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Project Summary

Description and Analysis of Inspection/Maintenance Programs for Oil-Fired Heating Systems in Switzerland and West Germany

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The report describes and analyzes inspection/maintenance programs for oil-fired heating systems in Switzerland and West Germany. Inspection programs for oil-fired residential and commercial heating systems were introduced in Switzerland and West Germany in the late 1960s, induced by public complaints about soot and odors. Today, annual or biannual inspections are required by law in both countries. Private or government inspectors perform the inspections, using simple instruments and after being trained for their duties in vocational courses. Both countries have stringent standards for the emission of soot and hydocarbons as well as for combustion efficiency. Installations not in compliance with the standards have to be adjusted by service technicians within a short time. Significant improvements in air pollution and energy savings have been achieved. Noncompliance with the standards decreased from an initial 40-60% to 5-15% today. The improvement in combustion efficiency (therefore, in fuel oil savings) averages 6%. The reduction of emitted hydrocarbons is substantial, although quantitative information is not available due to the qualitative nature of the inspection procedure. Smoke level is reduced from an average of 3 to 1.5. For oil-fired installations with an average annual oil consumption of more than 1300 gal. (4921 liters)/year, fuel savings exceed the inspection/maintenance costs.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Oil is the main fuel source for space heating in both West Germany and Switzerland, providing two-thirds of the total space heating energy. Natural gas, electricity, coal, and wood share the remaining one-third. Solar energy, other than direct gain through windows and indirect gain through heat pump systems, still makes only a negligible contribution.

Table 1 points out some of the differences between the energy use in West Germany, Switzerland, and the U.S. The U.S. has a high percentage of its space heating requirements supplied by natural gas and therefore a relatively

Table 1. Information of Energy use in the U.S., West Germany, and Switzerland

Country	Per Capita Energy Consumption (gal. of oil equiv.)	Per Capita Energy Consumption for Space Heating (gal. of oil equiv.)	Percentage of Space Heating Energy Consumption Provided by Oil
U.S.	*1900*	*380*	*33*
Switzerland	*552*	*280*	*70*
West Germany	*974*	*258*	*60*

low contribution is made by oil. The differences in total energy consumption per capita can be explained by two factors: (1) the U.S. and West Germany have a much higher production of energy intensive products than does Switzerland; and (2) the U.S. has a very high per capita consumption of energy for transportation, mainly due to longer commuting distances, sprawl development, and fewer mass transit systems.

The technology of oil heating systems is similar to that found in the U.S. Nozzle-type burners are used. Central heating boilers are the main type of heat exchangers because hydronic heating systems are prevalent. Unlike in the U.S., furnaces are not common in space heating applications.

In Switzerland the average sulfur content in heating oil was 0.36% (average between 1977 and 1979). In West Germany the value was around 0.4%.

With a sharp increase in oil consumption for heating purposes in the decade from 1950-1960, the public became aware of air pollution emitted by oil heating. Along with the increased population density in urban areas (more than 200,000 inhabitants/mi^2) came an increase in public awareness of the amount of physical air pollution by odors and soot emitted from heating chimneys. When problems arise, Europeans typically assign the responsibility for solving them to their local or regional governments. In the case of air pollution, complaints emerged and were directed to local Public Health Departments. Unfortunately, nobody kept a record of the number of complaints until 20 years ago. Today, the treatment of public complaints is a widely recognized managing tool for air pollution control. We can therefore only guess how many complaints were necessary to trigger action. The Public Health Department of the City Zurich (Switzerland) decided in 1964 to introduce an inspection program for residential oil heating installations. Although simple in design and equipment, the inspections proved to be effective. The idea of governmental inspections for oil heaters spread rapidly to many other cities in Switzerland and Germany, and is now also well accepted in rural areas in the two countries. Under fire protection regulations, the maintenance of heating equipment has been regulated since the last century. With the new oil heating inspection, air pollution control and (later) energy conservation have become the new focal points.

Design and Organization of Inspection Programs

At the beginning, the inspectors had only a Bacharach smoke pump for checking the smoke level. The inspectors were advised to watch for a yellow color on the smoke-filter papers. This color indicates traces of partially burned or unburned oil. No information was collected about the odors emitted.

Today, the equipment has become more sophisticated. The Bacharach pump was replaced by a powered sampling instrument. The filter paper has grown in exposure area, and the volume of air pumped through has increased proportionally. Besides reducing sampling errors with more precise sampling, the larger filter paper also allows for a simple chromatographic procedure for testing oil traces. A drop of a solvent (alcohol, xylol) placed in the middle of the paper flushes any traces to the outside rim, where they are concentrated and easily detectable by a yellowish color.

In addition to this equipment for air pollution sampling, inspectors today check combustion efficiency as well. This is usually done by measuring CO^2 and stack temperature to determine energy loss through the stack.

In Switzerland a smoke level of 2 or less on the Bacharach scale is mandatory. A smoke level of 3 or less is mandatory in West Germany. No visible traces of oil on the filter paper are allowed. If an installation fails to meet either standard, the owner is legally obligated to have the installation serviced by a licensed service technician. If the inspection following this service still reveals noncompliance, the installation has to undergo a fundamental improvement, usually consisting of replacement of the burner or the boiler; sometimes even a new stack has to be built to deliver sufficient draft for proper functioning of the installation.

West Germany has legal efficiency standards. In Switzerland federal efficiency standards are set as guidelines. Several state and local governments have already declared these standards mandatory. The standards expressed in percentage efficiency are summarized in Table 2.

Whereas a federal law regulates the organization of oil heating inspection in West Germany, in Switzerland the state and local governments are responsible for introducing and enforcing these requirements. There are two fundamentally different ways of executing the inspections:

A) Inspection by government employees.

B) Inspection by private enterprise.

A) The idea of government employees having the right to inspect something in a private home may be strange to Americans. In European countries many examples of government intrusion (in spheres considered to be private in the U.S.) can be found. The public does not reject such intrusions in the case of oil heating inspections. In fact, in about half of the existing inspection programs in Switzerland, the task is performed by government employees.

B) Inspections are conducted by private persons in Germany. The local chimney sweeps are in charge of inspecting the heaters when they do their conventional job. In both Germany and Switzerland, homeowners are required to have their boilers, furnaces, and chimneys cleaned at least once a year by a licensed chimney sweep. Combining the inspection with the cleaning task has obvious economic synergies. The legal assignment of inspections to chimney sweeps depends, of course, on the willingness of the professionals, who are usually organized in guilds or trade associations, to perform the task.

Results of Inspection Programs

When inspection/maintenance programs were first introduced, the rate of rejections varied between 40 and 60 percent. These high percentage figures were mainly due to a lack of correct burner adjustments. Technicians install-

ing the equipment were not properly trained and homeowners were not aware of the implications of an incorrectly adjusted burner in terms of energy use and air pollution.

During the first few years of the inspection programs, a sharp decrease of violations occurred. Figure 1 summarizes the results achieved over five to eight inspection cycles for two Swiss cities (Zurich and Basel) and West Germany. The violation percentage reaches an equilibrium level after several years. In case of annual inspections the equilibrium level is about 9 percent with biannual inspections (Zurich), the equilibrium level appears to be higher. A theoretical model based on a two-level Markov process supports this hypothesis. The model predicts an equilibrium level of 9 percent violations for an annual inspection cycle, and 17 percent biannual inspection program.

Data gathered from inspection and maintenance programs indicate that there is an interdependence between the violation rate and equipment size and the violation rate and equipment age. There was a much lower violation rate for larger equipment. This is attributed primarily to better maintenance and operation of large equipment and the resulting lower emissions of particulates and unburned hydrocarbons.

As for age as an independent variable, the results are split into age of burner and age of boiler. Poor performance of newer burners is explained mostly by adjustment problems in the first months of operation, while older burners show a steadily decreasing performance with increasing age. Also older boilers were designed mostly for coal as fuel and had square flame chambers. Newer boilers are designed for oil burners and have a tube-shaped flame chamber, allowing an even thermal density function around the flame and higher efficiency.

The total benefit in air pollution reduction for the city of Zurich is estimated to amount to: 1 percent of total SO^2 emissions, 60 percent of total soot emissions. and 25 percent of total hydrocarbon emissions.

Table 2. *Efficiency Standards in Germany and Switzerland*

Capacity, gal./hr	*Country*	Installation Date, Efficiency in % *1978 or Earlier*	*1979-1982*	*After 1982*
0 - 1.7		*84*	*87*	*87*
1.7 - 8.4	*Switzerland*	*86*	*88*	*88*
>8.4		*88*	*89*	*89*
0.06		*82*	*84*	*86*
0.7 - 1.4	*Western*	*83*	*85*	*87*
1.4 - 3.3	*Germany*	*84*	*86*	*88*
> 3.3		*86*	*87*	*89*

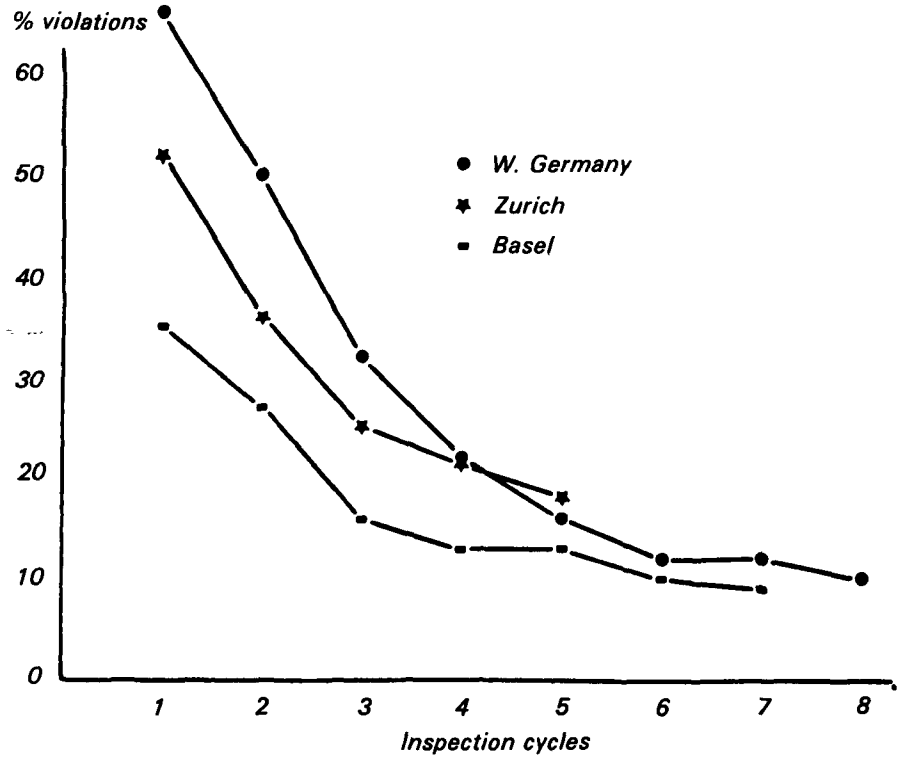

Figure 1. Results of inspection programs in Zurich, Basel, and West Germany.

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The complete report, entitled "Description and Analysis of Inspection/ Maintenance Programs for Oil-Fired Heating Systems in Switzerland and West Germany," (Order No. PB 82-224 957; Cost: $7.50, subject to change) will be available only from:
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