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PERFORMANCE EVALUATION OF KITCHEN EXHAUST DRAFT HOODS.(U)
MAR 80 P B SHEPHERD, R H NEISEL DAAK70-78-D-0002

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PERFORMANCE EVALUATION OF KITCHEN
EXHAUST DRAFT HOODS

FINAL REPORT



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TECHNICAL NOTE

PERFORMANCE EVALUATION OF KITCHEN EXHAUST DRAFT HOODS FOR MESS HALLS AND COMMERCIAL APPLICATIONS

PURPOSE

This Technical Note provides a basis for comparing the energy conservation and payback periods for these different alternatives in the selection and operation of kitchen draft hoods for mess halls and similar applications.

APPLICABILITY

This Technical Note applies to all Facilities Engineering elements responsible for Design, Operation, and/or Maintenance of Energy Conservation Programs at Army installations.

DISCUSSION

The operation of kitchen draft hoods may present a significant potential for energy conservation by reducing the volume of tempered air exhausted from a building. There are three different, potential methods for conserving energy and reducing costs associated with the operation of kitchen hoods over gas burning appliances.

1. Rewire hood units to provide individual control for each fan so that each fan may be turned off when its use is not required.
2. Replace a hood with an energy-efficient hood which uses untempered air for a large portion of the draft air.
3. Replace a hood with an energy-efficient hood which uses a heat exchanger to extract a large portion of the heat in the tempered exhaust air.

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ECONOMICS

Methods have been devised to compare the potential energy and cost savings offered by the three alternatives. These potential savings will likely be quite variable depending on climate, size of hood(s), annual hours of exhaust operation, and energy costs.

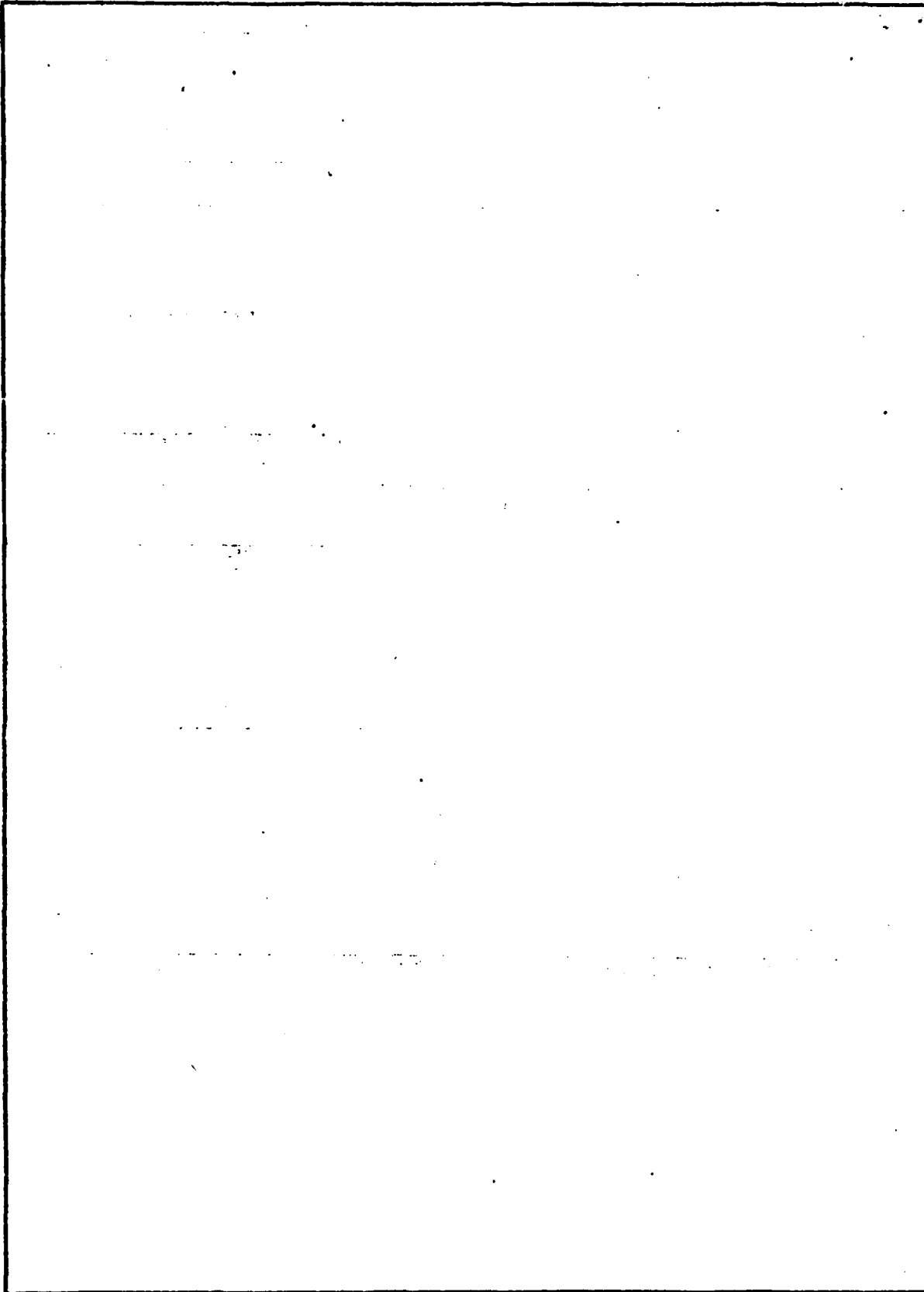
It is not possible, therefore, to generalize on the energy savings and cost effectiveness of the several retrofit possibilities.

GUIDELINES TO IMPLEMENTATION

The Facilities Engineering Support Agency has prepared a report entitled "Performance Evaluation of Kitchen Draft Hoods". The Survey Section of this report discloses many manufacturers of energy conserving draft hoods. Manufacturers should be consulted for up-to-date technical information estimates of installed costs of suitably sized units, and energy conservation surveys of facilities. The field application of information in the report and manufacturer information may be evaluated according to the methods detailed in Appendix A of the report. This Appendix shows how to estimate comparative energy savings and payback periods for the three alternatives.

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REPORT FESA-TS-2065

PERFORMANCE EVALUATION OF KITCHEN EXHAUST DRAFT HOODS

P. B. SHEPHERD, R. H. NEISEL
JOHNS-MANVILLE SALES CORPORATION
RESEARCH & DEVELOPMENT CENTER
KEN-CARYL RANCH, DENVER, COLORADO 80217

MARCH 1980

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TECHNOLOGY SUPPORT DIVISION
FORT BELVOIR, VIRGINIA 22060

SUMMARY

Increased energy costs have required attention to many modes of energy conservation other than the usual fundamental one of heat loss through exterior building elements. Kitchens are known to consume large quantities of energy. An important part of that energy use is the energy required for heating or cooling air which is then exhausted to outside for the purpose of removal of heat, grease, odors, water vapor, and particulates from the kitchen.

The purpose of this study was to determine what equipment and techniques are available to reduce energy usage in ventilation of commercial or institutional-type kitchens. A survey of equipment producers was made to find what was available.

We discovered 17 systems which are offered for energy conservation. These range from the simple but effective procedure of individual control of sections of the exhaust hoods to allow shutting off the fans on sections not in use; to provision of 60 to 90 percent of untempered air for exhaust; to cleaning, odor removal, and recirculation of hood air from electric appliances; to recovery of the heat content of the exhaust air and reuse of that heat (see Appendix II for illustrations).

All of the systems appear to have merit and fill needs. For example, cleaning and recirculation of the air may be advisable where installation of exhaust ducts is very expensive or impracticable as on the lower floors of high rise buildings. The other systems appear competitive to one another and careful evaluation is needed to determine the most cost effective system for an application.

The suggestion is made that cost comparison of the various and diverse energy conserving systems may best be obtained through comparison of energy usage records in actual operation.

Guidelines are offered for estimating the comparative energy savings payback periods for three basic, energy conserving alternatives in kitchen draft hood operation.

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SURVEY

The initial steps in the Survey were to conduct a Literature Search to determine what equipment and modes of operation had been proposed for energy conservation in kitchen ventilation. This was followed by attendance at a food preparation industry exposition¹ to determine what equipment was currently available. Other sources of information as to producers of ventilating hoods were the listings of approval agencies.^{2,3,4}

A survey form and questionnaire was prepared (see Appendix B) and was sent to 82 producers on a list compiled from the above sources. Where required, a telephone followup call was performed; although in several cases, recipients of the questionnaire phoned to indicate their interest and capabilities.

Of the 82 questionnaires mailed, six were returned as unknown, perhaps due to moving or going out of business; eight replied they did not manufacture energy conserving models; and one replied their designs were manufactured only for use in their own facilities.

Fourteen producers returned completed questionnaires and sent brochures and data covering their 17 products. One returned an incomplete questionnaire and no brochure, while one returned no questionnaire but a complete brochure with energy conserving features. Thus, informational replies were 31 out of 82, or 38 percent. Those who offer energy conserving items were 18 percent of those questioned. It is estimated the majority of the polled manufacturers with energy conserving items did reply to the questionnaire.

A breakdown of the replies received shows seven in which untempered air varying from 60 to 90 percent of total air exhausted replaced exhaust of similar quantities of tempered air. Four systems used air cleaning, odor removal, and recirculation. Three reclaimed heat from the exhaust and used it to heat the

incoming air; while three other systems operated by reduction of the quantity of air exhausted. The air cleaning systems, of course, are restricted to electric heat; while the other approaches may be used either with gas or electric heating. The gases generated by combustion of solid or gaseous fuel may not be recirculated.

It was noted that chains of restaurants were major users of energy conservation methods. This presumably is because ordering for multiple installations reduces design costs.

There were six replies to the question in the survey calling for an estimate of future growth in the market for energy conserving hoods. They ranged from "Excellent" to "5 to 10 percent a year", 15 to 25 percent a year, 30 percent a year, to a maximum of trebling of the market from 1979 to 1980, and a 5 times multiplication from 1979 to 1981.

AFFIRMATIVE RESPONDANTS TO QUESTIONNAIRE

Manufacturer

Allied Air Products Company
6655 Creek Road
Cincinnati, Ohio 45242
Mr. Chris A. Noe
(513) 891-0400

AMF Wyatt, Inc.
1938 Wyatt Drive
Cheyenne, Wyoming 82001
Mr. E. H. Brown
(307) 634-5801

Bastian Blessing Co., Inc.
422 N. Griffin Street
Grand Haven, Michigan 49417
Mr. R. F. Plattner
Vice President of Engineering
(616) 842-7200

Cambridge Engineering, Inc.
P. O. Box 28609
St. Louis, Missouri 63141
Mr. James Siercy
Chief of Engineering
(314) 567-6767

Century 21 Pollution Control,
Inc.
5104 Hillsboro Avenue
Minneapolis, Minn. 55428
Mr. Walter Diachuk
(612) 535-3652

Gaylord Industries, Inc.
9600 SW Seely Avenue
P. O. Box 558
Wilsonville, Oregon 97070
Mr. David K. Black
Vice President
(503) 682-3801

Method Of Conservation

Make-up air heated by
exhaust heat of hoods by
use of 63 to 71 percent of
exhaust heat.

Grease removal is 99
percent.

Hood Exhaust may be 60 to
70 percent untempered air
from outside.

Untempered outside air up
to 85 percent of total
exhausted.

All air is cleaned and
recycled with 10 percent
fresh air added.

Use Heat Reclaim Units
to transfer heat from
exhaust to intake air.
Supplied data on savings.

Manufacturer

Industrial Industries, Inc.
12614 Hempstead Road
Houston, Texas 77018
Mr. Paul Ungerleider
Product Manager
(713) 462-6121

Jenn Industries, Inc.
3035 Shadeland Avenue
Indianapolis, Indiana 42226
Mr. John A. Bratt
Manager of Engineering
(317) 545-2271

L. D. I. Manufact. Co.
611 Erie Avenue
Logansport, Indiana 46947
Mr. Paul L. Buel
(219) 722-3124

The Molitron Company
Molitor, Inc.
P. O. Box 1457
Englewood, Colorado 80150
Mr. Fred L. Bloemendaal
Sales Manager
(303) 789-2231

Quest Cleanair Ventilator, Ltd.
871 Homer Street
Vancouver V6B 2W4
British Columbia, Canada
Mr. David Russell
(604) 685-9388

Vent-Cair, Inc.
P. O. Box 919
San Bernadino, Calif. 93402
Mr. Joseph A. Bagley
(714) 888-3191

Ventrogard, Inc.
2712 Landers Avenue
Nashville, Tennessee 37211
Mr. Donald Trittin
(615) 255-6541

Method Of Conservation

One model exhausts mixture with 75 percent untempered air. Second model cleans and recirculates 80 percent of exhaust.

Individual control of exhaust over separate heating units permits shut-off for items not in use. Claimed savings of up to 25% due to schedule of operation of various units.

Up to 80 percene of the hood exhaust air is untempered. Supplied an independent laboratory report on air quantities.

The heat in the exhaust system air-scrubbing water is reclaimed to heat or cool make-up air. Supplied comparative data on savings.

Air volume exhausted is reduced by 60 percent. Heat exchangers and air recirculation packages are available.

Up to 90 percent of exhaust is untempered air. Supplied data on savings.

Up to 80 percent of exhaust is untempered air. A ductless, air cleaning and recirculating system is also available.

Manufacturer

Ventwell Industries, Ltd.
2240 West Odgen Avenue
Chicago, Illinois 66012
Mr. Sidney Blumberg
Vice President
(312) 733-1290

Ventilation, Inc.
P. O. Box 14461
Houston, Texas 77021
Mr. Fideas Sanchez
(713) 741-3472

Method of Conservation

70 to 90 percent of exhaust
is untempered air. Supplied
data on savings.

One model provides up to
85 percent untempered air
for exhaust. Another model
reduces the exhaust air
volume by two-thirds to
reduce loss of tempered air.

NOTE: Although no completed questionnaire nor brochures in
response to the canvas were received from Seco Products
in St. Louis, field reports and brochures obtained
otherwise indicate their energy conserving product is
satisfactory.

REQUIREMENTS FOR KITCHEN HOODS

The major requirements for exhaust hoods for cooking equipment have been to remove cooking vapors from restaurant air, provide adequate air without window or door openings, prevent negative interior pressure greater than 0.02 inches of water, and promote safety from fire and other hazards. The primary source for these requirements has been NFPA No. 96-1976, "Standard for Vapor Removal from Cooking Equipment". This is issued by the National Fire Protection Association. Capacity of wall hoods is suggested at 100 cfm per square foot of hood area, 150 cfm per square foot for Island hoods, and 300 cfm per linear foot for "backshelf" type hoods. Velocity in exhaust ducts should be between 1500 and 2300 fpm.

These requirements are also demanded by building codes such as the Model BOCA Basic Mechanical Code/1978 or the Uniform Mechanical Code/1979.

No specific reference to hoods is contained in ASHRAE Standard No. 90-75 or 90-75R, which have set requirements for energy conservation of all sorts.

Hoods, Grease Extractors, Grease Filters, and Dampers may be listed by Underwriters' Laboratories, Inc. Listings appear under:

- Guide YXLT "Ventilating Equipment for Restaurant Cooking Appliances"
- Guide YXZR "Dampers"
- Guide YYMZ "Grease Extractors for Exhaust Ducts"
- Guide YZHW "Power Ventilators for Restaurant Exhaust Appliances"

Test procedures and requirements for "Grease Extractors for Exhaust Ducts" are contained in Underwriters' Laboratories, Inc. Standard No. UL710. UL197 contains procedures and requirements for "Cooking Appliances, Commercial Electric". UL555 contains procedures and requirements for "Dampers, Fire". UL586

contains procedures and requirements for "Filter Units, High Efficiency, Particulate, Test Performance Of".

Most manufacturers also obtain National Sanitation Foundation approval.

CALCULATIONS

The energy cost of exhausting heated or cooled air may be calculated from fundamentals such as the density of air at standard conditions (0.075 pcf) and specific heat (0.241 Btu/lb/°F) of air. This does not take into account power requirements for blowers or pumps, but only for heat content of air.

The most common method of estimation of makeup air heating costs is the formula given in Industrial Ventilation.⁵

$$\text{Yearly Cost} = \frac{0.154 \times Q \times D \times dg \times C}{q}$$

where:

- Q = air volume, cfm
- D = operating time, hours per week
- q = available heat per unit of fuel
(assume 1000 Btu/cubic foot for gas)
- dg = degree days/year
- c = cost of fuel, dollars/unit

Assume a 25 by 6 foot island hood operating at 150 cfm per square foot is located at Colorado Springs, Colorado where the average degree days total 6423 (ASHRAE data) and the hood is operated 80 hours per week. Assume also that the cost of natural gas is \$3.67/MM Btu or \$0.00367/cubic foot. (The cost was taken from a Department of Energy "representative average unit costs of energy" and was published in the Federal Register, Vol. 44, No. 125, June 27, 1979.)*

* Cost of 4 fuels were presented for residential use as follows:

<u>Fuel</u>	<u>Dollars/Million Btu</u>
Electricity	\$14.56
Natural Gas	3.67
No.2 Heating Oil	4.49
Propane	5.99

$$\text{Yearly Cost} = \frac{0.154 \times 22500 \times 80 \times 6423 \times 0.00367}{1000} = \$6,534.27/\text{Year}$$

If the exhausted tempered air is reduced by 75 percent, the cost is reduced to 25 percent of the above.

The proof of savings in energy submitted by respondents to the questionnaires in many cases was by calculations. The calculation method presented in the handbook "Industrial Ventilation" is extensively used by the proponents of a reduction in the volume of tempered air which is exhausted. Assuming that units work as designed, there is much merit to the method.

In addition to calculations, some of the respondents presented before and after energy costs when an energy conserving system had replaced a standard system. A second technique is to compare energy costs at comparable operations. In any of the cost comparisons, it is desirable to be sure comparisons are made with allowance for measures of weather severity such as degree days or summer cooling hours. Hours of operation and volume of operation must also be considered, as well as the type of operation. Frying operations will, of course, produce more exhaust products than will wet operations such as boiling.

Preparation of test methods for determining efficiency of energy conserving hoods would require different test methods for the differing methods of conservation. Completely different tests would be needed for methods which supply untempered air to the exhaust hoods as compared to those which reclaim heat from wash water or exhaust air. Air filtration and odor removal would depart still further from methods used for energy reclamation. All would be presumed to require actual simulation of cooking operations. Underwriters' Laboratories, Inc. Standard 710 on Grease Extraction does include actual cooking in broilers of eight meat cakes per foot of length of the exhaust hood on a

continuous basis until temperature equilibrium is attained. Liquid grease is also heated to 600°F and ignited to determine maximum exit gas temperature and fire safety. One manufacturer pointed out that their Underwriters' Laboratories, Inc. test program was conducted with untempered make-up air in quantities as recommended by the producer during the Fall of 1978. When the Underwriters' Laboratories, Inc. report is issued (tests were satisfactory), it should also serve to justify their untempered make-up air system by an independent test agency.

Several producers presented before and after energy consumption figures or comparison of similar units with standard and energy conserving hoods, where such information included the following:

1. Total energy consumption - gas, electricity, water
2. Weather data
3. Records of hours of operation for all units
4. Volume of food throughput

It is believed significant analysis of costs can be made and valid comparisons may be performed. Records of usage from energy and water utilities coupled with equipment and operation records may be corrected for weather variation and operational volume to yield significant data.

Controlled experiments may also be conducted at military bases to yield significant results. The facilities examined at Fort Carson, Colorado appeared very suitable for such experiments. It is suggested that installation of meters for gas and/or electricity and water used at mess halls would equip those facilities for conducting comparative evaluations. Military or institutional facilities are particularly suitable for comparisons as usage may be controlled in a manner not possible in commercial operation.

It should also be remembered that control of energy consumption used in slack usage hours with consequent lower charges or black box sequencing of energy use to avoid higher demand rates may offer significant savings.

Other sources of conservation such as heat exchangers on dishwater or laundry water discharge may also offer opportunity for savings.

It appears desirable to conduct such evaluations on three types of units:

1. Those which reduce the amount of tempered air exhausted by control at the hood rather than by supplying untempered air by means of inlet ducts. This appears to require the least capital investment.
2. Those which replace 60 to 90 percent of tempered with untempered air in the exhaust. This requires greater capital investment, but may offer equal or better rate of return.
3. Heat exchange units where exhaust heat is transferred to incoming air to reclaim otherwise wasted energy. The heat exchange may be from the water used for grease removal or directly from the exhaust gases.

For the type of installation used in military bases, units which filter, deodorize, and recirculate hood exhaust do not appear to be needed. Such units appear to be better suited to special locations where the cost of exhaust ducts is excessive.

The savings data presented by several producers is impressive, but is viewed as advertising data which may not have been obtained with as strict attention to engineering detail as may be required for definitive results.

In the absence of independently developed savings data it may be necessary to accept completely the figures presented by the manufacturers. If those figures are evaluated and comparisons made, it may be possible to discount possible over-optimistic claims.

If the presently installed hoods in a mess facility are satisfactory except for energy usage, it should be possible to save by wiring the blowers so that

individual exhaust units are not in operation when no cooking is being performed at that station. Jenn Industries, Inc. (see Pg. 5) claim that savings up to 25 percent may be achieved by such operation. The cost of rewiring must be viewed in terms of the possible savings and the payoff period determined. Savings may be achieved in fuel costs for air tempering, power to exhaust blowers, fuel to the cooking units turned off, water cost where scrubbing is part of the system, and light and heat if complete sections may be taken out of service.

A review of the data presented on pages 4 and 5 shows that, in general, three methods of energy savings are prevalent in the industry with one additional for special cases.

1. Individual control of exhaust fans over separate units. This is exemplified by Jenn Industries and investment in new units may be lower so that a satisfactory return on investment could be achieved.
2. Reduction of tempered air exhaust by design of the hood unit or by introduction of outside (untempered) air to replace tempered air as part of the exhaust stream. Ten manufacturers have such units available:

<u>Manufacturers</u>	<u>Percentage of Tempered Air</u>
Bastien Blessing	30-40
Cambridge Engineering	Down to 15
Gaylord	25
Industrial Industries	25
L. D. I. Mfg.	20-30
Quest	40
Vent-Cair	10
Ventrogard	20
Ventwell	20-30
Ventilation, Inc.	15

The low percent tempered air claims are those that should be more energy efficient. A group of four averages 15 percent while the remainder average 27 percent. The grand average is 24 percent.

3. Heat recovery from exhaust air which is used to heat incoming air. Six manufacturers have such units available:

<u>Manufacturer</u>	<u>Percentage of Heat Recovered</u>
Allied Air Products	63 to 71
Century 21 Pollution Cont.	60
Gaylord Industries	65
Industrial Industries	65
Molitron	"33% reduction in energy use"
Quest	"Custom designed"

Note: Three manufacturers appear on both lists as they produce both types of unit. It appears that 65 percent heat recovery efficiency is generally accepted.

4. Cleaning and recirculation of all air with electric cooking. (Gas cooking could yield harmful exhaust gases.) Because of the many items of expense on which savings may be achieved, it is best to use total operating expenses from well kept records to verify the system operating costs. Fuel cost for heating the exhausted air is the most significant amount of expense.

For those installations which reduce the volume of tempered air exhausted, the average reduced amount is 24 percent. Of the four producers who claim a larger reduction than average, only one presented energy use data. The data were not definitive on the amount of savings, due to unavoidable differences in the restaurants compared. However using the Industrial Ventilation formula⁵ and the data used as an example in the Calculations Section, the yearly (1978) cost for heating the air would be \$6,534. The average efficiency of air to air heat transfer units may be taken as 65 percent. The loss in heat should, therefore, be 35 percent or \$2,287 for a yearly savings of \$4,247. Three

of the six producers provided use data but only one of the sets of data was definitive. That did indicate a 30 to 35 percent savings. It must be remembered that initial cost and upkeep must be considered as well as energy cost and these should be estimated for each installation.

A suggested course for those considering action to conserve energy in mess hall operation is as follows:

1. Obtain, or take steps to obtain, operating cost data for a year for the existing facility. These should include amount used and cost for gas, electricity, water, detergents, etc., together with records as to personnel served and degree day data per month or per period of record. These will give the basis for justification of the change, as well as comparison figures to show what savings have been made after the change.
2. Prepare specifications for the facilities to be provided and advertise for bids on energy efficient equipment of at least two types. Request estimates on savings to be achieved and, if possible, guarantees as to minimum savings.
3. Examine the claimed performance in the submitted bids in light of the average figures presented in this report. Request proof of any larger-than-usual claims.
4. To evaluate a unit after installation, assume that energy usage is billed for the calendar month. In order to compensate for variability in the weather, the energy used should be expressed as quantity per degree day.

Monthly and annual summaries for degree days may be obtained from:

The National Climatic Center
Federal Building
Asheville, North Carolina 28801
Attention: Publication.

That is excellent for past records. If current monthly data is desired, it may be better to obtain it from the local weather station and avoid the delay for publishing. The average and 1976 data for the previous Colorado Springs example is as shown:

	<u>Average</u>	<u>1976</u>
January	1,128	1,075
February	938	782
March	893	891
April	582	512
May	319	314
June	84	80
July	9	0
August	25	11
September	132	191
October	456	593
November	825	859
December	<u>1,032</u>	<u>988</u>
Annual	<u>6,423</u>	<u>6,296</u>

In the example in the "Calculations" section, the following data would be developed:

1. Note the standard degree days are developed on a 65°F basis. The hall air temperature was assumed as 70°F. On that basis, the annual average degree days would be $6,423 \times \frac{70}{65} = 6,917$.
2. Gas consumption records will be in hundred cubic feet (CCF). If we assume the records show 35,000 CCF were used during the heating season, the corrected usage would be $\frac{35000}{6917} = 5.06$ CCF/degree day.

3. This usage figure may then be compared to figures developed for previous years to determine what heating savings were achieved through the improved hood design.
4. If electric heating is employed, the record of consumption is kilowatt hours (KWH). The comparison is similar with corrections made for recorded degree days and usage per degree day compared to previous records. One KWH equals 3,413 BTU.
5. If prediction of savings from a proposed system is desired, the comparison would be made on the basis of reduction in heated air exhausted.

CONCLUSIONS

Atmospheric vented kitchen draft hoods can be a source of significant energy loss through displacement of tempered air.

New types of energy-efficient hoods offer some potential for conserving energy and reducing operating costs.

Electric switch installation and time-management of existing hoods may offer a viable alternative to replacing older hoods with energy-efficient units.

RECOMMENDATIONS

Follow the guidelines in Appendix I to compare three alternatives for energy conservation in the selection and operation of kitchen exhaust hoods.

REFERENCES

- ¹National Restaurant Association, "Restaurant, Hotel, Motel Show", McCormick Place, Chicago, May 20 to 24, 1978.
- ²Gas and Oil Equipment Directory, September 1978, Underwriters' Laboratories, Inc. Guide YXLT, "Ventilating Equipment for Restaurant Cooking Appliances". Also, YXZR, "Dampers"; YYMZ, "Grease Extractors for Exhaust Ducts"; and YZHW, "Power Ventilators for Restaurant Exhaust Appliances".
- ³Building Standards, July-August 1978, Research Committee Reports of International Conference of Building Officials, "Ventilation and Grease Extractors".
- ⁴Research Report Listing, April 1978, Building Officials and Code Administrators International, "HVAC Systems and Equipment".
- ⁵Industrial Ventilation - American Conference of Government Industrial Hygienists, 14th Edition, 1976, pg. 7-11 to 7-19.
- ⁶Energy Audit Procedures, Federal Energy Administration, Federal Register 6/29/77.

APPENDIX A

GUIDELINES FOR CALCULATION OF ENERGY SAVINGS AND PAYBACK FOR KITCHEN EXHAUST HOOD ALTERNATIVES

- I. Calculate estimated annual cost to heat replacement air for tempered exhaust air lost through existing exhaust hoods.

Use Industrial Ventilation Formula:

$$\frac{0.154 Q D dg c}{q}$$

Q = Air volume exhausted by fan, cfm
D = Fan operating time, hours per week
dg = Degree days per year for your location
q = Heat content of fuel unit*
c = Fuel cost, dollars per fuel unit

Answer will be dollars per year at present operating cost.

*Examples - 100,000 BTU per 100 cu. ft. natural gas
140,000 BTU per gallon fuel oil

- II. Calculate annual dollar savings from each of three alternatives:

A. Rewire present units so that individual units may be turned off when their use is not required. Multiply annual cost from I by required hours per week of operation and divide by present hours per week of operation. Subtract this answer from the annual cost and the final answer will be dollars per year estimated savings.

- B. Replace present unit(s) with units which reduce or replace tempered exhaust air. Multiply annual cost from I by 0.76. Note that the factor, 0.76, may be replaced by the actual factors for units being considered IF the manufacturer provides reliable engineering data to support his claim. Answer will be dollars per year estimated savings.
- C. Replace present units with exhaust air heat recovery units. Multiply annual cost from I by 0.65. Note that the factor, 0.65, may be replaced by the actual factor for units being considered IF the manufacturer provides reliable engineering data to support his claim. Answer will be dollars per year estimated savings.

III. Calculate estimated payback time for alternatives, IIA, IIB, IIC, using the expression:

$$Y = \frac{\log \left\{ \frac{C}{aS} (a-1) + 1 \right\}}{\log a}$$

Y = Years to payback investment

C = Installed cost of kitchen vent hood alternatives IIA, IIB, IIC in turn.

$$a = \frac{1 + 15}{1 + 12} \text{ (15\% energy escalation rate) / (12\% interest rate)}$$

Note: Interest and escalation may be adjusted as circumstances dictate.

S = Annual energy savings for each kitchen vent hood alternative IIA, IIB, IIC in turn.

In general, the alternative with the shortest payback time will be the best choice. There are, obviously, other considerations which enter decision making processes. For examples:

*Wiring modifications under IIA would not be a wise choice if the remaining estimated useful life of present hoods is less than the payback period.

*Budget constraints may, at times, eliminate one or more alternatives.

IV. Calculate estimated annual energy savings from each of three alternatives.

Estimated energy savings are easily calculated from the information used on Page 20 and Page 21 as follows:

Divide dollars per year from IIA, IIB and IIC by fuel cost, C , from I. Multiply this answer by heat content of fuel unit q , from I. The answer will be BTU's per year estimated savings.

APPENDIX B

SURVEY OF THE KITCHEN EXHAUST HOOD INDUSTRY

The purpose of this survey is to provide information as to available or proposed energy saving devices which will reduce energy consumption in commercial kitchens. The information you provide will be incorporated into a document providing authoritative, State of the Art information on kitchen exhaust hood equipment. It is intended that this document will be used by Military Service Specifying Authorities in future procurement and as a guide to energy saving possibilities by Regulatory Bodies, Manufacturers, Installers, and Consumers.

NAME OF COMPANY

STREET ADDRESS OR P.O. BOX, CITY, STATE, ZIP CODE

NAME OF PERSON RESPONDING
TO THE SURVEY

TELEPHONE NUMBER

INSTRUCTIONS

Please prepare and return one (1) copy of this survey for each item of equipment now manufactured or proposed to:

Mr. R. H. Neisel
Johns-Manville Sales Corporation
Research & Development Center
Ken-Caryl Ranch
Denver, Colorado 80217

303-979-1000, Extension 4384

If information is not provided because it is proprietary, please indicate.

If information is not available, please so state.

If more space is necessary, please use the back page.

This form may be reproduced or additional copies are available upon request.

Thank you for your cooperation and assistance.

1. TYPE OF EQUIPMENT MANUFACTURED

a. Description:

b. Model Designations and Limits:

c. Method of Operation for Energy Saving:

2. CAPACITY OF EQUIPMENT AND TYPE OF KITCHEN FOR WHICH DESIGNED

a. Exhaust Capacity - Cubic Feet/Minute:

b. Dimensions:

Length	feet	inch
Depth	feet	inch
Height	feet	inch

c. Type of Kitchen:

Snack Bar	Yes	No
Restaurant	Yes	No
Mess Hall or Large Restaurant	Yes	No
Single Family Dwelling	Yes	No

d. Other Details:

3. PRINCIPLE OF OPERATION FOR ENERGY CONSERVATION

a. Reduction of Conditioned Air Exhausted:

b. Recovery and Reuse of Heat Energy:

c. Cleaning, Odor Removal, and Recirculation of Air:

d. Other. Please Describe.

4. INDICATED MARKETS

a. New Construction:

b. Replacement:

c. Retrofit:

d. Commercial Food Preparation:

e. Institutional Food Preparation:

5. JUSTIFICATION OF ENERGY CONSERVATION CLAIMS

a. Engineering Calculation. Please Describe or
Send Copies:

b. Records of Energy Use Before and After
Installation. Please Detail:

c. Test Programs. Please Detail or Send Copies:

1) In-House:

2) Governmental, Association, or Commercial:

6. RESTRICTION ON USE OR INSTALLATION

a. Type of Installation:

b. Code or Specification Approvals or Compliance:

1) Model Building Code or Other Approval:

2) NFPA Standard Compliance No. 96-1976 or
Other:

3) ASHRAE Standard 90-75 or 90-75R:

4) Underwriters' Laboratories or Other Listing:

5) Other:

7. WHAT IS YOUR ESTIMATE OF THE FUTURE GROWTH OF THE ENTIRE
INDUSTRY FOR ENERGY CONSERVATION IN KITCHEN EXHAUST HOODS?
DIRECT COMMENTS TOWARD ESTIMATES IN THREE YEAR INCREMENTS
STARTING IN 1979.

8. DISTRIBUTION

a. Distribution Channels Principally Used:

Direct	Contractor
Dealer	Other

b. Do Distribution Patterns Differ by Geographical Area? If So, How? See attached Federal Energy Administration Regional Map as a Guide.

c. What Degree of Control do You as a Manufacturer have Over the Installation of Your Product?

1) Own Installation:

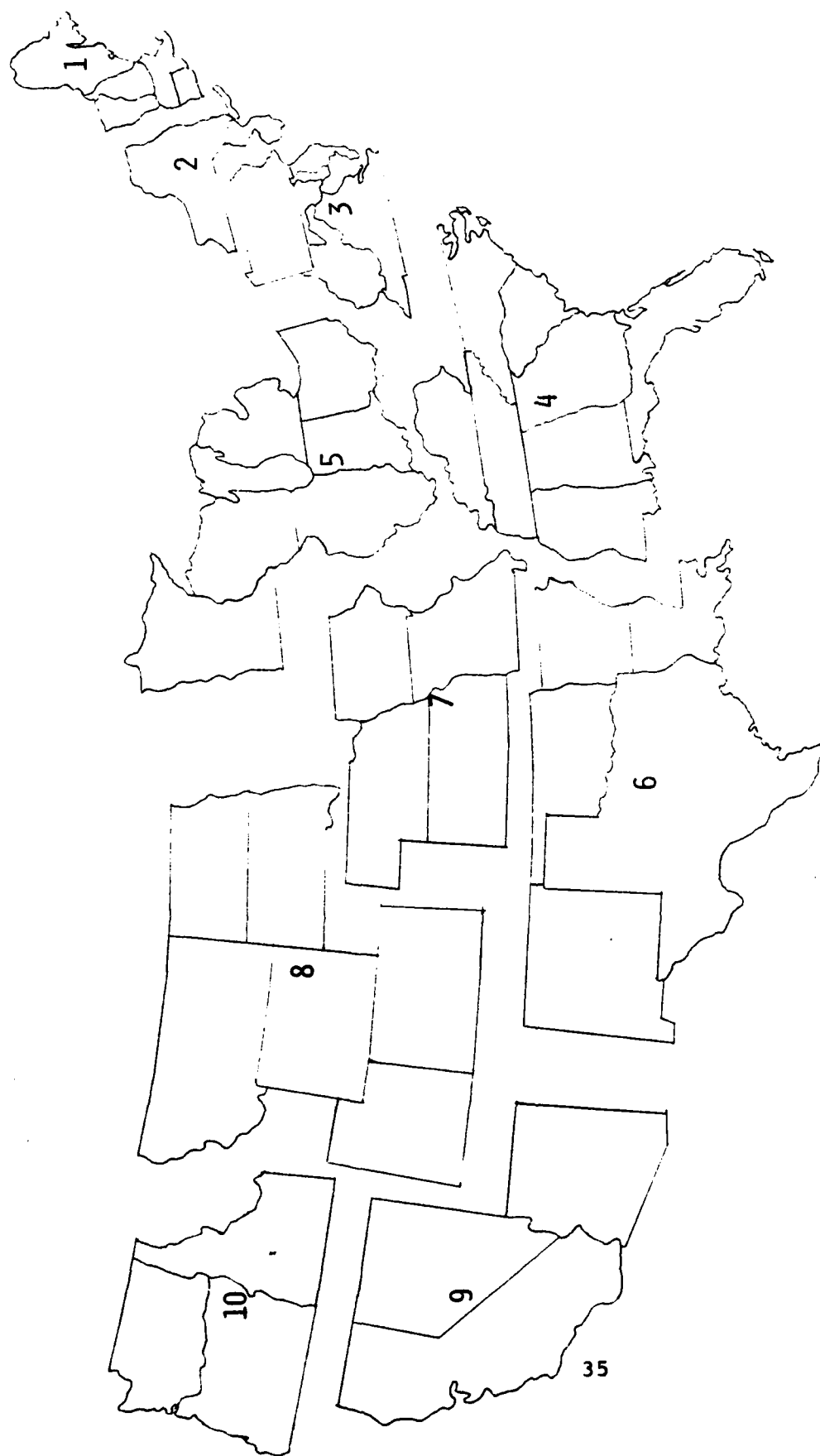
2) Licensed Installer:

3) None:

4) Comments:

9. WHAT ARE THE APPROXIMATE CURRENT INSTALLED COSTS TO THE ULTIMATE PURCHASER OF YOUR PRODUCTS BY THE FEA REGIONS? DO YOUR PRICES VARY ONLY BY SHIPPING CHARGES AND WHAT ARE THE FOB LOCATIONS?

10. ADDITIONAL REMARKS:



FEDERAL ENERGY - REGIONS
ADMINISTRATION

APPENDIX C
VENTILATION SYSTEMS

These illustrations show the manner in which various ventilation and energy conserving systems operate. The illustrations are reproduced, with permission, from brochures printed by various manufacturers.

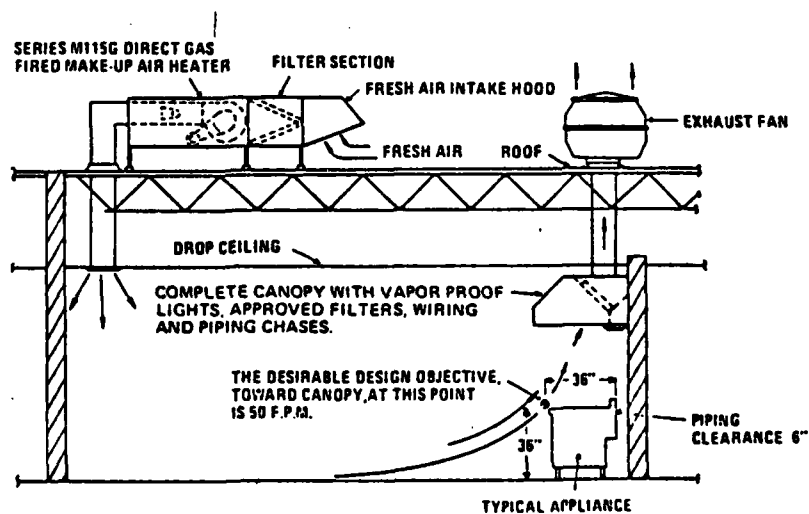
Methods

THE TRADITIONAL PUSH-PULL SYSTEM

TYPICAL MINIMUM CODE VENTILATION REQUIREMENTS AND ACCEPTED RULES OF THUMB.

(MINIMUM ONLY - CERTAIN APPLIANCES REQUIRE GREATER FLOW RATES)

1. CANOPY SIZED - A) ON 100 FPM ACROSS FACE WHEN WALL MOUNTED (OPEN ON 3 SIDES, AS SHOWN)
B) ON 150 FPM ACROSS FACE WHEN CEILING HUNG (OPEN ON ALL SIDES, ISLAND LOCATION)
2. VENTILATION RATE: 4 C.F.M./SQ. FT. OR 20 TO 30 AIR CHANGES PER HOUR, FOR ENTIRE KITCHEN AREA.
3. NFPA #96 IS THE STANDARD THAT SHOULD BE USED.



Systems advantages:

1. lowest installed costs.
2. effective ventilation: tried and proven - it works.
3. preserves traditional selection and purchasing procedures.
4. effective "free" kitchen cooling when outside temperatures are below 75°F.

Systems disadvantages:

1. may require systems coordination by owner, general contractor, consultants, etc., and all suppliers to provide a complete integrated system.
2. true air conditioning will be expensive both in first and operating costs.

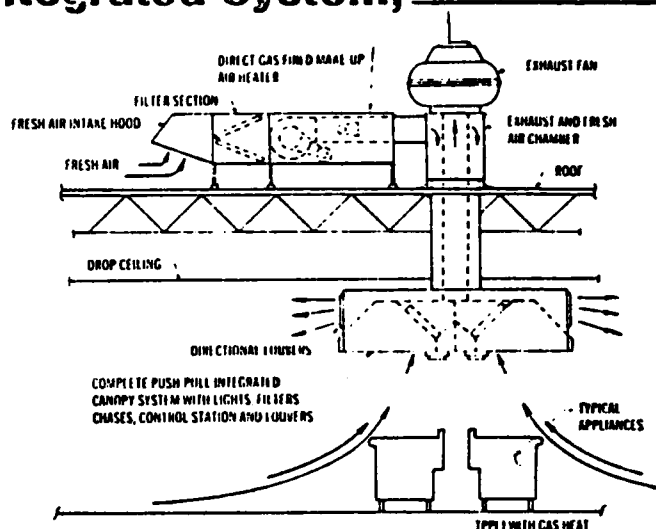
the Traditional Push-Pull Integrated System;

System Advantages:

1. Effective ventilation — tried and proven, it works.
2. Single source responsibility.
3. Low installed cost.
4. Meets all national codes, NFPA Bulletin #96 and NSF Bulletin #33 bulletins, as standard.

System Disadvantage:

True air conditioning only possible at high first cost and operating cost.



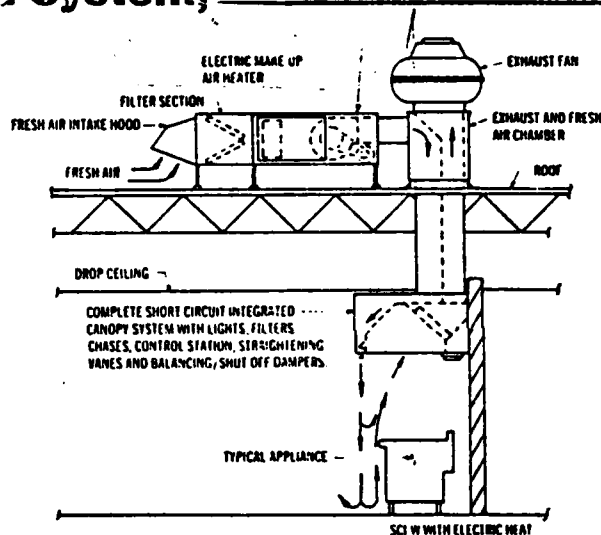
the Short Circuit Integrated System;

System Advantages:

1. Effective ventilation — tried and proven, it works.
2. Single source responsibility.
3. Low installed cost.
4. Meets all national, NFPA Bulletin #96 and NSF Bulletin #33, standards.
5. Reduces air conditioning requirements from 70-85%

System Disadvantage:

System, as standard, includes opposed blade dampers and adjustable straightening vanes in the slot to control air flow at ambient make-up air temperatures below 75° F. This may not be effective under all conditions.



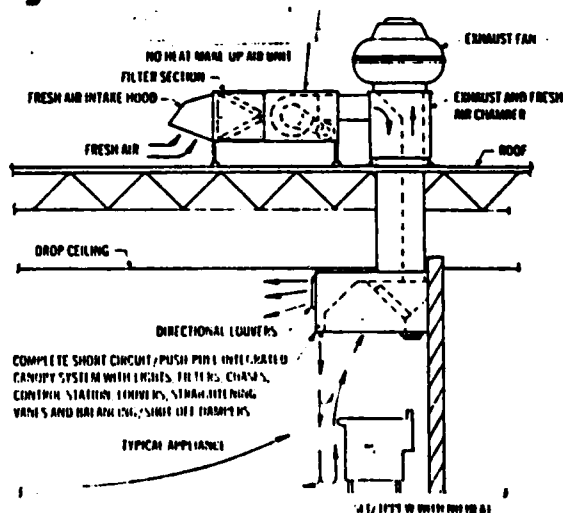
the Combination Integrated System.

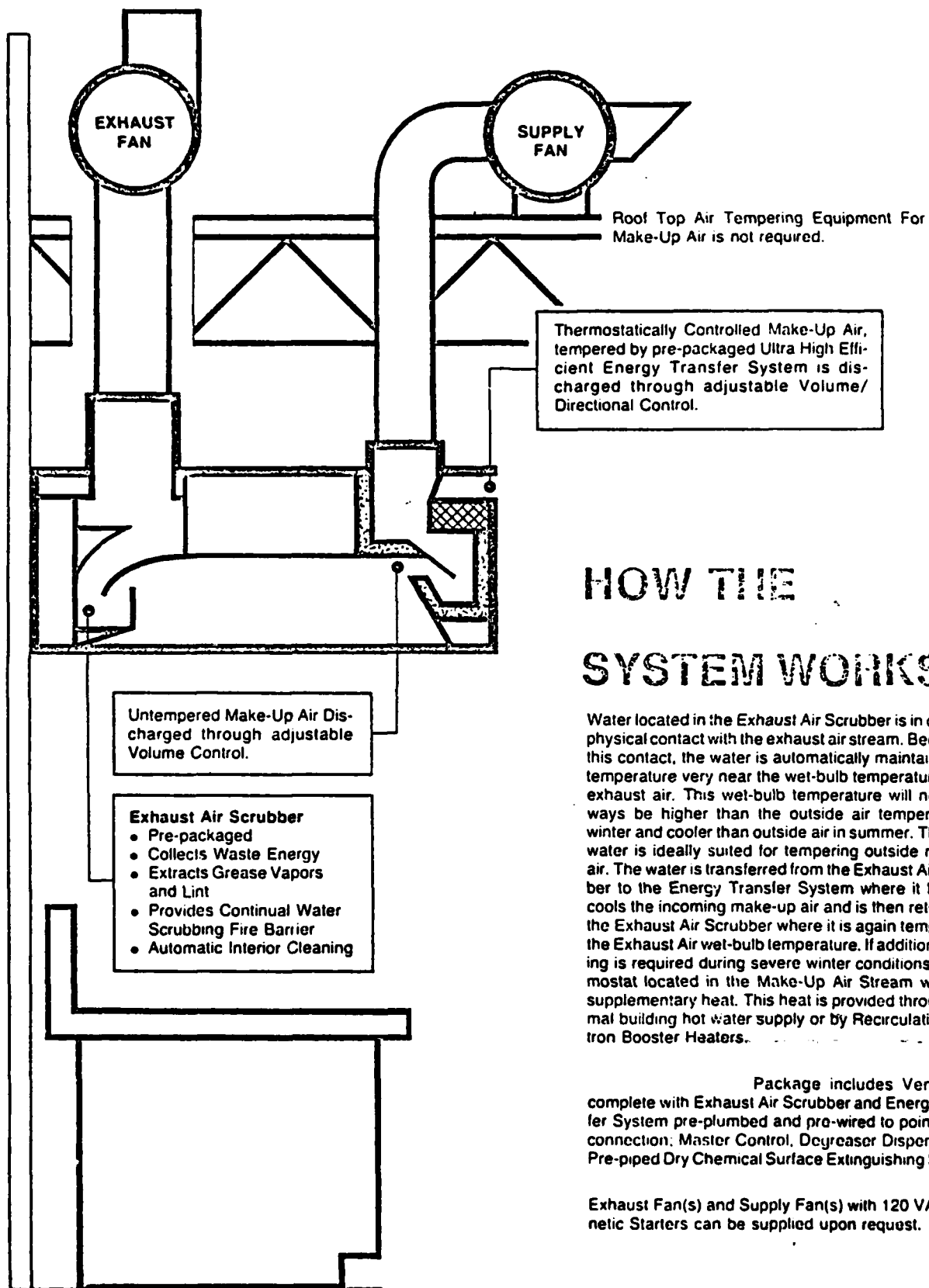
System Advantages:

1. Effective ventilation — tried and proven, it works.
2. Single source responsibility.
3. Low installed cost.
4. Meets all national, NFPA Bulletin #96 and NSF Bulletin #33, requirements.
5. Reduces air conditioning requirements from 70-85%
6. Proper comfort conditions can be maintained all year round regardless of ambient conditions — a space thermostat can also be provided to provide for true free cooling.

System Disadvantage:

1. None.





HOW THE SYSTEM WORKS

Water located in the Exhaust Air Scrubber is in constant physical contact with the exhaust air stream. Because of this contact, the water is automatically maintained at a temperature very near the wet-bulb temperature of the exhaust air. This wet-bulb temperature will nearly always be higher than the outside air temperature in winter and cooler than outside air in summer. Thus, this water is ideally suited for tempering outside make-up air. The water is transferred from the Exhaust Air Scrubber to the Energy Transfer System where it heats or cools the incoming make-up air and is then returned to the Exhaust Air Scrubber where it is again tempered to the Exhaust Air wet-bulb temperature. If additional heating is required during severe winter conditions, a thermostat located in the Make-Up Air Stream will order supplementary heat. This heat is provided through normal building hot water supply or by Recirculating Molition Booster Heaters.

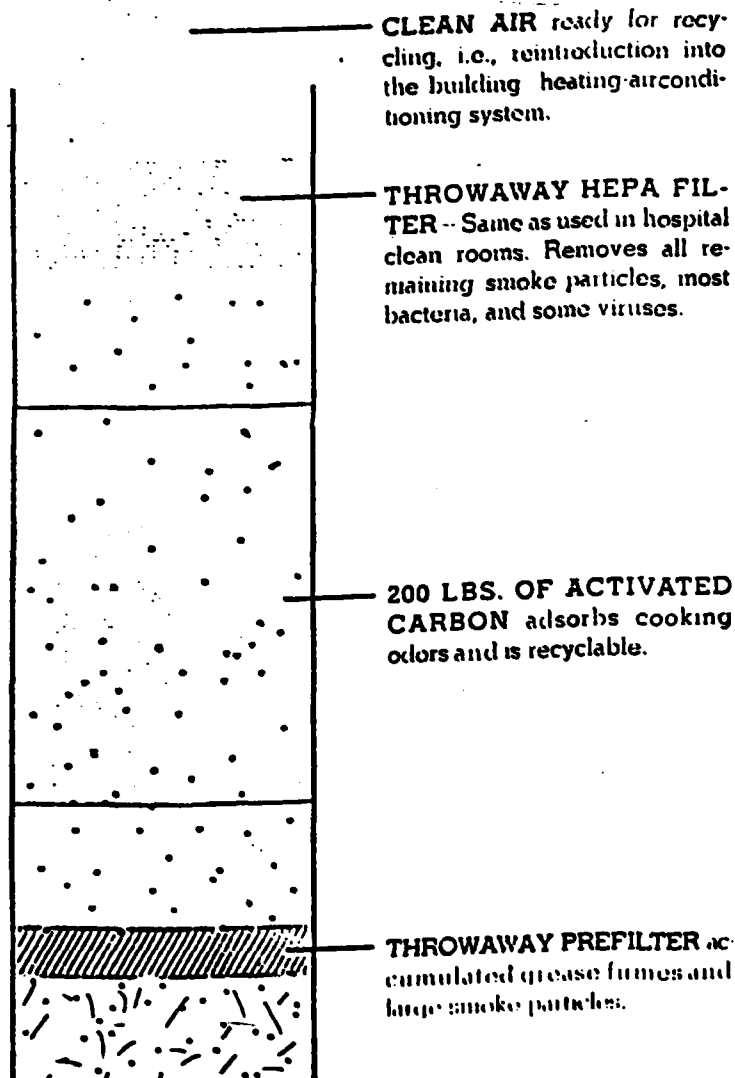
Package includes Ventilators, complete with Exhaust Air Scrubber and Energy Transfer System pre-plumbed and pre-wired to point of final connection; Master Control, Degreaser Dispenser and Pre-piped Dry Chemical Surface Extinguishing System.

Exhaust Fan(s) and Supply Fan(s) with 120 VAC Magnetic Starters can be supplied upon request.

a three stage, high efficiency, fume, odor and smoke removing system, designed to operate with the Twister hood, over electrical cooking equipment. The exhaust air is then returned to the building heating-airconditioning system for energy conservation.

Air purifying modules handle up to 1500 cfm of air. They are of stainless steel construction and may be ganged to increase system air handling capacity.

The control module contains gauges and circuitry to measure and display the status of each filter section.



ENTERING AIR

