II-A-96-01
II-A-1014

TTRU-01-02 #1
(ONAC)

TRUCK TRANSPORT REFRIGERATION UNITS

SUMMARY REPORT

19 March 1982
31 March 1982
6 April 1982

TRUCK TRANSPORT REFRIGERATION UNIT (TTRU) SUMMARY REPORT

INTRODUCTION

The U.S. Environmental Protection Agency has conducted a review of the draft noise emission regulation planned for Truck Transport Refrigeration Units (TTRU's). This review was performed from the standpoint of the prevailing conditions of the national economy, the economic difficulties being experienced by the truck and TTRU industries, the President's policy to reduce the burdens of Federal regulations, and the changes in the Agency's regulatory priorities due to national need and budgetary constraints.

The text will present pertinent information relevant to the Agency's review of the draft TTRU noise emission regulation. The subjects covered include the legislative background and historical development of the draft regulation, a description of the draft regulation, the environmental and economic impacts of the draft regulation, the present economic factors, and the mitigating factors motivating the decision not to proceed with the regulation. This report also provides a brief profile of the TTRU product and industry.

BACKGROUND OF THE DRAFT REGULATION

Through the Noise Control Act of 1972, Public Law 92-574 (86 Stat. 1234), later amended by the Quiet Communities Act of 1978, the Congress established a national policy "to promote an environment for all Americans free from noise that jeopardizes their health and welfare." In pursuit of that policy, Congress stated, in Section 2 of the Act, that, "while primary responsibility for control of noise rests with State and local governments, Federal action is essential to deal with major noise sources in commerce, control of which requires national uniformity of treatment." A major objective of the Act was to provide a national uniformity of treatment for major noise sources distributed in commerce. This objective was inspired by the contention of several major industrial groups, including the automotive industry, that the proliferation of diverse noise limits in various states and communities would negatively impact production efficiency and manufacturing costs. The costs associated with compliance with a single, uniform national standard would be less than if manufacturers needed to modify their assembly line practices in order to manufacture products with different quieting treatments and characteristics to comply with the various noise regulations in the locales where the products were to be sold.

As part of that essential Federal action, subsection 5(b)(1) requires the Administrator, after consultation with appropriate Federal agencies, to publish a report or series of reports "identifying products (or classes of products) which in his judgment are major sources of noise." Further, Section 6 of the Act requires the Administrator to publish proposed regulations for each product, identified as a major source of noise, and for which, in the Administrator's judgment, noise standards are feasible.

The noise standard must set noise limits requisite to protect the public health and welfare, taking into account the magnitude and conditions of use, the degree of noise reduction achievable through application of the best available technology, and the cost of compliance. The Act categorizes the products of concern into four classes: construction equipment, transportation equipment, any motor or engine (including any equipment of which an engine or motor is an integral part), and electrical or electronic equipment.

Inasmuch as a number of different types of transportation equipment operate at the same time, e.g., trucks, buses, motorcycles and automobiles, the quieting of one product type, e.g., trucks, is often not, in itself, sufficient to adequately reduce transportation noise to a level necessary to protect health and welfare. Accordingly, the EPA's noise regulatory program developed a coordinated approach for controlling overall transportation noise in which various types of transportation equipment were evaluated alone or in combination to assess their contribution to transportation noise and its impact on the nation's population.

Under the mandate of the Act and EPA's approach for the control of transportation noise, medium and heavy trucks were formally identified on June 21, 1974 (39 FR 22297). This regulation applied to newly-manufactured trucks. The regulation did not address any truck auxiliary equipment.

In order to deal with the noise problem of such auxiliary equipment and to supplement the truck noise regulation in controlling transportation noise, the Administrator, in accordance with Subsection 5(b)(1) of the Act, published a report on May 28, 1975 (40 FR 23107) that identified truck transport refrigeration units as a major source of noise. Several other products were also identified in this report as major sources of noise.

It was recognized that, in comparison with other noise sources, the noise impact associated with TTRU's was of a lower order of magnitude. However, in view of the actions already taken by the Agency to control noise emissions from medium and heavy trucks, control of TTRU was needed to avoid reducing the effectiveness of that regulation.

Following this identification, comprehensive studies were performed as part of the regulatory development process for TTRU. The Agency conducted detailed investigations of TTRU design, manufacturing and assembly processes, noise measurement methodologies, available noise control technology, costs attendant to noise control methods, costs to test vehicles for compliance, costs of record keeping, anticipated economic impacts, and the potential environmental and health and welfare benefits associated with the application of various noise control measures.

The results of the Agency's studies led to the conclusion that the regulation of TTRU noise would result in a reduction in environmental noise and that the regulation was feasible through the application of readily available noise control technology, taking costs of compliance into account.

SUMMARY OF THE DRAFT STANDARD

Based on the results of the pre-regulatory studies, EPA developed a draft noise emission standard for TTRU's. The draft standard set noise emission limits for the operation of newly manufactured TTRU's. The draft standard specified sound levels measured, at a distance of 50 feet (about 15.2 m) from the surfaces of the TTRU, in decibels on the A-weighted scale, using a slow meter response.

The following table summarizes the recommended not-to-exceed noise emission levels for TTRU's.

TRUCK TRANSPORT REFRIGERATION UNIT
A-Weighted Sound Pressure Level
(@.50.Feet), Decibels

Effective Date	Current Range	Recommended Not-to-Exceed Level
July 1, 1979	*57-75	69

*This low noise level is observed during electrically-powered operation

The draft standard incorporated an enforcement program which included production verification, selective enforcement auditing procedures, warranty, maintenance, compliance labeling and anti-tampering provisions.

The recommended regulatory level was chosen to provide the greatest possible reduction of noise impact for the least possible cost. The effective date was selected to permit sufficient time for all segments of the industry to develop and put into production the necessary noise control features for compliance. Furthermore, the Agency, through the draft regulation, was pursuing a strategy through which major contributors to overall

residential neighborhood noise were to be identified and subsequently regulated. This was necessary because only through a coordinated approach (regulating medium and heavy trucks and their auxiliary equipment, including the refrigeration unit where applicable) could the Agency accomplish its overall objective of quieting all major noise sources in residential areas in order to reduce the environmental noise to the extent believed appropriate.

RATIONALE FOR STANDARD SELECTION

In arriving at the draft standards, the Agency examined the various types of residential neighborhoods and certain urban areas, such as truck stops, in which TTRU contributes to environmental noise. Studies were conducted to determine the contribution by the TTRU to total residential neighborhood and urban area noise level. These investigations indicated that in urban neighborhoods, TTRU's were a significant contributor to the overall environmental noise, causing annoyance and probability of sleep and speech interference.

The Agency examined the available technology, costs, and potential economic impact to achieve various reduced noise levels of TTRU's. The noise levels examined ranged in value from the present average levels (engine-driven) (70-75 dB) to 65 dB, measured at 50 feet. Estimates of the costs to quiet refrigeration units were developed from engineering cost data provided by industry and independent Agency estimates, taking into consideration industry accounting practices and list prices of refrigeration units.

In its studies, EPA recognized that various procedures, as well as combinations of procedures, existed that would enable the three major categories of TTRU's to comply with the draft regulation. For the purpose of estimating noise reduction feasibility, costs and economic impacts of the draft regulation, EPA considered the contributions made by each noise source to the total radiated levels, and then estimated the reduced levels that could be reached for each source through the application of state-of-the-art technology. EPA considered the following list of reasonable noise control treatments: improved muffler; application of sound absorptive material; quieter compressor fans; and partial engine enclosures.

These treatments were shown to be feasible and were demonstrated in the TTRU's used in tests. Each manufacturer was expected to use treatments or combinations of treatments from this list, or others that they would develop, that would produce the required quieting at the lowest cost for their TTRU's.

ESTIMATED COST AND ECONOMIC IMPACTS

The cost impact of quieting refrigeration units to meet the draft regulatory standard is best expressed in terms of potential increase in list price. This information is shown in the Table below. As shown, the Agency's studies indicated that the potential increases in the average list price for the quieted TTRU's would range from 2.0 to 2.5 percent, depending on the class of unit, resulting in an overall average list price increase of 2.25 percent.

Estimated Prices

Class of Unit	Discounted Average List Price (1981$)	Mid Range Price Increase (1981$)	Percent Price Increase
Trailer Nose Mount	$10,100	$206	2.0
Trailer Under Mount	10,100	252	2.5
Truck Mount	4,160	91	2.2

In terms of societal resources, the Agency initially estimated capital costs for the first year of compliance at about $8 million (1981 dollars). The equivalent annual cost over a 20 year period was estimated at approximately $17 million (1981 dollars).

Other aspects of potential economic impact estimated by early studies were:

1. Impacts on manufacturers and employment. No significant changes in plant and equipment investment levels were anticipated. No unemployment was expected to occur due to the regulation of noise emissions of TTRU's. Persons who could have been affected by the reduced production of truck

transport refrigeration units amounted to less than 2 percent of the total TTRU's work force of about 7000 persons. However, an offsetting increase in employment was expected to occur due to testing and compliance activity and procurement of noise control components and materials resulting from the regulation.

2. Impacts on Exports and Imports. No change in the balance of trade with foreign countries that would be unfavorable to the U.S. was anticipated.

Domestic TTRU manufacturers would have been able to export both quieted and unquieted products to foreign countries depending on the requirements of the foreign market. To the extent that some foreign markets required quiet refrigeration units, domestic manufacturers would be in an improved competitive position.

At that time, refrigeration unit imports had not significantly penetrated the United States market. This indicated that the U.S. producers had a net cost/technology advantage over foreign producers. This was not expected to change.

3. Macroeconomic assessment. No macroeconomic impact was expected because the industry is small and the expected changes were minor in magnitude.

4. Impact on energy use and costs. No increase or decrease in the energy requirements to operate the units was anticipated.

There was however the possibility that some small manufacturers of refrigeration equipment would elect to leave the industry due, in part, to the imposition of a noise regulation.

ESTIMATED HEALTH AND WELFARE BENEFITS

EPA's analysis indicated that for the most part, the noise impacts from TTRU's were highly localized. The noise impact was particularly severe where vehicles were parked overnight in high density population urban areas, awaiting loading and unloading operations.

Consequently, the Agency examined the health and welfare benefits that various levels of reduced noise emissions from TTRU's would provide to the noise-impacted population. The public health and welfare impacted associated with the draft standards were assessed in terms of the number of people impacted by the noise of TTRU's, the severity of impact, and the noise impact relief that would be achieved by quieting the refrigeration units.

The EPA estimated that approximately 9 million persons were exposed to residential neighborhood noise levels due to operation of TTRU's at noise exposure levels above that level identified by the Agency as requisite to protect public health and welfare, i.e., L_{dn} = 55dB. It was estimated that compliance with the proposed standards would result in a reduction in the number of persons so exposed to about 3 million persons over a period of 12 years, representing about a 67 percent decrease in impacts.

The reduction in extensiveness and severity of impact was evaluated in terms of effects due to individual noisy events, such as sleep and speech interference, as well as effects due to generalized annoyance, which can be assessed by reductions in L_{dn}. Accordingly, the "level-weighted population" (a general measure of the extent and severity of noise impact that takes into account partial impact on people at different levels of noise exposure) (See Figure 1) was expected to decrease by about 74 percent from 503,000 in the base year to about 133,000 persons after 15 years.

~~9~~ 12

FIGURE 1

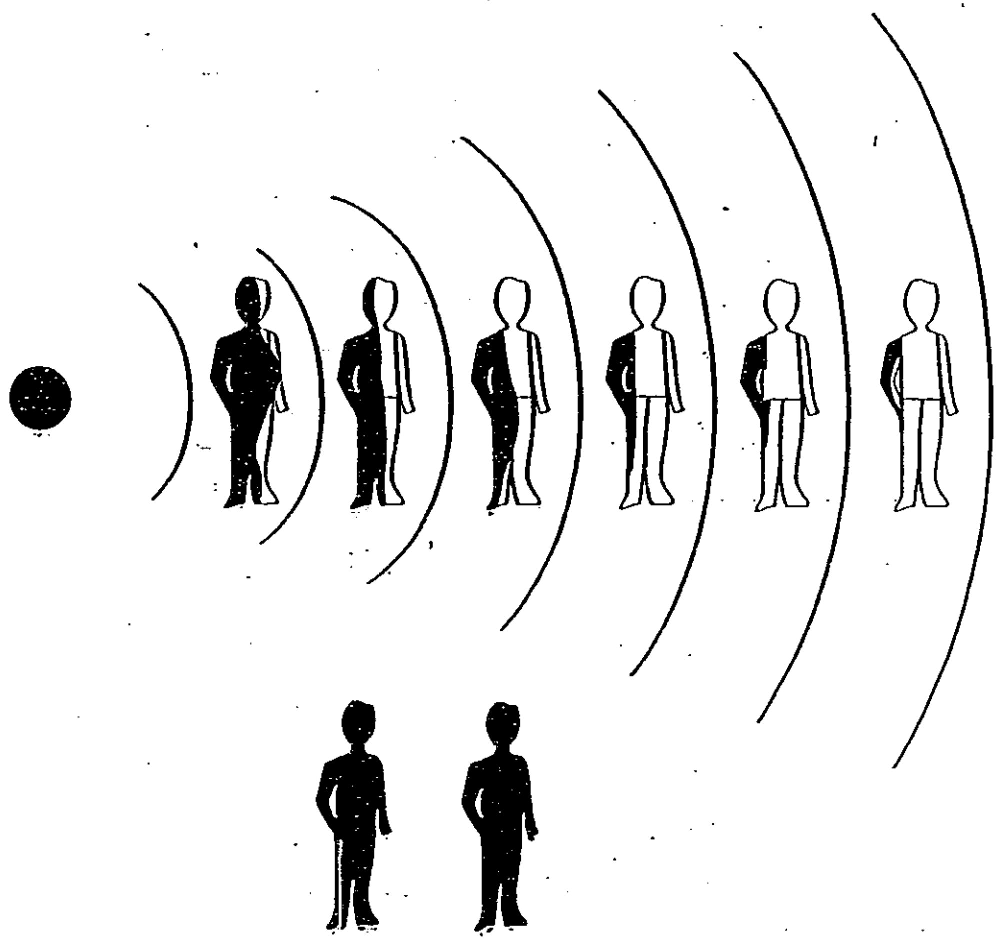
EQUIVALENT NOISE IMPACT

EQUIVALENT NOISE IMPACT: A METHOD TO ACCOUNT FOR THE EXTENT AND SEVERITY OF NOISE IMPACT

Equivalent Noise Impact (ENI) expresses both the extent and the severity of a noise impact. The extent of impact refers to the number of people who are adversely affected, while the severity represents the degree to which each person is affected. ENI provides a simple, single number used to compare benefits of different noise reduction options.

It has been determined that an outdoor L_{dn} value of 55 dB (or an indoor L_{dn} of 45 dB) represents the lower threshold of noise jeopardizing the health and welfare of people. In the range above these levels, noise may be a cause of adverse physiological and psychological effects. These effects often result in annoyance and community action. Above an L_{dn} of 75 dB, noise, in time, may cause hearing loss and the possibility of other severe health effects.

The computation of ENI allows one to combine the number of people jeopardized by noise above an L_{dn} of 55 dB with the degree of impact at different noise levels. The figure is a pictorial representation of the ENI concept. The circle is a noise source which emits noise to a populated area represented by the figures. The various partial amounts of shading represent various degrees of partial impact by the noise. Note that those people closest to the noise source are more severely threatened. The partial impacts are then summed to give the Equivalent Noise Impact. In this example, 6 people who are adversely affected by the noise (partially shaded) results in an Equivalent Noise Impact (ENI) of 2 (totally shaded).



Recognition of the intrusive nature of TTRU noise impact led the Agency to a single-event noise exposure analysis for assessing the health and welfare impact of truck transport refrigeration unit noise control. The benefits of the proposed refrigeration unit noise regulation, in terms of reduction of single-event impacts, relate to sleep awakening, sleep disturbance, and speech interference. For example, EPA estimated that the number of probable sleep disruption events (and similarly speech interference occurrences) would decrease from about 1.4 million nightly in the base years to about 0.7 million after 15 years as a result of the regulation, a reduction of 50 percent.

PRESENT ECONOMIC CONDITIONS

When the original pre-regulatory analysis for TTRU was undertaken, in the mid-1970's, the general economic well-being of the industry, the Nation in general, and the truck and truck manufacturing industries were positive. The Agency's decision to regulate TTRU's was based on the premise that these economic conditions would continue and, that strong consumer demand would alleviate any adverse cost and economic impacts resulting from a noise emission regulation. However, these early assumptions and the information contained in the Agency's pre-regulatory analysis are not consistent with the economic conditions which have evolved over the past several years. Beginning in 1978, TTRU manufacturers have been experiencing a marked decrease in their refrigeration unit shipments.

The truck and truck auxiliary equipment manufacturers are an integral part of the automotive industry. Performance of the automotive industry is highly correlated to the performance of the overall economy; as problems occur in the economy, these industries are generally among the first to be impacted.

The economic problems presently faced by the auxiliary equipment industry, e.g., truck transport refrigeration manufacturers, are illustrated by comparing the overall index of industrial production to that for transportation equipment. During the period of 1975 through 1979, the index of industrial production increased by more than 29 percent; it decreased 3.9 percent overall during 1980, and rose 3.4 percent in 1981. However, the index for transportation equipment experienced a 14.2 percent decrease with the

index for motor vehicles and parts decreasing 26.3 percent during the 1979 to 1981 time frame. Thus, while industrial production declined on an overall basis, it declined disproportionately more in those sectors of the economy where TTRU manufacturing and sales is concentrated.

MITIGATING FACTORS

Significant benefits to the health and welfare of operators and bystanders were expected to be gained by the issuance of a Federal noise emission regulation for TTRU. In the absence of a Federal initiative to control TTRU noise, the Agency anticipates that protection can be effectively provided to the public by other sources.

Since enactment of the Noise Control Act of 1972, and the "Quiet Communities Act" of 1978, significant strides in noise control program development and capabilities have been made at the State and local level. This is illustrated by the steady growth of State and local noise control programs and ordinances. As of June 30, 1981, based on figures submitted by each EPA Regional Office, there were 272 cities with populations over 25,000 that had "active" noise control programs. "Active" programs are defined as those with ordinances that incorporate quantitative noise level (decibel) limits, the commitment of personnel and budget, and an active enforcement program. Many more communities have ordinances, either qualitative or nuisance type, which give them the legal capability to enforce noise control if they choose to do so. In 1981, twenty-four States had enabling legislation for noise control and a number of others have programs operating under general authorization, e.g., in health departments, though not specifically mandated.

There are several noise control options exercisable at the discretion of State and local governments. One option is simply to require operators to turn off the TTRU during delivery operations. This option, however, would not be feasible where it becomes necessary to park the refrigeration unit for long

periods of time while on delivery, or overnight under high ambient temperatures, i.e., at truck terminals while loading or unloading. However, this condition can be cured by State and local governments through the establishment of property line noise ordinances. This action would motivate fleet operators to use TTRU units that offer dual power sources (electric motor and internal combustion engine) to drive the refrigeration system when the trailer is parked. The electric motor option permits the unit to be "plugged in" to an electric outlet. Operating in the electric mode permits the TTRU to operate at a much lower noise level, since the internal combustion engine, which is the primary noise source, is disengaged and turned off. This technology is currently available and is known to be utilized on a broad scale by a major supermarket chain in the Southeast.

In addition to the State/local capacity to regulate the use of noisy products, EPA has worked with these governments to establish a new approach as an alternative to regulations, known as the Buy Quiet Program. Rather than manufacturers being required by law to reduce noise levels of products (consistent with technological and economic feasibility) they are motivated to reduce those levels through competitive market forces. Currently, the market for quiet is being organized through State and local agencies and some utilities, but can easily be expanded to the private sector market. Over 100 State and local units of government are currently participating.

In the case of TTRU's, two major manufacturers have reduced the noise emission of their units. A leading manufacturer, starting in 1972, has reduced by approximately 6 dB the noise level of his trailer mounted units. Another manufacturer has included as standard equipment an improved muffler

that provides an additional 3 dB noise reduction over earlier units. Both manufacturers offer their customers, through their dealers, a retrofit "noise reduction kit." These voluntary actions were motivated by market demand and competition.

SUMMARY

In 1975, when TTRU's were identified for Federal regulation, the general economic well-being of the industry, the Nation in general, and the truck and auxiliary equipment manufacturing industry were positive. However, significant changes in the economic and political climate have occurred which prompted a re-examination of the Agency's prior decision.

In light of the depressed economic conditions that currently prevail in the trade and truck auxiliary equipment industries, the imposition of a Federal regulation and its attendent compliance costs would be inappropriate at this time. Further, in consideration of the significant growth of state and local noise control programs since TTRU's were identified as major noise sources, and the fact that the noise emission from these products can be cost-effectively controlled at the local level, the administrator believes that the absence of a Federal regulation will not deprive citizens of the protection requisite to their health and welfare. This latter factor, together with the industry's voluntary noise reduction program, makes it reasonable for the Federal government to withdraw TTRU's from the Agency's report identifying major noise sources.

APPENDIX A

TRUCK TRANSPORT REFRIGERATION UNIT

THE PRODUCT AND INDUSTRY

DESCRIPTION OF THE PRODUCT

Truck Transport Refrigeration Units (TTRU's) are used to maintain perishable goods at a controlled temperature (either hot or cold) and are generally installed on the cargo body of a truck trailer. This definition excludes air conditioners that are intended to cool truck cabs and refrigerated containers that are primarily intended for ship transport but are carried over land by rail or flatbed trucks.

TTRU systems vary in size and configuration from a set of small components, much like an automobile air conditioning system, to self-contained diesel-powered units. The largest provides more than ten times the cooling power of the smallest and generates more than 20 dB higher sound levels. Large units may keep a 40-ft trailer-load of ice cream frozen at -20°F; smaller units may keep sandwichess in a catering truck at +40°F. These units are divided into the following classes:

- o Trailer units
- o Single-package truck units
- o Variable speed units

Trailer units (units designed for trailer application) have the highest cooling capacity and are always powered directly or indirectly by diesel engines that are separate from the truck engine. Single-package truck units are generally applied to medium-to-large straight trucks (rarely to trailers),

have a medium-range cooling capacity, and are powered by gasoline or gas engines (never diesels). Variable speed units are generally found in small-to-medium trucks. They have a small cooling capacity, and are always (by definition) powered by the truck's main engine.

Trailer Units

Trailer refrigeration units are mounted on the trailer body and include self contained diesel, electric motor, or gasoline engine powered units. This arrangement permits parking the trailer for storage, loading, or unloading without immobilizing the tractor. There are three basic types of trailer units:

1. Nose-mounted diesel (with optional electric drive for standby operation);
2. Nose-mounted electric with an undermounted diesel generator set;
3. Undermounted refrigeration units.

Nose-mounted Diesel

A typical nose-mounted diesel unit is shown mounted to a trailer in the photograph in Figure 2. The unit is designed to have minimal depth in order to fit easily between the trailer body and truck tractor. To maximize cargo-carrying space, all major manufacturers use the same arrangement of components, keeping principal components, such as the diesel engine, on the outside and locating only the evaporator inside the trailer.

Figure 3 shows a cutaway view of a nose-mounted unit. The diesel engine and compressor are located in the bottom half of the unit, with the condenser, radiator, and cooling fan at the top behind a protective grid. In this particular unit, the air-intake cleaner is on the right side and the exhaust muffler on the left side of the unit.

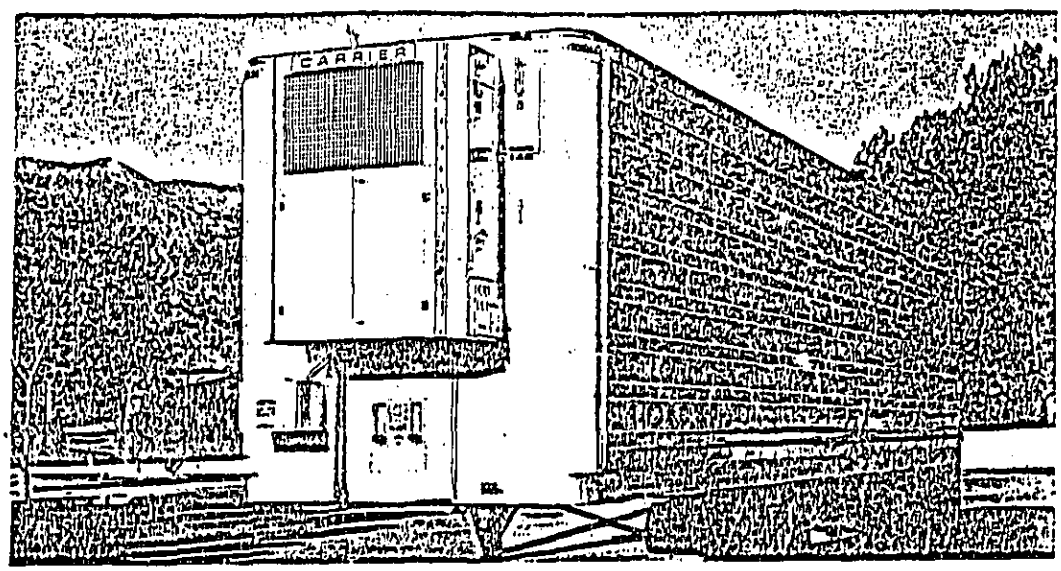


Figure 2. Nose-Mounted Unit on Trailer (Courtesy of Carrier-Transicold Co.)

Units such as these typically operate in several thermostatically controlled modes to maintain a preset trailer temperature. When the trailer is much warmer than desired, the refrigeration unit will run at maximum speed (about 2200 engine rpm), delivering the greatest possible cooling and generating maximum noise. When the trailer temperature is only slightly warmer (about 50°F) than desired, the unit will operate at a slower constant speed (about 1350 engine rpm), which is also quieter.

Many diesel nose-mounted units also employ a 15-hp electric motor that is used to drive the refrigeration system in a standby mode when the trailer is parked. The motor requires only an external 230-volt electrical supply. The electrical standby mode enables the engine to be declutched and left inoperative, thereby avoiding expenses associated with engine wear and maintenance as well as the noise associated with engine operation. Because motors

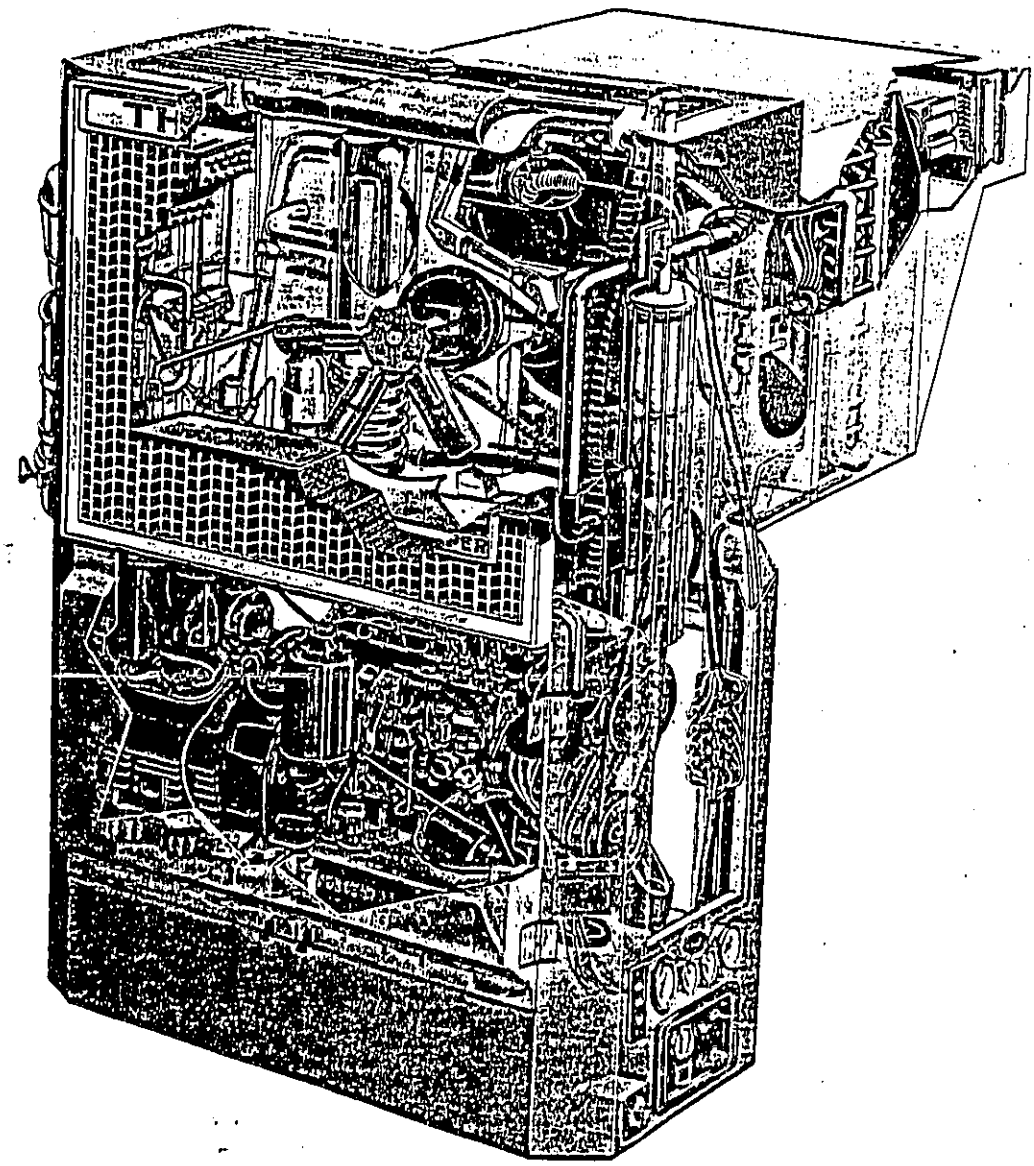


Figure 3. Cutaway View of Nose-Mounted Unit (Courtesy of Thermo King).

are easily turned on and off, the standby system operates efficiently in cool, off, and heat modes.

Nose-Mounted Electric Unit With An Undermounted Diesel Generator Set

Some trailers use a split system involving an electrically driven compressor in the nose unit and an undermount diesel generator to provide electrical power for over-the-road operation. Figure 4 shows photographs of representative units along with a line drawing illustrating their arrangement on a trailer.

The operation of the electrical nose-mounted unit is like that of the diesel nose mount in the standby mode.

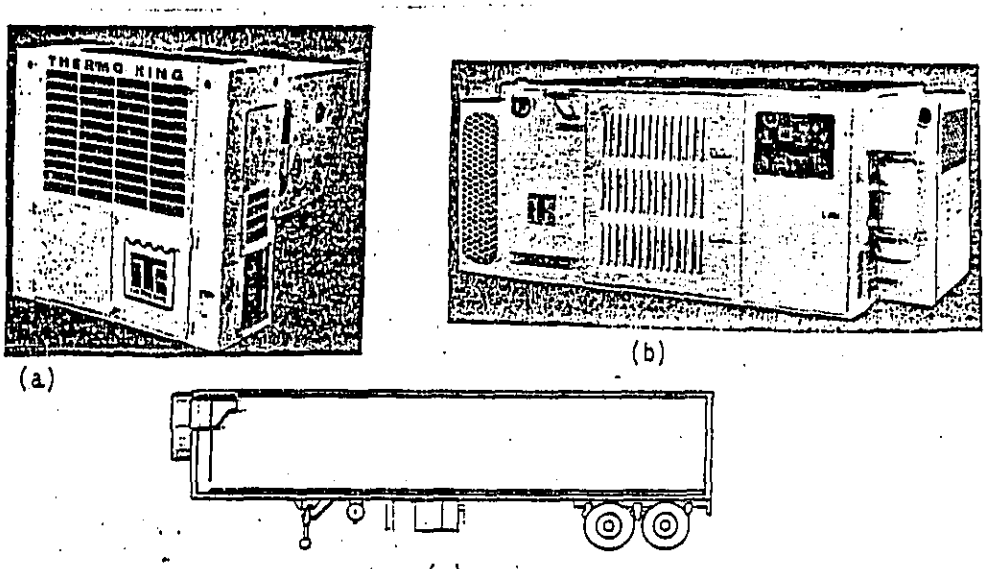


Figure 4. Photographs of (a) An Electric Nose-Mounted Unit and (b) An Undermount Generator, Along With a Sketch (c) of Their Arrangement on a Trailer.

Undermount Refrigeration Units

Several companies offer an undermount refrigeration unit comprised of a diesel-engine driven compressor, a condenser, and auxiliary equipment. As shown in Figure 5, this unit allows the evaporator to be externally mounted in a pod, thereby maximizing cargo-carrying space within the trailer. Refrigerant is piped between the undermount unit and the evaporator. The undermount unit also contains a generator or an alternator to power the electric fan motor in the evaporator section.

Undermount units, like nose-mounted units, operate in high-cool, low-cool, high-heat, and low-heat modes. An electric standby option is not generally offered with these units.

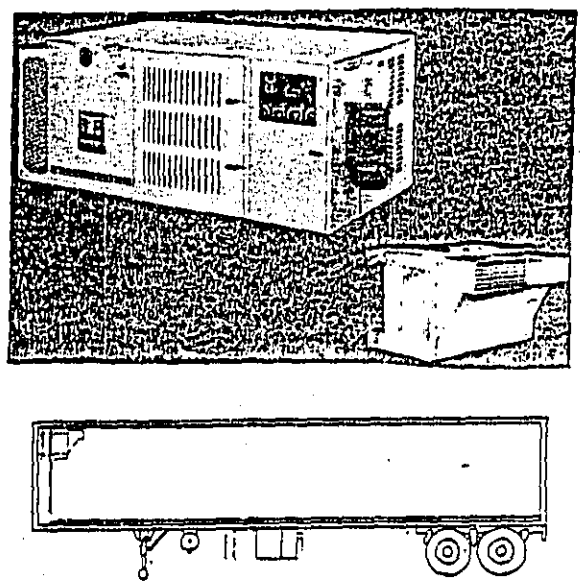


Figure 5. Undermount Refrigeration Set (Courtesy of the Thermo King Corporation).

Single-Package Truck Units

A representative model of a single-package truck unit is illustrated in Figure 6. These units are driven by air-cooled gas or gasoline engines and are rated at 11,500 to 25,000 BTU/hr. The internal arrangement of components for this type of unit is illustrated in Figure 7. The reciprocating compressor is driven either by the engine or by the electric standby motor.

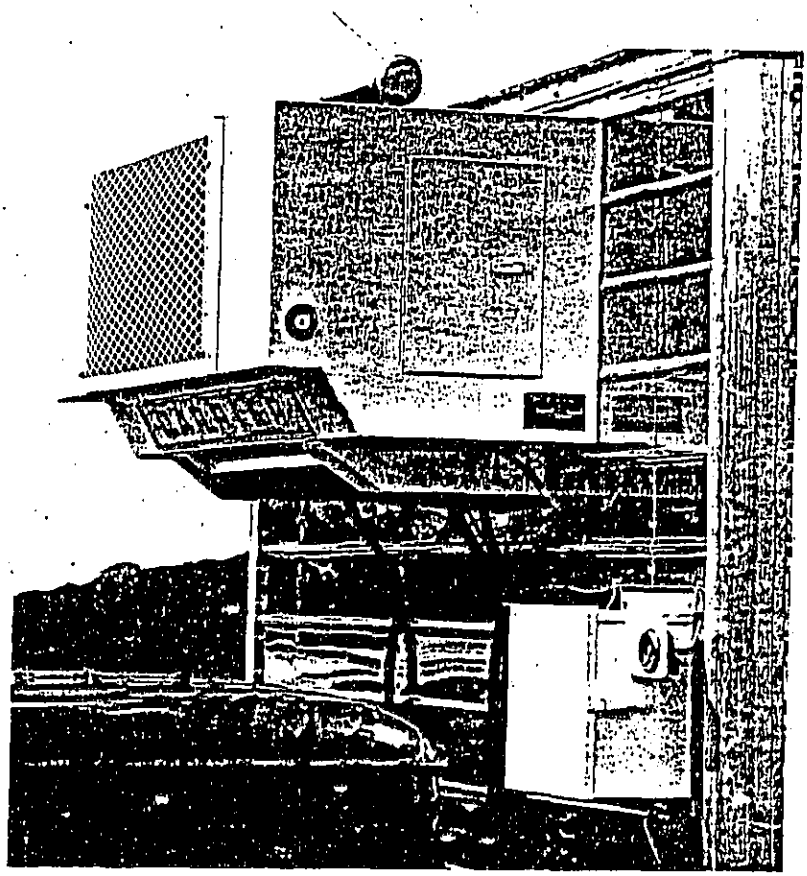


Figure 6. Truck Nose-Mounted Unit (Courtesy of the Carrier Transicold Company).

As with the diesel trailer units, the engine is always used during over-the-road operation. When the vehicle is parked, the compressor may also be driven by the engine but is preferably driven by the motor, which is plugged into a 230-volt electrical outlet.

When the engine drives the compressor, the motor is inoperative and the armature turns freely. When the engine is turned off, a centrifugal clutch disengages it from the motor and compressor, allowing the motor to operate the compressor unimpeded by the engine.

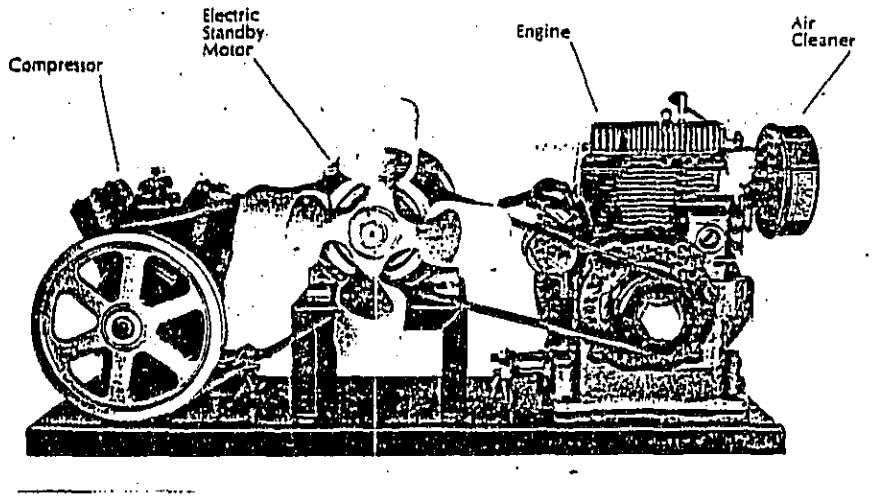


Figure 7. Arrangement of Truck-Mounted Unit Components (Courtesy of the Carrier Transicold Corporation).

Variable Speed Units

Variable speed units are so named because the compressor, which is driven by the truck engine, runs at a speed that varies according to engine speed. These units are used on small-to-medium trucks. Probably the most common type of unit is the one that uses an a compressor similar to an automobile air-conditioning unit, belt-driven by the engine. As illustrated in Figure 8, the condenser may be loocated over the cab, on the side of a van (as illustrated in Figure 8), or at any other convenient location. The evaporator is within the truck to maintain either the entire truck body or a compartment within it at a thermostatically controlled temperature.

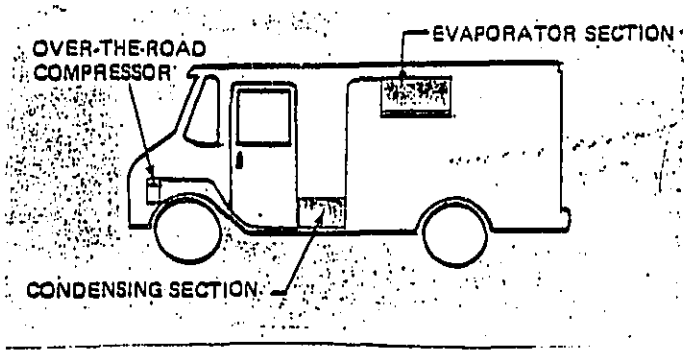


Figure 8. Variable Speed Unit Arrangement

Somewhat larger units use a power takeoff on the truck transmission to drive a compressor mounted to the truck's frame rail. The condenser for these units is mounted at the front of the truck body.

THE INDUSTRY

Background

The first truck and trailer mechanical refrigeration units were manufactured in the late 1930's. While the basic process was essentially the same for all manufacturers, there were some variations in the methods of operation.

Figure 9 depicts the general structure of the industry. Refrigeration manufacturers receive raw materials and components from suppliers; in the case of selected major components, the supplier may have been another division of the same corporation. Manufacturing methods differ between companies as a result of varying production rates and economies of scale. The level of vertical integration is relatively consistent between companies. All companies purchase engines, motors, generators, mufflers, instruments, and other automotive-type components. In addition each company manufactures its own frame and enclosure assemblies. The only significant difference between manufacturers exists in the make-versus-buy mix of compressors and refrigeration coils.

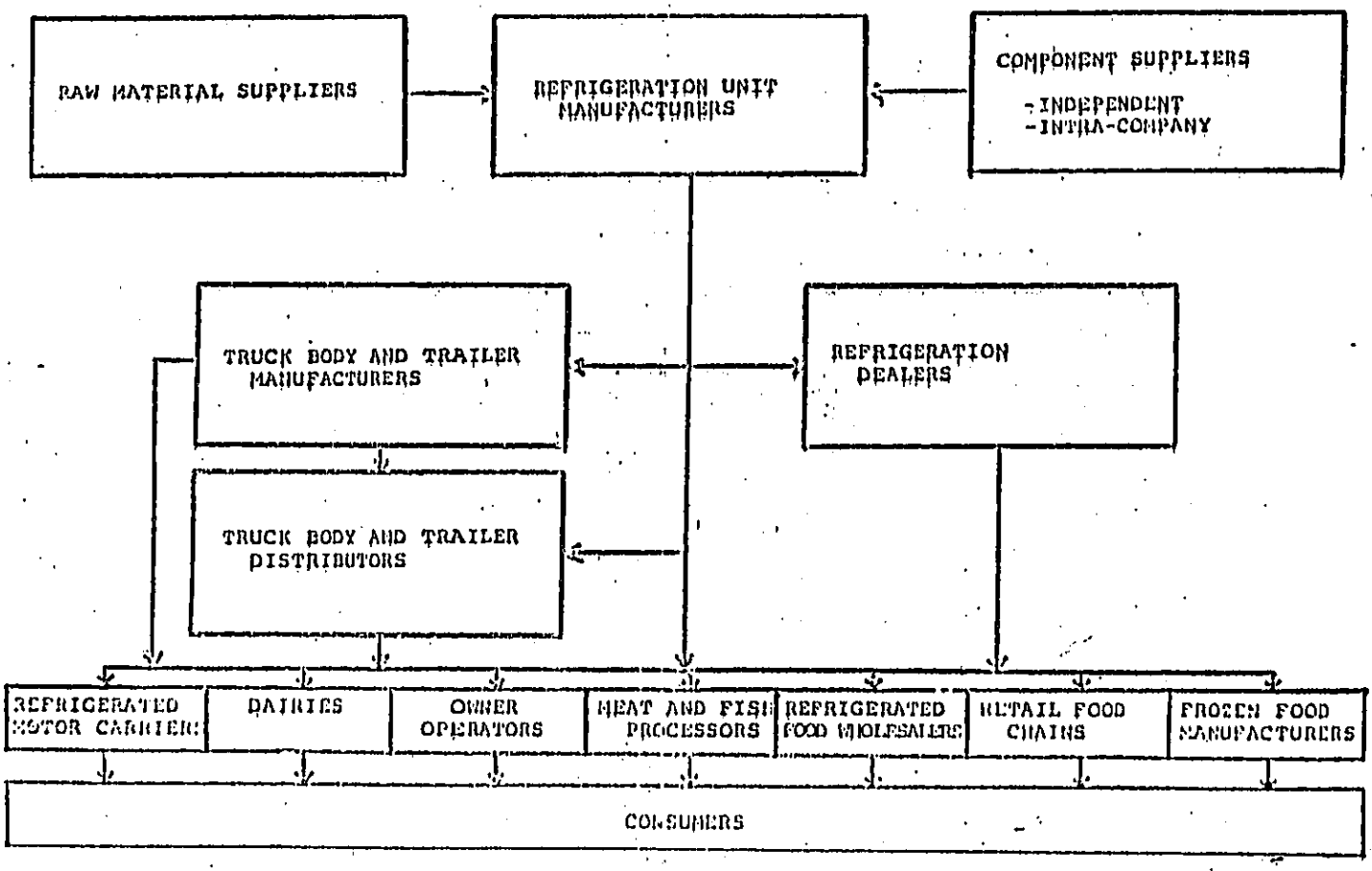
Refrigeration units are sold directly to refrigeration dealers, truck body and trailer manufacturer dealers, and end user fleet operators. Most of the refrigeration units are sold to refrigeration dealers. As shown, the number of end users is relatively large.

Based on 1974-5 data, EPA identified five truck transport refrigeration unit manufacturers of which two were large firms with employment of 27,000 to 199,000 employees, and three were small firms with employment of 25 to 517 employees.

It was estimated that in 1972 there were 195,000 truck transport refrigeration units in operation. Of those, trailer units accounted for 62 percent

FIGURE 9

TRUCK AND TRAILER MECHANICAL REFRIGERATION UNIT
INDUSTRY STRUCTURE



SOURCE: Air-Conditioning and Refrigeration Institute and field interviews with equipment manufacturers, dealers and end users.

of the 195,000 and variable speed and single package units accounted for 38 percent of the total.

In 1974, the total unit production of refrigeration units was estimated at 25,300 units with a value of $102 million. Trailer-mounted units accounted for the largest share of both unit numbers (60 percent of total units) and value (80 percent of shipments) while variable speed units accounted for only a small fraction of the units. Approximately 25 percent of the total 1974 production value was exported units and components.

Size and Growth of the Industry

According to the U.S. Census figures for 1972, approximately 45 percent of the total U.S. food commodity production was shipped between urban areas. Trucks transported 85 percent of these commodities. The remainder of the food commodities (55 percent) was transported and consumed within the urban area of production. It was assumed that trucks would also be the dominant carrier of food commodities within the urban area of production.

The demand for TRRU's was derived from the overall demand for movement of goods requiring refrigeration. Refrigeration manufacturers and dealers indicated that the dominant end users of this equipment were involved in the manufacture and distribution of food products, primarily meat, diary products and frozen foods. As depicted by Table 1, the production of food products had an average annual growth rate of approximately 1 percent for the 1964 - 1974 time frame. Forecasters estimated that this rate would continue through 1985.

TABLE 1

1964 - 1974 PRODUCTION AND 1980 AND 1985 PROJECTED
MAJOR FOOD PRODUCTION

	ACTUAL Pounds (Billions)					PROJECTED Pounds (Billions)		
	Year				Average Annual Growth 1964 -	Year		Average Annual Growth,
Commodity	1964	1965	1970	1974	1974	1980	1985	1974 - 1985
Meat*	29.7	28.3	34.6	36.3	2%****	41.5	54.5	2%****
Fluid Milk**	127.0	124.2	117.0	125.4	-1	112.0	110.0	-1
Frozen Foods***	12.4	14.1	17.4	23.5	7	32.0	40.0	5
Total	169.1	166.6	169.0	175.2	1%	185.5	195.5	1%

SOURCE: Predicasts, Inc., "Predicasts Composite Forecasts, 1975," Page A-24 and A-25

*Slaughtered product which includes the bulk of product categorized as SIC code 201, except fresh-frozen and poultry.

**Includes the bulk of product categorized as SIC code 202, except frozen.

***Includes meat, vegetables, fruit and specialty items.

****Rounded to the nearest percentage point.