Review of Fireplace Use and Technology

by

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Introduction

There are 27 million fireplaces currently in U.S. homes. Some fireplaces are used as supplemental heat sources, some are used for only aesthetic or minor heating purposes and some are even used as a primary heat source. There are two structural types of fireplaces — manufactured metal fireplaces (referred to as zero-clearance or factory-built fireplaces) and site-built masonry fireplaces. Industry experts estimate that about 20% of existing fireplaces are masonry and 80% are factory-built. There were approximately 0.4 million factory-built fireplaces sold in 1997. Factory-built fireplaces are designed to last 40 years or more. Masonry fireplaces can last indefinitely. Consequently, the 27 million fireplaces currently in homes will be available for use well into the future.

Emission Factors

The emission factor for fireplaces given in AP-42 is 17.3 g/kg. This value was estimated by the EPA using limited field and laboratory data. Estimates from more recent (albeit also limited) data, produces a value of about 12.5 g/kg. The typical burn rate of a fireplace is 3 kg/hr. The emission rates corresponding to an emission factors of 12.5 g/kg and 17.3 g/kg with a burn rate of 3 kg/hr are 37.5 g/hr and 51.9 g/hr. There has been some data suggesting that 60 g/hr is a more representative fireplace emission rate. Clearly, the particulate emission rate from a fireplace is dependent on what the “typical” burn rate is. There has been no consensus of opinions among industry experts on how reasonable these emission values are for fireplaces. Some think they are too low, some think they are too high and some think they are reasonable. There is, however, general agreement on the fact that the data base is very small and emissions are very variable.

Fireplaces as a Heat Source

A large number (albeit the minority) of fireplaces are used as significant supplemental heat sources. Fireplace inserts are designed for increased efficiency, and based on national surveys there are 7.1 million fireplaces with inserts in them. (The term "insert" as used in the survey is not what is often thought of as an insert. It most likely encompassed a variety of older fireplace designs and accessories, such as double-shell convection designs, convection tubes, blowers, etc. Some of the survey respondents also may have confused a zero-clearance fireplace unit with the term "insert.") Some fireplaces are even used as primary heat sources. In 1993, 0.4 million households used wood burning fireplaces as their main source of heat.

Fireplaces utilizing older technology may be able to reach efficiency levels in the 40% range. Older technologies that increase efficiencies and effectively reduce emissions by requiring less wood to provide the same heat include double-shell convection designs, convection tubes, the use of blowers to transfer heat, glass doors, and masonry fireplaces with contoured fire chambers (e.g., Rosin and Rumford designs). The open radiant fireplace, with an efficiency potential of approximately 7% is the simplest and most common fundamental unit. Efficiencies, emissions in units of mass particles per unit of heat delivered and effective emission reductions obtained with these older technologies as compared to simple open radiant fireplaces are shown in Table 1. In reviewing the data in Table 1 it should be noted that the effective efficiency of a given fireplace varies with outside temperature and chimney draft.

Certified non-catalytic, certified catalytic, and pellet inserts can be installed into and used in existing factory-built and masonry fireplaces. They are essentially wood stoves designed to be installed into fireplace firebox/hearth cavities. If properly installed, their performance is similar to that of their stove counterparts, albeit their efficiencies are slightly lower since convection and radiation of heat is more restricted by their fireplace cavity surroundings and fireplaces are often located along an outer wall. There are an estimated 0.5 million certified cordwood inserts and 0.2 million pellet inserts in use. The EPA lists four catalytic and six non-catalytic insert models as certified. Efficiencies, emission factors in units of mass particles per unit of heat delivered and effective emission reductions obtained with certified cordwood and pellet inserts as compared to simple open radiant fireplaces are shown in Table1.

Over the last 10 years, the use of natural gas and liquified petroleum gas (LPG) in place of cordwood has become widespread in fireplaces used for primary and supplemental heating purposes. Three types of gas units have the "fireplace-look." They are gas fireplace inserts, decorative gas fireplaces, and gas fireplace heaters. All have negligible particulate emissions, compared with cordwood fireplaces. Therefore, particulate reductions are near 100%. The environmental "downside" of the nearly 100% particulate reduction is that both natural gas and LPG are, of course, fossil fuels, not renewable biomass fuels. Gas fireplace inserts, like certified cordwood and pellet inserts, can be put into existing fireplaces. Decorative gas fireplaces and gas fireplace heaters are generally designed for new construction. Gas fireplace heaters are more sophisticated than decorative gas fireplaces, as they are designed more for efficiency whereas decorative gas fireplaces are designed more for flame presentation aesthetics.

Table 1

"Best Professional Judgement" Efficiencies, Particulate Emissions per Unit of Heat Delivered, and Effective Pollutant Reduction by the Use of Alternatives to Open Radiant Fireplaces and Cordwood

Appliance/ Fuel	Thermal Efficiency (%)	Mass of Particulate Emissions/Delivered Heat (g/MJ)	Reduction (%)
Conventional Open Radiant Fireplace	7	8.6	-
Double-Shell Convection, Natural Draft	13	4.6	46
Convection Tubes, "C" Shaped, Glass Doors	15	4.0	53
Double Shell Convection, Blower, Glass Doors	32	1.9	78
EPA Certified Non-Catalytic Insert	66	0.50	94
Certified Catalytic Insert*	70	0.45	95
Pellet Stove Insert	76	0.13	98
Gas-Fired Insert	75	Negligible	~100
Gas-Fired Fireplace	50	Negligible	~100
Certified Catalytic "Fireplace-Like" Wood Stove	70	0.45	95
Masonry Fireplace With Shaped Fire Chambers and Glass Doors	42	1.2	86

*With a well maintained catalyst after normal use, on the average a newer catalyst will produce lower emissions and an older catalyst higher emissions.

Some certified wood stoves are designed to have the appearance of fireplaces, to be "zero-clearance" units, and capable of being installed at the time of construction. The effective emission reduction they can offer over simple open radiant fireplaces is on the order of 95%. These units are sometimes called EPA certified fireplaces but, in fact, meet all of the EPA NSPS definition specifications for an "affected facility" wood stove (i.e., one that is subject to the NSPS regulation).

Fireplaces Used for Aesthetic and Minor Heating Purposes

In addition to the large number of fireplaces used for supplemental heating purposes, even more fireplaces are used for aesthetic or minor heating purposes. During the 1994-1995 heating season, 17% of surveyed fireplace owners reported burning wood once or twice a season, 13% reported burning wood once or twice a month, and 18% reported burning once or twice a week. The sum of these three categories corresponds to about 13 million fireplaces in the United States. Even though these statistics do not provide an exact number of fireplaces used for aesthetic and minor heating purposes, they do illustrate the relative magnitude of use. As these data indicate, many fireplaces are used very infrequently. Of the 27 million total fireplaces in the United States, survey data suggest that only 16 million of them were used to burn wood in any given 12-month period.

As with wood stoves which are designed and used for the utility of residential space heating, it is important to use the most appropriate reporting units for providing a means for comparison between fireplaces. Unlike wood stoves however, fireplaces can be used partially or totally as space heaters or they can be used partially or totally for aesthetic or recreational purposes. In the case of appliances used as sources of heat (i.e., wood stoves and "heating fireplaces"), the use of emissions mass per unit of heat delivered (i.e., grams/MegaJoule), is appropriate. In this sense, masonry heaters can be considered a special case of a "heating fireplace." In the case of appliances used strictly for aesthetic or recreational purposes however, emissions rates (grams/hour) or emissions factors (grams/kilogram of fuel burned) provide for better comparisons. For emissions inventory purposes, having g/hr information for a population of fireplaces would only require the determination of population usage hours for calculating an estimated total airshed impact. On the other hand having g/kg information for a population of fireplaces would only require the determination of total wood usage by the population for calculating an estimated total airshed impact.

The burn rate of a fireplace used only for aesthetic purposes is mostly related to the size of a typical sustained "warm" aesthetic fire, usually about 3 kg of cordwood per hour. The amount of wood burned and the resulting emissions are not directly related to heat demand, but are more or less constant for a given appliance. Wax fire logs typically have a fixed burn rate associated with them. Manufacturers of wax logs generally recommend a one-at-a-time usage rate with each log having a specified burn duration. Since most wax fire logs burn in the range of 0.7 to 1.3 kg/hour, it more appropriate to use the mass of emissions per hour (i.e., g/hr) reporting units when a fireplace burning cordwood for aesthetic purposes is compared to a fireplace burning wax fire logs.

Manufactured wax fire logs are widely used in fireplaces nationwide. One hundred million manufactured logs are burned each year. Manufactured logs were burned some of the time in 30% of the fireplaces and exclusively in 12% of the fireplaces during the 1994-1995 heating season. Most wax fire logs are composed of approximately 60% wax and 40% sawdust. Paraffin or microcrystalline waxes are used. The heat content of wax logs is much higher than that of wood, and their moisture content is much lower. They are exclusively for use in fireplaces (not wood stoves), they typically require no kindling, and, as previously noted, are

designed for one-at-a-time use. Particulate emissions rates from fireplaces burning wax fire logs in the prescribed manner is about 68% lower than when burning cordwood.

There have been improvements in the design of cordwood fireplaces that minimize the underfire air supply and maximize combustion conditions with the introduction of secondary air. At least one such unit not currently in commercial production reportedly had very low emissions. Therefore, some new fireplaces may have emission rates lower than currently manufactured units. However, little data are available.

An alternative to burning cordwood in fireplaces for aesthetic or recreational purposes is decorative gas log systems. They are known to have negligible particulate emissions at all heat input levels and therefore, as with wax fire logs, the emission rate (g/hr) reporting units may be appropriate when comparing emissions from fireplaces burning cordwood and used for aesthetic or recreational purposes with those using gas logs.

The use of decorative gas logs has become very popular. During the 1994-1995 heating season, 17% of fireplaces used gas as fuel mostly for decorative gas logs. Decorative gas logs are designed to be used in masonry or factory-built fireplaces. Gas log sets consist of a control valve and burner assembly, a grate, and imitation logs made of cast refractory or cement. Their functions are primarily for aesthetics with flame appearance being the primary design criterion. Decorative gas logs have negligible particulate emissions, compared with cordwood-burning fireplaces. Therefore, particulate reductions are nearly 100%, compared with fireplaces burning cordwood. As with gas fireplaces and inserts, either natural gas or LPG can be used with decorative gas logs.

Regulatory Status

There is no federal certification requirements for fireplaces. They are exempt from EPA certification because their air-to-fuel ratios are in excess of the 35:1. The states of Washington (WAC 150-31-200) and Colorado (Regulation 4) have fireplace standards and currently provide the only regulatory impetus for the manufacture of fireplaces with low emissions. Two local air quality authorities in California (i.e., Northern Sonoma County and San Louis Obispo County) are in the process of developing fireplace emissions standards.