

UPGRADING RESIDENTIAL FORCED AIR FILTRATION

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ABSTRACT

Detached dwelling units with forced air heating offer the possibility to significantly lower levels of suspended particulate matter. Several medium to high efficiency filtration systems are compared with respect to capital costs, annual operating costs and maintenance requirements. Data from filter suppliers, heating system installers and maintenance companies is summarized. Costs for medium efficiency filtration are marginally higher initially and equivalent in the long term when compared with continued use of conventional low efficiency filtration. Energy impacts may be minimal, any losses due to increased resistance presumably balanced by gains in fan assembly efficiency due to cleaner operation. Maintenance at regular intervals is obligatory for such filters. Public health impacts may be anticipated from the considerable reduction in suspended particles of small diameter. Furnace industry policies have contributed to a deterioration in the efficiency of residential filtration. Complex distribution and marketing problems prevent widespread availability of medium efficiency filters at present.

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I. INTRODUCTION

As building tightening programs continue to degrade the quality of indoor air, concrete steps are needed to counter this trend. ¹⁾ Detached dwelling units were traditionally assumed to have had adequate exchange between indoor and outdoor air; they present some unique problems as well as promising possibilities for control.

Current attempts to control air quality in residences are often misguided and, at best, random. They range from the use of scent sticks to the installation of expensive electronic equipment. An example is suspended particulate matter: Even in the absence of tobacco smoke, concentrations of respirable size particles in the residential environment equal or exceed outdoor levels. ²⁾

The physical trapping of small particles on an appropriate filter is inherently a simple process, yet control of suspended particulates in residences usually involves quite primitive technology of very low efficiency. The worst is probably the hardware store variety of furnace filter used by almost 70% of Canadians who occupy detached dwelling units and who make up more than half of the population. ³⁾

Great improvements in fabric filter technology have been made during the past several years. ⁴⁾ Pleated products which offer many times the efficiency of the standard variety are available in common residential sizes. However, lack of public awareness of the importance of the filter to the functioning of the heating system has left very low efficiency filters as the norm. The better products are unknown to the residential consumer, but are

widely used in the commercial sector. Where a need for medium to high efficiency residential filtration has been expressed, and where sufficient financial resources were available, electrostatic precipitation has been the only option for the average consumer. 5)

Most low efficiency filters depend upon impingement of particles on an adhesive surface. Medium to high efficiency filters employ straining between fibres of varying diameters. The throwaway home furnace filter falls in the former category. Its greatest advantage is its ability to pass air even when heavily laden with dirt. This property of a filter is measured as the arrestance or dust holding capacity. Dust holding capacity is in reality the amount of dust which can be fed to a filter before it reaches a certain level of restriction of air flow; restriction is measured in pascals (Pa) of pressure drop across a filter.

The Canadian General Standards Board has issued a series of standards for air filters. 6) The standard for residential furnace filters requires only a maximum initial pressure drop, a minimum percent arrestance and a minimum dust holding capacity.

As a filter becomes clogged, its resistance to air flow rises. Less often recognized is the difference in the performance of a good filter and a poor one. Comparing two filters developing the same increase in resistance, the good filter shows a considerably greater rise in efficiency than does the poor one. The relationship between resistance to air flow and penetration of particles has been elegantly described in mathematical terms. 7)

II. OBJECTIVES

This study documents the feasibility of upgrading suspended particulate control capability in detached residential units with forced air heating.

Several medium to high efficiency filtration systems are compared with respect to capital costs, maintenance requirements and annual operating costs.

The study also examines the reasons for the present sad state of affairs in residential forced air filtration. It suggests strategies for raising public awareness of proper care and maintenance of the heating system in the short term, and it considers the desirability of using higher quality filtration products in residential units in the long term.

III. METHODS

Specifications for residential filter products were obtained from manufacturers and suppliers in Canada and the United States. Local filter suppliers, heating system installers and duct maintenance companies were interviewed in person. Capital costs and maintenance costs of various filter systems were calculated from data collected during these interviews. The views of a highly knowledgeable supplier with more than two decades of experience in filtration were given close attention in all stages of the study.

Energy impacts of improved filtration were identified qualitatively from the above sources and data supplied by a local energy utility research project.

Opinions were also sought from furnace manufacturers and representatives of the energy utilities, the real estate industry and the medical profession.

IV. RESULTS

A. Filter products

Specifications and retail prices were collected from six manufacturers and five local suppliers. Only products with test data based upon the ASHRAE 52-76 or the earlier 52-68 standard test were considered as upgrading options. Most medium to high efficiency filters are now rated by this criterion. Originally known as the NBS atmospheric dust spot test, it measures retention of particles of standardized "atmospheric dust" with an average diameter of 1.5 microns.

Conventional furnace filters are so poor that no ASHRAE efficiencies are supplied for them. They are commonly classified as about 5% efficient, however. Worse still is the metal screen type which has been used for one hundred years and is still found in residential furnaces.

At the other extreme are the HEPA (high efficiency particulate air) filters which require a special test method sufficiently sensitive to describe their performance; the DOP (dioctylphthalate) test measures the efficiency on molecules of this compound with a 0.3 micron diameter.

Electrostatically charged filtration media were not included in this study. Test data indicate very high efficiency, but residential applications are likely to be restricted to bag installations since resistance to air flow is high. There are no standards for such products.

The filter options are grouped according to average efficiency rating in Table I; the interview questions are shown in Appendix A.

Table I
Filter products See Appendix A

Average efficiency range a)	Brands	Thickness (mm)			Bag	Material	Use	Frequency of duct/fan cleaning
		25	50	100				
Below 10%	many	x	x			Metal, animal hair, fibre-glass, foam	Washable	3-5 years
15-20%	2	x	x	x		Polyester,		4 years
30-35%	3	x	x	x		Cotton and/or polyester	Computer rooms	5 years
35-40%	2		x	x	x	Cotton	Same, since 1972	6 years
50-55%	4	x	x	x	x	Cotton and/or polyester	Since 1978	8 years
75-90%	4	Electrostatic precipitation					Since 1960's	10 years
80-85%	3				x	Fibreglass	Hospitals	15 years
90-95%	3				x	Fibreglass	Hospital operating rooms	20 years
99.97% b)	1				x	Fibreglass and asbestos	Nuclear facilities	-

a) ASHRAE Test Method 52-76

b) DOP test, 0.3 micron particles

B. Installation

Estimates were obtained for installation of several filter options in existing residential units. Four installers were interviewed using the format shown in Appendix B. The responses are summarized in Table II.

None of the installers was able to respond to questions about the pressure drop which a residential heating system could accept from a filter.

Where a need for better filtration exists, the sale of the electrostatic option is made easy for the installer by impressive promotional material from the manufacturers.

Promotional material for medium to high efficiency pleated filters was not available from installers.

The value of promotional material in this business may be estimated by the experience of one installer. He leaves three one-page information sheets on the two-speed motor, the electrostatic air cleaner and humidification; about 50% of his clients take the two-speed motor, yet the furnace manufacturer reports only about 5% of total sales with this option.

An installer who carries quality filters reports little difficulty in selling them after a few minutes of face to face explanation of their advantages; it may be significant that in most cases the buyer has just paid him more than \$100 for a duct cleaning job, so the investment in a good filter is attractive.

Table II
Survey of installers

See Appendix B

Question	Company A	Company B	Company C	Company D
1. Services	Furnaces, ducts	Furnaces, ducts	Ducts, cleaning	Ducts, cleaning
2. Residential	100%	90%	20%	less than 5%
3. Static pressure	?	?	n/a	n/a
4. Pressure drop	?	?	?	?
5. Filters used	standard	standard	standard	25 mm 30-35% 50 mm 50-55%
6. Electrostatic *	\$685	\$525	\$650	refers elsewhere
7. Rack retrofit	\$75-100	\$60	not done	\$75
8. Two-speed motor	\$135	\$150	no demand	\$175
9. Special wiring	probably	routinely done	n/a	n/a
10. Demand for better filter	promotes electrostatic	promotes electrostatic	50-55% bag, 1/3 hp motor	as above or 80-85% bag
11. Increase public awareness	advertising, promotional materials	information brochures for client	tv ads	radio ads, consumer information

* Prices do not include recommended humidification or two-speed motor

C. Maintenance

Three duct cleaning services provided answers to the questions in Appendix C as shown in Table III. They differed in their responses to most questions, but on one thing they were unanimous: the condition of the furnace filter is almost always very bad.

Their horror stories demonstrate the element of procrastination so common to many maintenance obligations of the average person. Action on the furnace filter usually comes far too late. Some people, obviously embarrassed, replace it just before the cleaning men come. Others remove the filter altogether, hoping that the badly clogged system will operate more efficiently. The fan assembly is often caked with dirt so that the heating cycles have become longer to accommodate the decreased air flow to the home. This is the reason why maintenance companies advertise energy savings from regular duct and fan cleaning.

Table III

Survey of maintenance companies

See Appendix C

Question	Company A	Company B	Company C
1. Price	\$135	\$125	\$120
2. Residential	80%	50%	20%
3. Recommended frequency	2 years	3-5 years ^{a)}	every year
4. Actual frequency	allergics yearly	2/3 never done	most never done
5. Client motivation	dust	energy, dust	health, dust
6. Filter condition	plugged	98% plugged	plugged or gone
7. Replacement	yes, standard	yes, pleated	no, suggest standard
8. Requests for better	allergics	"Why not 100%?" ^{b)}	allergics
9. Better filter already	20% ^{c)}	less than 1%	none
10. Decreased frequency	3 years	7-10 years ^{d)}	4 years

a) Assuming regular changing of standard filter.

b) Response of clients to explanation of medium efficiency filter.

c) Respondent considered washable animal hair medium a good filter.

d) See Table I.

D. Costs

Using data from Tables I, II and III, a series of upgrading options has been chosen to demonstrate a wide range of possibilities in terms of efficiencies and costs. Table IV shows the estimated costs to the user in the first year. For example, upgrading to 30-35% efficiency would require two 25 mm filters at \$8 each, unless sufficient space for a 50 mm model were available. Including the \$125 cost of initial duct and fan cleaning service, the total cost for the first year of operation would be \$141. Cleaning may be presumed to be long overdue in the majority of homes, and it is a necessity after any renovations such as might be involved in retrofit work.

Using 1982 dollars, an estimated annual cost averaged over the first ten years is presented in Table V. In the example above, filter cost was \$16 per year, so nine additional years would add \$144 to the cost of the first year of operation. Including two additional \$125 cleanings, the ten year total would be \$535. An annual cost estimated to the nearest \$5 would therefore be \$55. For purposes of the calculations in Table V, the duct cleaning frequency estimates of the company with more than twenty years' service to the community were used. See Table I.

The required frequency of filter changing and the required frequency of duct cleaning is dependent upon the efficiency of filtration used, the level of dust in the home and the frequency of filter maintenance.

A simplified representation of the major residential options is shown in Figure I. However, the indicated annual costs in this figure do not reflect installation or maintenance.

Table IV
First year costs of upgrading options

Range	Type	Cleaning	Retrofit	Filters	Total
Below 10%	25 mm	\$125	-	3 x \$1.50	\$130
15-20%	25 mm	\$125	\$13 (frame)	4 x \$1.25	\$143
30-35%	25 mm	\$125	-	2 x \$8	\$141
30-35%	50 mm	\$125	(\$75) ^{a)}	\$12	\$137 (212)
50-55%	50 mm	\$125	(\$75) ^{a)}	2 x \$15	\$155 (230)
50-55%	100 mm	\$125	\$75	\$24	\$224
75-90%	electro	\$125	\$600-800	\$25 ^{b)}	\$750-950
80-85%	bag	\$125	\$360	\$75 ^{c)}	\$560
90-95%	bag	\$125	\$360	\$90 ^{c)}	\$575
99.97%	bag	\$125	\$500	\$1150 ^{c,d)}	\$1775

a) Sheet metal work may be required for placement of a 50 mm filter where a 25 mm product is normally used; more than half of the furnaces in use today can accept 50 mm filter.

b) This represents electricity for operation and monthly maintenance of a two-cell electrostatic precipitator.

c) This filter will last at least two years

d) This "absolute" system includes a 50-55% prefilter stage; at least one such residential installation is in operation in Canada.

Table V

Annual costs of upgrading options

Range	Type	Year 1 (Table IV)	Filters	Maintenance Years 2 - 10	Annual e) average
Below 10%	25 mm	\$130	\$5/year	\$250-375	\$45-55
15-20%	25 mm	\$143	\$5	\$300	\$50
30-35%	25 mm	\$141	\$16	\$250	\$55
30-35%	50 mm	\$137(212) ^{a)}	\$12	\$250	\$50-55
50-55%	50 mm	\$155(230) ^{a)}	\$30	\$150	\$60-65
50-55%	100 mm	\$224	\$24	\$150	\$60
75-90%	electro	\$750-950	\$25 ^{b)}	\$300 ^{c)}	\$120-140
80-85%	bag	\$560	\$40	\$80	\$100
90-95%	bag	\$575	\$50	\$60	\$110
99.97%	bag	\$1775	\$300	-	(\$400) ^{d)}

a) See Note a) in Table IV.

b) See Note b) in Table IV.

c) Includes \$175 for replacement of cells after ten years.

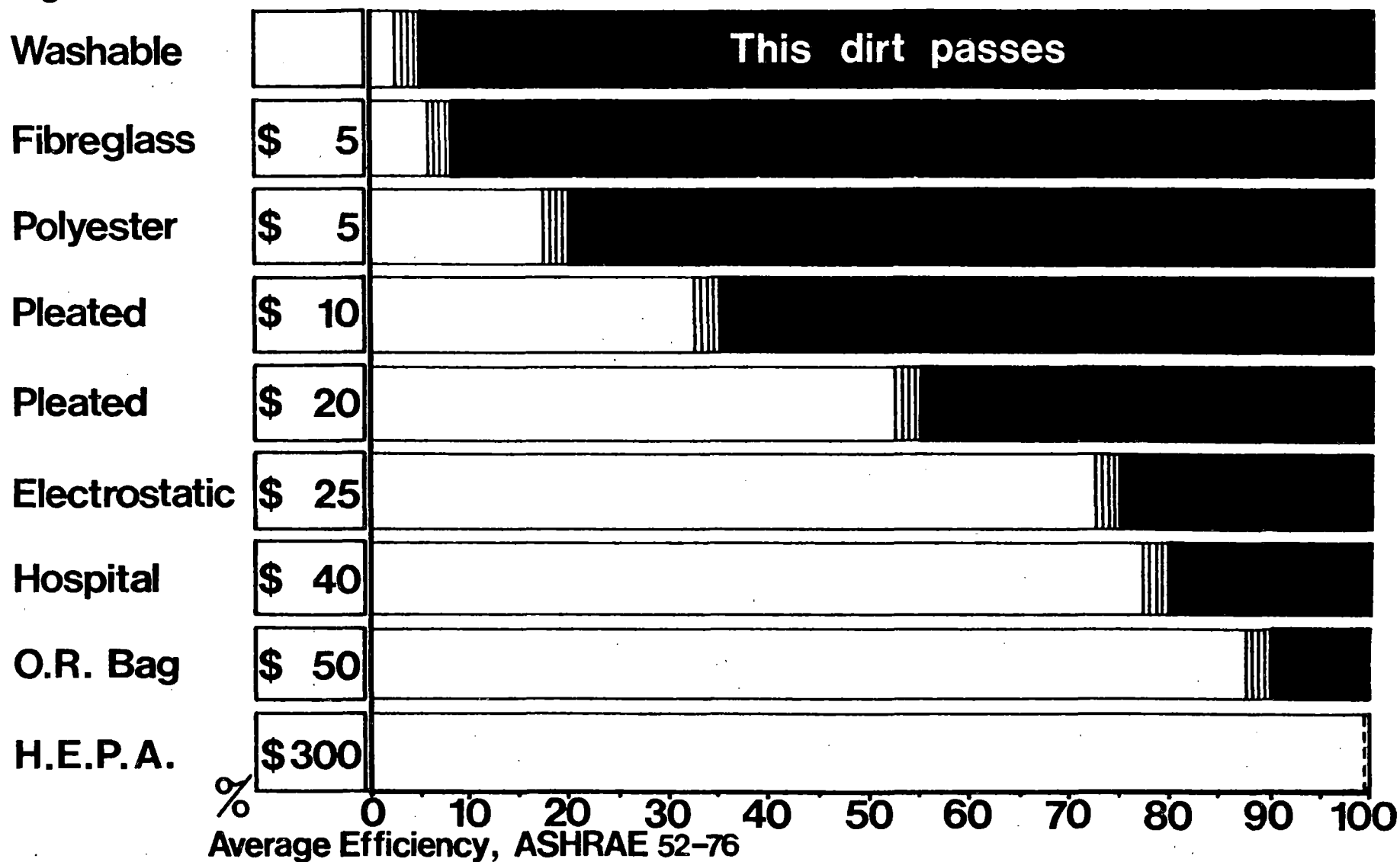
d) See Note d) in Table IV.

e) These estimates are rounded to the nearest \$5 or \$10.

Fig. I

Annual Cost

RESIDENTIAL FURNACE FILTER OPTIONS



V. ENERGY CONSIDERATIONS

Several furnace manufacturers and suppliers, energy utility representatives and heating consultants were interviewed. Some claimed ignorance of the existence of medium efficiency residential filters. Others expressed doubts about the ability of residential furnaces to operate efficiently with the increased resistances expected from such products. Concerns over excessive heat rise due to reduced air flow, possible damage to heat exchangers, stack losses and higher energy bills were raised.

These concerns were not supported by the experience of this investigator nor that of one company who has been installing pleated fabric filters for more than a dozen years without trouble.

A series of clean 25 mm filters and one 50 mm filter were tested for their effect upon resistance and air flow in a residential system. The worst case, a 25 mm filter rated at 35% efficiency, showed a substantially greater restriction than the cheap models, but the greatest reduction in air flow was less than 10%. The 50 mm product, rated at 50% efficiency, introduced a minor restriction and no measurable decrease in air flow.

More comprehensive experiments by a local energy utility group have shown the effect of plugged filters.⁹⁾ They placed cardboard strips over the surfaces of three kinds of filters to simulate various degrees of plugging. The decreases in air velocity were substantial, but the curve relating stack temperature to percent plugging rose quite gradually between 25% and 50% plugging and steeply thereafter. Using the stack losses and the temperatures of supply air and return air, they calculated changes in

overall efficiency for this particular house furnace. The figures reported were:

Filter plugging	Percent efficiency lost
25% plugged	3.44% or less
50% plugged	8.62%
75% plugged	18.96%

The report also indicates that addition of one or more fuel-saving devices to the system would more than compensate for such losses. However, the lesson is clear that regular filter changing has an effect upon total energy consumption.

Several factors must be considered in estimating the energy impact of a particular filter option. The choice of a 50 mm or 100 mm thick pleated filter greatly increases the available media area. This lowers the resistance of a filter to an acceptable level and permits a sufficient air flow.

However, as one moves up the scale of filter efficiency, the "forgiving" nature of the filter decreases, i.e., the quality filter which is not changed when dirty will have an effect upon air flow which a dirty cheap filter would not show. The low quality filter is called "forgiving" because it overcomes the problem of overloading by allowing dirty air to pass through it. A quality filter will not do this; when it becomes dirty, its resistance to air flow increases dramatically. Some years ago a pleated filter product in western Canada was condemned by the energy utilities because users had failed to properly maintain and change them. A knowledgeable supplier knows this problem and markets better grade filters carefully. Without a proper explanation of the characteristics of the quality filter to the consumer, a higher efficiency installation may create serious trouble.

One reason for the ability of residential furnaces to accept the resistance of better filtration is their design to accept air conditioning. All furnaces built since 1965 are designed to accommodate the extra resistance of an air conditioning cooling coil. The A coil imposes considerably greater resistance to air flow than does the heat exchanger. Furthermore, if allowed to become dirty from dust passing through a "forgiving" filter, the very fine fins of the coil become clogged and create a much greater resistance than the use of a higher efficiency filter would have caused in the first place.

Another energy impact of a filter is the protection it offers to the fan motor and squirrel cage assembly which move the air. Even with regular changes of conventional filters, an accumulation of dirt begins to block the narrow fins of the squirrel cage and thus decreases the supply of air to the fan. This eventually leads to longer "on" cycles of the furnace. As less air becomes available to the fan, the load on the motor decreases and the motor tends to speed up. Direct drive motors common on most new furnaces are particularly vulnerable.

The fan motor itself can become clogged with dirt if not protected. This may cause it to overheat. An illustrative example arose during this study. Smoke from the fan motor brought the fire department to a neighbour's furnace. The resident was served with a written notice to "make repairs to furnace motor." The motor was replaced, and the inspector returned on the next day to verify completion of the work. Subsequently, a visit by this investigator revealed occupants who had never opened the furnace, a filthy fan chamber, a squirrel cage plugged with many years' accumulation of dirt, two

new furnace filters lying flat on the floor of the fan chamber, and a brand new motor! The occupants reported that they had "noticed the furnace running much longer recently" despite the mild April weather. Although the exact cause of the motor failure was not established, fire officials had failed to demand the long overdue maintenance of the system which might prevent a recurrence.

Some energy consumers are aware of the potential of the filter to cause trouble. A survey of an energy utility customer service found more than 26% of all consultations dealt with furnace filters, more than any other topic. ⁹⁾

VI. PUBLIC HEALTH CONSIDERATIONS

Medical opinion on the value of upgrading furnace filtration is difficult to assess. Convention requires that potential health benefits of any innovation first be proven with massive statistical studies before the medical profession will make a recommendation. A medical association spokesman and a respected pulmonary disease specialist both called for exactly such data when interviewed on the subject of furnace filtration.

More meaningful responses were obtained from three other physicians in private practice. They readily admitted seeing many patients with symptoms whose onset coincided with the start of the furnace in late autumn. Told that retention of small particles could be increased by an order of magnitude with such products, they requested the names of suppliers of medium efficiency filters for use where the need arose.

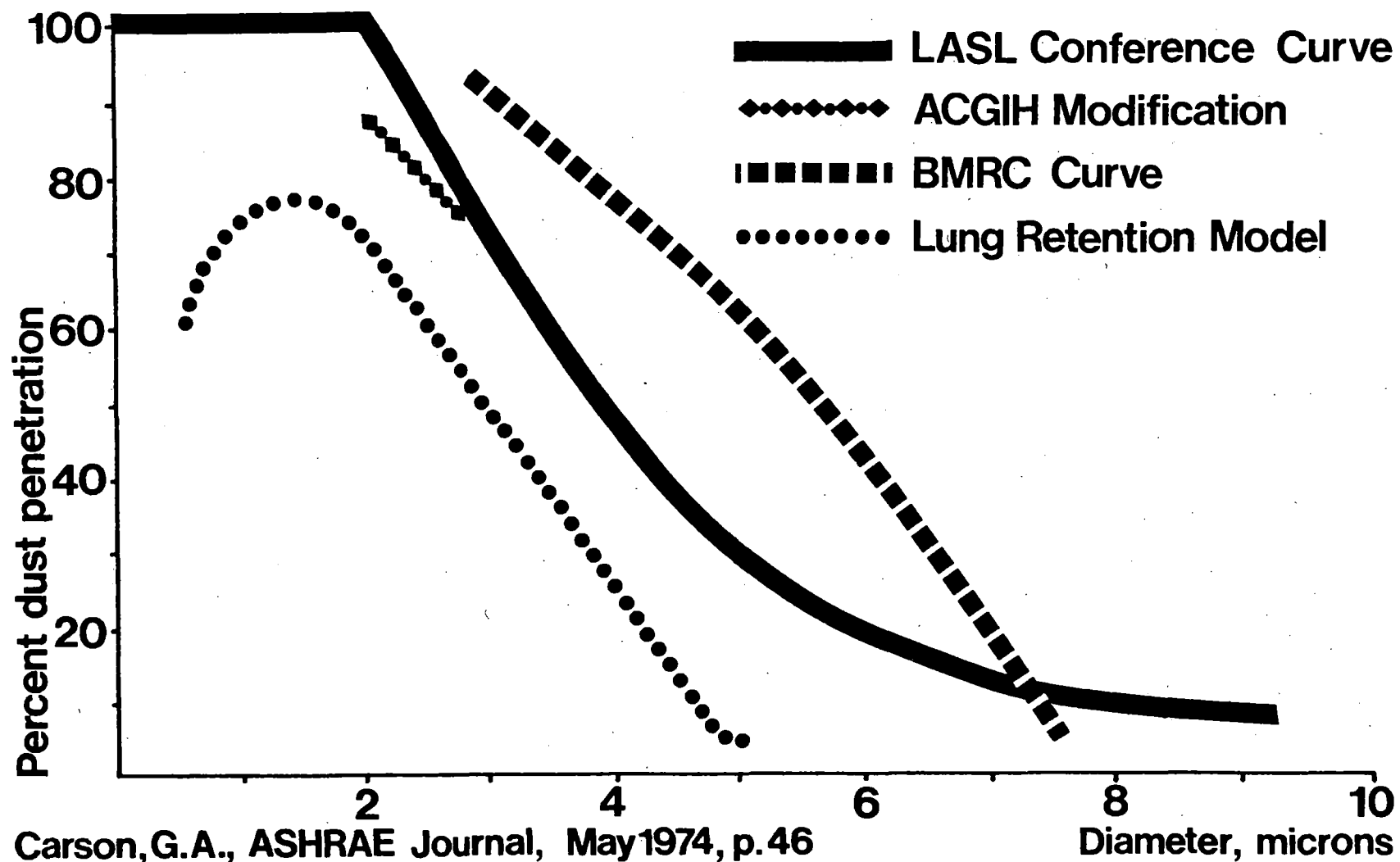
All five medical professionals were unaware of the existence of such products, assuming the only alternative for a patient in need of better filtration to be electrostatic precipitation.

The protective potential of improved filtration is evident from graphs of respirable dust lung penetration and lung retention plotted against particle size. Such curves show an increasing hazard with decreasing size of particle from 5-10 microns down to 1-2 microns. ¹⁰⁾ See Figure II.

By plotting manufacturers' data on filter efficiency vs. particle size on the same axes as the lung curves shown in Figure II, a graphic representation of the relative protective capabilities of various filtration efficiencies

Fig. II

RESPIRABLE DUST



can be created. See Figure III.

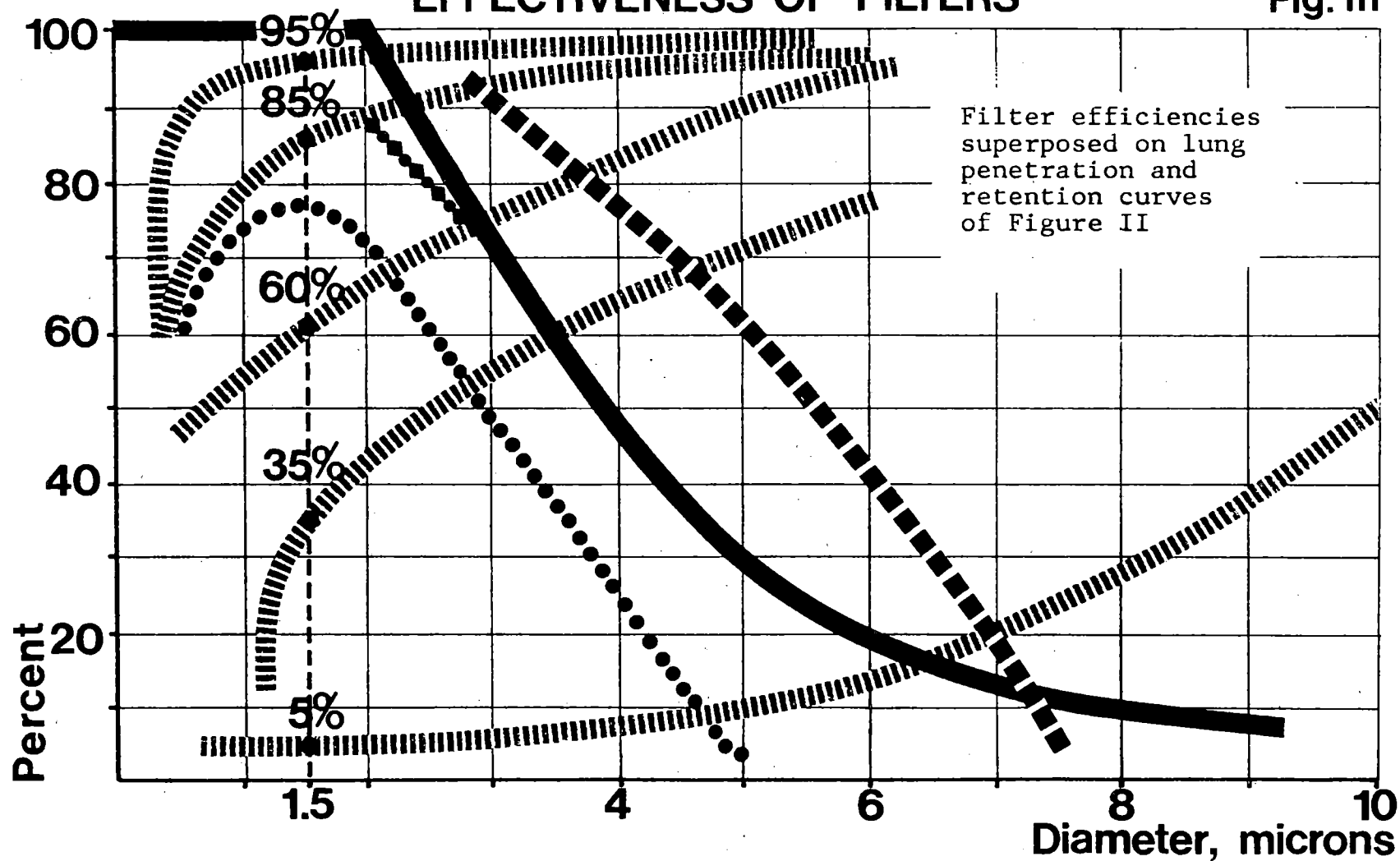
An example is the case of pollen allergy. Most pollen particles have a diameter of 10 microns or greater. Many allergy sufferers have found medium efficiency pleated filters to be quite helpful, as one would expect from the filter efficiency data.

Undesirable particulate matter comes in a wide range of sizes. Bacteria can be anywhere from 0.5 micron to 10 microns in diameter. Even medium efficiency filtration can considerably affect such particles, as Figure III indicates. However, smaller particles such as tobacco smoke, 0.01 to 1 micron, require quite high efficiency filtration for complete control.

Common house dust has the largest size range. Also known as atmospheric dust, it includes submicron sizes and visible particles above 10 microns. The effect of medium efficiency filtration on the latter is usually obvious to the user. For the smaller sizes, the curves in Figure III show clearly that the better the filter, the more of the particles are removed.

EFFECTIVENESS OF FILTERS

Fig. III



VII. MARKETING CONSIDERATIONS

Two decades ago all residential panel filters were of the 50 mm thickness. As cost considerations prevailed, furnace manufacturers reduced the thickness of the filter to 25 mm. Today in western Canada only 10% of furnaces employ a 50 mm panel, about 50% to 70% employ a 25 mm panel, and the rest use the hammock blanket format unique to furnaces of one popular manufacturer.

The six to eight different panel sizes for each thickness create an unusual inventory problem for the retailer. Worse still is the very low profit margin per unit of shelf space required. One large hardware store chain has already considered dropping furnace filters altogether. Retailers prefer the cut to order filter media which come in large rolls from which individual pieces are cut for customers; these allow a reasonable markup. The plasticized animal hair medium which can be vacuumed or washed is supplied in such rolls.

Furnace manufacturers admit that they use the cheapest possible product in order to remain competitive. The dealers and installers also have little motivation to supply better filters. Cost consciousness is so strong among this group that they won't even leave pamphlets about options, although the energy utilities encourage them to do so. They often quote \$1400 for a gas conversion even though the federal government grant of 50% up to \$800 requires a total of \$1600 for full applicability.

One manufacturer has received calls from purchasers of new homes containing his furnaces saying they couldn't find the filter. His inspection revealed that an unscrupulous installer had omitted the sheet metal work required to accommodate a filter.

Filter suppliers would gladly sell medium efficiency products instead of the low quality throwaway type. They know that the average person doesn't change the regular filter as often as recommended. One \$6 sale per year would be better than one or two \$1 sales per year, they say. However, the hardware store operators will not place yet another type of furnace filter on the shelf adjacent to the common variety which sells for a fraction of the price of the new one. A higher profit margin is no incentive if the prospect of actual sales is poor. One manufacturer reports that hardware chains would only carry better filters if they were assured that all the chains had agreed to introduce them simultaneously, an unlikely development in a free market.

Maintenance companies also complain about the variety of sizes of filters in use, and many don't bother to carry any on their trucks for this reason. One which does supply medium efficiency filters claims little difficulty. The client is asked for the size over the telephone; after the job is finished, the driver shows the client the difference in filters and quickly makes a sale as well as repeat business.

CONCLUSIONS

A variety of upgrading options is available to the residential furnace filter consumer. Costs for medium efficiency filtration are marginally higher initially and equivalent in the long term when compared with continued use of low quality filtration.

Reduction of visible dust is indisputable. Furnace and ductwork cleaning requirements are significantly reduced as well.

Energy impacts are highly dependent upon the reliability of the user to perform routine maintenance checks. The required frequency of such maintenance will depend upon several factors, including the level of filtration used. Either a commitment by the user to perform the required maintenance or an automatic warning device actuated by a certain pressure drop in the system is necessary for the successful application of medium to high efficiency filtration in the home.

In commercial and industrial installations maintenance of filters is recognized as a necessity and is usually done on a fixed schedule. No such statement can be made for the vast majority of residential units. "Forgiving" filters are one reason that there are not many more furnace disasters. Another is the relatively trouble-free combustion system of the popular gas-fired furnace. Under normal conditions a gas furnace can operate for years without ever having the front panel removed. The perceived need for maintenance is small.

Should the user try to check the filter, the cabinet

and the filter accessibility may be intimidating. The sharp metal edges around the cover and the filter rack are such that one may need "an engineer with gloves" to change the filter.

Filter plugging tests indicate that a furnace can accept a significant reduction in air flow with only minimal loss in overall efficiency up to about 50% plugging. The apprehension of utility personnel and others about potential energy losses and damage to the heating system is apparently based upon mistrust of the average user to clean or change the filter as required. The better filters are not very "forgiving."

Beneficial energy impacts of better filtration arise from protection of the fan motor and the fan assembly. Furnace cleaning may also reduce the film of soot on the surface of the heat exchanger. These effects have not been measured, but simulations of adverse conditions could be performed to estimate their magnitude.

Energy utilities periodically try to encourage filter changing by suggesting energy savings to be gained. They do not usually mention duct system and furnace cleaning advantages. A clean filter may help a dirty system to operate more efficiently if the old filter was plugged, but it will not unclog a filthy fan cage; not even a superior filter will do that.

Potential health benefits are difficult to quantify. Sensitive and allergic individuals appreciate the improvement afforded by medium efficiency filter products. Considering the levels of particulates found in the residential environment, and considering the ever widening range of materials in this aerosol, it is obvious that any reduction of this burden can do no harm.

The common furnace filter is so bad that the question of its real function must be raised. It may not be unreasonable to suggest that its primary purpose is protection of the heating system equipment, analogous to the case of the filter in an air conditioner. This may come as a shock to some, but ample evidence to support this unpleasant hypothesis exists. The fact that furnace filtration has deteriorated during the last two decades while awareness of the health hazards of suspended particulates has increased is not overly encouraging.

Complex distribution and marketing problems prevent the widespread availability of better filtration products to the residential consumer. The policies of furnace manufacturers and installers have also mitigated against the use of medium efficiency filtration.

A decade of intensive promotion of the virtues of the electrostatic precipitator has left the impression that no other option exists for the home. The energy utilities and the medical profession have contributed substantially to the popularity of this misconception. Consumer group literature has advised that cheapest is best in furnace filters, unless one can afford the electrostatic precipitator.

Faced with these odds, suppliers of filtration products have contented themselves with the ever growing market for better filtration in the commercial sector. There they deal directly with the user, and they often retain control over maintenance of the system, so important to the successful use of medium efficiency filtration.

Ironically, while oblivious to the potential of medium efficiency filters, consumers are eagerly purchasing

a variety of table model "air cleaners" which have hit the market recently.

The available evidence suggests that medium efficiency filtration in the home may have positive impacts upon health, maintenance requirements and energy consumption. Reduction in the thickness of the standard filter and the deemphasis upon maintenance brought about by the gas-fired furnace during the last two decades are two major obstacles to large scale application of such an improvement to the residential environment. Considerable effort will be required to change established attitudes, beliefs and practices before a medium to high efficiency filter becomes the norm.

RECOMMENDATIONS

Governments, consumer groups and energy utilities should move to update their official statements, if any, on the subject of residential furnace filtration.

Furnace filtration should be required by the National Building Code.

Manufacturers and installers should be required to provide a minimum 50 mm filter access space in all new furnaces sold in Canada as they did twenty years ago.

All forced air furnaces should have a differential pressure monitor which would actuate a flashing red light or other visual or audible signal near the furnace when the filter became clogged.

Medium efficiency filtration should be mandated in all government financed housing units in order to reduce maintenance costs. Strict instructions or controls for proper maintenance of filters should accompany the implementation of such a policy.

A short term study using simulation of fan and motor dirt accumulation and heat exchanger soot deposition should be undertaken to determine the energy impact of better filtration and/or duct maintenance.

A long term study of energy consumption and overall maintenance costs for housing with such filtration should be initiated. Housing with conventional filtration should be used as a control group. If the number of units is sufficient and the duration of the experiment is also sufficient, the groups of occupants should be studied for respiratory health indicators.

Government, industry, consumer groups, energy utilities, the real estate industry and the medical profession should make a concerted effort to alert the public to the advantages of proper heating system maintenance.

Duct cleaning should be required for any home being rented or sold where there is no written evidence of its having been done during the previous five years.

A system to bring a trained technician into the home periodically, as legislated in Ontario and Saskatchewan, should be established nationwide. A pilot project could be undertaken with the long term study recommended above.

Installers of furnaces, developers and real estate persons should be required to transfer all instructions and manufacturer's literature to the occupants of new construction. Government or real estate personnel should assume responsibility for informing home buyers about heating system maintenance. This could easily be done with a single information sheet delivered to the owner at the time of title transfer. An example could be taken from similar far more comprehensive requirements of the Swedish Building Code.

Furnace manufacturers should move to reduce the number of standard filter sizes required by the industry.

The educational system should reintroduce the teaching of fundamentals of home construction, engineering aspects of home operation and home maintenance as was customary in public schools a generation or two ago.

Appendix A

Filter suppliers questions

1. What products do you market for forced air systems?
2. What proportion of your business is residential?
3. What efficiency standard is used?
4. What are pressure drops at given velocities?
5. What sizes are available?
6. What are retail prices?
7. How much demand is there for better filters?
8. What could be done to increase public awareness
of the advantages of better filters for residences?

THANK YOU.

Appendix B

Installers questions

1. What products and services do you offer? Brochures?
2. What proportion of your business is residential?
3. What is static pressure rating of your furnaces?
4. How much pressure drop can your residential systems accept from a filter?
5. What type of residential filter do you supply?
6. What is the cost of an electrostatic air cleaner installation?
7. What is the cost of a 2" or 4" rack retrofit?
8. What is the cost of a two-speed motor retrofit?
9. Could the lower speed operation be shut off without affecting operation of the heating system?
10. How much demand is there for something better than the conventional residential heating system with a throwaway filter?
11. How could one increase public awareness of the various possibilities which we have discussed to upgrade the efficiency of filtration?

THANK YOU.

Appendix C

Maintenance questions

1. What services do you offer? Brochures?
2. What proportion of your business is residential?
3. How often do you recommend that a residential duct system be cleaned?
4. How often are such systems actually cleaned?
5. How would you characterize the motivation of your residential clients?
 - Dust problem
 - Health protection
 - Energy conservation
6. What is the condition of the filter in the system of residential clients?
 - Clean
 - Dirty
 - Plugged
7. Do you replace filters? If so, what type do you use?
8. Do residential clients ever ask for better filters?
9. What proportion of residences do you believe have a higher efficiency filter than the common variety?
10. How much could a higher efficiency filter reduce the need for duct cleaning in a residence?
11. What do you suggest might be done to improve public attitudes toward proper maintenance?
12. Similarly, what might be done to increase public awareness of better filter products?

THANK YOU.

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