controls/ignitor and fuel for the furnace to operate. A receptacle was installed to provide power to a condensate pump for the new furnace. Connection to the existing ¾" black metal gas piping was going to be utilized to supply gas to the new furnace. Gas is intended to be contained within the piping system both during and after the installation. The piping installation was in progress and not connected to the furnace at the time of the incident. The furnace electrical connection consisted of an armoured cable connected to a 15A, 120V receptacle in an electrical outlet box adjacent to the furnace. The outlet box, receptacle, and armoured cable had been installed and connected to the existing furnace circuit by the installer. Outlet boxes and receptacle cover plates are intended to protect electrical devices and wiring from damage and to prevent contact between energized parts and persons or objects. Receptacles added to existing circuits are required by code to be protected by Arc Fault Circuit Interrupters (AFCI).
	Failure scenario(s)			During the installation of the new furnace the following occurred: - A receptacle was installed on the existing furnace circuit without AFCI protection being installed as required by the BC Electrical code. - Wiring was not terminated properly onto the receptacle by the installer and it was in contact with the receptacle's metal cover plate. - The existing furnace gas valve and piping was removed by the installer from the charged gas pipe and fell to the floor. - Gas entered the basement area through the open pipe. - The installer reached down between the furnace and the wall to pick up the valve/pipe and likely bumped the receptacle and the cord that was plugged into it.

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		- Movement of the receptacle and cord caused the energized wiring to contact the bonded metal cover plate. - The gas was ignited by an electric arc between the receptacle wiring and the receptacle's metal cover plate.
	Facts and evidence	Interview with the owner: - The furnace installer had arrived earlier that morning to replace the furnace. - She said the incident occurred at about 11:30 when she heard a loud bang that sounded like something very heavy like the furnace fell over. - She was upstairs when it happened and did not hear anything for about a minute or so after the "Bang" and then heard the installer yelling for her to get out of the house. - They both exited the house at the same time – he appeared to be burned - having visibly red skin on his face and he was disoriented. - She indicated the installer said "the gas blew up!" and was phoning 911 when they got outside. Interview with the fire department investigator: - The fire department investigator indicated that the main gas valve at the gas meter was still on when fire crews arrived. The fire department shut the main gas valve off when they arrived at the scene to fight the fire. Interview with the installer: - He said he turned off the furnace shut off valve and removed the existing gas pipe to the furnace. - The main gas valve at the meter remained on. - The new furnace was put in place but the gas connection was not completed yet. - He indicated that he had installed the condensate pump receptacle and the electrical connection to the furnace and then turned the breaker back on before completing the gas work. He re-used the existing branch circuit. - He said he smelled a leak at the existing furnace gas piping where it connected to the old furnace shut off valve. - He said he was attempting to fix the leak by tightening the pipe and turned the pipe the wrong way loosening it. - He said the pipe came apart and he dropped it while trying to put it back on. - He said he went to pick the pipe up to re-install it when he saw a flash and then the gas ignited and the fire occurred. - The gas coming out of the open pipe was burning. - He exited the house and called 911. - He had a new valve that was intended to be installed to replace the old one. - When asked if he was qualified to do electrical and gas work he said he was a gas apprentice. He was not being supervised on site at the time of the incident nor had he received any schooling yet so he was not authorized to work as a gas fitter on his own. He was also not authorized to perform the electrical work. - When asked if he was attempting to change the furnace shut off valve with the gas pipe charged he indicated no. In my opinion I believe this may have been the case because the gas valve would have had to be turned 5 to 6 full turns to be removed from the ¾" gas line which would make it unlikely to be accidentally removed. Also

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the new valve was in close proximity to the open pipe (sitting on top of the new furnace).

- Discussion with Gas Safety Officers and other Gas Fitters indicated that it is uncommon for gas fitters to change valves on charged pipes but it does occur which is contrary to formal training programs for gas fitters, safe work procedures, and Work Safe BC Regulations.

Interview with the heating company general manager:

- He stated that unqualified installers are normally supervised on site by qualified gas fitters while doing gas and any associated electrical work. The gas fitter on this day was unsupervised because the person intended to supervise him was unavailable. A replacement supervisor was not provided.
- He indicated company policy was not to work on charged gas systems. The company policy required the main valve at the meter to be turned off and the system to be purged prior to working on it.
- The company does not currently have a written policy/procedure for shut off and lockout of gas piping but was in the process of developing one.

Observations of the gas piping system, receptacle and electrical connections to the furnace after the incident:

- The ¾" black rigid gas pipe was open near the furnace location approximately 3 feet from the floor level adjacent to the furnace. See figure 4, 5, and 6.
- Approximately 1 foot below the open gas pipe was the receptacle and outlet box. The box had a 15A, 120V receptacle and a metal cover plate that had just been installed by the furnace installer prior to the incident. See figure 5
- A section of pipe approx. 1 foot long with a shut off valve – nipple – T fitting – nipple – and drip cap was laying on the new furnace adjacent to a new gas valve. See figure 5
- The wall adjacent to the furnace was fire damaged on the studs and the wood paneling. The furnace and duct work were also fire damaged adjacent to where the open gas pipe was located. See figures 4, 5, 6, and 7.
- The fire pattern on the wall and furnace lined up with the end of the open gas pipe that was ignited during the incident. See figures 6 and 7.
- There was a new condensate pump sitting on the floor below the receptacle. The receptacle was installed and the pump was plugged into it at the time of the incident. See figure 4.
- The metal cover plate for the receptacle had extensive electrical arcing damage on the inside of the cover near the bottom right side of the receptacle. See figures 6, 8 to 11.
- Closer examination of the receptacle showed that the line conductor on the receptacle had come into contact with the cover plate and created a short circuit and the resulting electrical arc. See figures 8, 10, 12 and 13.
- Based on the location of the conductor connected to the receptacle it appeared that it was not installed or tucked into the outlet box properly at the time the receptacle was installed. The #12 gauge copper conductor was terminated to the side of the receptacle with the conductor protruding from the front of the receptacle rather than the back which is normal practice. This left the insulated conductor in contact

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		with the cover plate and the uninsulated part of the conductor in close proximity to the metal cover plate. See figures 8, 10, 12 and 13. - The damaged #12 gauge copper conductor was terminated on the screw terminals on the receptacle. The conductor was from the armoured cable that ran from the bottom of the outlet box to the connection at the furnace. See figures 5, 8, 10, 12 and 13. - The conductor had arced to the extent that it burned apart and was detached from the receptacle about 1-1/4 inches from the receptacle termination point. See figures 8, 10, 12 and 13. - The metal cover plate had arcing on it that was extensive enough to show through the metal cover plate to the front of the cover. This was a large sustained electrical arc that would have produce a significant amount of heat and a significant visible flash. It is unknown why the circuit breaker did not trip to prevent this type of arcing. See figure 11. - The existing branch circuit from the panel to the furnace was a 2 conductor #14 gauge copper non-metallic sheathed cable (15A, 120V branch circuit). Due to the fire damage the circuit could not be traced back to the breaker. Some breakers in the panel appeared to be in the tripped position and some were in the off position. All 15A, 120V branch circuits in the panel appeared to be terminated onto 15A rated circuit breakers. See figure 17. - There were no Arc Fault Circuit Interrupter (AFCI) breakers in the panel. The furnace installer installed a new receptacle on an existing branch circuit for the condensate pump. The current electrical code required AFCI protection for the installation of a new receptacle on the existing circuit. See figure 17. Other sources of ignition ruled out: - The hot water tank adjacent to the furnace was in operation at the time of the incident. However the pilot light and burner were ruled out as the ignition source. In order for the hot water tank to be the ignition source the gas in the basement would have had to accumulate from the ceiling down filling the house which when ignited would have likely caused a very large deflagration and damage to the entire structure which was not the case. - The furnace pilot light was considered as an ignition source because the electrical wiring to the furnace was connected and energized at the time of the incident. This was ruled out because the front access panel of the furnace was removed which activated the safety switch to disconnect the power to the furnace. No other competent ignition sources appeared to be present in the vicinity of the open gas pipe at the time of the incident.
	Causes and contributing factors	The cause of this incident is very likely the furnace installer's failure to shut off the main gas valve and purge the pipe prior to removing the furnace valve/pipe. The company's safe work procedures were not being followed by the installer which required the main gas valve to be shut off and the gas pipe to be purged prior to working on it. The furnace installer improperly installed a receptacle. An electrical arc from the receptacle ignited escaping natural gas from the open gas pipe.

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		The conductor connected to the receptacle was in contact with the receptacle's metal cover plate indicating it was not properly installed onto the receptacle and not properly tucked into the outlet box to prevent damage to the conductor's insulation. The energized conductor contacted the bonded metal cover plate causing an electrical fault and the resulting electrical arc. It's likely that if the furnace installer was a qualified gas or electrical worker or was being supervised by a qualified gas fitter that one or more of these contributing factors may have been recognized and steps taken to mitigate the hazard and prevent this incident.

Figure 1

This photo shows the front of the house where the incident occurred.

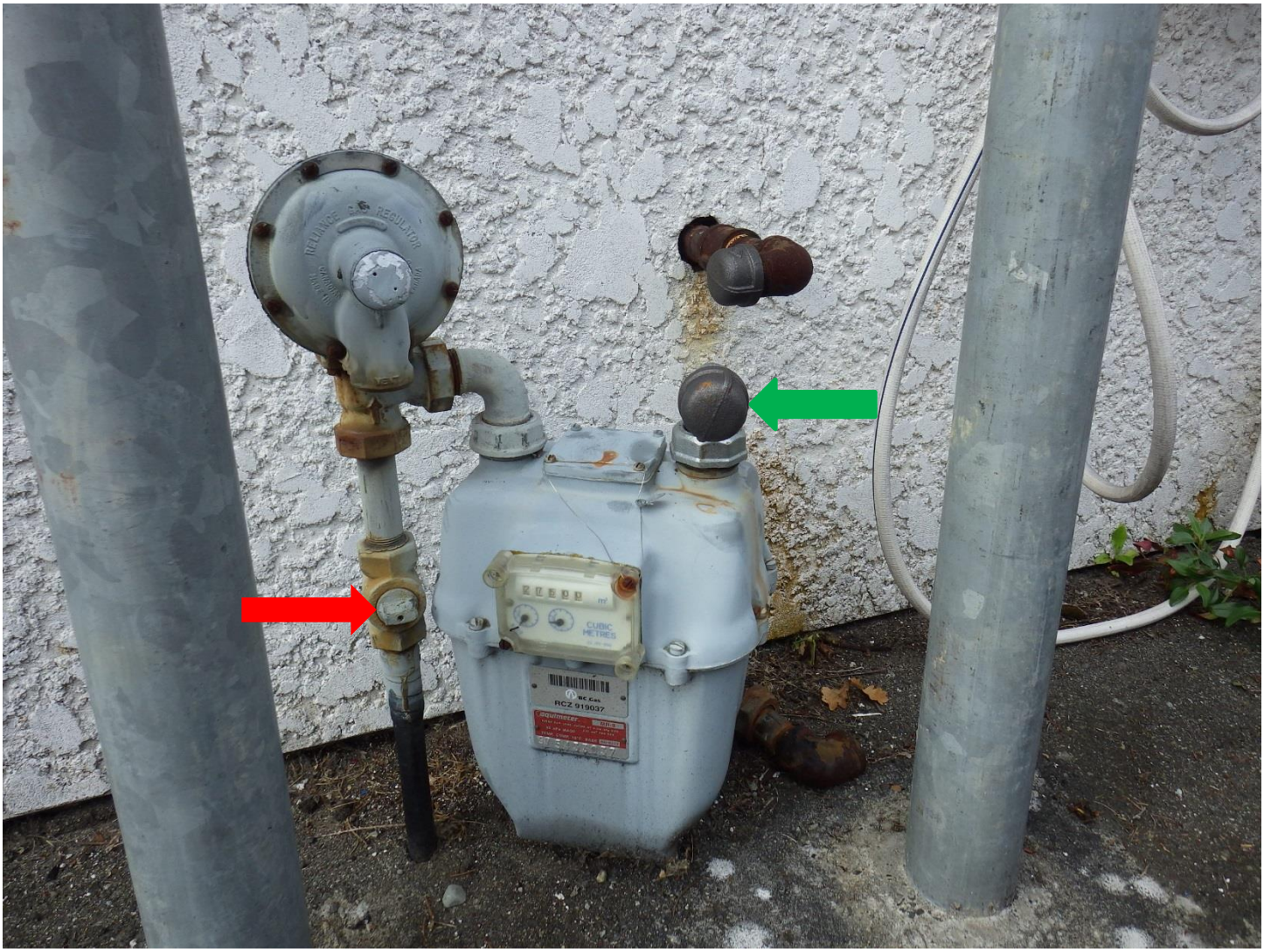
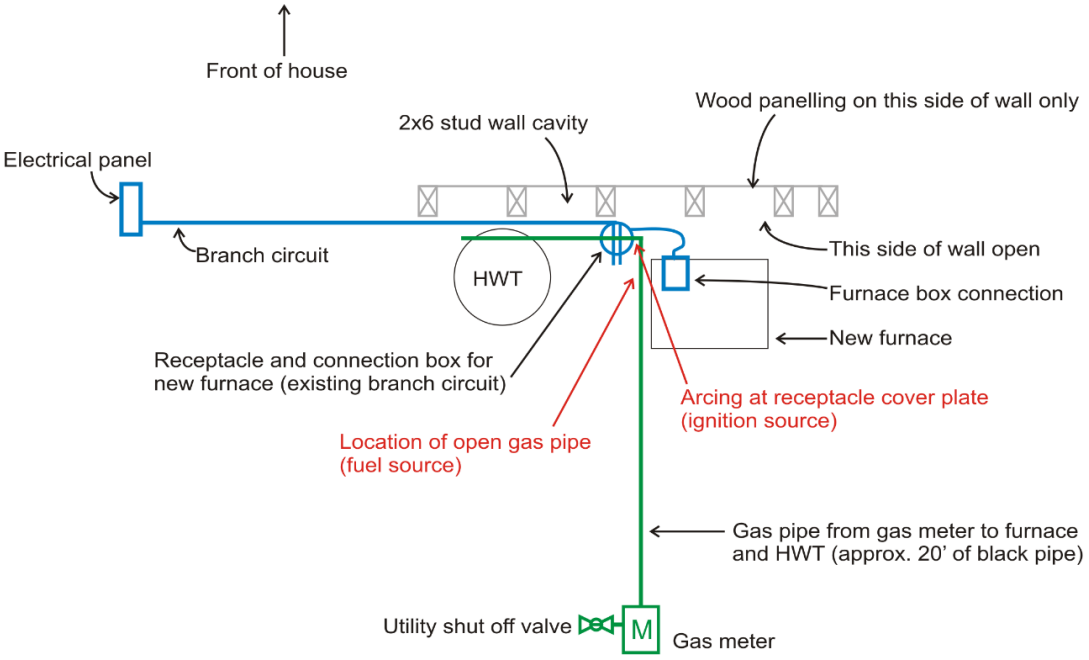
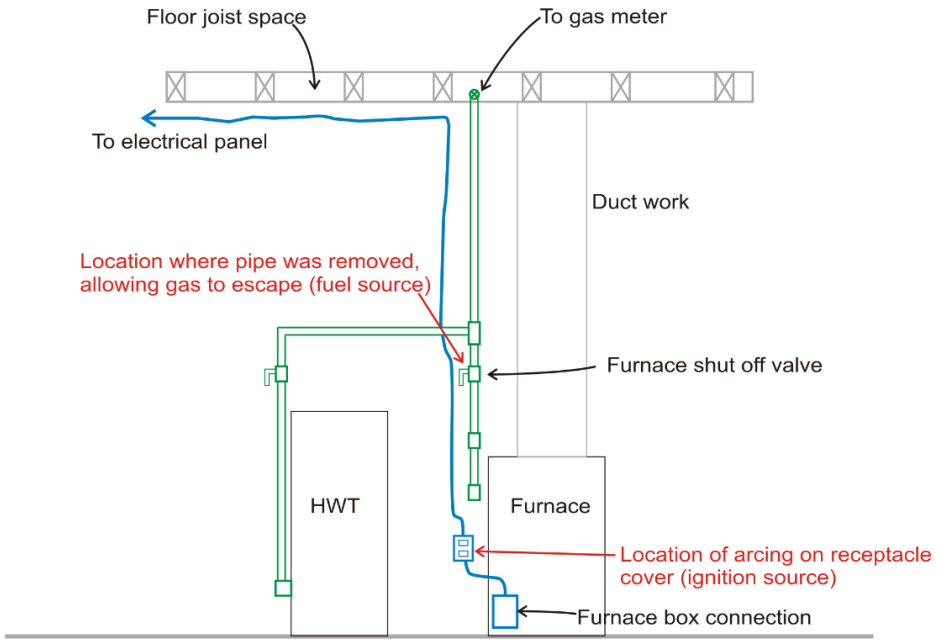


Figure 2

This photo shows the main gas valve at the meter that was turned off by the fire department at the time they attended the fire scene (see red arrow). The natural gas meter was disconnected from the house and capped off by the gas utility approximately a week after the incident occurred (see green arrow).



General basement layout for gas and electrical components - overhead view



General basement layout for gas and electrical components - wall view

Figure 3

This diagram shows the layout of the basement where the incident occurred. The diagram is not to scale and is intended for visual reference only.

Figure 4

This photo shows the new furnace in place and connected to the newly installed receptacle (see red oval). The gas pipe connection to the furnace was incomplete with the gas pipe open when the incident occurred (see red arrow). The condensate pump that was plugged into the receptacle at the time of the incident was sitting on the floor (see blue oval). The photo also shows the fire damaged wall adjacent to the furnace.

Figure 5

This photo shows the new furnace connected to the newly installed receptacle (see red oval). The gas pipe connection to the furnace was incomplete with the gas pipe open when the incident occurred (see red arrow). The green arrow shows the old furnace shut off valve and section of pipe that the installer removed which left the pipe open allowing gas to enter the basement. There was a new valve sitting on the new furnace (see green oval). The photo also shows the fire pattern on the studs and wood panelling adjacent to the furnace.

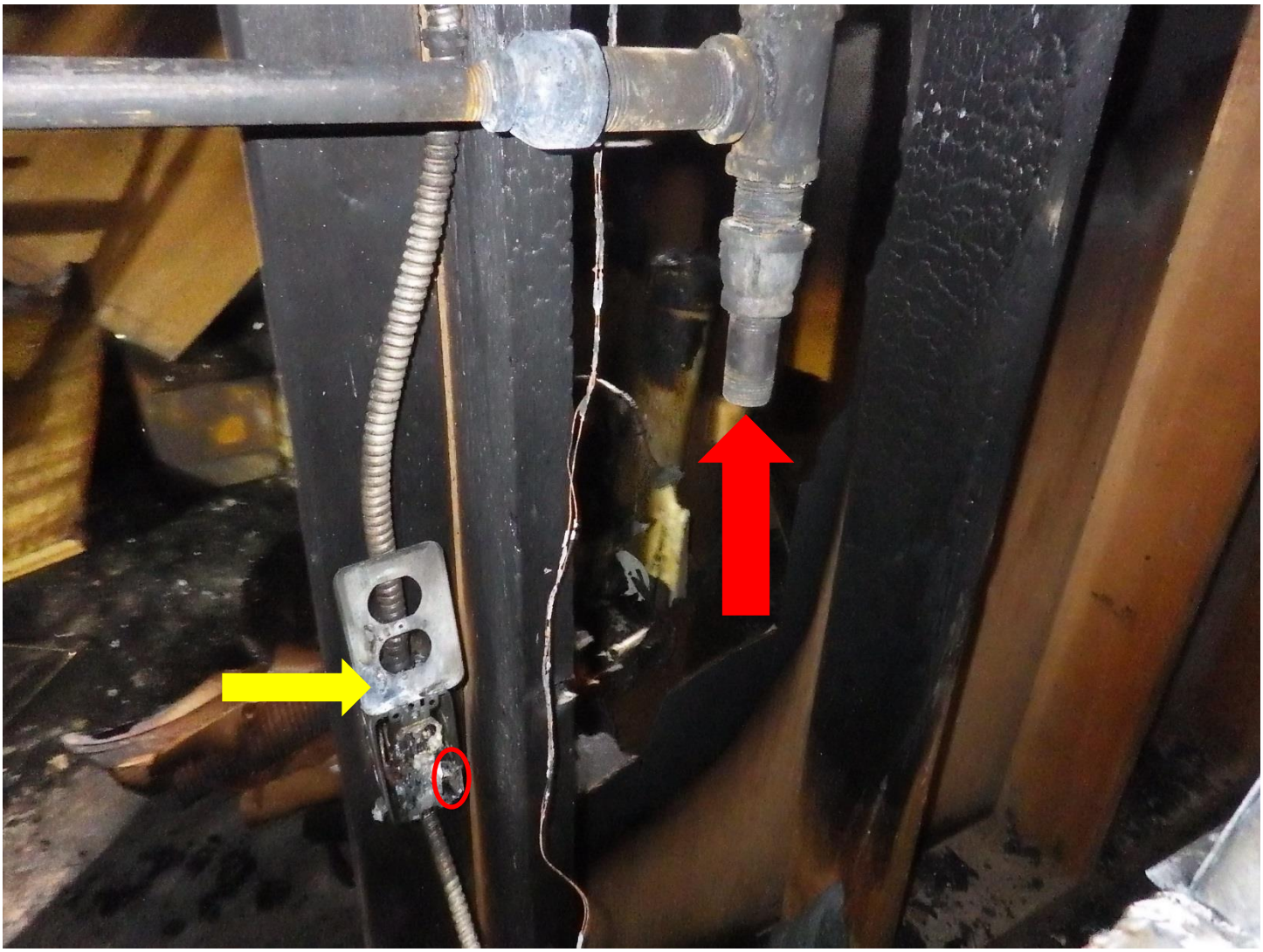


Figure 6

This photo shows the open gas pipe that allowed gas to enter the basement area prior to the incident (red arrow). It also the shows the area on the receptacle where the electrical arc occurred (red oval) - this is the point of origin of the explosion/fire. The yellow arrow shows the arc damage on the back of the receptacle cover. The cover was removed from the receptacle and placed on top of the outlet box for the photo.

Figure 7

This photo shows the open gas pipe (red arrow) and the side of the furnace that was located adjacent to the wall. The fire pattern on the side of the furnace (red oval) is from the flame that was coming from the open gas pipe.

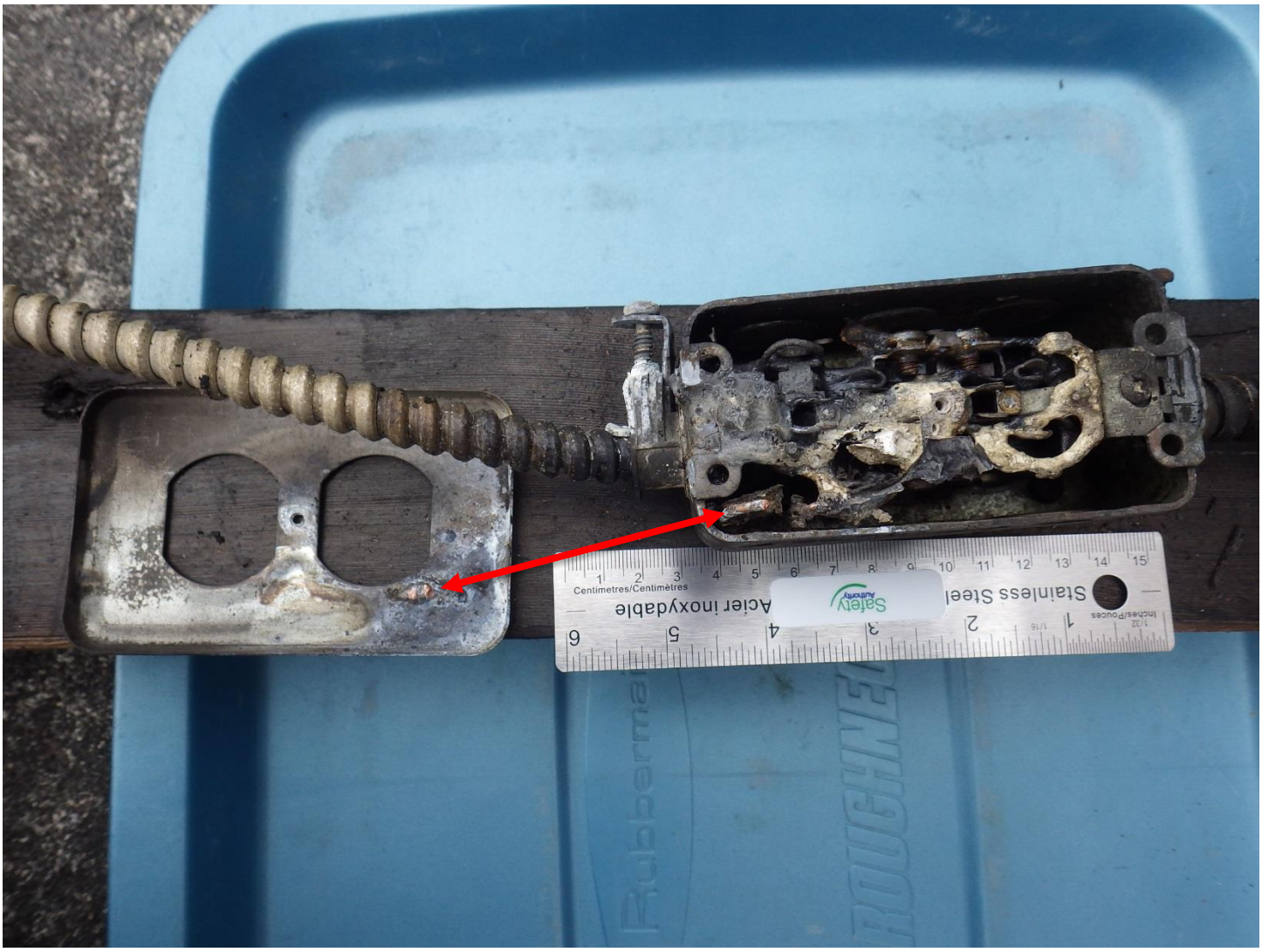


Figure 8

This photo shows the electrical outlet box, receptacle, and cover plate removed from the house for closer observation. The red arrows show the points between the conductor and the cover plate that contacted creating an electrical fault and the resulting electrical arc.

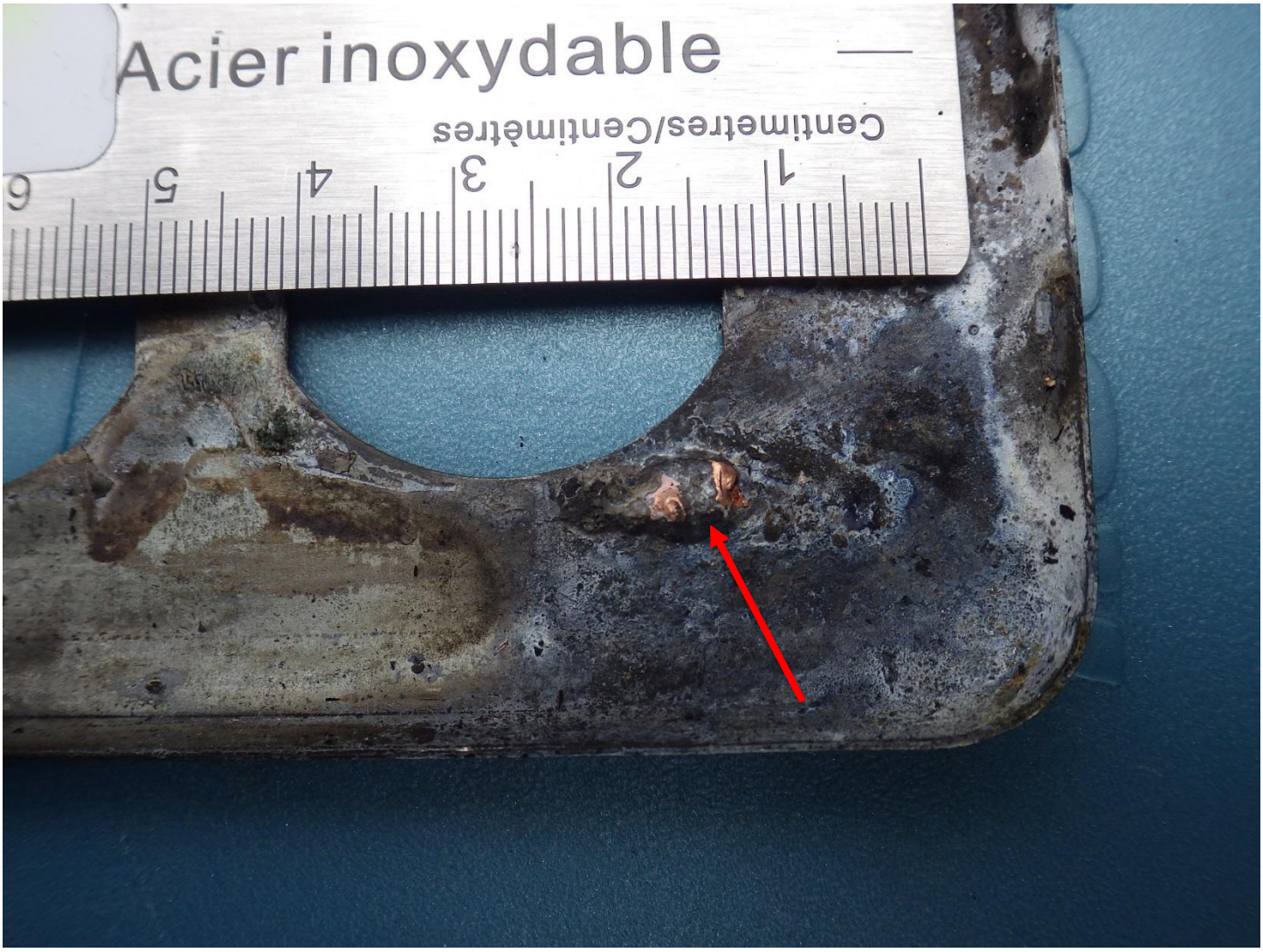


Figure 9

This photo shows a close up of the arc damage to the back of the cover plate. A piece of the copper conductor is melted to the cover plate.

Figure 10

This photo shows the piece of conductor that was removed from the receptacle. The conductor arced to the point that it melted the copper conductor apart (see red oval). The copper material melted to the cover plate is part of what used to be the conductor (see red arrow).

Figure 11

This photo shows the front of the cover plate in the location where the copper conductor contacted the back of the cover plate creating an electrical fault to ground and the resulting electrical arc that ignited the natural gas (see red oval).

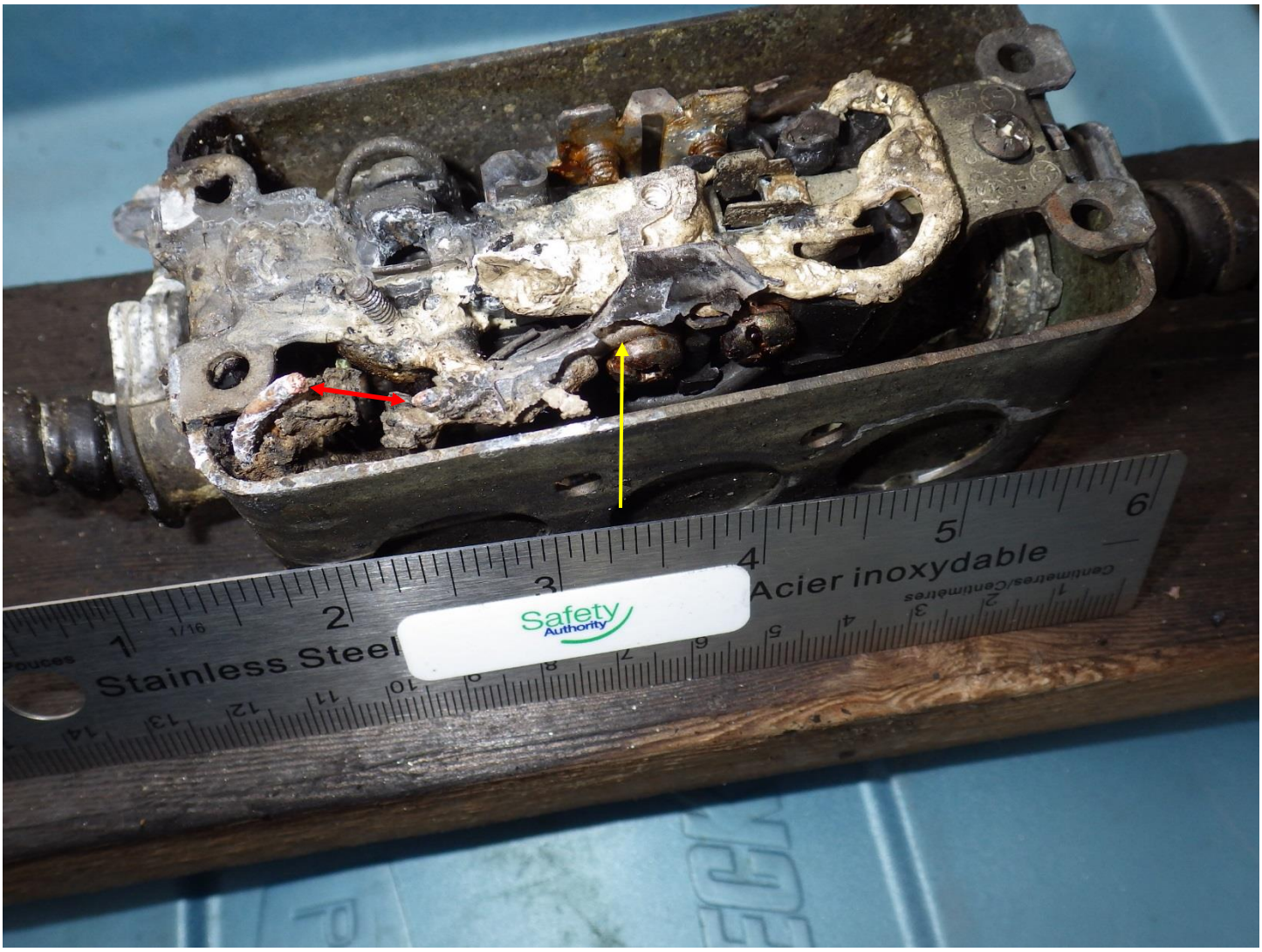


Figure 12

This photo shows the conductor for the receptacle melted apart (red arrows). The location of the conductor at the front of the receptacle indicates that it was not properly installed onto the receptacle or properly positioned in the outlet box prior to the cover being installed (see yellow arrow). The result was the energized conductor contacted the metal cover plate causing an electrical fault and the resulting electrical arc that ignited the gas. This is the point of origin of the fire.

Figure 13

This photo shows one end of the energized conductor that contacted the metal cover plate and caused an electrical fault melting the conductor apart and causing the electrical arc that ignited the gas.

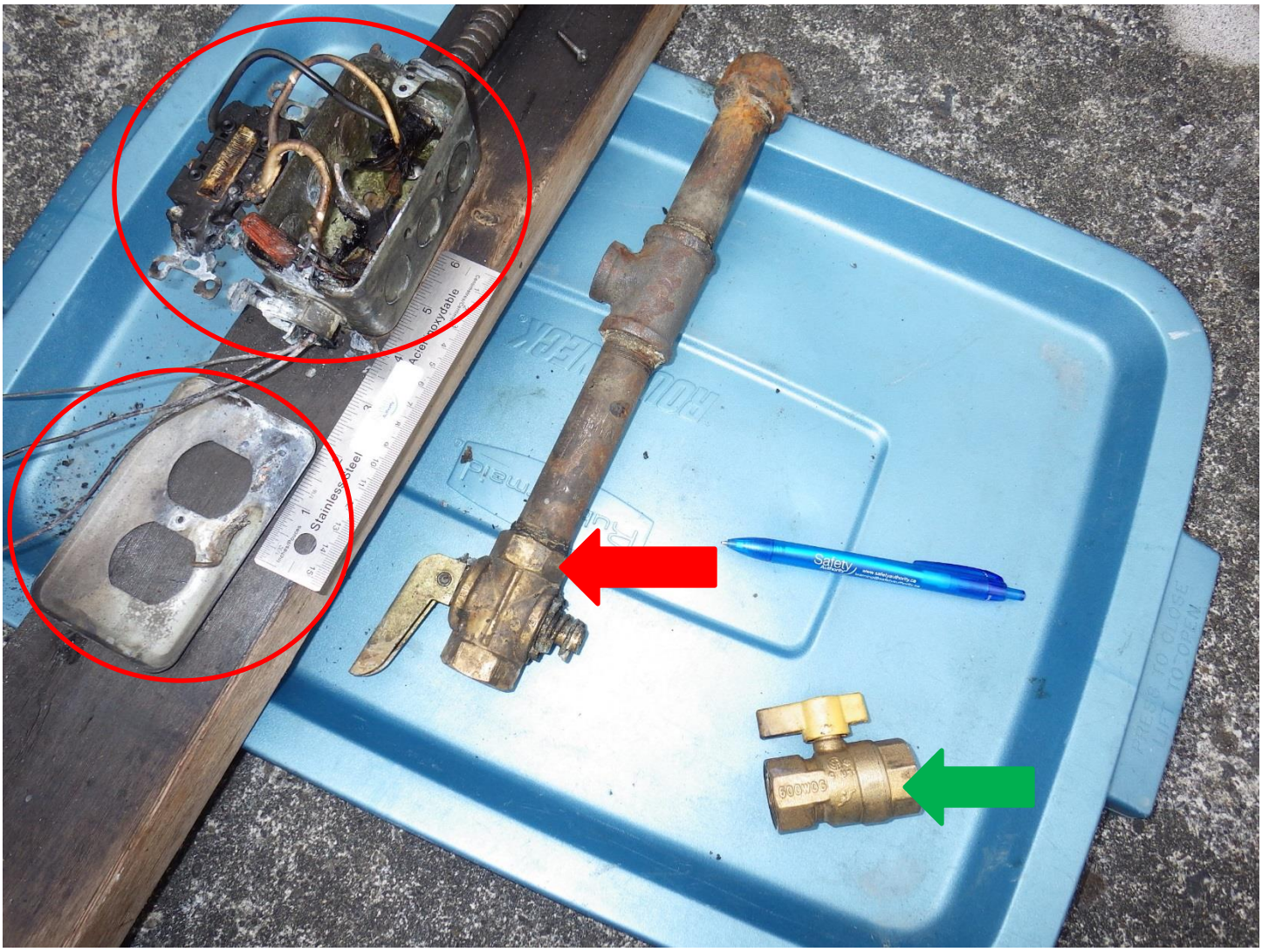


Figure 14

This photo shows the components involved in the incident. The gas valve and section of pipe that was removed (red arrow), the new valve that was sitting on the new furnace (green arrow), the outlet box/receptacle and the cover plate (red ovals).

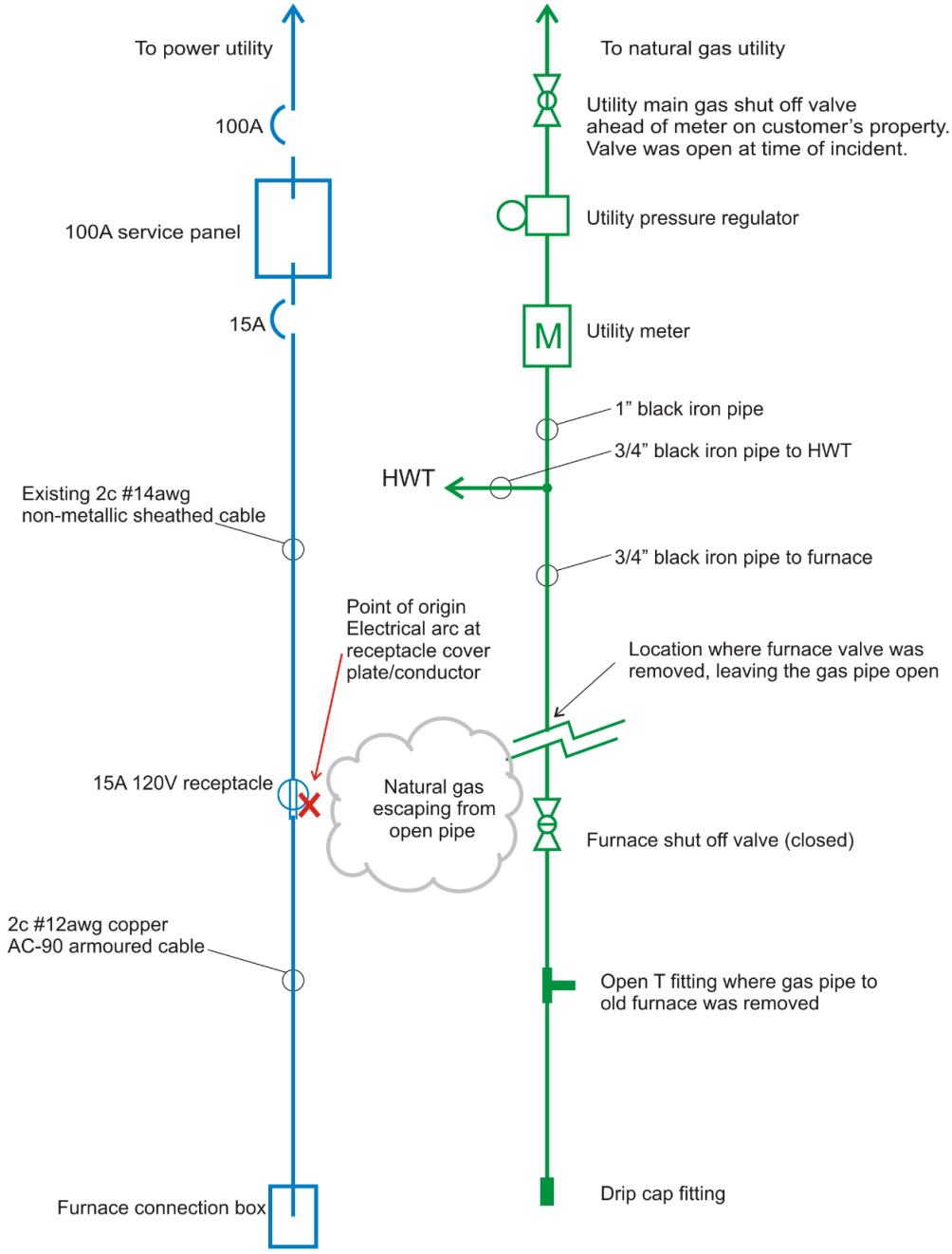


Figure 15

Electrical and gas one line diagram. This diagram is provided for visual reference only and is not to scale.

Figure 16

This photo shows the section of pipe that was accidentally removed by the installer which allowed gas to enter the house prior to the incident (gas valve, nipples, and fittings).

Figure 17

This photo shows the electrical panel with the cover removed. Due to damage to the branch circuit wiring the circuit breaker for the furnace could not be identified. All #14 awg branch circuit conductors were terminated to 15 Amp rated circuit breakers which appeared correct. Some breakers were tripped and some were in the off position.