EPA-600/2-91-060
October 1991

REVIEW OF ENERGY EFFICIENCY OF REFRIGERATOR/FREEZER GASKETS

by

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EPA Contract No. 68-02-4286
Work Assignment 2/129
(Radian Corporation)

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Prepared for:

U. S. Environmental Protection Agency
Office of Research and Development
Washington, DC 20460

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ABSTRACT

Home refrigerators are the largest consumers of electricity among household appliances and are consuming an estimated 8% of the total electricity used in the United States. Recent studies show that gasket area heat leakage may account for as much as 21% of the total thermal load.

The purpose of this study was to investigate the significance of heat leakage through the gaskets in household refrigerator/freezers, explore different design features, and suggest further study if necessary. This report presents the results of an extensive literature review, interviews with refrigerator/freezer and gasket manufacturers, and some engineering analysis.

The findings of this study included: 1) Manufacturers will likely incorporate improved gasket technology in the 1993 models. 2) There is little certainty about the magnitude of gasket heat leakage, although most believe it is significant. The significance will increase with introduction of advanced types of insulation. 3) Double door gaskets do not offer much potential due to several practical limitations and the advancement in single gasket technology. 4) Gasket infiltration may cause a significant portion of the load. 5) Safety requirements are critical for home refrigerator/freezers. It is unlikely that a mechanical door latching device would meet these requirements, even if it meets energy conservation goals.

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FIGURES

METRIC CONVERSION FACTORS

Readers more familiar with metric units may use the following factors to convert the nonmetric units in this report.

Nonmetric	Times	Equals Metric
Btu/hr	0.293	W
Btu/hr ft. °F	1.7306	W/m K
Btu/hr in. °F	20.7677	W/m K
Btu/lb	2.3244	kJ/kg
Btu/lb °F	4.1866	kJ/kg K
ft	0.3048	m
ft^3	0.028317	m^3
ft^3/lb	62.43	cm^3/g
ft^3/min	4.719×10^{-4}	m^3/sec
in.	2.54	cm
in. H_2O	249.06	Pa
lb	0.4536	kg
°F	(°F - 32)/1.8	°C

1.0 INTRODUCTION

Home refrigerators are the largest consumers of electricity among household appliances and consuming an estimated 8% of the total electricity used in the United States [1,2]*. The energy consumption for an average refrigerator sold in the United States grew over 350 percent from post World War II until 1975 [3]. This was partly due to larger and more feature-laden models of refrigerators. Since 1975, several studies have been conducted to develop a high efficiency refrigerator-freezer. To achieve this goal, various designs were developed and tested. Gasket improvements appeared in most of the studies as an option.

The gaskets in a refrigerator/freezer act as seals to contain the cold air and to thermally isolate the plastic liner from the outer steel structure (Fig. 1). Recent studies show that gasket area heat leakage may account for as much as 21% of the total thermal load [4]. The heat leakage through the gasket itself and through the adjacent door and cabinet surfaces is mostly through conduction. Some infiltration also occurs since the door seal cannot be perfect. Another source of energy consumption is the anti-sweat heaters placed near the gasket to eliminate condensation. Minimizing gasket heat leakage in a refrigerator/freezer reduces the need for anti-sweat heaters and lowers energy consumption.

Future generations of high efficiency refrigerator/freezers may well incorporate advanced types of insulation and other features to reduce the heat leakage considerably over present products. In this instance, the gasket heat leakage would become even more significant as a percentage of energy consumption. In the near term, higher energy efficiency standards are providing considerable impetus to reduce gasket heat gain.

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*Numbers in brackets denote references listed at the end of the report.

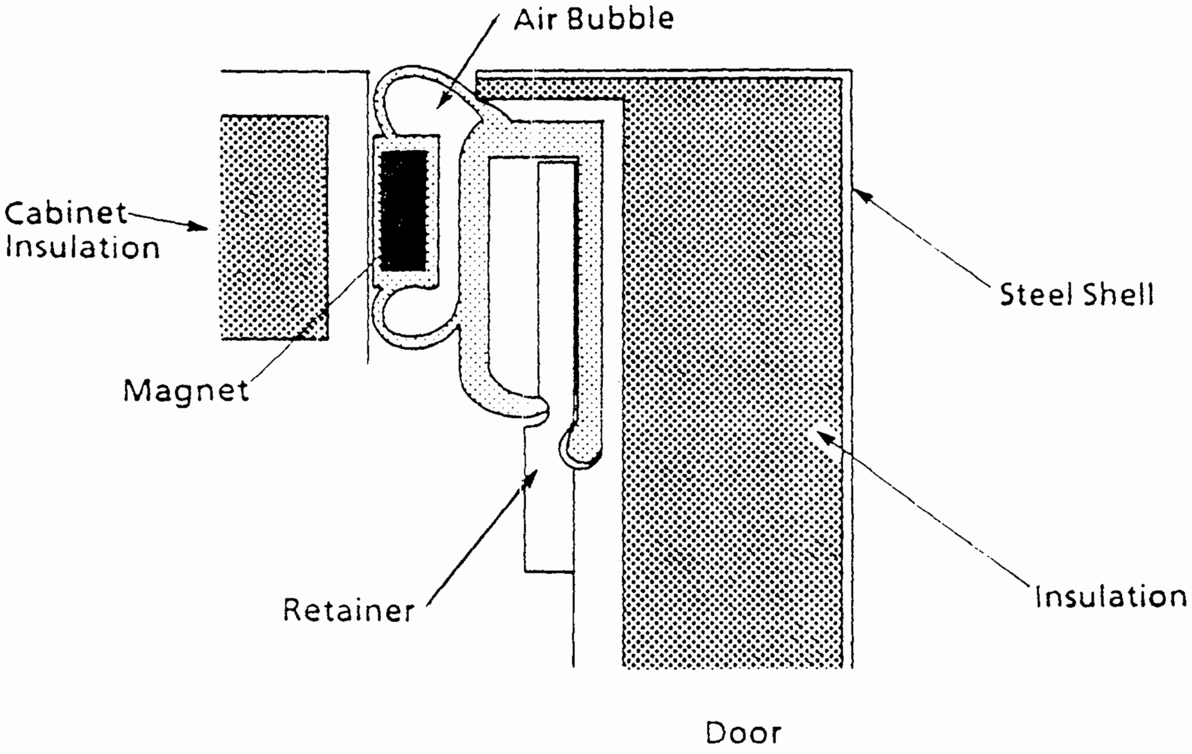

Fig. 1. Typical door gasket configuration.

The purpose of this study was to investigate the significance of heat leakage through the gaskets in household refrigerators/freezers, explore different design features, and suggest further study if necessary.

This study consisted of three major activities, as follows:

- An extensive literature review was conducted using the Iowa State University Parks Library and inter-library loan.
- Engineers were contacted at major appliance manufacturers and at gasket suppliers to the refrigerator/freezer industry.
- Analyses were conducted in-house.

2.0 REVIEW OF LITERATURE

A refrigerator/freezer cabinet consists of two or more compartments, with at least one compartment designed for the refrigerated storage of fresh foods at temperatures above 32°F* and with at least one compartment designed for the storage of frozen foods at 8°F or below. A significant portion of heat gain to a refrigerators/freezer occurs around the edges of the doors, through nearby portions of the cabinet surface, and through the door gaskets themselves. Gasket improvement was part of several studies that have been conducted to reduce energy consumption of refrigerator/freezers.

Kammerer and Maxwell [5] explored means for reducing energy use in existing refrigerator/freezer designs. They indicated that gasket heat gain might account for as much as 19% of the total heat load. However, they didn't include gasket improvements among their recommended design improvements.

Hoskins and Hirst [6] calculated the gasket loads for 12 and 16 cubic foot refrigerator/freezers. Although they did not include gasket improvements in their list of suggested design changes, their computer model simulated the open door condition

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*Users more familiar with metric units may use the factors listed at the end of the front matter to convert to that system.

and calculated the gasket load. The calculated heat loads for a 12 and a 16 cubic foot refrigerator-freezer are 13.54 and 15.16 watts (13% and 12% of the total thermal load), respectively.

Two major studies by Arthur D. Little Company (ADL) explored gasket improvements as design options for higher efficiency refrigerator/freezers. In the first ADL study [7], improvements were made to the door closure area to reduce infiltration of room air into the refrigerator. The second study by ADL consisted of two phases. Phase I, reported in reference [8], involved the design, construction, and laboratory testing of a 16 cubic foot high efficiency refrigerator/freezer prototype. Phase II, reported in reference [9], consisted of a field test that was carried out for an identical setup with the exception of the size. An eighteen cubic foot refrigerator/freezer was selected for the second phase. The use of a double door gasket was one of the seven options that underwent comprehensive computer analysis and prototype testing in the ADL Phase I study.

In phase I, a series of tests were conducted, and the energy saving potentials of double-door gaskets were evaluated. ADL reported a 47% reduction in freezer heat flow by incorporating a vinyl type secondary gasket into the freezer compartment of the base line unit (Fig. 2). However, this reduced the overall energy consumption by only 3%. The ADL study also showed that only the double door gasket in the freezer effectively reduced the energy consumption. This was due to two factors: the higher air flow in the freezer (air flow in the freezer is about six times that of the fresh food compartment) and the greater temperature difference between the freezer compartment and outside compared to the fresh food compartment and the outside. Infiltration of air was considered insignificant according to the ADL study (about 5 Btu/hr). In the Phase II study, double door gaskets on freezer doors were not considered due to the limitation existing with double door gaskets associated with freezing of trapped moisture which can jam the door shut.

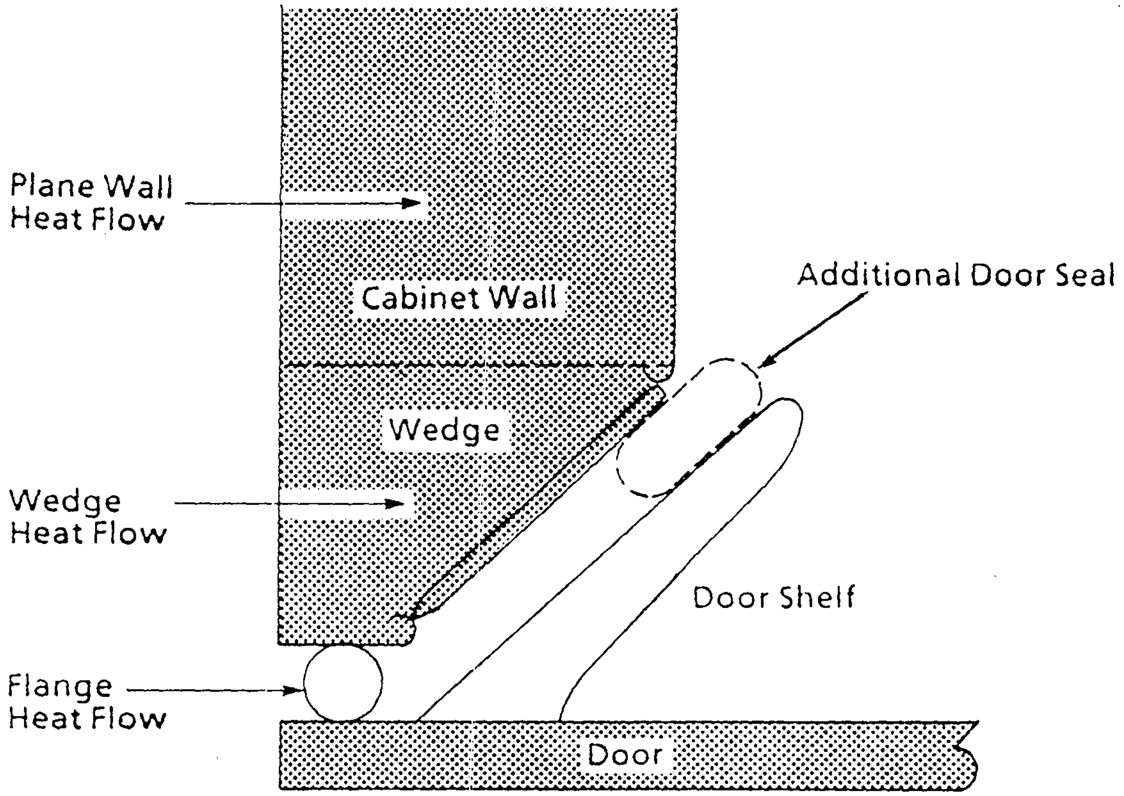

Fig. 2. ADL model of door closure area.

The results of the field tests as well as the data obtained from the Phase I study were published in four different reports. References [10] and [11] identified the results from Phase I, while references [12] and [13] highlighted the findings of the field test (Phase II) study.

Sterling [14] calculated the heat leakage through gaskets, using energy factor concepts. He determined increase in energy usage as the volume ratio (freezer volume/total volume) increases. According to Sterling, heat leakage through the gasket of a 15.6 cft refrigerator/freezer was as follows:

	Gasket Heat Leakage					
Volume Ratio	Freezer		Fresh Food		Total	
freezer/total	Btu/hr	Watts	Btu/hr	Watts	Btu/hr	Watts
0.20 (20% freez volume)	45.19	13.24	29.36	8.60	74.55	21.84
0.30	56.50	16.55	28.12	8.24	84.62	24.79
1.0	121.40	35.57	-	-	121.40	35.59

Sterling's work confirms that heat leakage through the fresh food gasket area is significantly less than through the freezer gasket area.

Lawrence Berkeley Laboratory (LBL) also conducted research on home appliances in order to update the selection of design options [15]. The LBL study indicated that double door gaskets cause problems in the field due to freezing of trapped moisture. An improved single door gasket, which provided some of the double door gasket benefits without the indicated problems, was added to the list of new design options for higher efficiency refrigerator/freezers. However, the LBL study did not indicate any specific design improvements.

A study done by the Department of Energy (DOE) did not include the double door gasket in the simulation analysis due to technical difficulties, but gasket improvement was among their design options [16]. These results were published in a paper by Turiel and Heydari [17]. The most recent study by Abrahamson, Turiel, and Heydari [4] indicated that about 21% of thermal load is due to gasket loss. They predicted that 5.9% of fresh food load and 16.5% of freezer load are due to gasket heat leakage.

In addition to the literature survey, the present study involved contacting major refrigerator/freezer manufacturers and gasket suppliers. Interviews with engineers indicated little agreement about the precise magnitude of gasket heat leakage. In addition, the definitions of the particular area associated with "gasket" heat leakage appeared to vary among manufacturers and among the other research studies discussed above. This may account for the apparent variation of between 10% and 30% of the energy consumption that different sources associate with gasket loads. Nevertheless, all manufacturers agreed that improved gasket design to reduce heat leakage was a priority for helping to meet new energy standards, and as such was receiving considerable attention in their companies.

3.0 FINDINGS AND DISCUSSION

The present section of the report deals with the following topics, which represent the major areas covered in the study:

- Double Door Gaskets
- Single Door Gaskets
  - Materials
  - Design Evolution
- Possible Gasket Design Improvement
- Gasket Infiltration
- Gasket Heat Leakage Determination
  - Analytical Estimates
  - Experimental Measurements
- Summary of Door Safety Regulations

3.1 Double Door Gaskets

Gasket heat gain appears to account for at least 10% of the thermal load. One concept for reducing the gasket loads is to insert an additional inner door gasket (Fig. 2). This improves the insulating value of the gasket area and reduces energy consumption. According to reference [8], incorporating a double door gasket in the freezer compartment caused the following heat flow reduction:

	Gasket Heat Flow (Btu/hr)	
	Base Line Value	Double Gasket
Evaporator fan on	62.5	41.9
Evaporator fan off	43.5	28.8

Despite the possible energy benefits, double door gaskets haven't been used by many manufacturers because of performance and cost. The limitations existing with double-door gaskets include the following:

- Ice has a tendency to form between the freezer compartment gaskets due to trapped moisture. The ice greatly reduces the thermal effectiveness and can freeze the door shut.
- Inner seal problems exist due to requirements for special gasket materials. The materials developed must be highly compliant and yet durable to serve as a good inner seal held by the force of the magnetic outer gasket.
- Double door gaskets tend to be visually unattractive.
- Difficulties can exist with ease of door closing, which can detract from consumer acceptance.
- Double door gaskets can make it more difficult to meet the minimum door opening force requirements of the Child Safety Act.

3.2 Single Door Gaskets

Due to double door gasket limitations, refrigerator/freezer manufacturers and their gasket suppliers have focused their efforts on producing thermally improved single gaskets with higher insulating values and better sealing characteristics. The improvements to single door gaskets make the double door gasket concept of energy saving less important. According to [15], heat gain by the present improved single gasket is only 10% less than the double gasket system proposed in 1980 in reference [8].

The following discussions detail some of the considerations which the present investigation uncovered concerning materials, design evolution, and possible gasket design improvements.

3.2.1 Materials. Door gaskets are usually made of flexible plastic. The most common plastic materials used in gaskets are: thermoplastic elastometer (TPE) and polyvinylchloride (PVC). These materials range from the very soft and delicate to rigid and wear-resistant, and their suitability is mainly related to such considerations. The primary thermal barrier in the gasket is trapped air "bubbles", which have low thermal conductivity. The materials themselves do not contribute significantly to the thermal resistance. The present study indicates that little improvement in thermal performance is possible in the area of gasket materials.

3.2.2 Design Evolution. Early designs for extruded gaskets depended upon mechanical compression provided by a latch mechanism to seal (Fig. 3a). While still suited to some applications, the compression design was improved dramatically by a development called "supported compression" (Fig. 3b). The next major design improvement was done by inserting magnetized extrusions of ferrite compounds for sealing (Fig. 3c). The magnets are used in place of latch and striker plate. This improvement resulted in consumer satisfaction and improved safety.

Remaining improvements in gasket design involved improving the thermal resistance. The next step was the "extended bubble magnetic" design (Fig. 3d). In addition to compression and magnetic attraction, this design introduced the "wand" which extended from the inner edge of the bubble. Currently the most efficient gasket

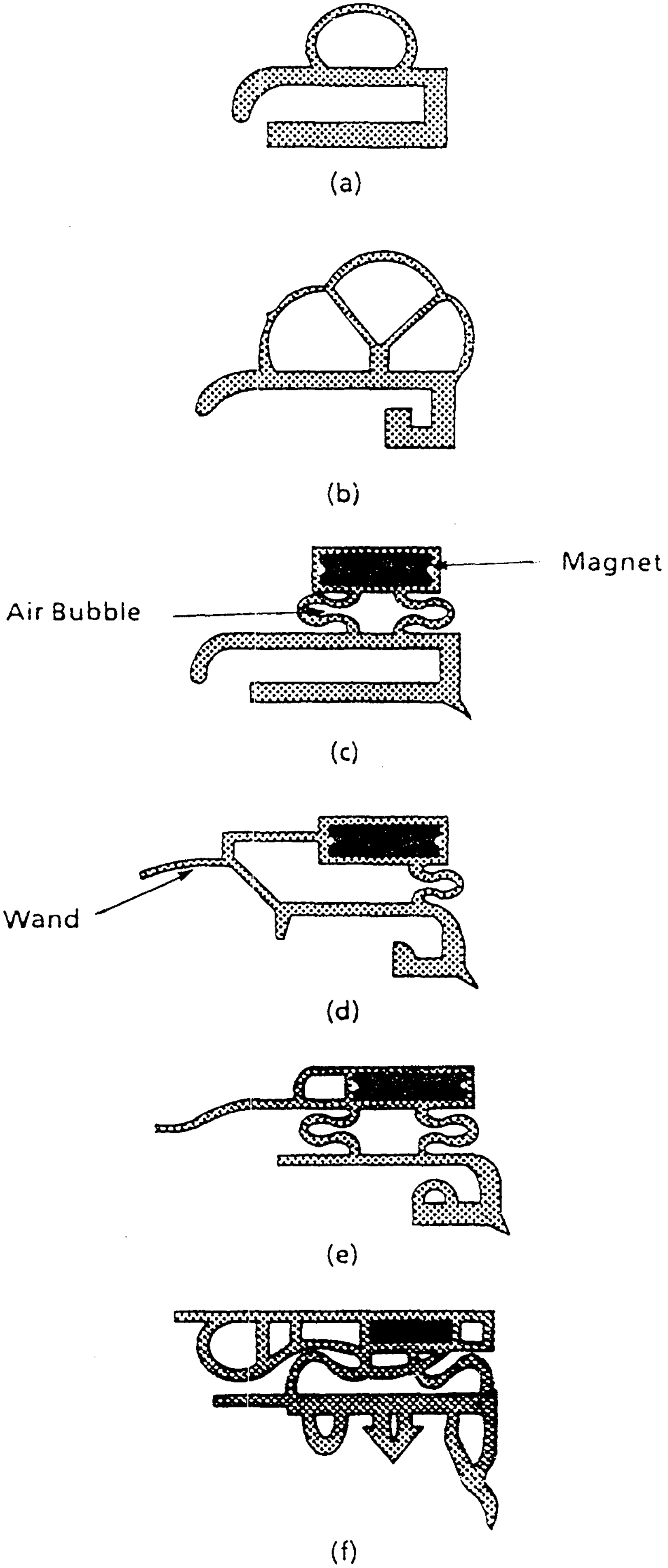

Fig. 3. Gasket evolution.

is the "multiple bubble magnetic" design (Fig. 3e), where the extra bubble acts as an insulator, reducing heat leakage. Figure 3f shows the newest gasket design with additional air pockets incorporated in the gasket and retainer area. These refinements will assist in reducing the heat leakage, and therefore improve the energy efficiency by an amount yet to be identified. Due to the expected enhanced performance, by 1993 the manufacturers of refrigerators/freezers will most likely standardize on this type of improved gasket.

3.2.3 Other Possible Design Improvements. Other possible areas of design improvement were identified in the course of the present study. These improvements can be divided into two separate categories: (1) reduction of the gap between the gasket and body, and (2) further increase in thermal resistance in the gasket area. It must be noted that some of the following concepts are already being incorporated and/or designed into existing products.

Possible areas of improvement include:

- The use of a half-bellows design (Fig. 3d), which eliminates alignment problems and turn over on the hinge side. In general, the bellows design provides the ability to expand or collapse and influences stability for maximum sealing effectiveness.
- To achieve maximum effectiveness, one manufacturer recommends a bellows thickness of 0.17 inch.
- The use of ribs as flow diverters within the compartments is quite common (Fig. 4). The purpose of the flow diverter is to direct the cold air away from the gasket area. This helps to reduce heat gain by conduction through the gasket and to reduce infiltration. The primary design challenge is to adequately distribute air throughout the compartment while reducing the impingement of air directly on the gasket. No quantitative estimate has been made of the impact of this practice on energy consumption.
- The addition of one air pocket (different sizes and shapes) to each side of retainer (Fig. 3f) can also be beneficial. This provides better retaining of gasket in the body, and still allows for easy sealing. Additional air pockets

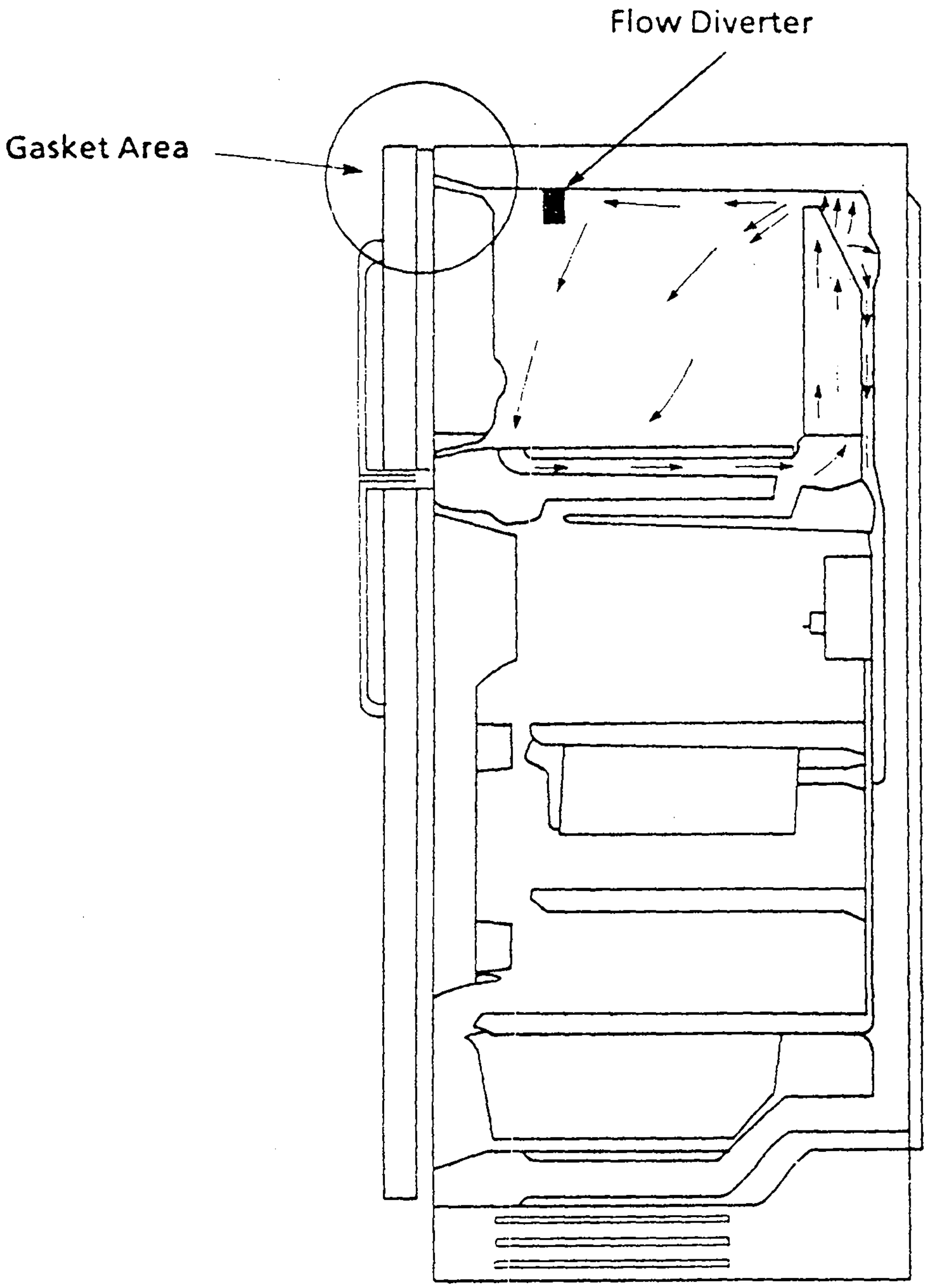

Fig. 4. Schematic of diverter.

increase the thermal resistance of the gasket and thereby reduce heat gain. However, the potential for this type of improvement is limited by the need for flexibility. Gaskets must typically collapse or expand from about 0.65 inch to about 1.0 inch.

- Another suggested improvement is to fill some of the air pockets with insulating materials such as fiberglass or foam. However, adding these materials would reduce the flexibility of the gasket, and would therefore be unacceptable. Further, a trapped bubble of stagnant air is one of the best insulating mediums available, and it is doubtful that any improvement in thermal performance would be realized by filling the pockets with solid materials.

- Mechanical door latching can provide better sealing than magnetic latches due to the increased pressure exerted by the door on the gasket. Potential improvements due to mechanical door latching are difficult to quantify. One effect would be to reduce infiltration, but the magnitude of this potential improvement is unknown. Another effect could be negative: to collapse the air bubbles that provide insulating value.
  Even if a mechanical latching door could be designed to reduce energy use and to meet the existing safety requirements (which are described later in this report), this feature still may not be suitable. Present practice dictates the availability of units with interchangeable right or left operation of the door, as desired by the customer. Thus, a universal reversible hinge design is commonly used to avoid having to market different models strictly due to door operation. The latching mechanism lacks this universality and would be used only as a last resort.

- Another potential area for reducing heat leakage due to door sealing is to design interior compartments that are separate from one another and that each have their own doors. This might reduce infiltration and provide greater thermal resistance between the coldest air and the outside of the cabinet. However, consumer acceptance and cost are likely to be barriers to the use of this concept. Also, reference [8] indicated that the expected savings with internal doors would be comparable to the savings obtained using double door gaskets, which is a much simpler and less costly alternative. The concept of internal doors is not expected to be seriously pursued in the future.

3.3 Gasket Infiltration

Infiltration is the uncontrolled leakage of air into the refrigerator-freezer through the door gasket. This is caused by a pressure difference across the boundary surface, and it accounts for some of the thermal load. After several conversations with different manufacturers and reviewing the literature, it is evident that there is no unanimity in the importance of infiltration. In fact, some literature contradicted the views of experts in the field. The literature showed that infiltration is about 5 Btu/hr, and some manufacturers indicated as much as 100 Btu/hr.

Because of the apparent uncertainty about the importance of infiltration, a brief engineering analysis was done as part of the present study. A summary of the analysis follows.

The following design conditions are assumed for the purposes of this analysis:

Room temperature, $T_o = 90°F$
Room humidity, $\omega_o = 0.031$ lb/lb (100% rel. humidity)
Specific heat of air, $c_p = 0.24$ Btu/lb°F
Specific volume of room air, $v_o = 13.986$ ft^3/lb
Freezer compartment temperature, $T_{in} = 5°F$
Inner humidity, $\omega_{in} = 0.0004$ (10% rel humidity)
Enthalpy of vaporization, $i_{fg} = 1042.7$ Btu/lb

The sensible heat load due to infiltration, q_{sens} can be expressed in terms of the leakage flow rate, Q, as follows

$$q_{sens} = \frac{Q\,c_p\,(T_o - T_{in})}{v_o} \tag{1}$$

Further, the latent load, q_{lat}, can be expressed as

$$q_{lat} = \frac{Q}{v_o}\,(\omega_o - \omega_{in})\,i_{fg} \tag{2}$$

Infiltration loads can be estimated using equations (1) and (2) for any given infiltration rate.

The infiltration rate is dependent upon the pressure differential that exists between the inside and the outside of the refrigerator/freezer box. Because of frictional pressure drop through the internal ducting, slight negative and positive gage pressures will exist between the suction and the discharge sides of the fan, respectively. The infiltration rate is also dependent upon the nature of the crack due to the gasket seal and any penetrations of the liner or ductwork. An estimate of this relationship can be obtained using Equation (7-10) of reference [18] and curve-fitting the relation for a tight-fitting door from Figure 7-5 of reference [18] to obtain

$$Q/L = \Delta p^{0.64} \tag{3}$$

where L is the effective crack length (one half the total gasket length for both doors) in feet, Δp is the pressure differential in inches of water, and infiltration rate Q is in cubic feet per minute.

Figure 5 shows the sensible, latent, and total loads as functions of pressure difference, assuming a total gasket length of 19.48 feet as in reference [8]. The curves show that the magnitude of the load due to infiltration may be substantial or may be negligible compared to other loads, depending on the pressure difference.

One industry representative quoted a value of 0.01 inches of water as characteristic of the magnitude of the pressure differential. With this value, the loads as determined from Fig. 5 would be

q_{sens} = 44.76 Btu/hr

q_{lat} = 70.47 Btu/hr

q_{tot} = 115.23 Btu/hr

From the calculations presented here and from the literature cited, there exists considerable uncertainty as to the magnitude of the infiltration effects. Although companies most likely have proprietary information, little actual data is available in the open literature.

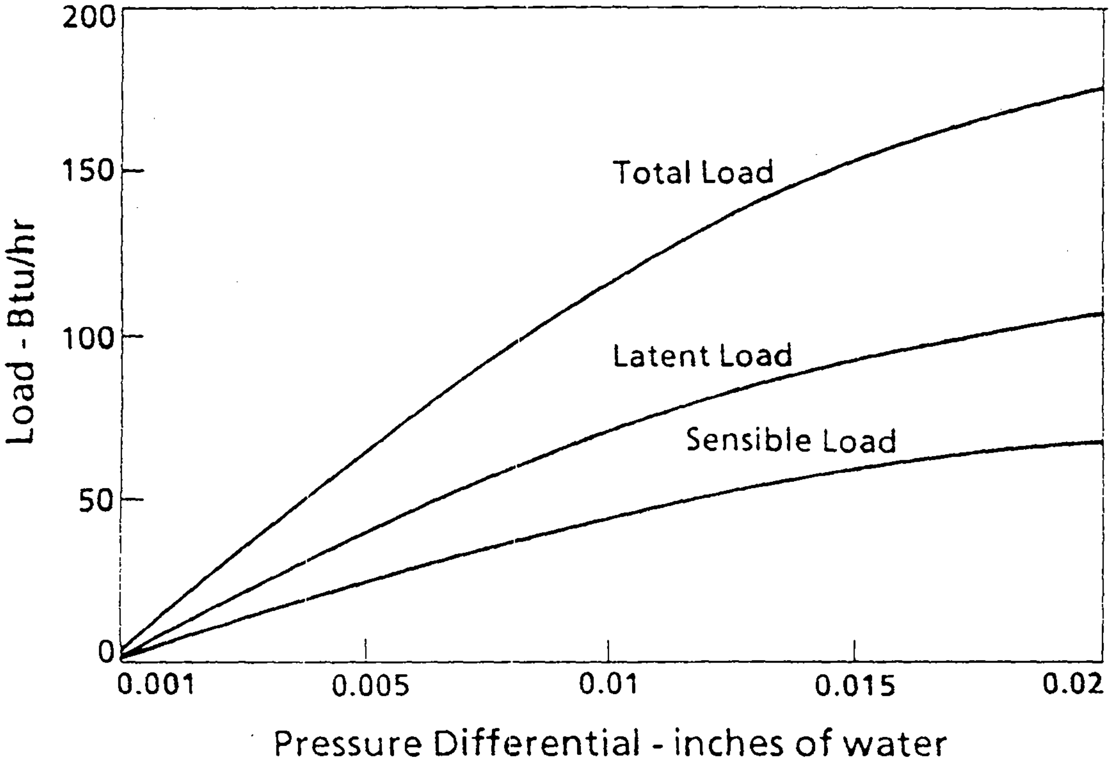

Fig. 5. Load estimates due to infiltration.

3.4 Gasket Heat Leakage

Gasket heat leakage, not including infiltration, is estimated using both analytical and experimental methods.

3.4.1 Analytical Estimates. Total gasket heat leakage is a combination of the following components (refer to Fig. 2):

- conduction along the flange
- heat leakage through the small gap between the gasket and wedges
- heat leakage through the gasket itself
- heat leakage between the gasket and door

Total heat load due to the gasket is calculated in various ways by different manufacturers. Two methods of determining this load are:

METHOD 1

$$q_{gasket} = H_g l \Delta t \qquad (4)$$

where

Δt = temperature differences between cabinet interior

l = total gasket length

H_g = gasket heat leak coefficient

Gasket heat leak coefficients can be found in reference [16], and are as follows:

	Value
Freezer-Fan on	0.0069 Btu/hr in °F
Freezer-Fan off	0.0041 "
Refrigerator	0.00141 "

METHOD 2

$$q_{gasket} = (L_r \, . \, \Delta T_r + L_f \, . \, \Delta T_f)(\alpha + \beta \cdot f) \qquad (5)$$

L_r = length of fresh food gasket (door perimeter)

L_f = length of freezer gasket (door perimeter)

α = 0.05 Btu/hr Ft °F (static-fan off)

β = 0.036 Btu/hr Ft °F (dynamic-fan on)

f = fan run time fraction

Using Equations (4) and (5) with the data from the infiltration calculation presented earlier yields the following results:

METHOD 1: q = 60.12 Btu/hr (fan on)

METHOD 2: q = 82.84 Btu/hr (50% fan run time fraction)

In light of these results, and the other information presented above regarding the importance of gasket heat leakage, it appears that there is considerable uncertainty about the magnitude of this effect.

3.4.2 Experimental Measurements. Experimental measurement of heat leakage through the gasket can be done in several ways. The following are two of the most common methods used. Each is based on a reverse heat leakage test, in which a heat source is placed inside the refrigerator/freezer, and the power input to the device is measured along with the inside and outside temperatures. Although the temperatures are not the same as those obtained in actual operation, the thermal resistances determined by such a test should be representative.

METHOD 1

Apply a constant heat source in the cabinet to measure the total heat loss of the unit. Also connect the same cabinet with an identical cabinet excluding the doors (see Fig. 6a) and measure the heat loss through the walls of the two cabinets. The difference between the original test and one half the value measured in the second test is the total door loss. The loss through the door itself could then be analytically calculated. Finally, the gasket heat loss would be

$$q_{gasket} = q_{total} - (q_{walls} + q_{door}) \tag{6}$$

This method leads to a plausible estimate of the heat gain through the gasket, but relies on some speculation as to the door loss.

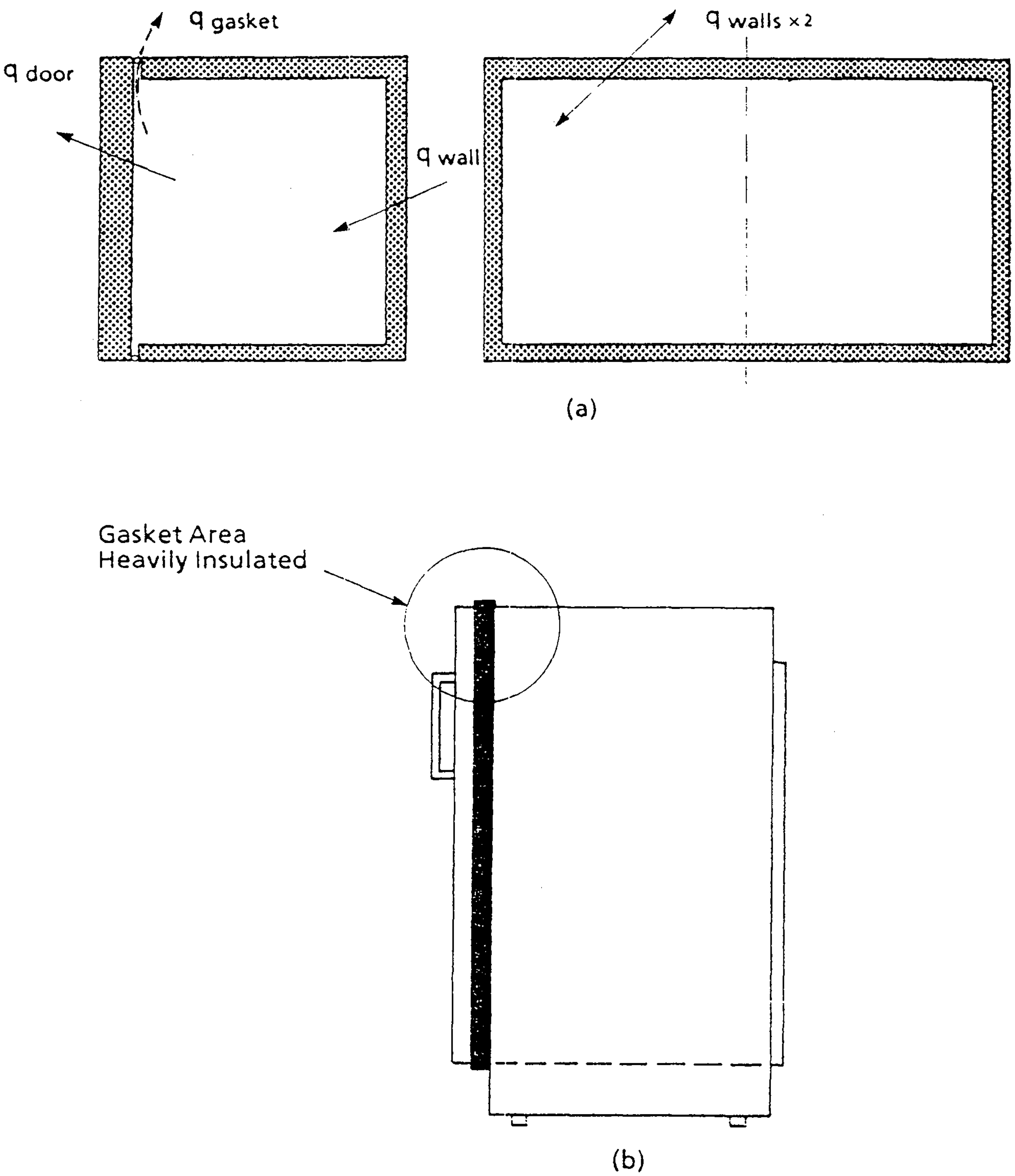

Fig. 6. Examples of possible configuration.

METHOD 2

A reverse heat leak test can also be applied to a cabinet that is insulated heavily around the gasket area (see Fig. 6b). This indicates the heat loss through the wall of the unit. Also, total heat loss through the unit can be measured if no insulation is added to the gasket area. Gasket heat loss is then calculated by difference. This method is more direct than the other method, but its accuracy also depends on taking the difference between two values that are nearly equal, which can lead to error.

4.0 APPLICABLE LATCHING-DOOR SAFETY REGULATIONS

According to the Consumer Product Safety Commission (CPSC) [19] and Underwriters Laboratories, Inc. (UL) [20], door-latching devices must follow standard rules and regulations. A door-latching device is a device that holds the door shut. A magnetic door gasket is considered a door-latching device for the purpose of these standards. Listed below are some of the requirements for latching devices; however, references [19] and [20] provide more detailed descriptions of the standards. Some of these requirements are:

- The door can be opened from a totally closed position from the interior.
- The opening device is accessible from anywhere in the interior.
- The device can be the application of an outward force from the interior.
- The applied force must not exceed 15 lb_f (66.7 N) directed perpendicularly to plane of the door anywhere along the latch edge of the inside of the closed door.
- A latch-release device must not depend on any electrical source for its operation.
- Latch-release device performance must be unaffected by spillage, cleaning, defrosting, and condensation.
- The device must satisfy wear and strength tests.

These regulations govern any changes that would be made to the door closure which are intended to improve energy conservation. It is unlikely that a mechanical door latching device will return to the market place, despite energy considerations.

5.0 SUMMARY AND RECOMMENDATIONS

This report presents the results of an extensive literature review, interviews with refrigerator/freezer and gasket manufacturers, and some in-house engineering analysis. The purpose of this study was to investigate the significance of gasket heat leakage, explore different design features, and to suggest further study if necessary.

The primary findings of this study were:

- The gasket area, including the gasket itself and the adjacent areas of the door and cabinet, has received considerable attention with respect to improvement of energy efficiency. Manufacturers will likely incorporate improved gasket technology in the 1993 models.
- There is little certainty about the exact magnitude of gasket heat leakage, although most believe it is significant. The significance will increase with future introduction of advanced types of insulation.
- Double door gaskets do not appear to offer much potential due to several practical limitations and the advancement in single gasket technology.
- Gasket infiltration may cause a significant portion of the load. There is little agreement about the magnitude of infiltration. However, calculations done in the present study suggest that infiltration may be an important cause of heat leakage.
- Safety requirements are critical for home refrigerator/freezers. It is highly unlikely that a mechanical door latching device could return to the market place that would meet these requirements, even if it meets energy conservation goals and can satisfy consumer interests.

Based upon the findings of this study, it appears that the uncertainty about the magnitudes of the heat leakage and infiltration effects can only be resolved by further experimental work. Undoubtedly much proprietary work has been done, but little information is available in the open literature. It is recommended that standard methodology be developed for heat leakage testing, and that an extensive experimental program be undertaken.

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TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-600/2-91-060

2.

4. TITLE AND SUBTITLE
Review of Energy Efficiency of Refrigerator/Freezer Gaskets

October 1991

6. PERFORMING ORGANIZATION CODE
EPA/ORD

7. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Iowa State University
Department of Mechanical Engineering
Engineering Research Institute
Ames, Iowa 50011

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.
68-02-4286, Task 2/129
(Radian Corporation)

12. SPONSORING AGENCY NAME AND ADDRESS
EPA, Office of Research and Development
Air and Energy Engineering Research Laboratory
Research Triangle Park, North Carolina 27711

13. TYPE OF REPORT AND PERIOD COVERED
Task Final; 7-11/90

14. SPONSORING AGENCY CODE
EPA/600/13

15. SUPPLEMENTARY NOTES AEERL project officer is Jane C. Bare, Mail Drop 62B, 919/541-1528.

16. ABSTRACT

The report gives results of an investigation of the significance of heat leakage through gaskets in household refrigerator/freezers, explores different design features, and suggests further study if necessary. The report gives results of an extensive literature review, interviews with refrigerator/freezer and gasket manufacturers, and some engineering analysis. (NOTE: Home refrigerators are the largest consumers of electricity among household appliances and are consuming an estimated 8% of the total electricity used in the U.S. Recent studies show that gasket area heat leakage may account for as much as 21% of the total thermal load.) The study found that: (1) manufacturers will likely incorporate improved gasket technology in 1993 models; (2) there is little certainty about the magnitude of gasket heat leakage, although most believe it is significant (significance will increase with introduction of advanced types of insulation); (3) double-door gaskets do not offer much potential due to several practical limitations and the advancement in single-gasket technology; (4) gasket infiltration may cause a significant portion of the load; and (5) safety requirements are critical for home refrigerator/freezers (it is unlikely that a mechanical door latching device would meet these requirements, even if it meets energy conservation goals).

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Heat Loss	Pollution Control	13B	20M
Gaskets	Safety	Stationary Sources	11A	13L
Refrigerators			13A	
Freezers				
Energy Dissipation			20K	
Efficiency			14G	

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 29
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE $17.00