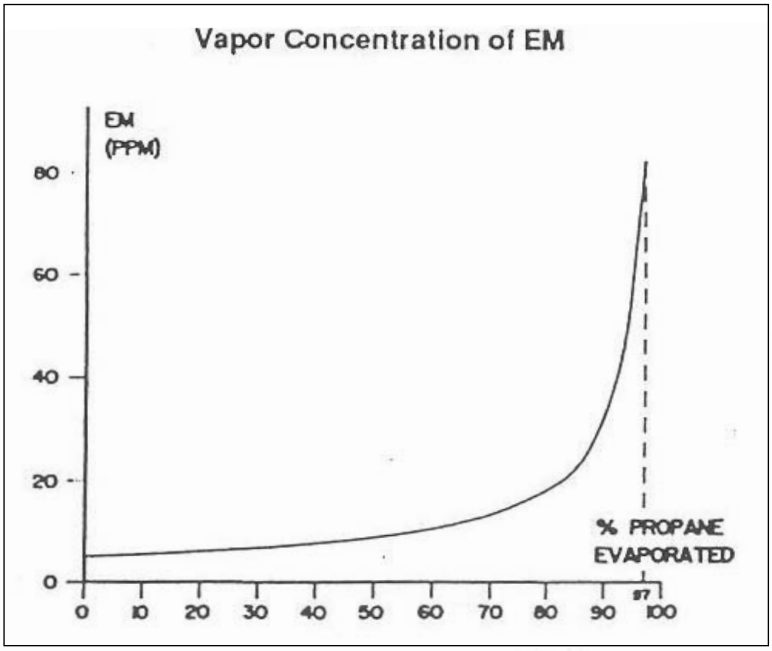
90% Multi-Poise Condensing Furnace Heat Exchangers and Sooting

Introduction

Heat exchanger sooting in 90% Multi-poise condensing furnaces can begin to form from several sources. The two most common are improper setup and maintenance, and high sulfur levels in the fuel. The intent of the following information is to address the operational changes of the furnace based on high sulfur levels as well as furnace setup and maintenance. The sources of high sulfur will also be addressed.



Example: Starting with clean tank and recommended 1 lb Ethyl Mercaptan per 10,000 gallons liquid LP gas.

Odorant Vapor Liquid Equilibria a Generalized Treatment by John Jacobus and David Swienton of Craddock, Heyer and Associates, Kingwood, Texas.

Sulfur level

Sulfur is a constituent in fossil fuels, and as long as all processes including refining and distribution are kept in strict control, will not harm fossil fuel burning equipment. Since Propane has more sulfur transported with it from a variety of sources than Natural Gas, furnaces using Propane for a fuel source may experience sooting more frequently than furnaces using Natural Gas as a fuel source. The highest concentrations of sulfur in Propane come from odorants.The odorant used in Propane is Ethyl Mercaptan, which is high in sulfur content. Although UL58-78 standard, "Liquid Petroleum Gas Code" suggests that 1 pound of Ethyl Mercaptan should be used per 10,000 gallons of liquid Propane, it is not uncommon for 1.25 to 1.5 pounds or more to be used. Propane distributors want to make sure that if a leak occurs, there is enough odorant to quickly attract the customer's attention. Since there is no regulation of local Propane distribution, this is a common practice.

Ethyl Mercaptan can also accumulate in the storage tank. As this happens, more Ethyl Mercaptan is carried with the Propane to the furnace. National Propane Gas Association information regarding maintenance, cleaning, and recertification of the Propane storage tanks does not address regular purging and cleaning of the interior of the tank, so the Propane distributors are left to clean the storage tanks as they deem necessary.

Excess Ethyl Mercaptan can also enter the furnace as the level of Propane in the storage tank is reduced. As the example indicates, when the Propane storage tank is approximately 20% full, the level of Ethyl Mercaptain in the Propane entering the furnace drastically increases.

This study used a clean storage tank and the recommended 1 pound of Ethyl Mercaptan per 10,000 gallons liquid Propane. The increased concentration of sulfur in the Propane increases the dew point temperature of the flue gas. With the increased dew point temperature, the flue gas begins to condense at the inlets of the secondary heat exchanger. The furnace is designed so that the flue gas should begin to condense after it is approximately 1/3 of the way through the secondary heat exchanger.

The flue gas condensate will have sulfur in it. The sulfur in the condensate forms sulfuric acid. Sulfuric acid does not readily evaporate. As the furnace continues to operate, this sulfuric acid solution becomes more concentrated. Levels of sulfuric acid in the condensate samples returned for analysis ranged from 14.3 to 870 Parts per Million. Analysis of one of the returned corroded furnace components found 2700ppm of sulfuric acid.

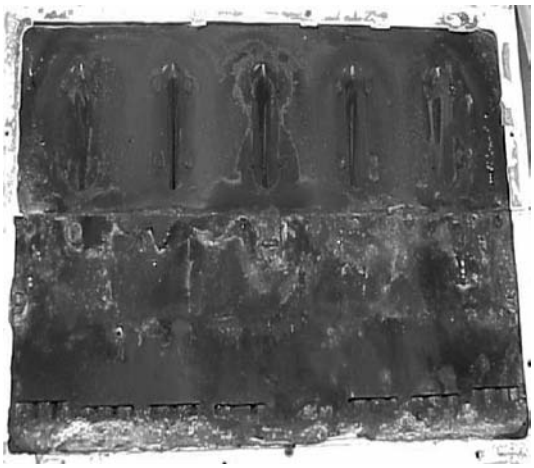
The concentration of sulfuric acid in the area of the primary cell outlet, cold spot baffle, coupling box, and secondary heat exchanger inlet can cause them to corrode (see example 1). This sulfuric acid attacks unprotected areas of the secondary heat exchanger and can cause the polypropylene to separate from the base metal (see example 2).

When the corrosion from these components begins to block the heat exchanger passages, the amount of air available for proper combustion is reduced. The condensing furnaces are designed to operate with excess air greater than 60%. When the excess air is reduced to below 30%, sooting can start. The corrosion and soot block additional heat exchanger passages until the furnace fails to operate properly.

The pressure switch will not prevent the furnace from operating since this heat exchanger blockage will cause the pressure differential across the heat exchanger to increase.

Visual inspection of the burners will not indicate reduced excess air until they begin to develop yellow tipping or sooting. Combustion analysis is necessary to determine excess air levels.

Refer to Attachment A for information regarding combustion testing and excess air.



Example 1: *Corrosion on cold spot baffle*

Example 2: *PPL separated from base metal due to sulphuric acid attack*

Proper Setup and Maintenance

When installing the furnace, it is necessary to verify that it is set up properly. The combustion system and the airflow system should be inspected. The use of a gas furnace check list similar to Attachment B at the time of installation is useful to establish a baseline. During routine maintenance or during a service call, this baseline can be used to identify any change in performance. Refer to Attachment C for additional items to check regarding Burner Operation and Proper Excess Air.

Inspection of the drain system, trap, and associated tubing should also be performed. A drain that is plugged or slow to drain allows condensate to build up in the secondary heat exchanger and collector box.

The excess condensate in the heat exchanger or collector box reduces the amount of air moving through the heat exchangers. Visual inspection of the burners will not indicate reduced excess air until they begin to develop yellow tipping or sooting. Combustion analysis is necessary to determine excess air. The condensing furnaces are designed to operate with excess air greater than 60%. When the excess air is reduced to below 30% sooting can start.

During initial furnace setup and routine maintenance, combustion analysis should be performed. Refer to Attachment A for information regarding combustion testing and excess air.

FURNACE BTUH INPUT	APPROXIMATE CONDENSATE
40,000	3 gal/day
60,000	4.5 gal/day
80,000	6.0 gal/day
100,000	7.5 gal/day
120,000	9 gal/day
140,000	10 gal/day

When converting the furnace to Propane, it is important to follow the current conversion kit instructions. It is important to follow specific instructions for items such as diverter plate, air shutter position, spoiler screws, orifice size, manifold pressure, and installation of the low pressure gas switch along with all instructions for the model and size of furnace that is being converted. The upflow and downflow furnaces must be installed so that they are pitched up to 1/2" toward the front of the furnace to insure proper drainage. Horizontal furnaces must be installed so that it is pitched 1/4" to 1/2" towards the front of the furnace.

Attachment A

Combustion Analysis

The furnace must be operating at steady state

- At least 15 min of operation
- Temperature rise at mid-point or slightly above

Perform combustion analysis

- Insert probe of combustion analyzer
- Preferred location is 12" away from inducer outlet
- Exhaust termination can be used for sidewall terminations

Excess air should be above 30%

- Refer to the following information for excess air conversion

Excess air below 30% can result in poor burner performance and/or sooting.

Propane HD-5

CO2/ EXCESS AIR

CO2 %	Excess Air %	CO2%	Excess Air %
11.30	20.0	8.91	50.0
11.20	21.0	8.84	51.0
11.10	22.0	8.78	52.0
11.00	23.0	8.72	53.0
10.91	24.0	8.66	54.0
10.81	25.0	8.60	55.0
10.72	26.0	8.54	56.0
10.63	27.0	8.49	57.0
10.54	28.0	8.43	58.0
10.46	29.0	8.37	59.0
10.37	30.0	8.32	60.0
10.28	31.0	8.26	61.0
10.20	32.0	8.21	62.0
10.12	33.0	8.16	63.0
10.04	34.0	8.10	64.0
9.96	35.0	8.05	65.0
9.88	36.0	8.00	66.0
9.81	37.0	7.95	67.0
9.73	38.0	7.90	68.0
9.65	39.0	7.85	69.0
9.58	40.0	7.80	70.0
9.51	41.0	7.75	71.0
9.44	42.0	7.71	72.0
9.37	43.0	7.66	73.0
9.30	44.0	7.61	74.0
9.23	45.0	7.57	75.0
9.16	46.0	7.52	76.0
9.10	47.0	7.48	77.0
9.03	48.0	7.43	78.0
8.97	49.0	7.39	79.0

Propane HD-5

O2/ EXCESS AIR

O2%	Excess Air %	O2%	Excess Air %
3.76	20.0	7.41	50.0
3.92	21.0	7.51	51.0
4.07	22.0	7.60	52.0
4.21	23.0	7.70	53.0
4.36	24.0	7.79	54.0
4.50	25.0	7.88	55.0
4.64	26.0	7.97	56.0
4.78	27.0	8.05	57.0
4.92	28.0	8.14	58.0
5.05	29.0	8.23	59.0
5.18	30.0	8.31	60.0
5.31	31.0	8.39	61.0
5.44	32.0	8.48	62.0
5.56	33.0	8.56	63.0
5.68	34.0	8.64	64.0
5.81	35.0	8.72	65.0
5.92	36.0	8.79	66.0
6.04	37.0	8.87	67.0
6.16	38.0	8.95	68.0
6.27	39.0	9.02	69.0
6.38	40.0	9.10	70.0
6.49	41.0	9.17	71.0
6.60	42.0	9.24	72.0
6.71	43.0	9.31	73.0
6.81	44.0	9.38	74.0
6.92	45.0	9.45	75.0
7.02	46.0	9.52	76.0
7.12	47.0	9.59	77.0
7.22	48.0	9.66	78.0
7.32	49.0	9.72	79.0

Natural Gas

CO2 / Excess Air

CO2 %	Excess Air %	CO2%	Excess Air %
9.73	20.0	7.65	50.0
9.65	21.0	7.59	51.0
9.56	22.0	7.54	52.0
9.48	23.0	7.49	53.0
9.39	24.0	7.44	54.0
9.31	25.0	7.38	55.0
9.23	26.0	7.33	56.0
9.15	27.0	7.28	57.0
9.07	28.0	7.23	58.0
9.00	29.0	7.19	59.0
8.92	30.0	7.14	60.0
8.85	31.0	7.09	61.0
8.78	32.0	7.04	62.0
8.71	33.0	7.00	63.0
8.64	34.0	6.95	64.0
8.57	35.0	6.91	65.0
8.50	36.0	6.86	66.0
8.43	37.0	6.82	67.0
8.37	38.0	6.78	68.0
8.30	39.0	6.73	69.0
8.24	40.0	6.69	70.0
8.17	41.0	6.65	71.0
8.11	42.0	6.61	72.0
8.05	43.0	6.57	73.0
7.99	44.0	6.53	74.0
7.93	45.0	6.49	75.0
7.87	46.0	6.45	76.0
7.82	47.0	6.41	77.0
7.76	48.0	6.37	78.0
7.70	49.0	6.34	79.0

Natural Gas

O2 / Excess Air

O2%	Excess Air %	O2%	Excess Air %
3.82	20.0	7.50	50.0
3.97	21.0	7.59	51.0
4.12	22.0	7.69	52.0
4.27	23.0	7.78	53.0
4.42	24.0	7.87	54.0
4.56	25.0	7.96	55.0
4.71	26.0	8.05	56.0
4.85	27.0	8.14	57.0
4.98	28.0	8.23	58.0
5.12	29.0	8.31	59.0
5.25	30.0	8.40	60.0
5.38	31.0	8.48	61.0
5.51	32.0	8.56	62.0
5.63	33.0	8.65	63.0
5.76	34.0	8.73	64.0
5.88	35.0	8.81	65.0
6.00	36.0	8.88	66.0
6.12	37.0	8.96	67.0
6.23	38.0	9.04	68.0
6.35	39.0	9.11	69.0
6.46	40.0	9.19	70.0
6.57	41.0	9.26	71.0
6.68	42.0	9.33	72.0
6.79	43.0	9.40	73.0
6.89	44.0	9.47	74.0
7.00	45.0	9.54	75.0
7.10	46.0	9.61	76.0
7.20	47.0	9.68	77.0
7.30	48.0	9.75	78.0
7.40	49.0	9.82	79.0

Attachment B

Gas Furnace Checklist

Distributor Name _____

Distributor Address _____

Dealer Name _____

LP Tank Level - % of Full _____ Use LP Low Cutoff Switch? Y___ / N___

Customer Name _____

Customer Address _____

MODEL # _____ SERIAL # _____ SERIES _____

Date of Original Installation _____

New Construction OR Replacement Furnace

Type of Fuel (circle one) Natural Gas or Propane

Fuel Supplier _____

Furnace Location:
(circle one for each category)

BASEMENT ATTIC

UTILITY ROOM GARAGE

CRAWL SPACE CLOSET

Furnace Position:

UPFLOW DOWNFLOW

HORIZONTAL RIGHT OR LEFT

Furnace Vent System - PVC

VENT TYPE: DIRECT VENT (2-PIPE) NON DIRECT VENT (1-PIPE)

PVC: Long radius ells? Y N (circle one)

Pipe Dia _____ # of Elbows _____ Total Length _____ ft.

Termination Type: (circle one) Concentric OR 2-pipe (std)

Termination Location: (circle one) Roof _____ Sidewall** _____

**Ht. Above Grade _____ # of Combustion Air Disks installed _____

Attachment B

Gas Furnace Checklist

Condensate Trap Location? Left Side, Right Side, Blower Shelf, Bottom

Verify condition of Drain Trap, all Rubber Tubing, and Drain Hoses.

Description of surrounding area of termination if sidewall vented:
shrubs, swimming pool, another appliance vent, etc.

_____

_____

High Fire _____btu/hr Low Fire_____btu/hr

MANIFOLD PRESSURE**_____" W.C. Low Fire_____" W.C.

SUPPLY PRESSURE**_____" W.C. ORIFICE #_____

**Supply pressure should be checked with all other gas appliances running clocking gas meter

GAS PIPE SIZE AND LENGTH FROM GAS METER TO APPLIANCE

Dia_____ Ft Pipe_____

TOTAL (COMBINED) GAS INPUT OF ALL GAS APPLIANCES AT SITE

_____BTU

LEAVING AIR TEMPERATURE_____(F) high _____(F) low

RETURN AIR TEMPERATURE _____(F) high _____(F) low

STEADY STATE - AFTER 10 MINUTES OF OPERATION

TEMPERATURE RISE _____ (F) high fire

_____ (F) low fire

**Temperature rise is equal to the supply air temp minus the return air temp @ steady state operation.

The supply temp should be measured away from the line of sight of the Heat Exchanger.

Excess air % _____

Attachment C

Additional Items to Inspect

Burner operation:

Burners

- Inspect burner flame retainer for corrosion
- Inspect burner flame retainer for blocked splines
- Crossover gap (thickness of a dime)

Burner Box Leaks

- Inspect igniter gasket

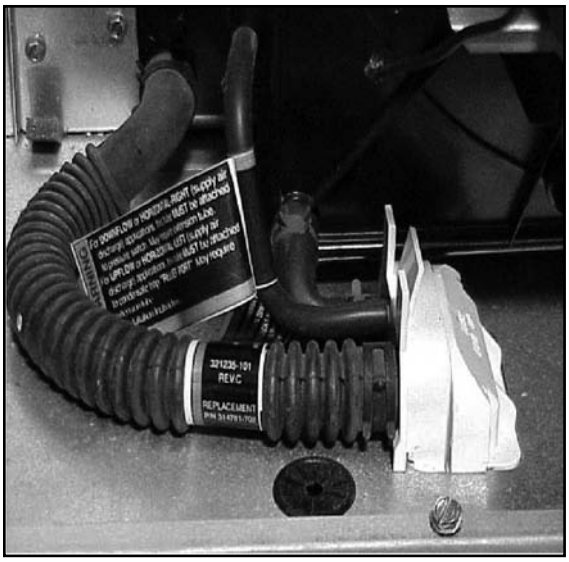
Notice how gasket seals across the entire base of Igniter

New gasket design 2/27/2004

- Inspect seal between burner box and cell panel
- Inspect seal between manifold and burner box
- Insure manifold and orifices are in alignment
- Insure the LP conversion is complete:
  - –Correct orifice size
  - –Correct manifold pressure
  - –Air shutter properly positioned
  - –Diverter plate installed
  - –Spoiler screws installed
  - –Low pressure gas switch installed

Proper Excess Air (30% minimum)

- Inspect for proper venting. Verify pipe size based on the Tables in the Installation, Start-up, and operating instruction manuals.
- Inspect drain
- Slow drains result in lower excess air level
- Debris found in traps of sooted furnaces
- Slow drain allow condensate to fill up secondary heat exchanger
- Verify condition of all tubing
- Verify that drain trap and drain line are clear and primed
- Inspect for leaks at coupling box
- Inspect for restricted secondary heat exchanger inlet or outlet



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