Fuel Consumption in Industrial Buildings

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SUMMARY

Annual fuel consumptions for seven large factories are compared against calculated requirements to illustrate seasonal thermal efficiencies of 7.7 to 49.7 per cent. Ineffective and uncontrolled ventilation is shown to be by far the most significant factor leading to fuel consumptions several times the necessary requirements.

Fuel savings of 38 to 80 per cent which have been achieved are illustrated.

Fuel savings of 20 to 80 per cent are shown to be possible in the factories studied, with 35 to 95 per cent savings possible where heat recovery is provided in addition to other improvements.

1 INTRODUCTION

Much of the attention now being given to reducing fuel consumption for space heating of industrial premises is misdirected as a result of an inadequate understanding of the various factors involved.

There is an absence of recognised criteria against which present fuel consumptions can be judged. Boiler plant combustion efficiencies and conventional assessments of annual fuel consumptions can be highly misleading if the heating and ventilating systems are ineffective, or based on extravagant design criteria.

This paper examines industrial heating and ventilating systems of widely different designs to draw attention to the very substantial fuel savings which can be made by the effective application and control of ventilation, by improved thermal insulation and by heat recovery from exhaust air.

2 PRELIMINARY CONSIDERATIONS

It is essential to consider why heating and ventilation are required in industrial premises, as follows:-

(a) To maintain satisfactory control of temperature, humidity and air movement in the working zone.

(b) To provide sufficient fresh air to meet the requirements of personnel.

(c) To remove, or to limit within acceptable levels, the build-up of objectionable fumes and contaminants.

(d) To provide make-up air to replace that extracted by process plant or equipment.

Whilst these four criteria should be considered as fundamental, two or more appear in many installations to have escaped the designers' and specifying authorities' attention, as will be illustrated in this paper.

Limitations to the capital expenditure during the initial construction have, in many cases, placed restrictions on the Engineering Systems adopted. With increased fuel costs, which will continue to rise, it is now clearly in the national interest that priorities are reconsidered. New buildings and engineering systems must be constructed for minimum energy consumption consistent with the minimum life cycle costs, taking fuel, maintenance costs and relevant interest charges on capital expenditure into account.

3 HEATING AND VENTILATING SYSTEMS IN THE PREMISES STUDIED

The heating and ventilation systems in the premises studied included a variety of alternative designs, from which a selection has been listed in Table I.

These premises include large modern industrial buildings with the usual office accommodation.

The premises studied provide for a range of engineering manufacturing and assembly activities, collectively representing a total floor area exceeding 240,000 m² and accommodating over 5,000 persons.

4 EFFECTIVENESS OF THE SYSTEMS

Each of the systems reviewed in the paper provide adequate temperatures in cold weather, with the exception of areas suffering infiltration of cold draughts, particularly near external doors. It is disappointing that there were no corresponding complaints of 'warm' draughts from roof ventilators or other openings which permit the escape of warm air and provide 'stack effect' which increases the infiltration at the doors and windows.

Many ventilation and temperature control problems have remained unsolved, particularly in areas with high temperature process equipment. In most cases, additional roof extract fans, or natural ventilators, have been installed to release excess heat emitted and reduce overheating during mild and warm weather. Whilst these measures to some extent alleviate overheating locally, the exhaust ventilators discharge high volumes of heated air, drawn from surrounding areas within the factory. In doing so, infiltration problems are aggravated in surrounding production areas, particularly near doors and windows.

Further complaints, commonly found, arose with systems incorporating conventional unit heaters and downstream fresh air supply units mounted over a wide range of heights within roof trusses. Whilst these units are still in common use, experience, computer analysis of discharge characteristics and smoke tests of air movement, have shown their limitations in providing satisfactory air distribution and overcoming stratification. This leads to excessive temperatures at roof level and wasteful fuel consumption, illustrated in Tables III and IV and Figs 11—14.

Details of the systems and their effectiveness are given in Table II.

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5 ANNUAL FUEL CONSUMPTIONS

Recent annual fuel consumptions of the selected premises are listed in Tables III and IV indicating fuel consumptions for unit area and unit volume, in addition to seasonal thermal efficiencies of the systems. Monthly comparisons of actual fuel consumptions for four of the premises studied are given in Figs 11—14.

It is normal practice to estimate annual fuel consumption on a degree day basis, base 15.5°C (60°F), on the assumption, usually unchecked, that the heat gains from personnel, lighting and equipment will provide a 3°C (5°F) temperature rise. This practice to-day is inexcusable for industrial premises where internal heat gains usually represent 20 per cent of the maximum heat input required, often substantially more. These gains represent a substantial 'bonus', illustrated in Fig 5, which should be evaluated and recovered instead of being rejected.

For this paper, each of the premises have been compared on a similar degree day basis and on the average internal temperature actually maintained, taking into account construction differences, height factors, exposure, hours of operation and the heat gains experienced from lighting, power, process applications and occupants.

In view of the wide range of design criteria and arrangements for ventilation, each of the estimated annual fuel requirements have been calculated on the systems original design criteria.

Estimated heat gains from solar radiation have also been included in the comparisons to take account of the very substantial differences between the premises, particularly in respect of roof glazing.

The tabulated comparisons of fuel consumptions and Seasonal Thermal Efficiencies of conventional systems, between 7.7 and 47.7 per cent, make it abundantly clear just how inefficient and ineffective the majority of installations are. Why is this the case and how can substantial improvements be introduced?

6 GENERAL CONCLUSIONS AND FURTHER INVESTIGATIONS

Tabulated results clearly show that higher standards of thermal insulation do not in themselves ensure low fuel consumption.

Whilst the fuel consumptions in each instance reflect deficiencies in many respects, including the use of higher than intended internal temperatures, each of these factors is small in proportion to the losses from excessive ventilation and infiltration.

Comparisons show unexpectedly high fuel consumptions in each of the premises in which process plant provides high heat emissions into the factory, despite the 'bonus' of heat gains. Although, apparently illogical, this is explained by wasteful extract ventilation accompanied by increased air infiltration, arising from ineffective ventilation for cooling in the process areas.

In one example of this problem, it was found that in addition to the supply and extract ventilation units originally installed in the heat treatment area, a further 42 large roof mounted supply and extract fans had been added, without significant benefit. Further action had been taken to enable 124 fire ventilators to be used for heat release through the roof, thereby achieving, in total, an overall extract ventilation rate for the *whole* factory almost double the original design criteria. This resulted in doubling the net heating requirements and possibly trebling the annual fuel consumption without solving the original problem, but adding to discomfort from draughts in other areas of the factory.

It is not generally appreciated that ventilation and infiltration losses often account for 50—70 per cent of the design heat requirements. When wasteful extract ventilation is applied to overcome ineffective design, the fuel consumption may be multiplied several times, still without the occupants being comfortable. This is illustrated clearly in Fig 12 showing the actual fuel consumption in Premises E, with a calculated seasonal thermal efficiency of 7.7 per cent.

7 REVIEW OF VENTILATION DESIGN CRITERIA

The recognised infiltration design allowances are based on estimates of 'fortuitous leakage of air due to imperfections in the structure'. Whilst they may be calculated, with dubious accuracy, these allowances are used by design engineers to ensure that adequate heating capacity is available under the most severe external design conditions. They do not relate to ventilation rates considered necessary, only to what may be expected unless particular care is taken to limit infiltration.

The Factories Act defines the minimum permissible rate of ventilation to be 5 litres/s (10 cubic feet/minute) per person. Whilst this may prove to be impracticably low for satisfactory fresh air distribution, or for make-up air to factory premises, it emphasises the degree of inefficiency permitted or even designed into most installations. Arbitrary 'air change' criteria often give 50—100 times this figure, as illustrated in Table II, still with unsatisfactory results.

Recognition must, of course, be given to potential hazards arising from concentrations of dusts, fumes or chemical contaminants, cooling requirements near process equipment and the requirements for general summer cooling. These must not be confused with normal day-to-day fresh air requirements during the heating season.

Whilst a few industrial processes demand high general exhaust ventilation rates, the majority of cases may be more effectively and more economically controlled by screening or local extract equipment operating in conjunction with appropriate make-up air supply systems.

Experimental work has repeatedly shown that for comfort the speed of air movement is important. Not only must air movement reach minimum levels, but it must not exceed maximum levels, usually within the range of 0.1m/s—1.5m/s.

Accepted velocities will, in each case, depend on the level of physical activity of the subject, the air stream temperature, humidity and the mean radiant temperature of the surroundings. Recent tests in several of the premises confirmed practically no measurable air movement in the working zones, other than immediately below fresh air supply units and near external doors.

It is suggested that the arbitrary air change rates, currently in use for factory ventilation systems arise from past experience of inadequate air movement and poor air distribution, rather than insufficient fresh air supply. Not only are stagnant air conditions detrimental to comfort and fume concentrations, but encourage stratification, whilst the boilerplant is permitted to continue firing, achieving little more than continuous loss of hot air through the roof ventilators.

Factories are generally less densely occupied than offices and do not readily lend themselves to a fresh air supply related to occupation levels. Despite this, the fresh air, where provided at all, is frequently introduced at low velocity from large high level units remote from the majority of the personnel. It is hardly surprising that the quantity of fresh air supplied by this method must be grossly excessive to achieve satisfactory results.
Each of the premises in the survey has been studied using alternative ventilation design criteria, listed in Table V, to illustrate the potential fuel savings arising from effective ventilation and control of infiltration. The potential fuel savings, as high as 70—80 per cent, indicate that two of these premises consume *at least three times* the fuel that should be necessary, and a further two consume almost twice that considered necessary.
The validity of these conclusions is illustrated in Tables III and IV, particularly Premises B which operates at approximately 60 per cent of fuel consumption of the previous conventional system (Premises A), *whilst also providing an effective ventilation system* for dispersal of welding fumes.
It had earlier been thought that a substantial increase in fuel consumption would be unavoidable in eliminating the fume problem.*

8 FUNDAMENTAL REQUIREMENTS FOR EFFECTIVENESS AND FUEL ECONOMY

Only the careful selection of appropriate design criteria and effective application of these under proper control can achieve optimum working conditions with minimum operatings costs. Higher temperatures and particularly higher air changes, whether intentional or accidental, can drastically increase fuel consumption, as illustrated in Figs 1, 2, 7 and 8. The first requirement, therefore must be to establish the particular requirements of the occupants and the activities, the minimum air supply, exhaust and make-up air requirements. In particular, requirements for summer or local cooling should be established from assessments of the heat gains, and acceptable internal design criteria. Only thereafter can these criteria be designed into an effective and economic system.
Effective air distribution and the facility for selection of the minimum fresh air supply and exhaust are essential for economic operation during the heating season.
Attention must be given to prevention of infiltration with door curtains etc: and sealing of gaps in the structure wherever practicable.
Systems must be designed to take advantage of heat gains from lighting and equipment. Systems which permit stratification of air at high levels, due to inadequate air circulation rates, should be avoided, particularly where roof extract ventilation is to be used.
Heating systems should incorporate fully modulating temperature control equipment and be zoned to avoid local overheating. Provision should be made for door heaters to operate independently of a central plant in mild weather, when heating will not be generally required.

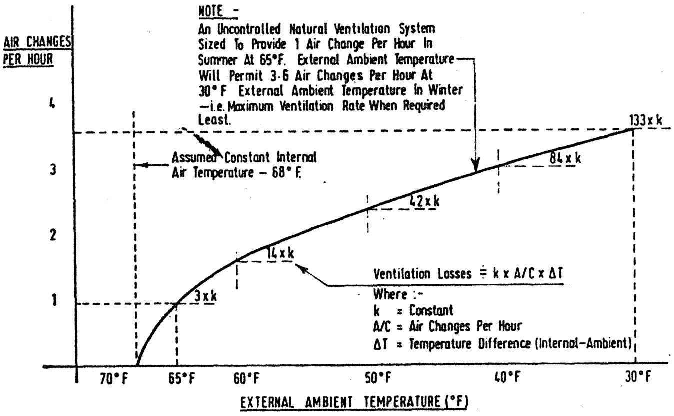

Fig 1—Effect of External Temperature on Natural Ventilation System.

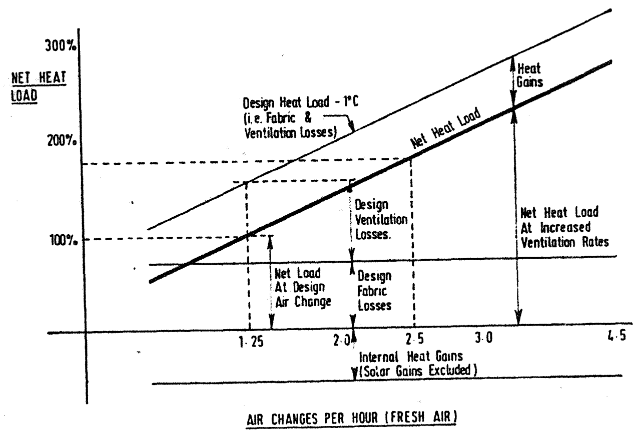

Fig 2—Typical Graph of Heat Load against Air Changes.

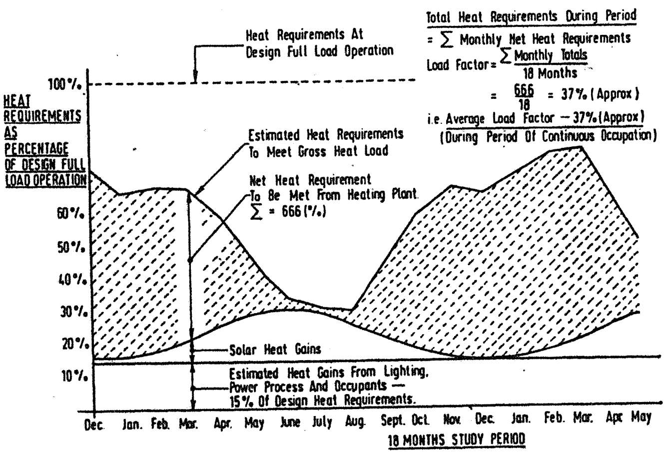

Fig 3—Monthly Heat Requirements: Average Industrial Premises—Without Machinery and Process Heat Gains.

Where local cooling is required, designs must incorporate supply ventilation systems capable of delivering ambient or tempered air directly into the working zone. Extrac

*Extensions to Premises B to provide machining facilities of 11,000 m², only recently completed and incorporating many improvements, are expected to operate with *further* fuel savings of 62 and 90 per cent, compared to Premises B, in the zones where heat recovery has been incorporated, and offers savings of 72 and 75 per cent in other zones where controlled ventilation and improved thermal insulation are proposed and where the addition of heat recovery to existing equipment could not be economically justified. A further project involving the modernisation of existing factory premises of 14,420 m², completed in 1976, shows fuel savings of approximately 80 per cent against the previous level prior to modernisation and renewal of the heating installation.
In each of the cases mentioned above the improvements were subjected to individual consideration and proved to be financially justifiable with periods as short as 25 months for the repayment of the capital expenditure involved.

Table I: Outline of Heating and Ventilation Systems Installed

Premises	Factory Activities	Outline of Heating and Ventilation Systems in each of the Premises
A	Heavy structural fabrication, welding and machining.	Coal fired steam boiler plant, steam unit heaters and high level (10m) fresh air supply units. Natural draught roof ventilators in addition to extract from paint booths.
B	Heavy structural fabrication, welding and machining.	LPG (Butane) direct fired heating and ventilation units ducted to adjustable supply louvres above head level (3m). Natural draught roof ventilation units and ventilators, each under control of a central monitoring console.
C	Heavy structural assembly, finishing and vehicle engine test facilities.	Oil fired HPHW boilerplant, high temperature radiant strip heating and high level fresh air supply units (11m). Supply and extract to balance paint booth. General exhaust by roof extract fans linked with air supply units.
D	Components storage centre, with large receiving and despatch areas.	Oil fired indirect air heaters with high temperature and high velocity air distribution ducted to injector diffusers mounted within the roof trusses (7m). Roof extract fans for summer use only.
E	Machining and assembly, including extensive heat treatment facilities.	Oil fired LPHW boilerplant and unit heater installation. No fresh air supply. Extract by means of roof ventilators with additional extract from heat treatment areas.
F	Light machining, chemical treatment and assembly, with mainly female staff.	Oil fired steam boilerplant with unit heater installation, including fresh air supply units at high level (4m). Extract by means of roof extract fans with additional extract in process and treatment areas.
G	Light machining and assembly work. Extensive storage for completed products.	Oil fired steam boilerplant with unit heater installation, including fresh air supply units at high level (4m). Extract by roof extract fans.
H	Machining and assembly line production, with extensive heat treatment area.	Oil fired HPHW boilerplant with radiant strip heating and with fresh air supply units at high level (7m). Extract by means of roof extract fans linked to air supply units, supplemented by additional fans and natural draught ventilators.

Table II—Ventilation Design Criteria and Effectiveness of Systems Instaled

Premises	Ventilation Design Criteria-Winter Fresh Air Supply			Effectiveness of Systems Installed
	Air changes per hour (overall)	Litre/sec per m² (cfm/sq.ft)	Litre/sec per person (cfm/person)	
A	1.5 (natural)	5.1 (1.00)	401 (8.50)	High level air supply and extract units ineffective for fume dispersal or removal. System unable to provide adequate temperature control or local cooling. Excessive infiltration at doors. System replaced by 'B'.
B	1.5 (Mech)	5.1 (1.00)	401 (850)	High air circulation rate with controlled fresh air supply/recirculation effective in fume disposal. Facility for adjustment to increase or reduce air movement in the working zone for local cooling or fume dispersal as required.
C	1.25 (Mech)	4.7 (0.92)	425 (900)	High level supply and extract units ineffective in removal of fumes in engine test bay. Additional roof extract fans installed. Excessive infiltration at doors.
D	1.125 (Natural)	2.8 (0.56)	472 (1000)	Extensive loading bay doors allow infiltration and draughts. Overhead unit heaters at doors only marginally effective.
E	1.25 (Natural)	2.2 (0.44)	68 (145)	Severe overheating in process areas. Additional extract fans installed. Draughts cause problems at doors.
F	1.1 (Mech)	1.7 (0.33)	35 (75)	Overheating in process area. Additional extract fans installed. Draughts cause problems at doors.
G	1.1 (Mech)	1.7 (0.33)	94 (200)	Summer overheating due to uncontrolled solar gains and limited ventilation.
H	2.6 (Mech)	6.8 (1.34	245 (525)	Severe overheating in heat treatment areas. Severe draughts around perimeter. Oil mist 'hanging' in machining areas.

Recommended Minimum Criteria (assuming no process fumes etc:)

Factory Inspectorate — 5 litre/sec per person. (10 cfm/person)
I.H.V.E. Guide — 8 litre/sec per person (16 cfm/person) or 0.8 litre/sec per m².
ASHRAE Standard (62 — 73) — 7 — 35 cfm/person (depending on the factory processes).

Table III—Annual Fuel Consumptions of Installations

Premises	Details of Premises: Area	Average Height	Average 'U' Value	Annual Fuel Consumption for Unit Areas and Unit Volume		Equivalent Annual Hours Operation at Full Load	Actual Load Factor Over the Heating Season
	m^2 (Sq. ft.)	m (ft.)	W/m²°C	GJ/m² (Therms/Sq. ft.)	GJ/m³ (Therms/Cu. ft.)	Fuel Consumption / Design Heat Loss	
	Intermittent Operation—108 hours/week average:						
A	32,980 (355,000)	10.7 (35.1)	3.70 (Very Poor)	3.64 (3.21)	0.34 (0.091)	4,141	0.95
B	32,980 (355,000)	10.7 (35.1)	3.70 (Very Poor)	2.24 (1.97)	0.21 (0.056)	2,546	0.58
C	18,670 (201,000)	11.3 (37.1)	2.15 (Good)	3.07 (2.71)	0.27 (0.073)	4,296	0.99
D	8,960 (96,500)	8.8 (28,9)	1.35 (Very Good)	1.33 (1.17)	0.15 (0.040)	3,206	0.74
E	8,700 (93,800)	6.1 (19.9)	3.35 (Poor)	1.87 (1.65)	0.31 (0.083)	3,465	0.80*
F	15,240 (164,000)	5.2 (17.1)	3.40 (Poor)	2.39 (2.10)	0.46 (0.123)	4,774	1.10*
G	13,470 (145,000)	5.6 (18.3)	3.57 (Poor)	1.86 (1.63)	0.33 (0.089)	3,971	0.91
	Continuous Operation—168 hours/week average:						
H	78,690 (847,000)	8.9 (29.3)	3.33 (Poor)	4.52 (3.99)	0.51 (0.136)	5,121	0.76*

*Premises with high internal heat gains from process equipment or machinery.

Table IV—Seasonal Thermal Efficiencies of Installations (Based on their Original Ventilation Design Criteria)

Premises	Present Annual Fuel Consumption (Gross Input)	Average Temperature Maintained	Temperature Rise from Heat Gains	Net Annual Heat Requirements	Net Annual Heat Requirements (useful solar gains deducted)	Overall Seasonal Thermal Efficiency	Maximum Central Plant Efficiency	System Utilization Efficiency
	Joules 10⁶—GJ (therms)	°C (°F)	°C (°F)	Joules 10⁶—GJ (therms)	Joules 10⁶—GJ (therms)	per cent	per cent *	per cent
Factories with Intermittent Operations—108 hours/week average								
A	120,300 (1,140,000)	18.5 (65)	4 (7)	70,500 (668,000)	55,200 (523,200)	46	75	61.3
B	74,000 (701,000)	20 (68)	4 (7)	76,300 (723,000)	61,000 (578,600)	82.4	92	89.3
C	57,400 (544,000)	18.5 (65)	4 (7)	28,600 (272,000)	26,800 (254,000)	46.7	80	58.4
D	11,900 (113,000)	18.5 (65)	5 (9)	7,100 (66,800)	7,000 (66,400)	58.8	80	73.5
E	16,300 (155,000)	20 (68)	13 (23)	1,600 (15,300)	1,260 (11,900)	7.7	80	9.6†
F	36,400 (345,000)	20 (68)	6 (11)	13,500 (128,000)	10,500 (99,500)	28.8	80	36.0†
G	25,000 (237,000)	20 (68)	4 (7)	13,600 (129,000)	10,600 (100,000)	42.4	80	53.0
Factory with Continuous Operation—168 hours/week								
H	356,000 (3,300,000)	20 (68)	4 (7)	188,800 (1,790,000)	177,000 (1,670,000)	49.7	80	62.1†

* Assumes "Maximum Central Plant Efficiency" is defined as $\left(\frac{\text{Heat output from plant}}{\text{Heat supplied in fuel}} \times 100\right)$ per cent

† Premises with high heat gains from process equipment or machinery

Table V—Potential Fuel Savings from Alternative Ventilation Design Criteria (After Improvements to Minimise Infiltration Losses)

Premises	Limiting Factors in Determining Alternative Criteria	Alternative Ventilation Design Criteria —Winter Fresh Air Supply			Estimated Original Air Change Rate (In Practice)	Potential Reduction in Gross Heat Load	Potential Reduction in Annual Fuel Consumption
		General Supply litre/s per m² (cfm/sq. ft.)	Process/Extract Requirements litre/s. (cfm)	New Overal Air Change Rate (fresh air supply)			
						per cent	per cent
A	Not applicable—System replaced by 'B'	—	—	—	—	—	—
B	Control of welding fumes in part of premises. Paint Booth Extract. Heat control in steel cutting areas.	4.0 (0.8)	25,000 (50,000)	1.5 (including Paint Booth)	1.5	—	System already operating on 1.5 A/C (approx:)
C	Paint Booth supply and extract. Engine test bay	2.0 (0.4)	75,000 (150,000)	1.6 (including Paint Booth)	2.5	15	20—25
D	Paint Booth Extract. Large loading doorways.	0.8 (0.16)	10,000 (20,000)	0.9	1.2	15	20—25
E	Temperature and fume control in heat treatment area.	2.0 (0.4)	5,000 (10,000)	1.5	4.5	47	70—80
F	Temperature, fume and contaminant control in chemical treatment area.	2.0 (0.4)	5,000 (10,000)	1.4	2.5	27	40—45
G	No particular requirements	0.8 (0.16)	—	0.6	1.5	25	40—45
H	Temperature and fume control in heat treatment area. Oil mist from volatile cutting oils.	2.0 (0.4)	100,000 (200,000)	1.25	3.8	48	60—70

Recommended Minimum Criteria: *Factory Inspectorate* — 5 litre/s per person. (10 cfm/person)
(assuming no process fumes etc:) *I.H.V.E. Guide* — 8 litre/s per person (16 cfm/person) or 0.8 litre/s per m².
ASHRAE Standard (62 — 73) — 7 — 35 cfm/person (depending on the factory processes).

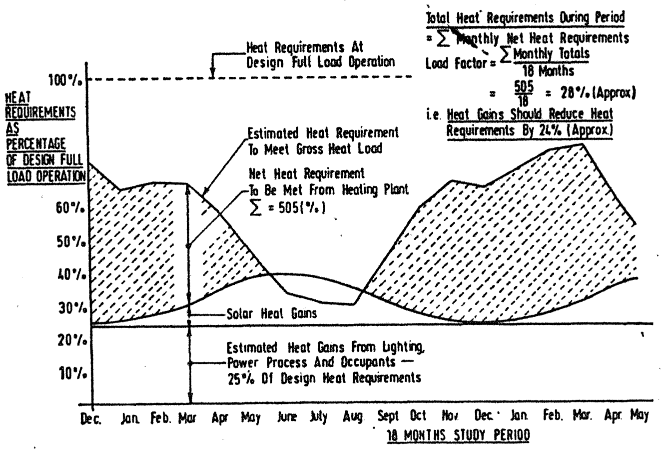

Fig 4—Monthly Heat Requirements: Average Industrial Premises—With Machinery and Process Heat Gains.

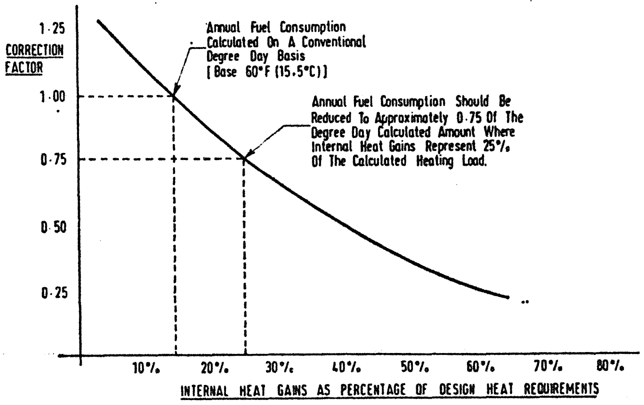

Fig 5—Estimated Correction Factors for Fuel Consumption with Varying Heat Gains.

Table VI—Potential Fuel Savings from Heat Recovery (After Improvements to Minimise Infiltration Losses and with New Ventilation Design Criteria)

Premises	Design Load with New Ventilation Criteria	Potential Heat Recovery (Assume 50 per cent Efficiency)	Design Heat Load with Heat Recovery	Heat Gains Machinery and Equipment	Potential Overall Reduction in Annual Fuel Consumption	Potential Fuel Reduction From New Ventilation Criteria	Potential Fuel Reduction Attributable to Heat Recovery	Remarks
	per cent of Original Gross Load	per cent of Original Gross Load	per cent of Original Gross Load	per cent of Original Gross Load	per cent of Original Fuel Consumption	per cent of Original Fuel Consumption	per cent of Original Fuel Consumption	
A	N/A	N/A	N/A	—	—	—	—	—
B	100	25	75	18	35—40	NIL	35—40	—
C	85	14	71	20	50—55	20—25	30	—
D	85	22	63	25	55—60	20—25	35	—
E	53	12	41	60	90—95	70—80	15—20	Heating required for Cold Start-Up only.
F	73	17	56	28	70—75	40—45	30	—
G	75	8	67	18	45—50	40—45	5	—
H	48	11	37	18	70—80	60—70	10	Heating required only during severe weather.

NOTE: In each case higher efficiency Heat Recovery Systems may be considered against the Capital Costs of the Installations.

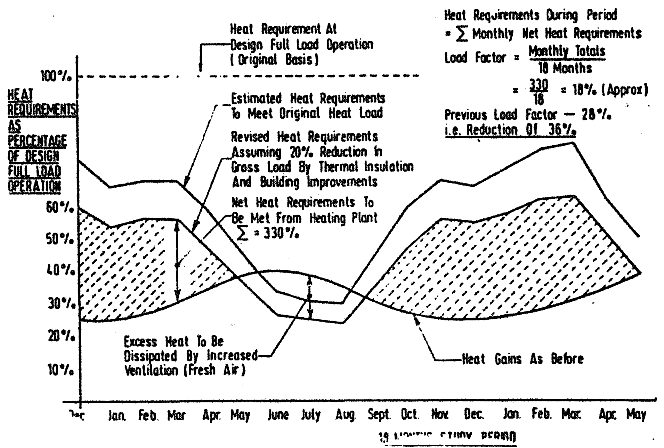

Fig 6—Monthly Heat Requirements with Thermal Insulation Standards Improved.

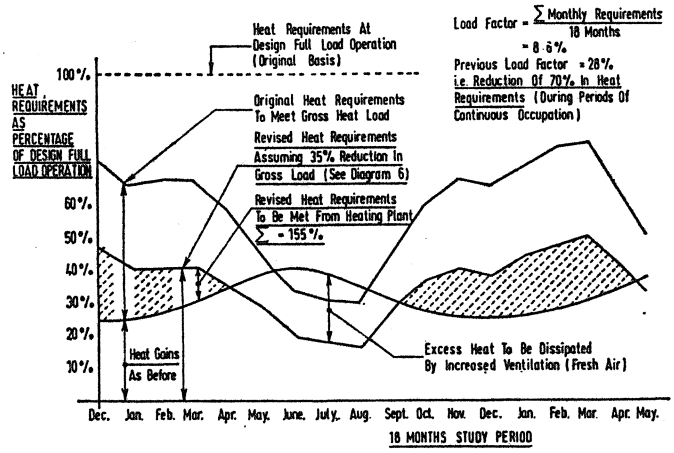

Fig 8—Monthly Heat Requirements with Reduced Air Changes.

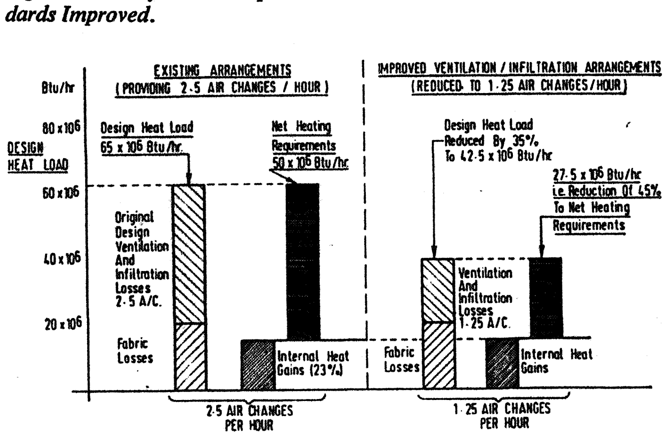

Fig 7—Illustration of Heat Load with Reduced Air Changes.

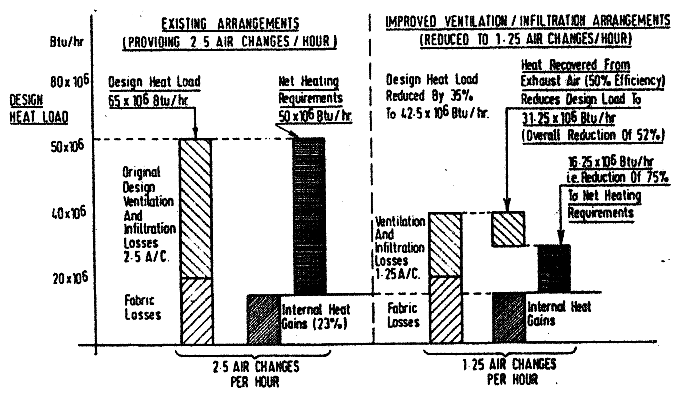

Fig 9—Illustration of Heat Load with Reduced Air Changes and Heat Recovery.

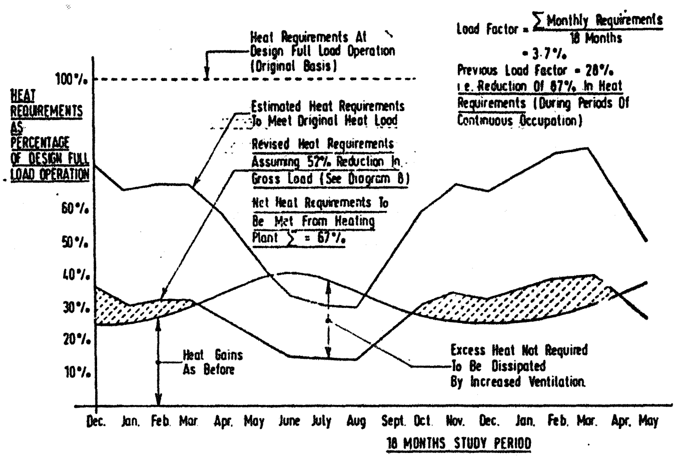

Fig 10—Monthly Heat Requirements with Reduced Air Changes and Heat Recovery.

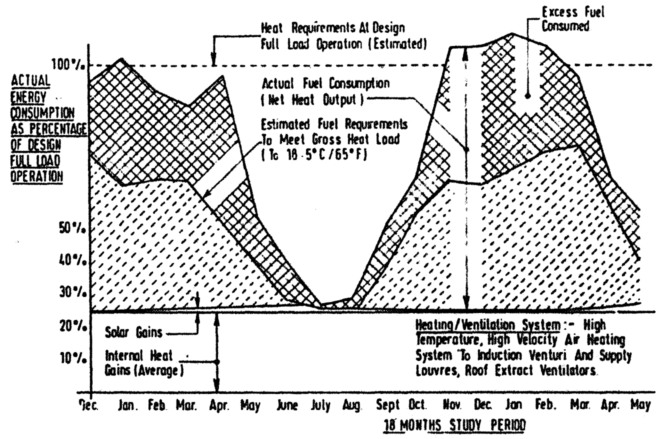

Fig 13—Graphs of Fuel Consumption in Premises Studied. Premises D: High Temperature High Velocity Air System—Oil Fired.

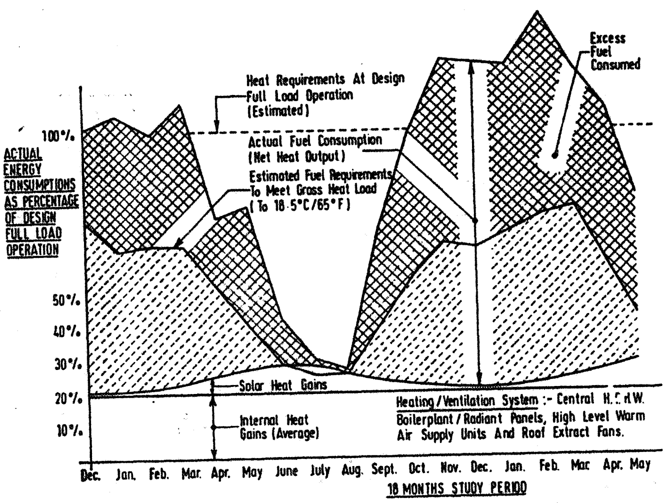

Fig 11—Graphs of Fuel Consumption in Premises Studied. Premises C: HPHW boilerplant—Oil Fired. Radiant Heating.

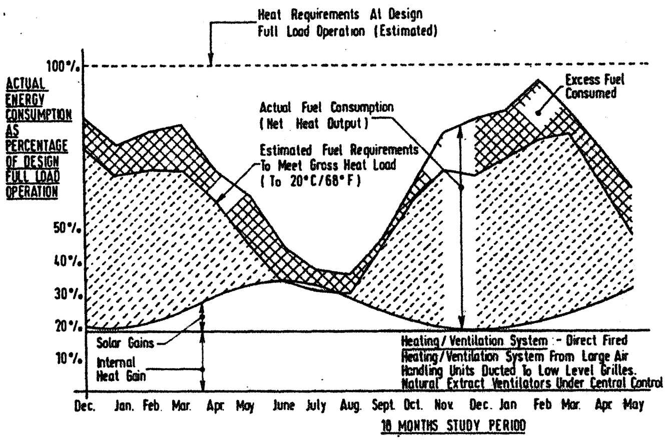

Fig 14—Graphs of Fuel Consumption in Premises Studied. Premises B: Low Velocity Air System—Direct Gas Fired.

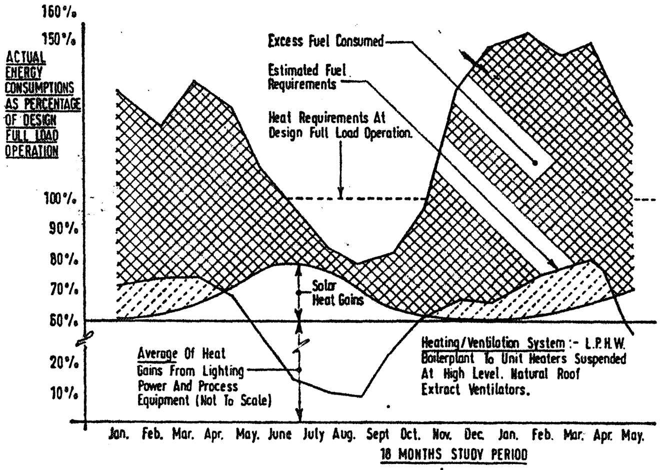

Fig 12—Graphs of Fuel Consumption in Premises Studied. Premises E: LPHW boilerplant—Oil Fired. Unit Heaters.

ventilation alone cannot resolve an overheating problem without generating other problems elsewhere. Operating and maintenance staff should be trained to recognise and control the overall systems of air movement and sources of infiltration to the maximum benefit of the occupants at minimum fuel cost.

9 THERMAL INSULATION OF PREMISES

New premises may readily be constructed to high thermal insulation standards without substantial additional cost, if due consideration is given to materials and particularly the extent of glazing to be adopted. The addition of thermal insulation to existing premises is, however, likely to be more expensive than for new premises. In some cases the potential fuel savings may be considerably underestimated due to the omission of the anticipated heat gains from lighting, equipment etc: from the calculation of fuel consumptions. This effect is illustrated in Fig 6 indicating potential annual fuel savings of 36 per cent in a typical building as a result of a 20 per cent reduction of the design heat load by thermal insulation of the premises.

10 HEAT RECOVERY

When appropriate ventilation criteria have been established, due consideration should be given to heat recovery to the make-up air systems from the exhaust ventilation systems.

Where large volumes of warm air must be exhausted and are not unduly chemically contaminated or dust laden, heat recovery loops, thermal wheels or heat exchangers should be considered.

Exhaust air losses in larger industrial buildings may easily represent 60 per cent of the heating load, even after adopting appropriate criteria. A heat recovery system with an efficiency of only 50 per cent can therefore reduce the gross heating load by 30 per cent and the net heating requirements and fuel consumption by an even greater amount when heat gains are taken into account. This is illustrated in Table VI and Figs 9—14, which show the combined effects of improved ventilation and heat recovery offering savings from 35 to 95 per cent.

11 CONCLUSION

Many existing industrial heating and ventilation systems are grossly inefficient, some consuming several times the fuel which should be necessary. Opportunities exist for very substantial improvements.

Insufficient attention has been paid to effective ventilation or cooling of process areas, at the expense of a vast increase in annual fuel costs.

Insufficient attention has been given to heat loss from uncontrolled natural ventilators and uncontrolled infiltration.

Many installations release heat which could usefully be redirected during the heating season to reduce fuel consumption.

Potential savings arising from improvements to structure and engineering systems may be substantially underestimated, if the effects of heat gains are not taken into account.

Most existing installations do not permit independent operation of door heaters or local systems in particularly exposed zones. Where practicable, this enables central plant to be used for substantially shorter heating seasons, avoiding unnecessary standing losses, frequent start/stop operation and inefficient utilisation in periods of low heating load.

In many cases, where substantial heat gains are generated by lighting, machinery and process equipment, and where buildings are well insulated, the provision of a centralised boilerplant may not be justifiable or necessary if the heat already generated is recovered and recycled.

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