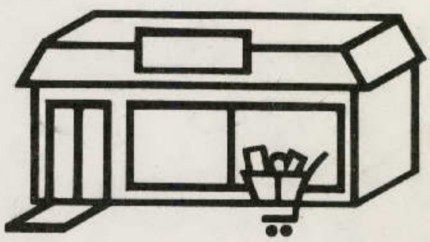
TEXAS ENERGY MANAGEMENT

1979 WORKSHOPS

TEXAS ENERGY MANAGEMENT

SUPERMARKETS



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Energy Management in Supermarkets

A Workshop Sponsored by
The Governor's Office of Energy Resources

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ENERGY FACTS

ENERGY FACTS

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Why Conservation?

The events of recent months have again exposed the United States' vulnerability to fluctuations in the supply of foreign petroleum and have brought energy back into the American consciousness in a manner reminiscent of the days of the Arab oil embargo in 1973. We are again being forced to realize that a stable supply of imported oil to heat our homes, power our cars, generate our electricity and fuel our economy is not a certainty. Hopefully, this painful realization will have a lasting impact on energy consumption patterns in this country.

Consider the following facts about U.S. oil consumption. In 1973 while importing approximately 6 million barrels of oil per day at a total cost of about $8 billion, the U.S. had a positive balance of trade of $9 billion. In 1977, we imported 9 million barrels of oil per day at a cost of $46 billion and ended the year with a $30 billion balance of trade deficit. We currently import approximately 46% of our petroleum needs. Pfojections of present usage patterns indicate that by 1985, without drastic changes, we face the prospect of importing 12-14 million barrels of oil per day and a $100 billion dollar trade deficit. Clearly this would have a devastating effect on our economy and would undermine our position as leader of the free world.

Armed with these figures, it's not too difficult to see that we're going the wrong direction, -- rapidly. We simply can't afford this. We must collectively and individually come to grips with energy usage to avoid the economic havoc of a $100 billion trade deficit.

From a personal and business viewpoint, the logical course to pursue is one of learning to better conserve and manage our energy resources through more efficient and intelligent use. Reduced consumption will yield lower expenditures, more profit, a sounder economy and a brighter future for us all.

Hopefully, the ideas passed on today will help you implement an energy conservation program in your facility.

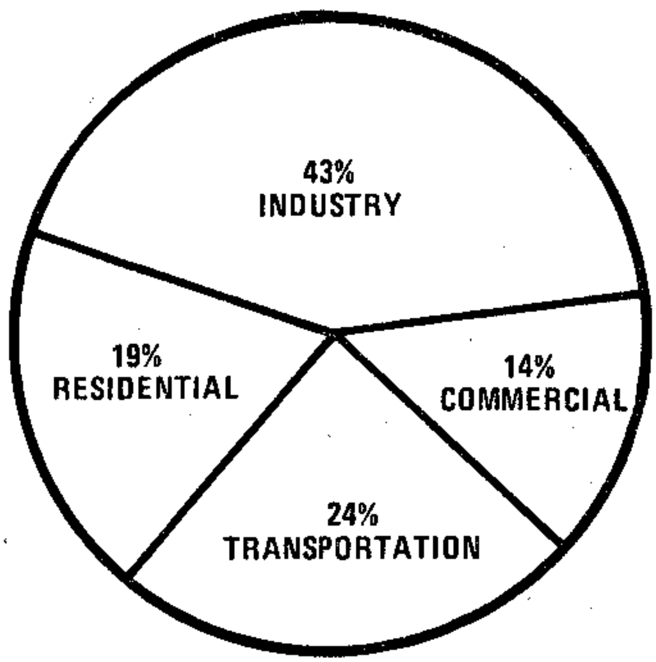
1978 WORLD OIL PRODUCTION

	MILLION BARRELS PER DAY
U.S.S.R.	11.40
UNITED STATES	8.66
SAUDI ARABIA	7.80
IRAN	5.25
IRAQ	2.50
VENEZUELA	2.15
LIBYA	2.05
CHINA	2.00
KUWAIT	1.90
NIGERIA	1.80
INDONESIA	1.65
ABU DHABI	1.45
CANADA	1.30
MEXICO	1.27
ALGERIA	1.26
UNITED KINGDOM	1.10

ENERGY OVERVIEW

Division of Total U. S. Energy Consumption

Total energy use in the United States can be divided by business sectors into the areas shown below. Note that the entire commercial sector consumes about 14 percent of the nation's energy supply.

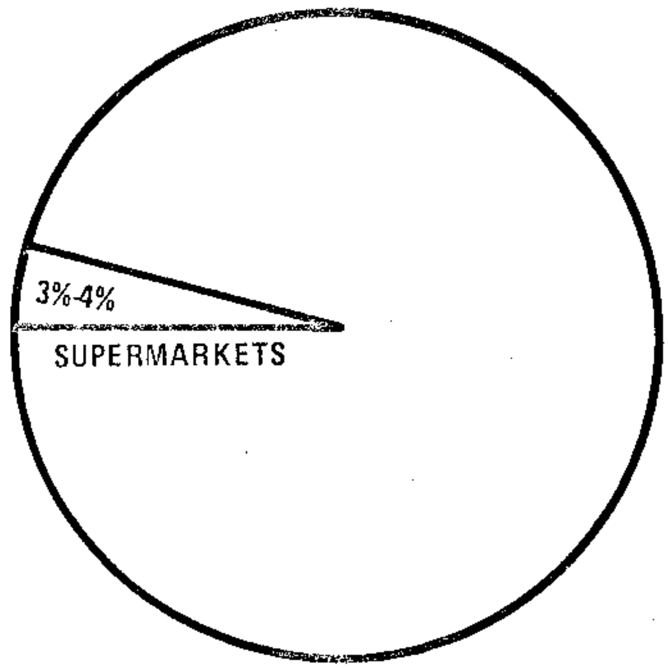


Division of Total U.S. Energy Consumption

"A Study of the Impact of Reduced Store Operating Hours on Sales, Employment, Economic Concentration and Energy Consumption." (October 1974) Federal Energy Administration.

How Supermarkets Relate to the Energy Dilemma

Supermarkets consume about 3 percent - 4 percent of the nation's total energy.



Supermarket Share of U.S. Energy Consumption

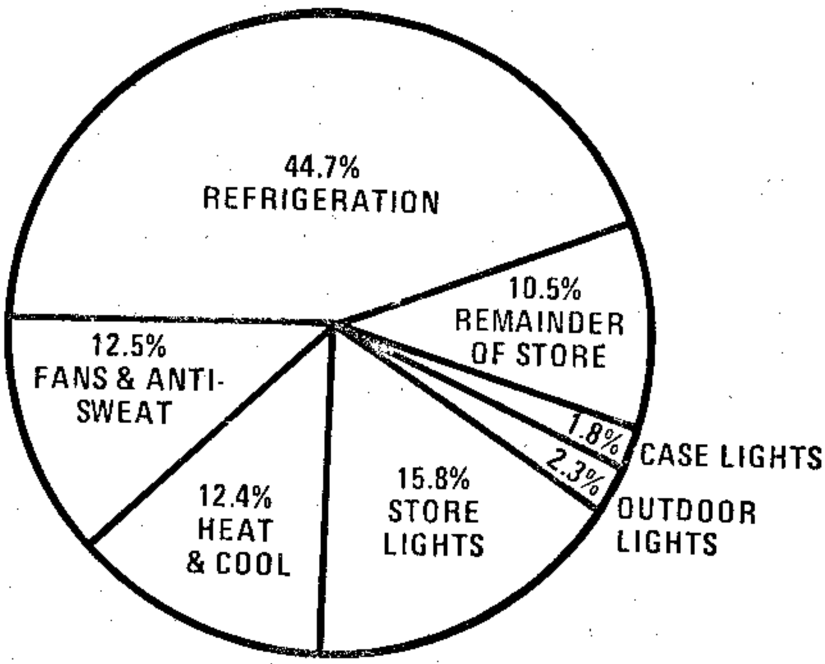
This four percent does not include the energy used in producing, processing, and transporting the food in the supermarket.

Supermarkets typically find energy costs add up to 1 to 3 percent of sales, which very well may be an amount that exceeds profits. Recent reports indicate that energy costs in a supermarket rank second only to labor and occupancy costs.

"Guide to Energy Conservation For Grocery Stores" Federal Energy Administration.

Where is Energy Used in Your Facility?

A typical breakdown of the energy consumption in a supermarket can be seen in the diagram below. Notice that the refrigeration equipment, including fans and anti-sweat devices, account for about 57 percent of the total energy.



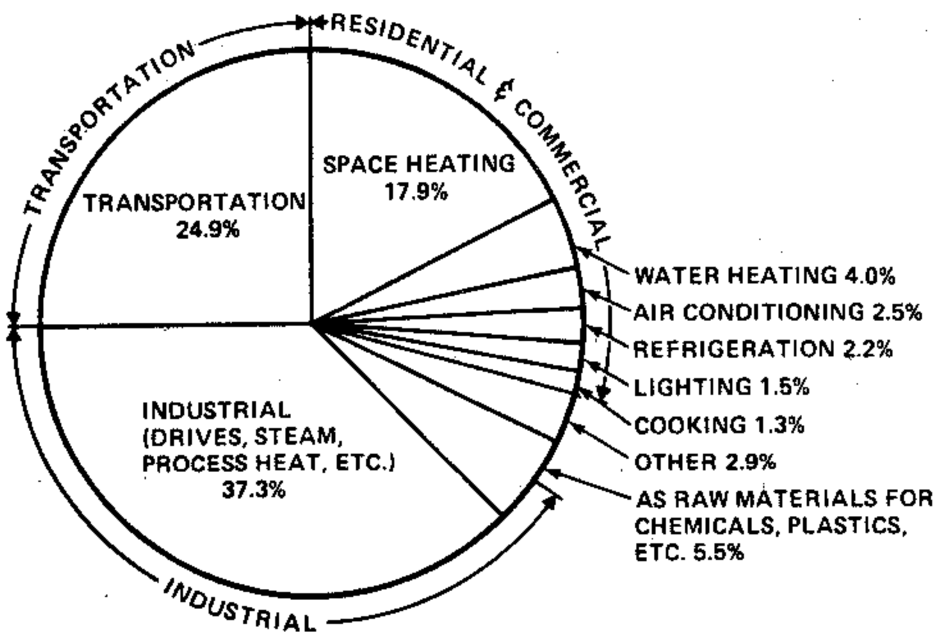
Energy Consumption in a Supermarket

"Guide to Energy Conservation for Grocery Stores" Federal Energy Administration.

WHAT IS THE REAL POTENTIAL FOR ENERGY CONSERVATION?

Let's look specifically at the area of energy used to heat and cool residential and commercial buildings. This graph illustrates that these two energy uses account for over 20% of our total energy consumption.

MAJOR USERS OF ENERGY



REF: A.D. LITTLE

The Department of Commerce projection shown on graph 1 assumed that we should be able to reduce our consumption of energy used for these purposes by 10% in the year 2000. (This is a 10% reduction as compared to what the use would be if no conservation measures were taken.) This would represent a conservation of energy equivalent to about 2 million barrels of oil per day in the year 2000. Actually, the potential for reduction in this area is *much greater*.

The forecasting firm of Arthur D. Little estimates that if all existing technology were applied in the modernization of existing buildings and in the design of new buildings, we could affect a reduction of over 2 million barrels per day of oil equivalent in *existing* buildings, and over 1 million barrels per day oil equivalent in *new* buildings by the year *1980. This represents 25% of the total energy required for this purpose*. In other words, we could affect a reduction of over 3 million barrels per day of oil equivalent by 1980 compared to what we will use if reduction techniques are not used.

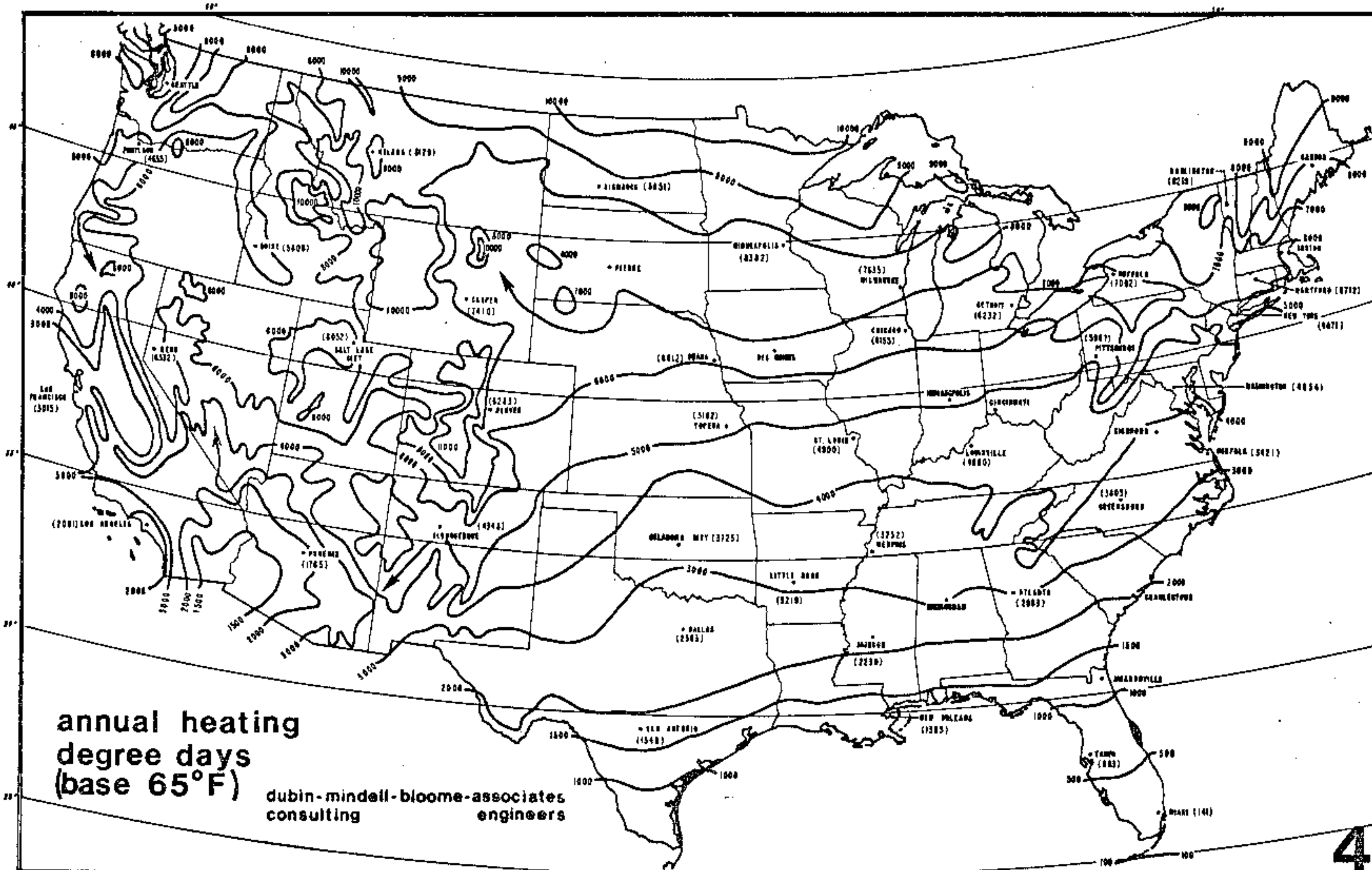
If that's true, then why don't we do it?

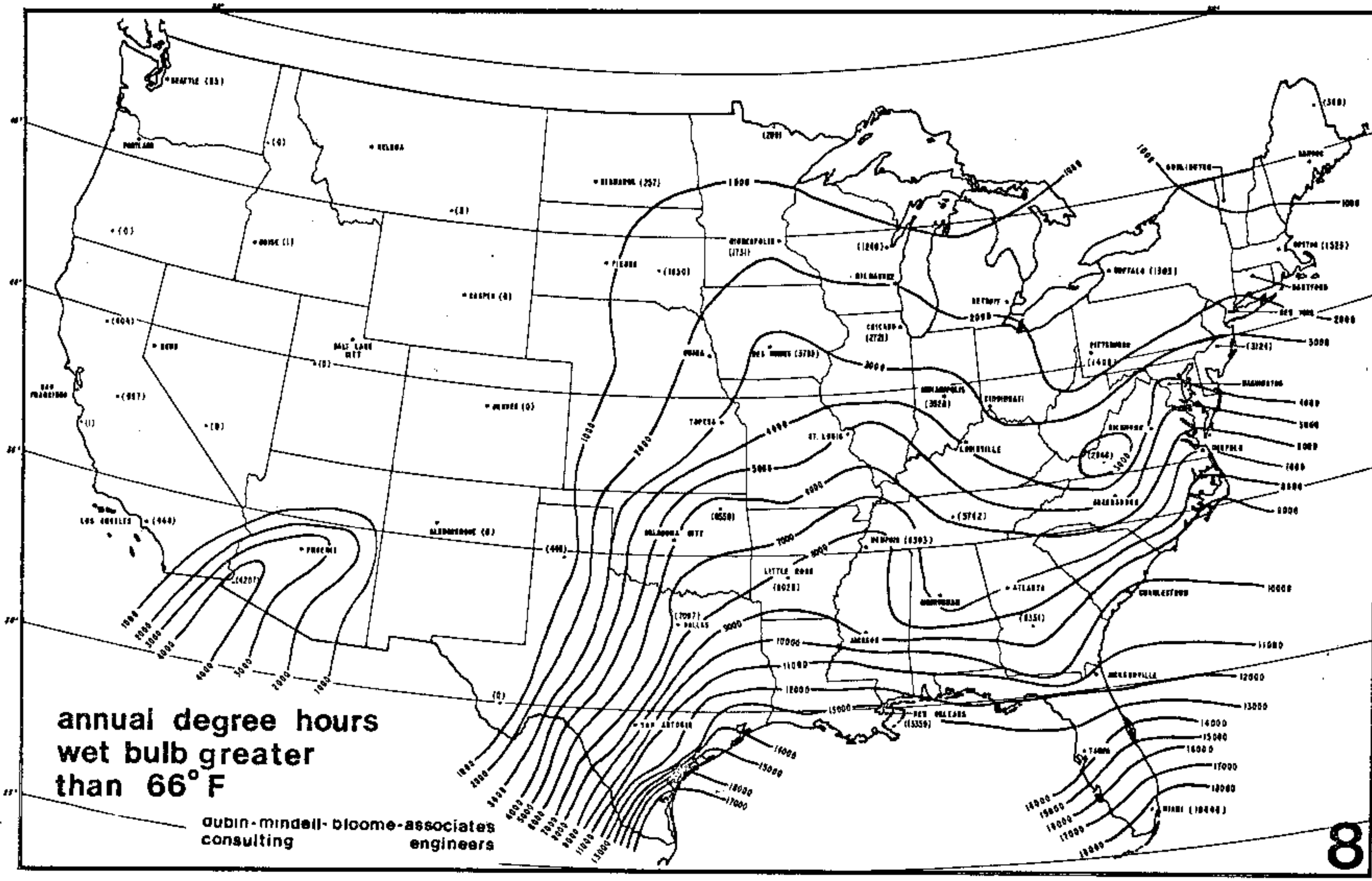
That's a good question. And there are a lot of answers.

For one thing, there's a lack of awareness of the seriousness of the energy situation, and of what can be done to meet it.

Secondly, it is going to require an investment of capital to get the job done.

Extracted from: Guidelines for Saving Energy in Existing Buildings. Building Owners and Operators Manual: ECM 1 Vol.





annual degree hours wet bulb greater than 66° F

dubin-mindell-bloome-associates consulting engineers

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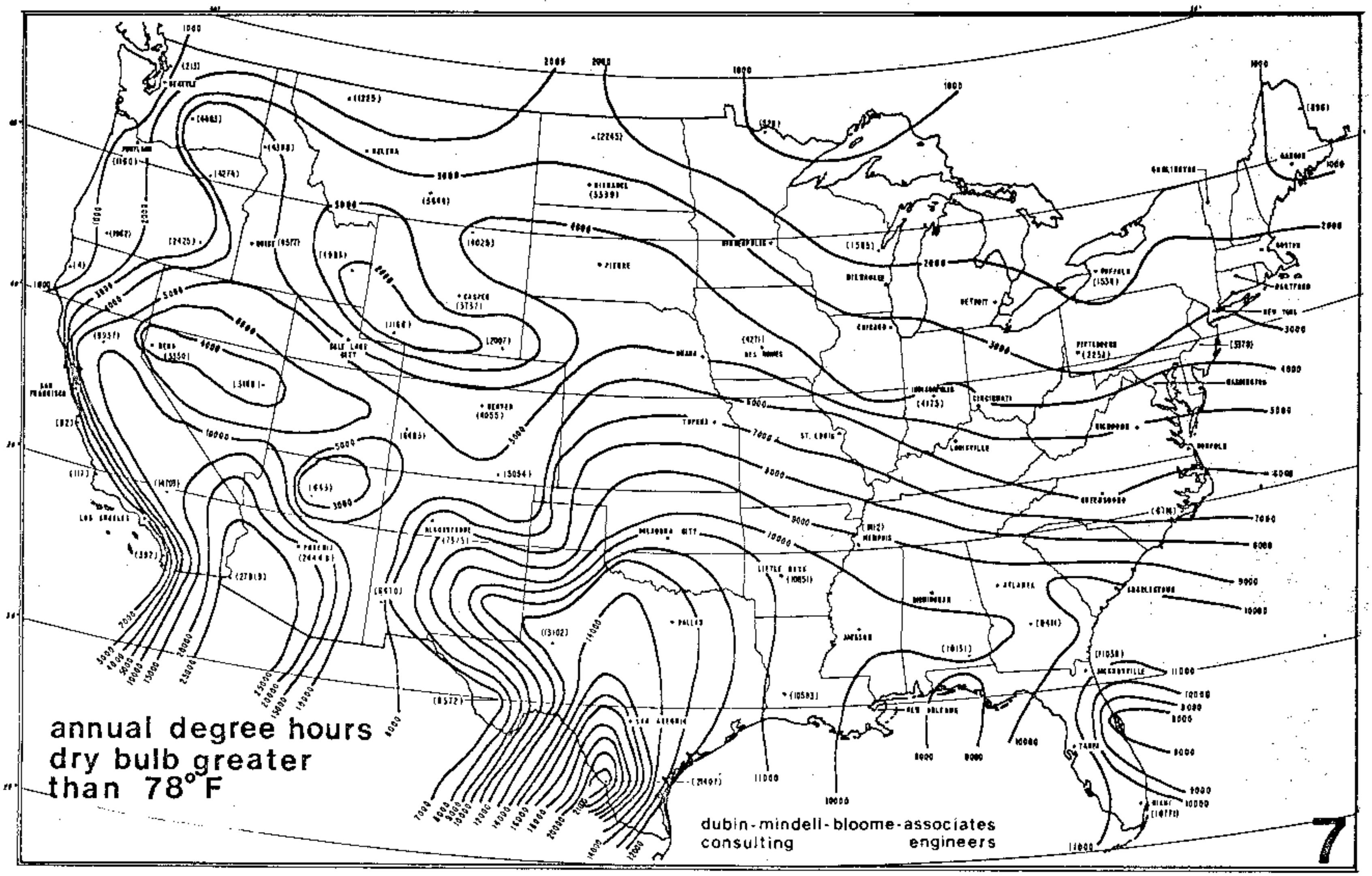
annual degree hours
dry bulb greater
than 78°F
dubin-mindell-bloome-associates
consulting engineers
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TEXAS ENERGY ADVISORY COUNCIL

VOLUME I, NO. 2

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Sheila Moritz, Editor

TEAC NEWS

TEXAS ENERGY POLICY: 1979 UPDATE

A major statement on Texas energy policy was adopted and published by the Council in February, 1977. Since then major changes in world, national and state events have occurred, requiring an update of the statement. During September through December of 1978 the staff, the Advisory Committee to the Council and the Council worked through a process of revising the policy statement. The new statement, *Texas Energy Policy: 1978 Update*, was adopted by the Council at the December 15, 1978 Council meeting. The major changes and additions contained in the more recent version are summarized in this article. Copies of the policy statement may be obtained by writing or calling the TEAC office.

A "State Role in Energy Policy Formulation" section was added concerning the need for explicit state input to national energy policy decision. National decisions on energy policy have major and disproportionate impacts on sectors of the economy and geographic regions of the country, particularly Texas. It is, therefore, important for states to have access to information and to participate in the national debate over energy policy.

The section on "Agriculture" was partially rewritten emphasizing that the energy needs for Texas agriculture are season oriented and require a reasonably certain fuel supply for successful production. The section recognizes that the State provided for relief from agriculture curtailment in legislation enacted by the 65th Legislature and recommends that agriculture maintain a high priority in demand policy and regulatory considerations of the legislature.

Two major additions to the section on "Boiler Fuel Restrictions" recognizes Texas' pivotal role with regard to a national boiler conversion policy and the potentially significant economic impact of rapid mandatory boiler conversion from the use of oil and gas to other fuel sources. The statement recommends the use of tax incentives for any conversion rates above that already occurring, balancing the economic costs of conversion and the economic benefits of natural gas and oil conservation in boiler fuel policy, and consideration of the environmental effects from mandatory conversion.

The "Conservation Through Government Programs" section discusses the need for government entities to employ energy conservation measures, thereby demonstrating conservation potential and providing information and encouragement for conservation in other sectors; it recommends that state government continue to support conservation programs aimed at reducing fossil energy consumption.

The section on "Conservation Through Public Awareness" emphasizes that the public needs to be made aware of conservation practices and methods which can be implemented with significant energy savings for either the retrofit of existing buildings or the construction of new ones. The statement recommends that Texas continue to encourage dissemination of energy information designed to provide energy conservation assistance and technical information.

The section on "Energy Emergency Preparedness" recognizes that energy emergencies can have debilitating effects if government and industry are not prepared for such an event and discusses cooperation between government and industry and the coordination of energy emergency measures by state agencies. It recommends that a long-term state energy emergency preparedness plan be formulated and adopted.

The "Gas Purchase Contracts" section was rewritten and discusses federal government actions and regulations under the Natural Gas Act of 1978, the Texas Railroad

Commission's work on setting realistic allowables, the benefits and adverse effects of "take-or-pay" provisions of gas purchase contracts, and the declaration of surplus natural gas. It recommends that the State of Texas continue its strong resistance to federal encroachment in the intrastate natural gas market; that the Railroad Commission continue its effort to balance statewide production with demand; and that provision be made for further study of the effects of "take-or-pay" provisions of gas purchase contracts on the natural gas market.

The section on "Industrial Energy Efficiency and Cogeneration" discusses the production of electricity from steam, and institutional and technical changes which are needed for better use of energy resources. This section's recommendations concern encouragement of the cogeneration of process steam and electricity, and the amendment of the Public Utility Regulatory Act to facilitate cogeneration.

The section on "Utility Rate Reform" was revised and discusses, among other matters, recent regulatory policy by the Public Utility Commission which established "flat" rates within user classes and the practical application of marginal cost pricing concepts to electric utility rate structures. Major recommendations suggest that utility rate structures should be used to accurately reflect costs to all consumer classes and should not be used for income transfer purposes, rate reform should be done equally for all energy utilities, and rate structures should encourage efficient allocation of scarce energy resources.

The "Community Impacts of Energy Development" section discusses the community impacts of energy development and facility construction. The section recommends that the State study alternative means of helping communities provide front-end financing for dealing with community service requirements associated with energy development.

A new section on "Energy Production from Agricultural Products" pertains to agriculture's role as a potential producer of energy and recommends that the state expand its support and encouragement of the rapid development of this alternate source of renewable energy.

The section on "Federal Coal Leasing" recommends that the national program called for by the Coal Leasing Act Amendments of 1977 be expedited so as to insure the timely and efficient development of federally owned coal.

The section entitled "Interconnection of Utility Systems" concerns intrusion of the federal government into Texas intrastate utility systems for purposes of interstate interconnections. The section encourages the PUC to continue to allow separate intrastate systems and to resist federal intrusion.

The "Interstate Utilities and System Reliability" section recommends that study be given to the creation of interstate compact commissions to resolve the problems of unequal regulation affecting the operation and reliability of Texas systems.

The primary focus in the "Nuclear Power" section is on encouragement of breeder technology and reprocessing and the streamlining of the licensing process to facilitate decision-making.

The section entitled "Production and Pricing of Crude Oil and Refined Products" discusses the problems of crude oil price controls and the entitlements program and recommends their orderly elimination.

The section on "Production and Pricing of Natural Gas" emphasizes support of a federal policy of phased deregulation and the use of all available means of preventing further federal intrusion into the intrastate market.

A new section was added entitled "Uranium Processing" recommending that state legislation be developed to satisfy certain federal conditions to allow state agencies to retain regulatory control of the licensing process for uranium mining and milling in Texas.

The section on "Technology Development Policy" recommends state support of RD&D for developing energy sources through direct funding, coordination and encouragement of federally funded Texas projects. The section recommends that market forces and the removal of institutional and regulatory barriers should provide the basis for commercialization of new technologies.

A new section, "Energy Taxation Policy", deals with the objectives and uses of energy taxation. The section recommends that federal energy taxation in the form of a crude oil equalization tax is inappropriate and that the objective of increasing domestic oil prices to world market levels should be accomplished through decontrol. The section recognizes the important role of energy taxes in supporting public services in Texas, the instability of this tax source because of changing energy markets and the need for study of the long-term implications of maintaining the current energy tax structure compared to available alternatives.

The new section on "Environmental Policy" deals with energy-related environmental policies of interest to Texas and seeks to address the major areas where the development, production and use of energy resources have significant implications for the integrity of the human and natural environment.

An "Energy Facility Siting" section recommends, among other things, that the present state government approach of regulating the impacts of energy activities rather than the activities themselves be continued.

The "Air Quality" section recognizes the critically limiting importance of existing state and federal air pollution policies to the use of coal and new energy facility siting and construction. The statement recommends the State Implementation Plan be revised to allow Texas assumption of permitting authority regarding prevention of significant deterioration policies.

The section on "Water Quality and Supply" recommends that revised national standards for thermal discharges from electric power plants continue to allow for maximum engineering flexibility in designing cooling systems and that requirements for documenting the effects of thermal discharges take into account regional climatic and environmental variation. It recommends that primary responsibility in addressing energy related water quality issues rest with the state.

The section on "Surface Mining Regulation" recommends continued state regulation of surface mining operations in Texas through the rewriting or amendment of the Texas surface mining law to meet the requirements of the Federal Surface Mining Control and Reclamation Act of 1977.

A "Nuclear Waste Disposal" section recommends that Texas continue to work with the federal government to determine the suitability of Texas geologic formulations for long-term storage, that Texas seek the powers of approval over the location in Texas of any waste disposal site and that the State support reprocessing of spent nuclear fuel.

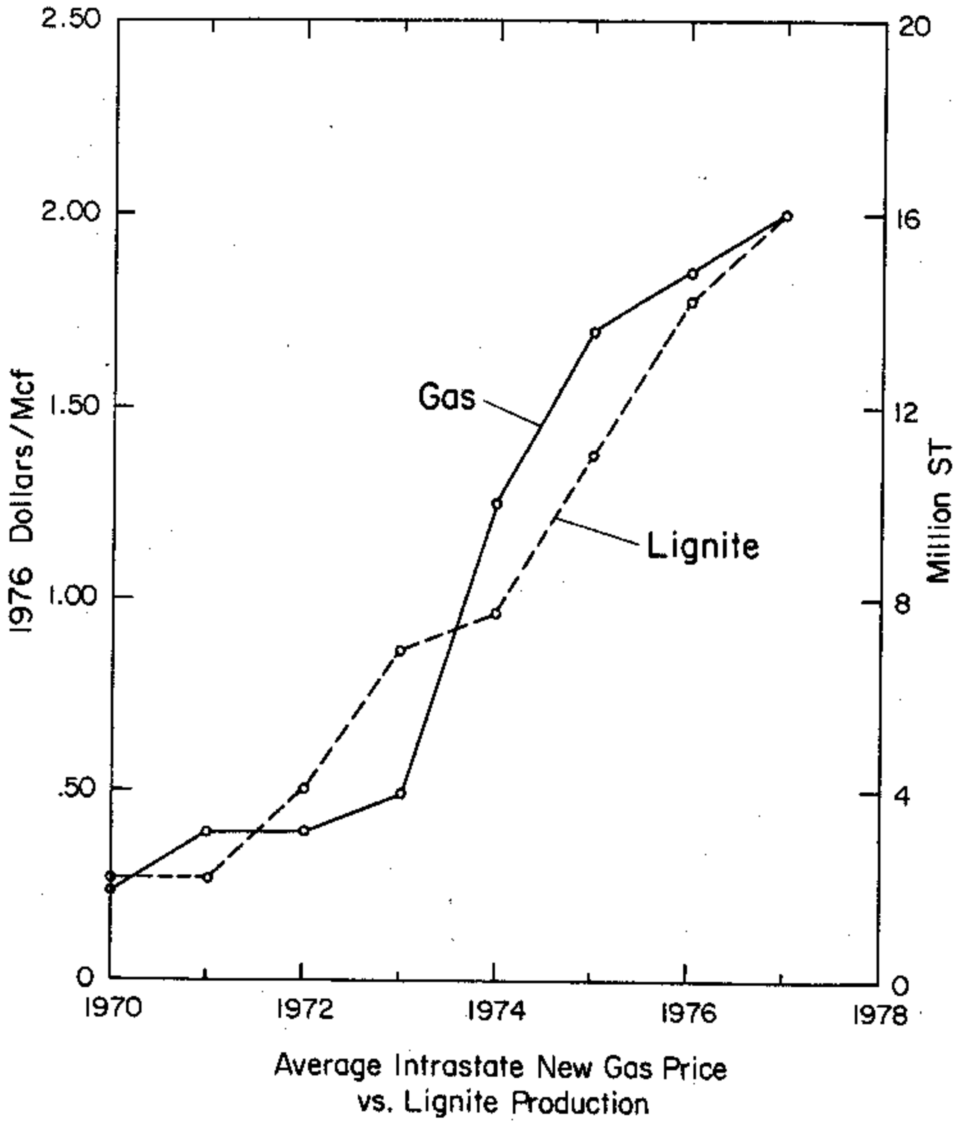


Figure 2. Correlation of rising intrastate gas price and increasing lignite production in Texas.

TABLE 3. TEXAS LIGNITE STEAM-ELECTRIC STATIONS

STATION	LOCATION	OWNER	SIZE MW	START UP	ANN PROD 10^6 ST[1]
Sandow	Alcoa Milam Co.	Alcoa	3(120)	1954	2.1
		Alcoa and Tx. Power & Light Co.	575	1981	2.7
Big Brown	Fairfield Freestone Co.	Texas Utilities Co.	575 575	1971 1972	2.7 2.7
Monticello	Monticello Titus Co.	Texas Utilities Co.	575 575 750	1974 1975 1978	2.9 2.9 3.8
Martin Lake	Tatum Rusk Co.	Texas Utilities Co.	750 750 750 750	1977 1978 1979 1983	3.5 3.5 3.5 3.5
Forest Grove	Athens Henderson Co.	Texas Utilities Co.	750	1982	3.8
San Miguel	Christine Atascosa Co.	So.Tx.& Medina Elec. Coops and Brazos Elec. Power Coop	400 400	1980 1985	2.7 2.7
Gibbons Creek	Carlos Grimes Co.	Texas Municipal Power Agency	400 400	1981 1984	2.7 2.0+
Twin Oak	Bald Prairie Robertson Co.	Tx. Power & Light Co. and Alcoa	750 750	1984 1985	3.5 3.5
Mill Creek	Oak Hill Rusk Co.	Texas Utilities Co.	750 750	1986	3.5
Undetermined	Harrison Co.	Southwestern Elec. Power Co.	640 640	mid-1980's	3.0
Oak Knoll	Oletha Limestone Co.	Texas Utilities Co.	750 750		
Undetermined	Unsited	Lower Colo. River Authority & Partners	600-750	1984	3.0

[1]Estimated from unit size, 80 percent capacity factor, 9,750 Btu/kwh, and lignite appropriate to each unit of 7,300, 6,700, or 5,000 Btu/lb.

TABLE 4. WESTERN COAL STEAM-ELECTRIC STATIONS

STATION	LOCATION	OWNER	SIZE MW	START UP	ANN CONSUM 10^6 ST[1]
Harrington	Amarillo Potter Co.	Southwestern Public Service Co.	360 360 360	1976 1978 1980	1.45 1.45 1.45
Welsh	Cason Morris Co.	Southwestern Elec. Power Co.	528 528 528	1977 1980 1982	2.25 2.25 2.25
J. T. Deely	Elmendorf Bexar Co.	Public Service Board of San Antonio	418 418 375[2]	1977 1977 1986	1.75 1.75
W. A. Parish	Booth Fort Bend Co.	Houston Lighting & Power Co.	660 660 550	1978 1979 1980	2.65 2.65 2.20
Undetermined	Unsited		750	1984	2.85
Fayette	Fayetteville Fayette Co.	Lower Colo. R. Auth. and City of Austin	550 550	1979 1980	2.05 2.20
Coleto Creek	Fannin Goliad Co.	Central Power & Light	550 550	1979 1986	1.75
Plant X	Sudan Lamb Co.	Southwestern Public Service Co.	475 475	1982 1984	1.80 1.80
Morgan Creek	Colorado City Mitchell Co.	Tx. Elec. Service Co.	460[3]	1983	1.75
Tradinghouse Cr.	Waco McLennan Co.	Tx. Power & Light Co.	713[4]		
Permian Basin	Monahans Ward Co.	Tx. Elec. Service Co.	497[4]		
De Cordova	Granbury Hood Co.	Tx. Power & Light Co.	713[3]	1985	2.70
Undetermined	Unsited	West Texas Utilities	250 250	1982 1985	0.95 0.95

[1]Estimated from unit size, 80 percent capacity factor, 9,750 Btu/kwh, and coal appropriate to each unit of 10,700, 9,200, 9,000, 8,500, 8,200, & 8,000 Btu/lb.

[2]Bituminous coal or lignite.

[3]Conversion of gas-fired unit to coal firing.

[4]Possible conversion of gas-fired unit to coal firing between 1983 & 1985.

TABLE 6. INCREASES IN AIR POLLUTANT EMISSIONS

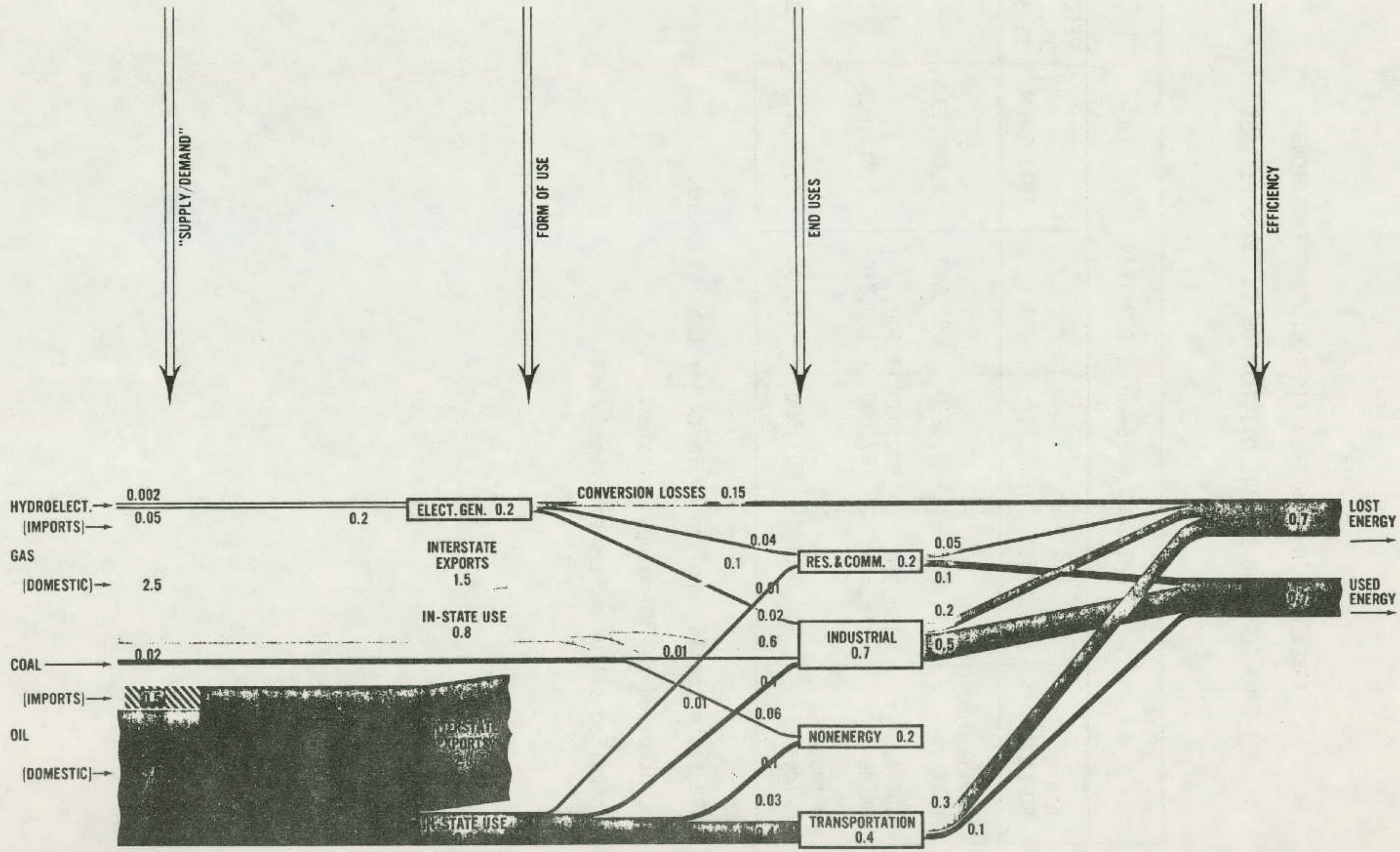
FROM COAL AND LIGNITE UTILIZATION IN TEXAS BY 1985

EMISSION RATE--TONS PER YEAR					
AIR POLLUTANT	INDUSTRIAL	UTILITY	TOTAL	1973 TOTAL[1]	PERCENT INC. OVER 1973 TOTAL
Particulate Matter	11,520	81,280	92,800	1,406,132	6.6
Sulfur Oxides	188,100[2] 18,810[3]	1,520,000[2] 152,000[3]	1,708,100[2] 170,810[3]	1,214,909	140.6[2] 14.1[3]
Nitrogen Oxides	162,000	509,600	671,600	2,111,113	31.8

[1]1973 State totals supplied by Texas Air Control Board.

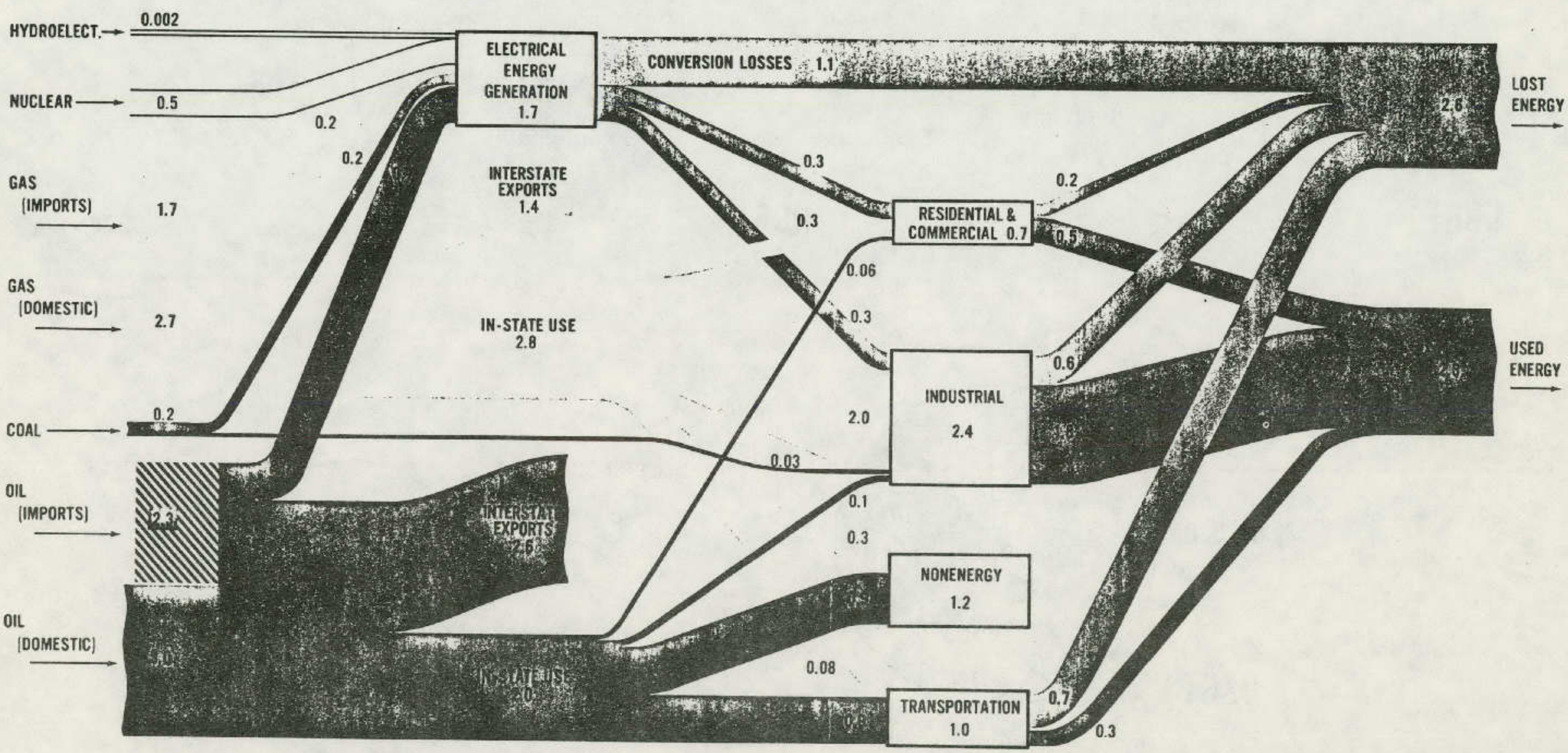
[2]Uncontrolled sulfur oxides emissions.

[3]Controlled sulfur oxides emissions (90%).



(UNITS: MILLION BBLS OF OIL EQUIVALENT)

1985



(UNITS: MILLION BBLS/DAY OIL EQUIVALENT)

D

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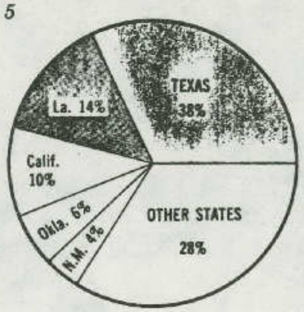
Texas Proportion of U.S. Crude Oil Production, 1960-1985

Figure 5

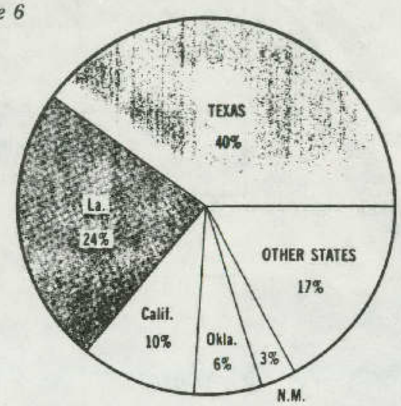


1960

U.S. 7.8*

TEXAS PROPORTION 3.0

Figure 6

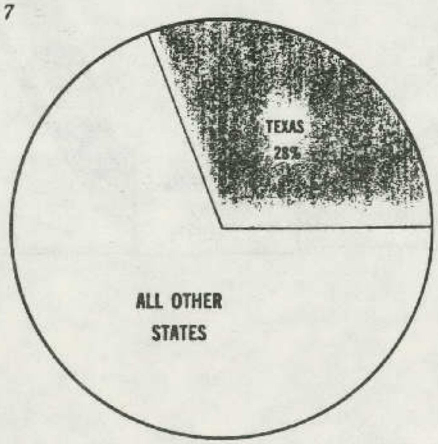


1970

U.S. 10.4

TEXAS PROPORTION 4.2

Figure 7

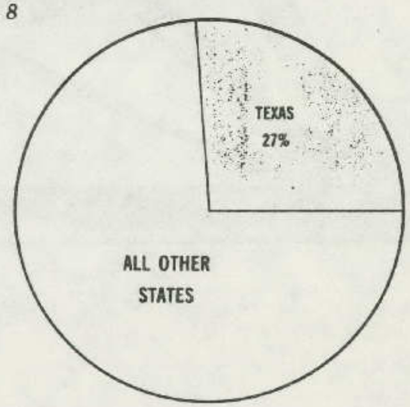


1980

U.S. 11.5

TEXAS PROPORTION 3.2

Figure 8



1985

U.S. 11.0

TEXAS PROPORTION 3.0

H

* All figures are Millions of Barrels per Day of Oil.
Size of the four graphs gives volumetric proportion.

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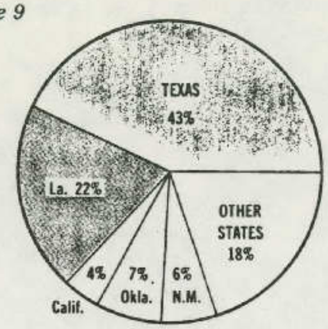
Texas Proportion of U.S. Natural Gas Production, 1960 -1985

Figure 9

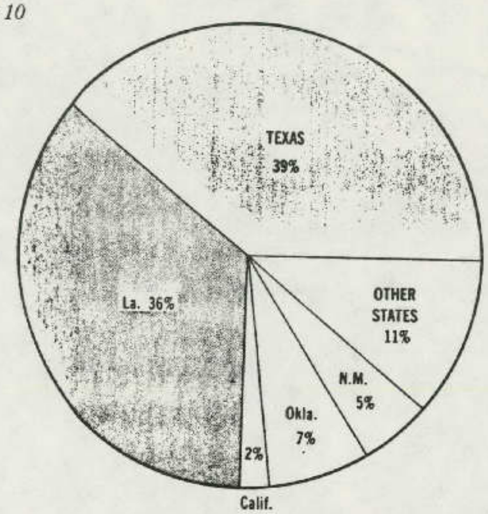


1960

U.S. 5.8*

TEXAS PROPORTION 2.5

Figure 10

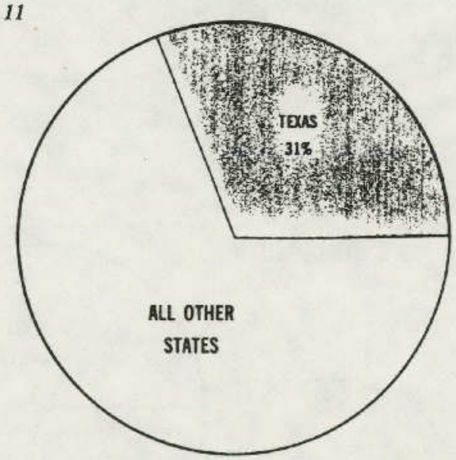


1970

U.S. 10.3

TEXAS PROPORTION 4.0

Figure 11

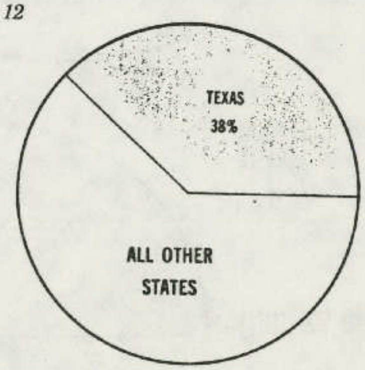


1980

U.S. 10.0

TEXAS PROPORTION 3.1

Figure 12



1985

U.S. 7.1

TEXAS PROPORTION 2.7

I

* All figures for Natural Gas are Millions of Barrels per Day Oil Equivalent.
Size of the four graphs gives volumetric proportion.

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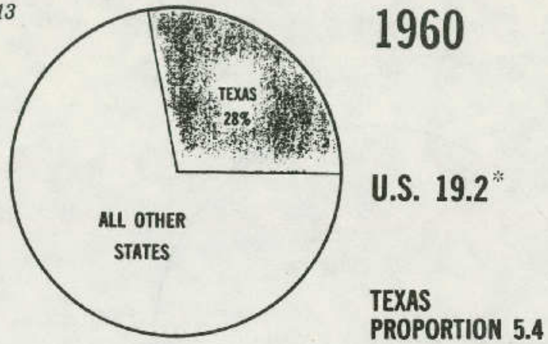
Texas Proportion of U.S. Total Energy Production, 1960 -1985

Figure 13



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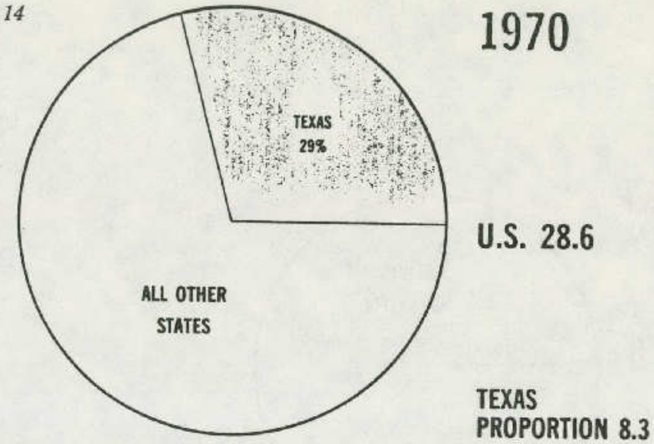

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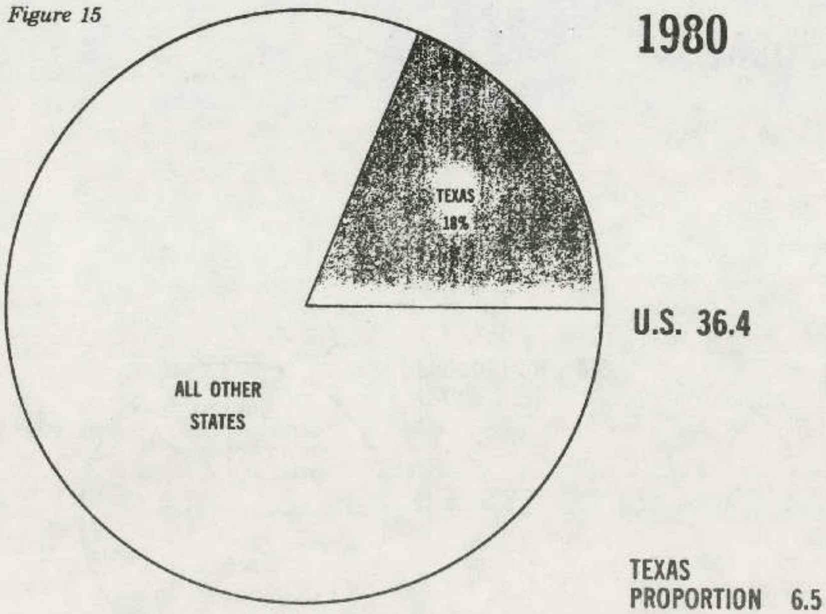

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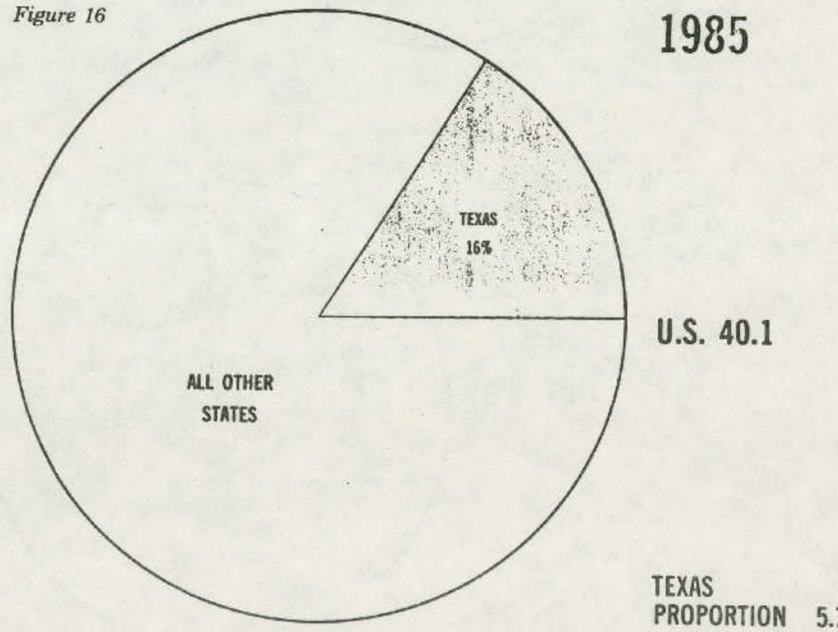
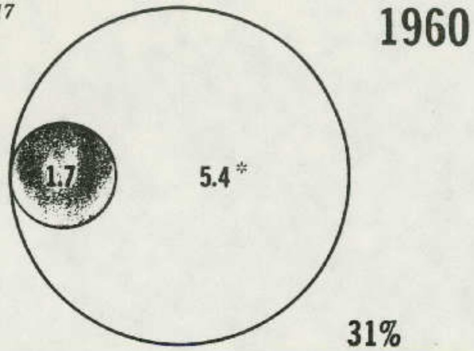


* All figures are Millions of Barrels per Day Oil Equivalent.
Size of the four graphs gives volumetric proportion.

J

Texas Total Energy Production/Consumption, 1960-1985

Figure 17



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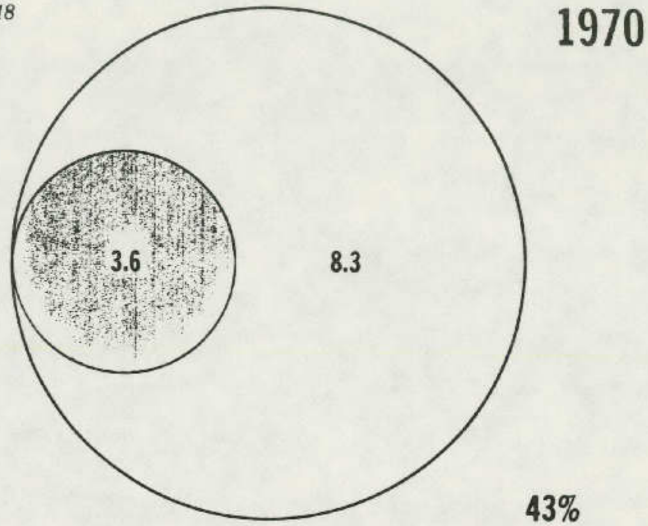

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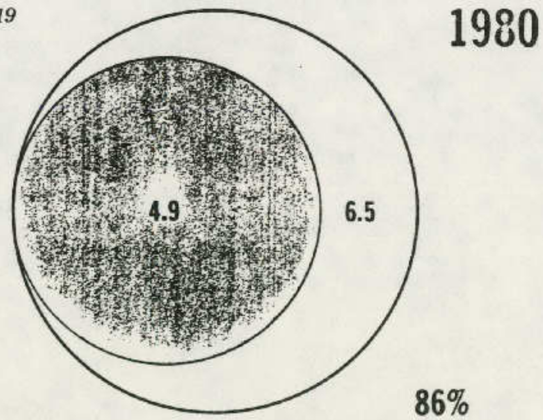
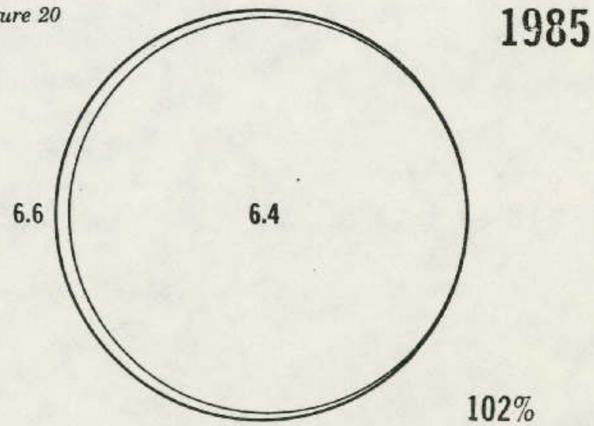


Figure 20



◯ Production ◯ Consumption

* All figures are Millions of Barrels per Day Oil Equivalent.
Size of the four graphs gives volumetric proportion.

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K

2

ENERGY MANAGEMENT

Energy Management/Control Systems

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ENERGY MANAGEMENT

Energy Supply

Energy consumption per capita in the United States is 2.3 times that of the western European nations and 2.6 times that of Japan. These figures clearly illustrate that we have major opportunities for more efficient energy use without impairment of our standard of living. The United States is very fortunate in having extensive resources of petroleum, natural gas, coal, uranium, and other fuels.

But as we know only too well from the early weeks of 1979, no source of imports can be considered truly reliable. Production in Iran, interrupted in November 1978, was not resumed for 3-4 months thereafter, and even then not at the pre-revolution level. For a few weeks, Iran did not produce enough oil for its own consumption, and the world had to do without that part of the 5.25 million barrels per day which Iran had normally exported. Western European nations, Japan, and Israel were harder hit by this sudden end of exports than was the United States, since the U.S. was only importing 500,000 barrels a day from Iran. But by May the United States was feeling the result of the disruption in the form of gasoline lines across the nation. The impact of the Iran shortage would have been felt much more, and sooner, but for the increase in production by Saudi Arabia from 7.8 million barrels per day in 1978 to a near capacity production of 11.5 million barrels per day.

It might be well to keep in mind who produced oil in what quantities in the world in 1978. The United States, just three years ago was still the number one producer of oil and natural gas liquids in the world. In 1978, the Soviet Union was number one in oil production, and exceeded the number two producer Saudi Arabia by nearly three million barrels per day. The United States regained the number two position from Saudi Arabia in the full flow from the Alaskan North Slope.

	Million Barrels Per Day
U.S.S.R.	11.40
United States	8.66
Saudi Arabia	7.80
Iran	5.25
Iraq	2.50
Venezuela	2.15
Libya	2.05
China	2.00
Kuwait	1.90
Nigeria	1.80
Indonesia	1.65
Abu Dhabi	1.45
Canada	1.30
Mexico	1.27
Algeria	1.26
United Kingdom	1.10

To put this in perspective, United States imports of crude oil in December of 1978 were on the order of 6.8 million barrels per day, up 11% from 1977, 15% since 1976, and 114% since 1973, the year of the Arab embargo. As long as the United States must rely on imports for such a high percentage of its energy supply, the ever-changing social and economic order in the supplying nations will make that supply uncertain. Thus, supply as well as cost is a consideration in wise and farsighted energy management. The talk in early 1979 of rationing of gasoline and forced closing of gasoline stations on Sunday is not without justification.

Energy Cost

Beginning in the 1950's, energy prices in the United States and the free world had declined in real value. The cost of production was considered to be the major variable, not the real worth of the oil, gas, or coal in the ground. In the fall of 1973 that suddenly changed, and that change continues unabated today. We have laws on the books in the United States that will gradually phase out price controls on both crude oil and natural gas. So it seems reasonable to assume that oil and gas prices, on the average will increase by the average rate of inflation plus a gradual, but increasing, price increment to bring domestic oil and gas prices to the "free market" or world price. And then we should expect these prices to rise by at least the average rate of inflation in the free world. Long-term contracts now held by some electric and gas utilities will ameliorate the increase and slow its total impact, but they will not change the eventual result.

The cost of energy has in the past been so relatively inexpensive that the majority of businesses made little effort to limit their energy consumption. Whether it was something as simple as shutting down an air conditioning unit at night and on week-ends or turning off unnecessary lights, standard practice was to ignore the potential savings in energy costs since the energy bill seemed insignificant when compared to other plant operating costs.

But with energy costs rising 400 to 800% in many places over the last few years, we have all been forced to re-evaluate our attitudes. When energy bills approach and exceed 5% of total expenses, most owners, managers, and operators begin to realize the potential profit to be realized by using energy more wisely.

Total Energy Management

A need for energy management has quite obviously replaced the earlier cry for energy conservation; so energy management is the subject for the remainder of this workbook.

All buildings have three fundamental systems which affect energy use. These are energized systems, non-energized systems, and human systems.

Energized systems are those which consume energy directly. Typical energized systems include, among others, those used to provide heating, ventilation, cooling, humidification, dehumidification, lighting, hot water heating, interior conveyance, food cooking, dishwashing, and waste handling as well as various pieces of equipment such as typewriters, computers, copying machines, and specialized process equipment unique to the process conducted in the building.

Nonenergized systems are those which do not consume energy directly, but which do affect the amount of energy which an energized system must expend to get its job done. Typical nonenergized systems include walls, windows (glazing), floors, roof, ceiling, doors, etc., as well as weather, landscaping, siting, and similar factors.

Human systems comprise those persons who affect when and in what quantity energy is consumed. These persons include building owners and managers; operating and maintenance personnel; as well as occupants or users of the building. Were it not for this third category of systems, energy management conducted solely by operating and maintenance personnel might suffice. But since there are so many ways the tenant or occupant can influence the amount of energy used, there is a need for total energy management. Accordingly, this manual is intended for management, technical personnel, and occupants. The word total thus implies actions on the part of every person who in any way is connected with the use of the building.

Viewed in the total context, total or overall energy management becomes not a series of disconnected unrelated actions, but rather a logical progression of management and planning actions. The necessary and desirable actions are listed here:

1. Decide to implement overall energy management system
   - assign responsibility
   - sell idea
2. Set up system to track energy use in BTU/SQ. FT./MONTH and BTU/?/MONTH where "?" is any other unit of measure you desire.
   - past year(s)
   - future
3. Develop Overall Energy Management Program with involvement at all levels.
   - orientation, education, program for all employees or occupants
   - operations and maintenance
   - plant modifications, mechanical and lighting systems, building shell

4. Conduct an energy audit
   - -- preliminary energy audit, walk-through survey or mini-audit
   - -- computerized analysis
   - -- detailed energy analysis or maxi-audit

5. Establish tough and measurable energy use goal, using energy tracking system for measurement
   - -- implement all no-cost actions
   - -- implement selected capital improvement retrofit projects and measure energy savings

6. Report the results in both energy and dollar terms.

Accomplishment of total energy management goals requires that top management be committed to the concept. Based on this commitment, managers and operators can set in motion the necessary management actions. The first of these involves the assignment of responsibility and the initiation of actions to convince all personnel of the need for such a program.

The first substantive management effort should be a review of the building's past energy consumption. This review will be discussed in detail later in this section. It should include the development of an energy use index in BTU's (British Thermal Units) of energy used per square foot of heated and cooled space -- computed monthly and added for all twelve months for the year for an annual use index. Such computations will permit energy use in the building to be compared with similar sized energy efficient buildings and with other buildings of a similar size and similar use.

Concurrently with this use analysis for each building, a program of actions and a schedule should be established. These actions should and must involve all employees or occupants, and all operating and maintenance personnel. All of these personnel must be trained in the recognition of inefficient situations and in the proper actions to be taken.

An energy audit is next. An energy audit is a comprehensive building survey, the purpose of which is to determine where opportunities for energy conservation exist. In many cases significant waste can be eliminated through repair of faulty equipment and improved maintenance and operating practices. Numerous other options are available, some requiring little change from current procedures, others involving modifications much broader in scope. The energy audit may vary in detail and complexity, usually with final results proportional to the initial invested effort, from a walk-through survey to a computerized analysis and to a detailed energy analysis.

Following a review of the audit results, it is management's responsibility to turn opportunities into actual savings and to establish priorities. Many of these will require little or no cost, others will require more study, detailed cost analysis, and major expenditures of funds.

Finally, the results of the program should be reported to all those involved from time to time to insure continued maximum effectiveness of the programs.

OFFICE BUILDING ENERGY MULTIPLYING FACTORS

	MULTIPLIERS COOL	HEAT	ELECTRIC
1. Hours of Operation			
One Shift Only	1.00		1.40
More than one but less than three	1.24		1.40
Three Shifts	1.49		1.90
2. Controls			
Heating and Cooling			
Heating only			0.95
Simultaneous heat and cool	1.74	1.74	1.54
3. HVAC System Type			
Thru wall units	1.41	0.62	0.84
Central chilled water			
Rooftop or packaged units	1.41		
4. Glass Area			
Less than 25% single glass or any quantity of double glass	0.82	0.73	0.94
25% to 75% single glass			
More than 75% single glass	1.21	1.31	1.04
5. Ventilation			
Less than 0.25 CFM/SF			
More than 0.25 CFM/SF	1.05	1.25	1.05
6. Energy Type For Cooling			
Electric			
Steam or Hot Water	5.00		
7. Lighting			
Less than 50 FC or 2 W/SF	0.81		0.71
50 to 100 FC or 2 to 4 W/SF			
More than 100 FC or 4 W/SF	1.14	1.00	1.31
8. Other Uses in Building			
None			
Computer (less than 5% SF)	2.05		2.04
Parking (less than 20% SF)			1.11
Commercial or Food Service (up to 10% SF)	1.11		1.11
More than any of above (Not Considered)			
9. Climate			
Less than 3,000 DD	1.24	0.79	
3,000 to 6,000 DD			
More than 6,000 DD	0.91	1.29	
10. Energy Type For Heating			
Purchased steam, hot water or electric			
Gas or Oil Boilers	1.61	1.49	

Product of Multipliers (By Category)

ENERGY (BTU/SF/YR) = Product of Heating Multipliers x 29000 =
Product of Cooling Multipliers x 11000 =
Product of Electric Multipliers x 44000 =

EXAMPLE:

An office building in Atlanta in which hours of operation are from 7 a.m. to 8 p.m. each day, that has over 75% glass single pane, that brings in over .25 CFM per sq. ft., uses approximately 5 watts per sq. ft. 120 FC at the 3½ ft. level, has a gas fired boiler, and a terminal reheat system.

HEATING

1.0 x 1.74 x 1.31 x 1.25 x .79 x 1.49 = 3.35 x 29,000 + 97,150 BTU/Sq.Ft.

COOLING

1.24 x 1.74 x 1.21 x 1.05 x 1.14 x 1.24 = 3.87 x 11,000 + 42,570 BTU/Sq.Ft.

ELECTRIC

1.4 x 1.54 x 1.04 x 1 05 x 1.31 = 3;04 x 44,000 + 133,760 BTU/Sq.Ft.

273,480 BTU/Sq.Ft.

ENERGY USE IN BTUs PER SQUARE FOOT

Year: 1978

Structure: Yaring's University Store Austin, Texas

MONTH	ELECTRICITY						NATURAL GAS				TOTAL ENERGY		
	CONSUMPTION		DEMAND		COST				COST				
	KWH	MILLION BTU	ACTUAL	BILLED	TOTAL	PER KWH	MCF	MILLION BTU	TOTAL	PER MCF	MILLION BTU	TOTAL COST	BTU PER SQ.FT.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14
JAN	16,600	56,655,800	52	52	$804.00	4.84¢	89	91,670,000	251.02	$2.82	148,325,800	$1055.02	13,276
FEB	15,280	52,150,640	60	60	787.61	5.15¢	58	59,740,000	181.27	3.13	111,890,640	968.88	10,015
MAR	15,840	54,061,920	60	60	763.75	4.82¢	27	27,810,000	91.50	3.39	81,871,920	855.25	7,328
APR	17,960	61,297,480	60	60	1013.59	5.64¢	23	23,690,000	82.26	3.58	84,987,480	1095.85	7,607
MAY	24,320	83,004,160	76	76	1323.09	5.44¢	7	7,210,000	22.75	3.25	90,214,160	1345.84	8,075
JUN	26,800	91,468,400	76	76	1508.24	5.63¢	8	8,240,000	23.92	2.99	99,708,400	1532.16	8,925
JUL	30,680	104,710,840	76	76	1553.36	5.06¢	6	6,180,000	18.84	3.14	110,890,840	1572.20	9,926
AUG	28,920	98,703,960	80	80	1481.54	5.12¢	6	6,180,000	19.47	3.25	104,883,960	1501.01	9,388
SEP	27,680	94,471,840	72	72	1425.36	5.15¢	6	6,180,000	20.10	3.35	100,651,840	1445.46	9,009
OCT	21,160	72,219,080		76	1053.29	4.98¢	7	7,210,000	24.00	3.43	79,429,080	1077.29	7,110
NOV	16,440	56,109,720		64	790.80	4.81¢	7*	7,210,000	23.80	*3.40*	63,319,720	814.60	5,668
DEC	17,600	60,068,800		62	896.30	5.09¢	36	37,080,000	118,34	3.29	97,148,800	1014.64	8,696

Column 3 = Column 2 x .003413

Column 9 = Column 8 x 1.03

Column 12 = Column 3 + Column 9

Column 13 = Column 6 + 10

*No bill - Planergy estimate

Square Feet = 11,172
105,023 BTU/SqFt/Yr
8,752 BTU/SqFt/Mo

* Note: BTU per Square Foot: Divide column 12 by number of square feet of conditioned (heated and/or cooled) space in building or facility metered for gas and electricity.

ENERGY USE IN BTUs PER SQUARE FOOT

Year: ____________ Structure: ______________

MONTH	ELECTRICITY						NATURAL GAS				TOTAL ENERGY		
	CONSUMPTION		DEMAND		COST				COST				
	KWH	MILLION BTU	ACTUAL	BILLED	TOTAL	PER KWH	MCF	MILLION BTU	TOTAL	PER MCF	MILLION BTU	TOTAL COST	BTU PER SQ.FT.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14
JAN													
FEB													
MAR													
APR													
MAY													
JUN													
JUL													
AUG													
SEP													
OCT													
NOV													
DEC													

Column 3 = Column 2 x .003413

Column 9 = Column 8 x 1.03

Column 12 = Column 3 + Column 9

Column 13 = Column 6 + 10

* Note: BTU per Square Foot: Divide column 12 by number of square feet of conditioned (heated and/or cooled) space in building or facility metered for gas and electricity.

ENERGY USE IN COMMERCIAL BUILDINGS

As part of its effort to develop building performance standards, the Department of Energy had AIA Research Corp. survey 6,254 recently completed buildings to estimate how much annual energy use the structures require per gross square foot per year. The nonresidential results are summarized below.

One way to view the results is to see how much more efficient than the median were the top 20 percent of the category's buildings. Regulators could argue that a level reached 20 percent of the buildings might eventually by reached by 50 percent, particularly if the differences among survey results from different climatic zones are modest. Using this approach, the greatest room for improvement lies in warehouses, secondary schools and hospitals.

Another way to view the results is to compare them with the nationwide median for high-rise apartment buildings, which is 49,000 British thermal units per year per square foot, and which would be 49 in the table below. The statistics are based on design characteristics, not actual energy consumption. The estimates exclude energy needs for hot water, office equipment, commercial equipment and the like.

DEFINITION OF CLIMATIC ZONES: The Minneapolis zone, with maximum heating and little cooling, also includes Binghamton, Madison (Wis.), and Milwaukee. The Chicago zone, with heavy heating and little cooling, also includes Akron, Allentown, Boston, Columbus, Denver, Detroit, Hartford, Johnstown (Pa.), Omaha, and Spokane. The Newark zone, with substantial heating and little cooling, also includes Albuquerque, Charleston (West Va.), Kansas City (Mo.), Louisville, Portland (Ore.), and Washington (D.C.). The Dallas zone, with moderate heating and much cooling, also includes Bakersfield and Las Vegas. The San Francisco zone, with moderate heating and little cooling, also includes Atlanta, Birmingham (Ala.), Raleigh, and Sacramento. The Miami zone, with little heating and much cooling, also includes Baton Rouge, Mobile, Phoenix, and San Antonio. The Los Angeles zone, with little heating and little cooling, also includes San Diego. The two levels of climatic air-conditioning needs are divided at 2,000 cooling degree-days per year. The five levels of climatic heating needs are divided at 2,000 heating degree-days per year and then at 4,000, 5,500 and 7,000. Degree days are a measure of how much and how often the outside temperature differs from 65 degrees.

In thousands of British thermal units of heat needed annually per gross square foot:

	Required By Median Bldg. In Category	Category's Extreme Cases	Mid-Range After Excluding Top 20% And Bottom 20%	Percent Saving In Energy Over Median Achieved By Worst Bldg. In Top 20%
OFFICE BULDINGS:				
Nationwide	61	28-199	48-80	21
Minneapolis zone	61	38-109	55-75	10
Chicago zone	71	28-199	63-76	11
Newark zone	59	30-140	49-82	17
Dallas zone	65	26-128	52-68	20
San Francisco zone	57	34-132	45-68	21
Miami zone	48	31-92	39-58	19
Los Angeles zone	51	29-92	34-54	33
RESTAURANTS:				
Nationwide	140	49-392	105-210	25
Minneapolis zone	138	89-390	114-184	17
Chicago zone	150	84-392	111-221	26
Newark zone	160	82-352	106-232	34
Dallas zone	125	54-279	104-157	17
San Francisco zone	137	49-379	102-153	26
Miami zone	120	76-280	104-154	13
Los Angeles zone	113	71-193	89-155	21
STORES:				
Nationwide	84	25-230	62-99	26
Minneapolis zone	88	56-190	72-120	18
Chicago zone	93	25-230	67-134	28
Newark zone	87	46-150	69-97	21
Dallas zone	80*	44-114	—	—
San Francisco zone	80	55-98	72-91	10
Miami zone	83	44-120	55-100	34
Los Angeles zone	62	31-141	40-86	35
THEATERS:				
Nationwide	53	20-166	40-69	25
Minneapolis zone	58*	35-83	—	—
Chicago zone	62	39-163	46-103	26
Newark zone	61	33-166	53-75	13
Dallas zone	57*	24-99	—	—
San Francisco zone	47	21-117	42-58	11
Miami zone	57	20-153	33-102	42
Los Angeles zone	34	27-142	30-45	12
ELEMENTARY SCHOOLS:				
Nationwide	50	23-165	47-79	6
Minneapolis zone	114*	80-135	—	—
Chicago zone	67	29-149	54-84	19
Newark zone	61	44-96	51-86	16
Dallas zone	57*	23-82	—	—
San Francisco zone	61	29-165	53-80	13
Miami zone	48	23-71	38-55	21
Los Angeles zone	49	30-91	39-65	20
SECONDARY SCHOOLS:				
Nationwide	49	16-242	35-66	29
Minneapolis zone	77*	52-100	—	—
Chicago zone	64	33-242	45-78	30
Newark zone	46	32-98	37-75	23
Dallas zone	34*	27-61	—	—
San Francisco zone	47	19-141	39-55	17
Miami zone	36	16-68	29-54	19
Los Angeles zone	34	22-66	24-49	29
WAREHOUSES:				
Nationwide	61	20-179	38-83	38
Minneapolis zone	75*	40-122	—	—
Chicago zone	72	33-179	61-99	15
Newark zone	69	22-93	48-80	30
Dallas zone	39*	20-56	—	—
San Francisco zone	50*	38-61	—	—
Miami zone	37*	22-44	—	—
Los Angeles zone	36*	31-45	—	—
CLINICS:				
Nationwide	60	33-162	52-79	13
Minneapolis zone	84*	42-162	—	—
Chicago zone	70	43-151	49-90	30
Newark zone	71*	46-127	—	—
Dallas zone	59*	45-76	—	—
San Francisco zone	65*	43-103	—	—
Miami zone	59*	33-104	—	—
Los Angeles zone	61*	38-104	—	—
HOSPITALS:				
Nationwide	160	85-493	113-231	29
Minneapolis zone	—	—	—	—
Chicago zone	209*	106-493	—	—
Newark zone	171*	91-301	—	—
Dallas zone	197*	91-442	—	—
San Francisco zone	227*	152-489	—	—
Miami zone	230*	200-238	—	—
Los Angeles zone	207*	85-380	—	—
COLLEGE BUILDINGS:				
Nationwide	56	31-168	41-88	27
Minneapolis zone	67*	39-103	—	—
Chicago zone	70*	51-124	—	—
Newark zone	46*	31-125	—	—
Dallas zone	83*	36-168	—	—
San Francisco zone	59*	38-134	—	—
Miami zone	73*	70-123	—	—
Los Angeles zone	87*	83- 89	—	—

* Asterisk means average is used rather than the median because too few buildings were surveyed to use distribution percentages. The average of the numbers one, three and eight is four, the sum divided by three. The median, the case ranked in the middle, is three.

Source: AIA Research Corp., "Phase One Base Data for the Development of Energy Performance Standards for New Buildings."

Extracted From: State of Wisconsin, Energy Conservation Manual, Wisconsin Restaurants

READING UTILITY METERS

To assist in checking the quantity of electricity, gas, or water used during the billing period, or other time periods as may be desirable, the following information on utility meters should be studied.

The meter faces illustrated are types in common use; however, your particular meter faces may vary somewhat. The illustrations should give enough information to familiarize you with general meter types and the method of reading meters.

ELECTRIC METERS

Electric meterings are of two major types:

Kilowatthour meter - general demand customers where the rate schedule is based only on kilowatthours.

Kilowatthour meters plus kilowatthour demand meter - for larger energy consumers. The rate is based on kilowatthours consumed plus maximum short-term energy demand. The demand charges, based on the demand meter reading, cover the cost to the utility to maintain sufficient energy-generating capacity to properly supply the large, short-term energy demand required of the customer. This demand is the maximum KW demand in any 15 or 30 minute interval during the billing period.

Reading Kilowatthour Meters

Meter dials are read from left to right noting the number the pointer is on or has passed. Note: Each pointer rotates in the opposite direction to its adjoining pointer. Therefore, start at 0 and rotate in the same direction the pointer rotates (0-1-2-3-4, etc.).

To determine energy consumed, subtract the initial reading from the final reading for any time period. Record times, reading, and energy consumed.

The meter face may have "multiply all readings by ___" inscribed on it. To determine the correct reading, multiply this multiplier as noted on the face, with the actual meter reading.

Reading Kilowatthour meter with kilowatt demand meter -

The kilowatthour meter reads as described in the kilowatthour meter section.

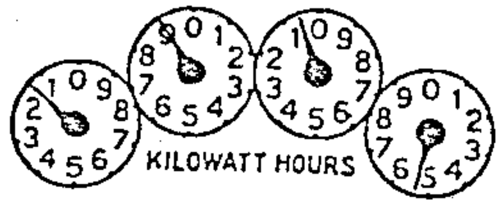
The kilowatthour demand meter may be separate from or be a component of the kilowatthour meter. Due to the many variations in demand meters and methods of reading each, you should consult with your utility company for instructions in reading your specific demand meter.

The meters shown herein are of (1) large single sweep dial face, and (2) the multiple dial face, similar to the kilowatthour meter dial faces.

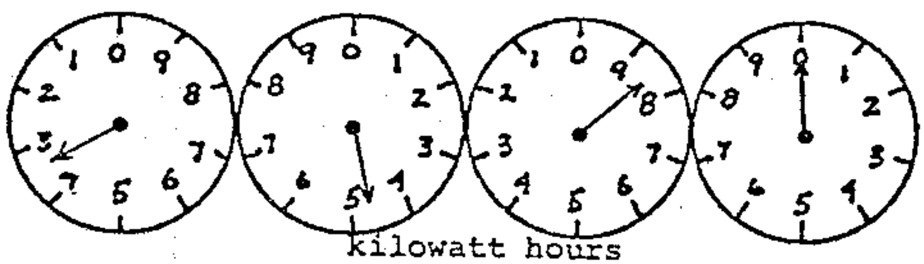
The sweep dial face meter records the maximum demand during the billing period. The pointers will indicate directly and hold the maximum KW demand during any period of the billing month. This indicated demand must be multiplied by the indicated dial face multipliers, if there is one, to obtain the correct KW demand for the period. The pointers must be reset to '0' by the meter reader. It, therefore, indicates maximum demand for the billing period only.

The multiple demand dials are read in the same fashion as the kilowatthour meter dials. The vertical line between dials indicates where the decimal point will appear in the reading. If there is no vertical line, the period comes after the reading from the last dial face. This reading must be multiplied by the indicated dial face multiplier, if there is one, to obtain the correct KW demand. The demand meter dials must be reset to '0' by the meter reader. This also indicates maximum demand for the billing period only.

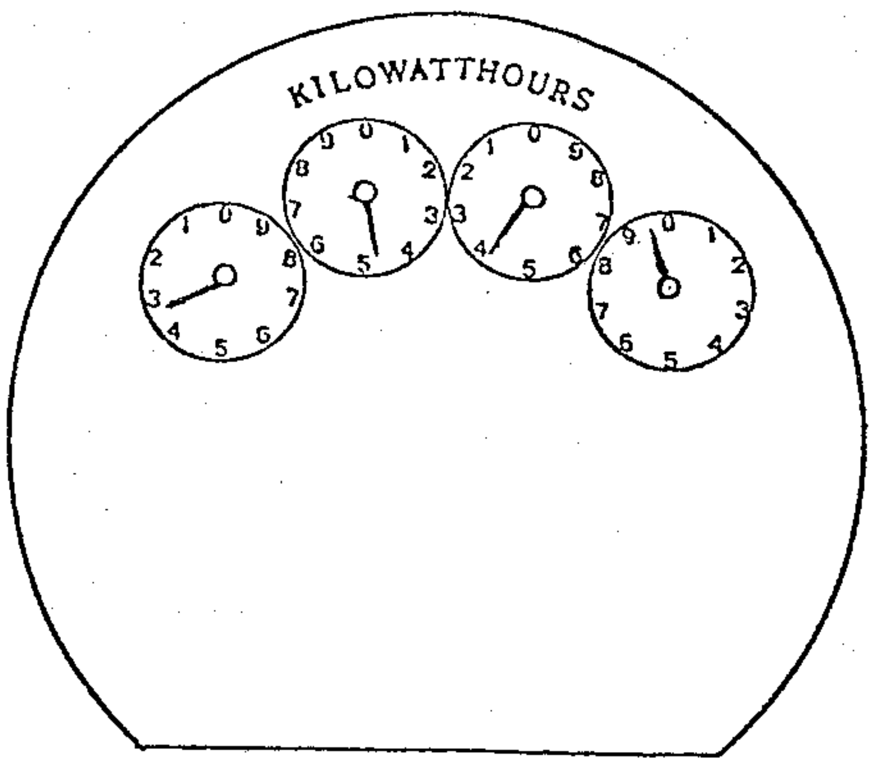
KILOWATTHOUR METERS



Reading = 1905 KWH

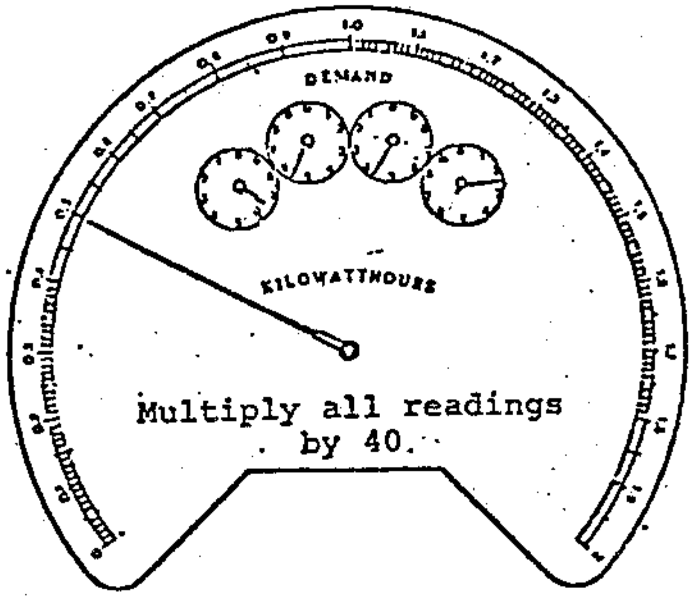


Reading = 3480 KWH

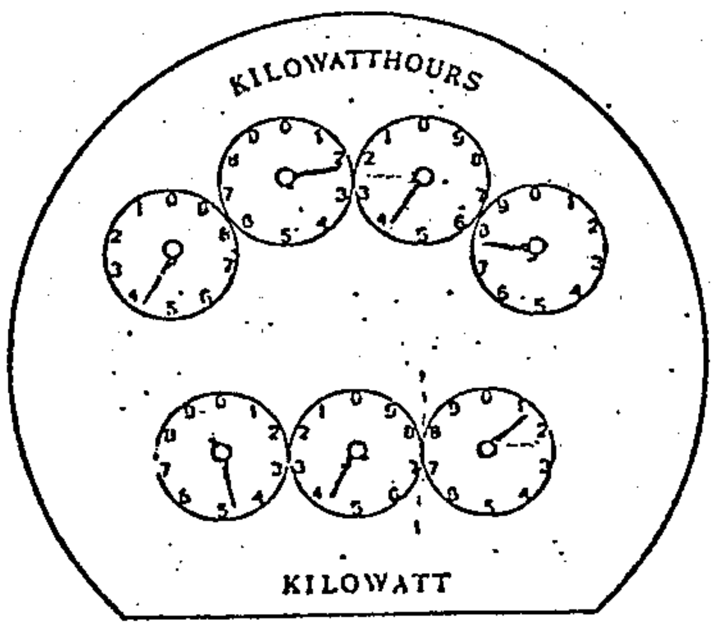


Reading = 3449 KWH

Kilowatthour Meters with Kilowatthour Demand Recorders

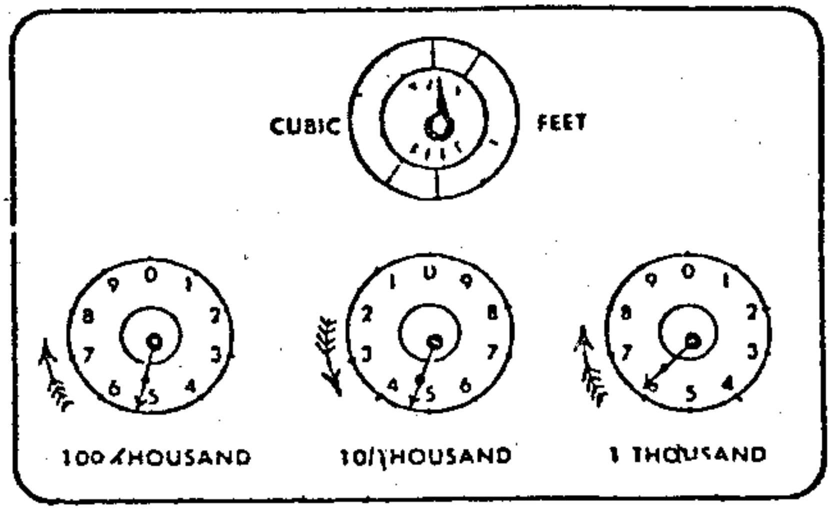


Reading 6542 KWH
.5 x 40 = 20 KW demand

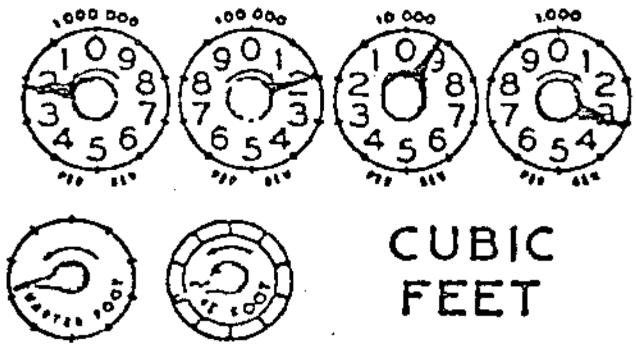


Reading 4247 KWHR
44.1 KW demand

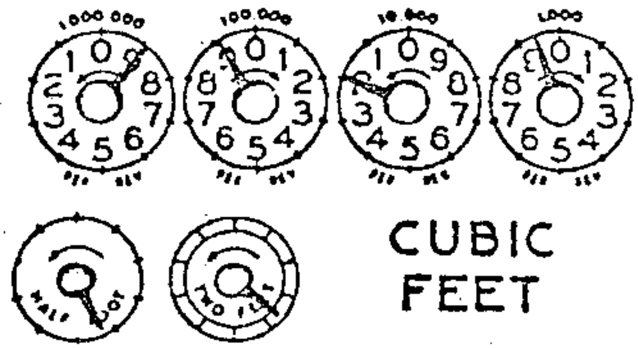
Gas Meters



Reading = 546,000 ft 3



Reading 2,193,000 $ft.^3$



Reading 8,929,000 $ft.^3$

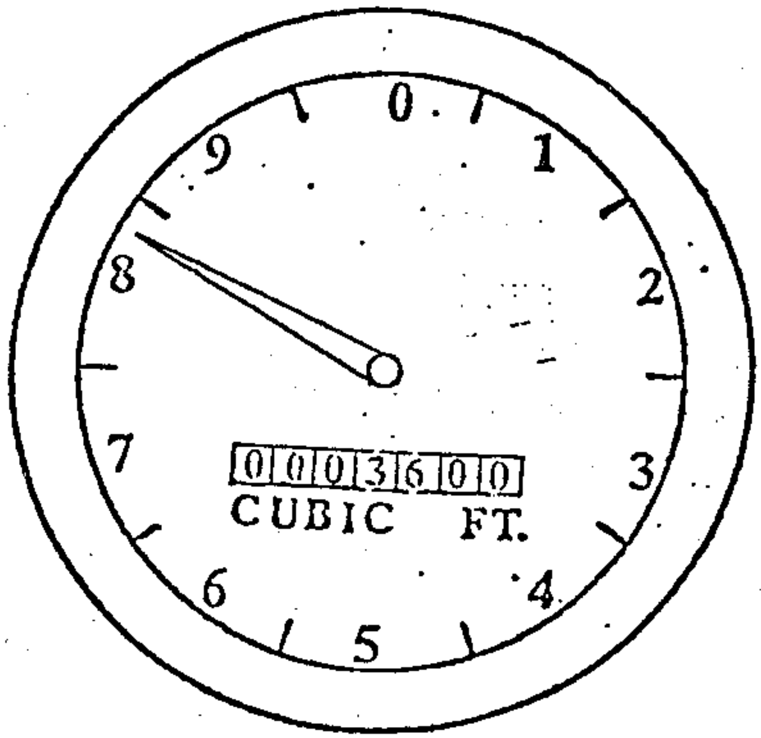
The above indicates different arrangements of gas meter faces. Others exist, however, are similar.

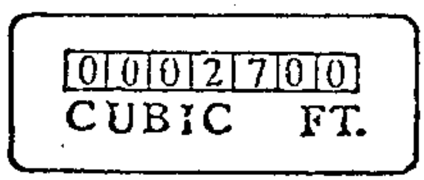
The low capacity, 1/4, 1/2, and 2 cubic feet dials are used to test the meter, as well as check gas consumption in the building under controlled gas usage.

The high capacity recording dials indicate the amount of gas consumption required to turn the pointer one revolution, i.e.: 1000 cubic feet, 10000 cubic feet, etc.

To determine gas consumed between billings, determine the reading at the start of the billing period (say 2,193,000 ft^3) and the reading at the end of the billing period (say 8,929,000 ft^3) and calculate the difference: 8,929,000 ft^3 - 2,193,000 ft^3 = 6,756,000 ft^3 or 67,560 CCF or 6,756 MCF of gas consumed.

Water Meters

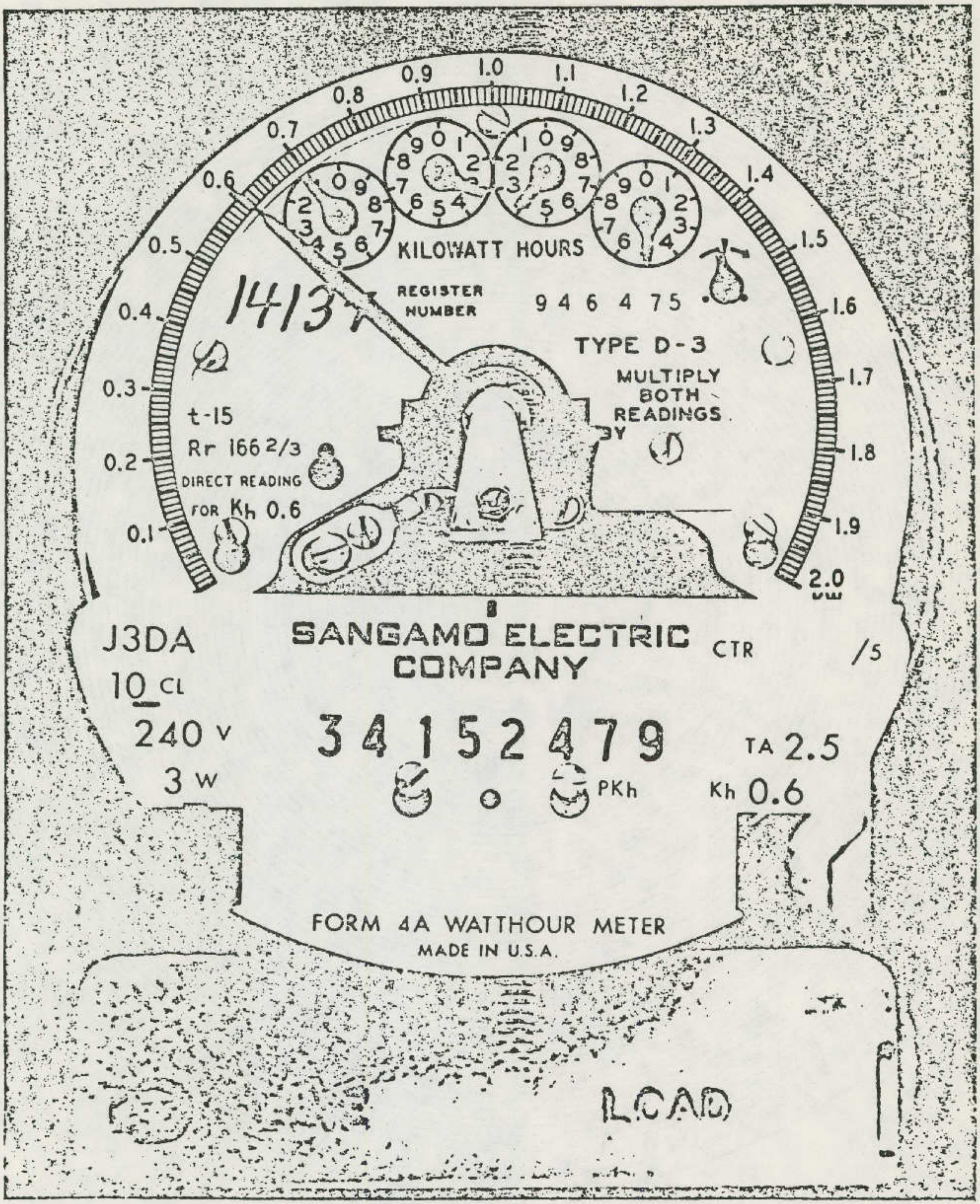


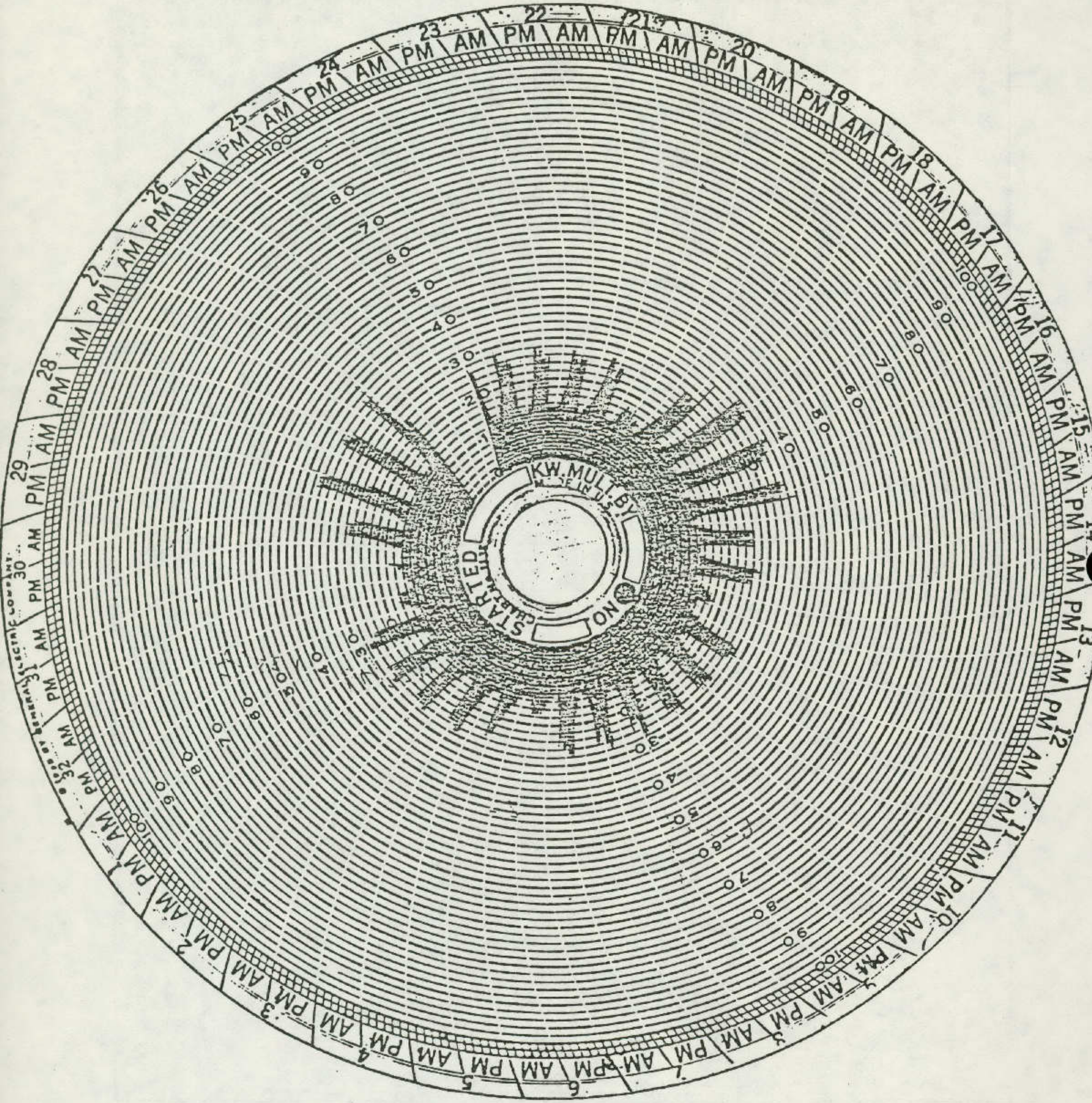


Water meter quantities are read directly as recorded on the meters as shown above. Meters may read in cubic feet, as shown, or in gallons. The type of measure will be shown on the meter face.

When using a circular dial with pointer, do not regard the pointer reading. This dial indicates only the instantaneous flow rate, in cubic feet per minute or gallons per minute.

To determine water consumed between billings, assuming the prior reading to be 2700 cubic feet and the present reading to be 3600 cubic feet, as recorded above, the consumption during the billing period would then be 3600-2700 = 900 cubic feet. 900 ft^3 x 7.48 gal/ft^3 = 6732 gals.


0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
KILOWATT HOURS
14137
REGISTER NUMBER
9 4 6 4 7 5
TYPE D-3
MULTIPLY BOTH READINGS BY
t-15
Rr 166 2/3
DIRECT READING FOR Kh 0.6
J3DA
10 CL
240 V
3 W
SANGAMO ELECTRIC COMPANY
CTR /5
34152479
TA 2.5
PKh
Kh 0.6
FORM 4A WATTHOUR METER
MADE IN U.S.A.
LOAD


KW. MULT. BY
STARTED
ON

Meter Readings Previous	Present	MULT	Kilowatt Hours Used	Description	Sales Tax	AMOUNT Incl. Sales Tax
51746	63333	60	695220	BASE RATE	628.51	13198.68
				FUEL	315.14	6618.00

KILOWATTS - 1968
BILLING KW IS 2088

ELECTRIC AMOUNT	19816.68 *
EXCESS FACILITIES	293.23

*3% LATE PAYMENT CHG ADDED
IF PAID AFTER MAR 15 1979.

AMOUNT DUE 20109.91

TEXAS ELECTRIC SERVICE COMPANY	Fuel Cost Per Kilowatt Hour	Service Period	Past Due After
100 W ABRAM ST P O BOX 887 ARLINGTON TX 76010 PHONE 336-9454	$0.0090660	DEC 27 To JAN 26	FEB 15 1979
	Service Address		Your Account Number
			RATE G

Payment: Bills are due when rendered and are past due if not paid within 15 days thereafter. Bills are increased 3% if not paid within 40 days after being rendered.

DEMAND

The kw recorded during the 15-minute period of maximum use during the month, but not less than 80% of the amount by which the highest kw, recorded at the premises during the billing months of June, July, August, September, or October in the 12 months ending with the current month, exceeds 30 kw.

AGREEMENT

An agreement for electric service with a term of not less than one year is required for customers having maximum electrical loads of 150 kw or more and may be required by company for smaller loads.

NOTICE

This established rate is subject to any change authorized by law, applicable charges in Rate M (Miscellaneous Service Charges), and to the provisions of company's service regulations.

F. Demand "Ratchet" Analyses

1977 Rate -- Texas Electric Service Company

Demand:

The KW recorded during the 15 minute period of maximum use during the month, but not less than 80% of the amount by which the highest KW recorded at the premises during the billing months of June, July, August, September, or October in the 12 months ending with the current month, exceeds 50 KW.

1978 Rate (effective October 26, 1978)

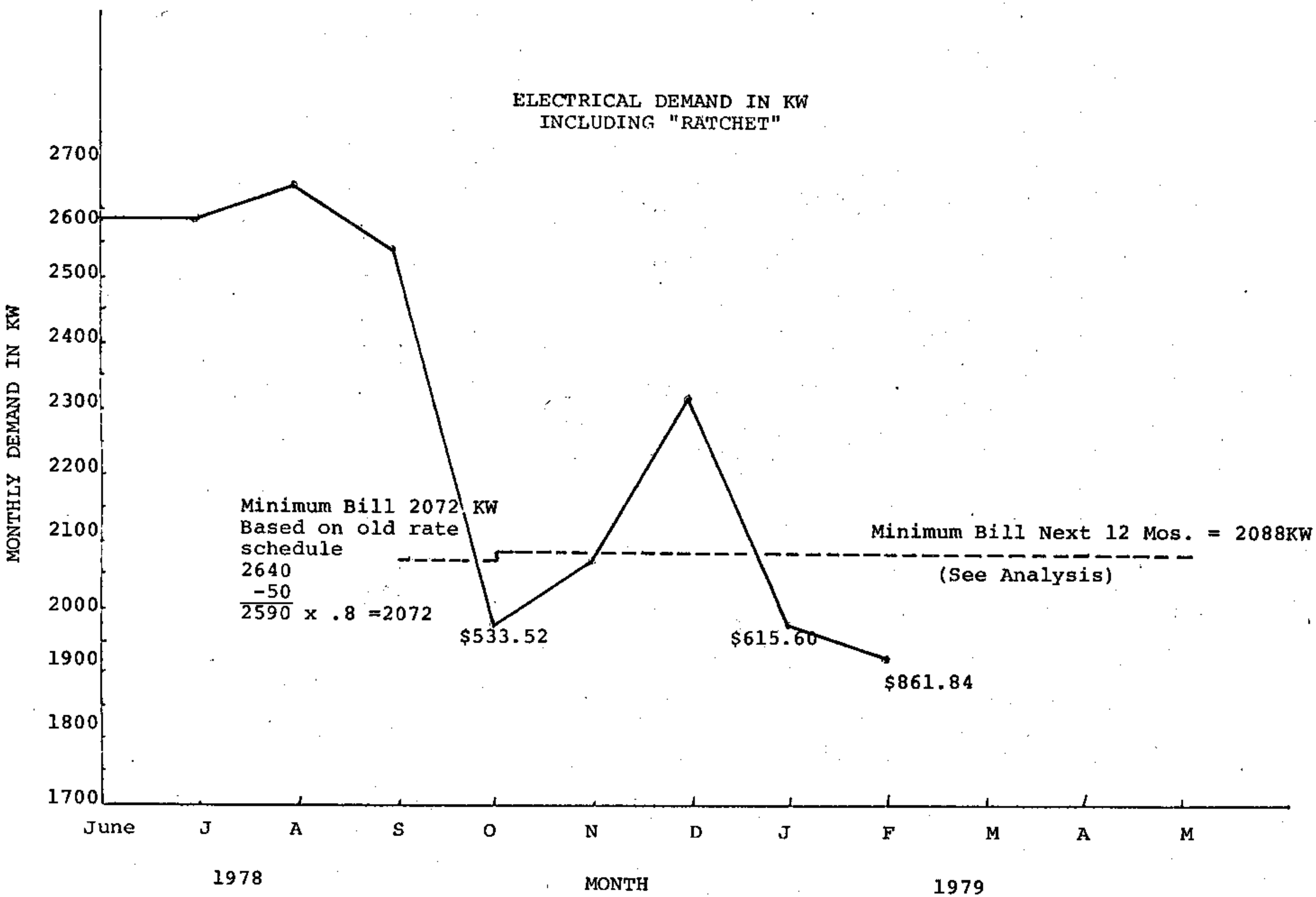
Identical to 1977 except "exceeds 50 KW" is changed to "exceeds 30 KW".

	1977 Demand	1978 Demand
June	2,592	2,592
July	2,400	2,592
August	2,256	2,640
September	2,352	2,544
October	2,304	1,968
Highest	2,592	2,640
Less	50	30
	2,542	2,610
	.8	.8
"Ratchet" =	2,034	2,088

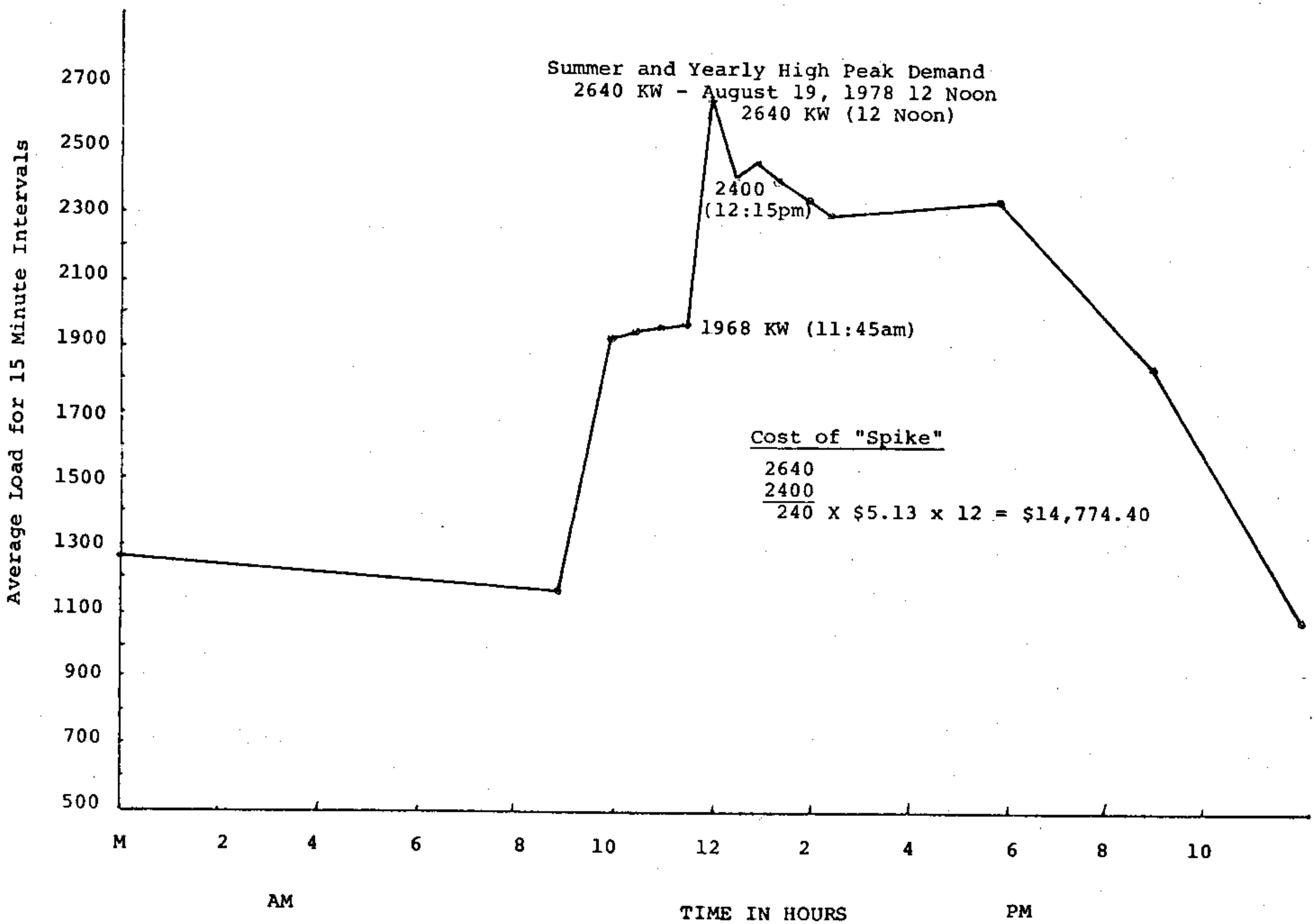
Lowest in winter of 1978 was 1,824 KW in February

All winter months of 1979 will be billed for minimum of 2,088 KW

This minimum bill has to date cost $533.52 in October, a small amount in November, $615.60 in January, and $861.84 in February for a peak demand set in August of 1978; these added costs were not for energy used, but for demand capacity which the utility must provide.


ELECTRICAL DEMAND IN KW
INCLUDING "RATCHET"
MONTHLY DEMAND IN KW
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
Minimum Bill 2072 KW
Based on old rate
schedule
2640
-50
2590 x .8 =2072
Minimum Bill Next 12 Mos. = 2088KW
(See Analysis)
$533.52
$615.60
$861.84
June
J
A
S
O
N
D
J
F
M
A
M
1978
MONTH
1979

24 HOUR LOAD PROFILE



Extracted from: Texas Industrial Commission Energy Conservation Workbook on Meat Products

APPENDIX A-13

FORM C-1 - ELECTRIC KW DEMAND SCHEDULE INSTRUCTIONS

1.0 GENERAL. This form may be used to gain an insight to the existing electricity usage patterns of the plant, and to determine whether a single or combination of several proposed electrical ECO's will affect the plant monthly KW demand. To determine the existing electrical usage patterns, fill out a sufficient number of these Forms until all electrical items of equipment in the plant have been profiled for each day type of each month. Subtotal the KW's for each hour of the day type on each FORM C-1. After all items of equipment have been profiled for each month's day type, total the hourly KW's to obtain a total KW for each hour of each month's day type. Each month's plant KW demand is the greatest hourly KW total observed when examining the total hourly KW's for all day types of each month. To determine the effects of one or a combination of several proposed ECO's, the auditor may examine the profiles for the plant and revise them according to the proposed ECO's requirements.

2.0 EXPLANATION.

a. Equipment I.D.#. Use same I.D.# for each item of equipment as used on other FORMS in this workbook.

b. Day Type. A group of one or more days which are distinguished by such characteristics as # of operating hours, # of personnel working, # of processes taking place, etc.

Example 1. The H.M. Smith Packing Company has a January schedule as follows:

DAY	OPERATING HOURS	OPERATIONS	
Mon. through Thurs.	7AM to 4PM	All	(1)
Friday	7AM to 2PM	All	(2)
Sat. & Sun.	Closed	None	(3)
Holiday on Jan. 1	Closed	None	(3)

Determine the number of day types.

Solution: There are 3 day types as numbered in right hand column above.

c. Peak KW Demand. Enter highest value of KW that each item of equipment can have during each hour of the day. Enter zero for hours "off" and enter highest value for hours "on". If item does not run continuously (e.g., a fan cycled by a thermostat), enter its highest KW value.

3.0 EXAMPLES. Samples of Form C-1 are shown on the following two pages.

#1 → 4: COMPRESSORS   12 → 15 LIGHTS
#5 → 11: MOTORS

Month: July
Day Type: Mon - Fri.

HOUR OF DAY (1=midnight to 1 am, 2= 1 am to 2 am, etc.)

PEAK KW DEMAND

Equip. ID #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	216	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	--->
2	167	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	--->
3	167	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	--->
4	167	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	--->
5	0	0	0	0	0	0	0	23	---	---	---	---	---	---	---	--->	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	5	---	---	---	---	---	---	---	--->	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	19	---	---	---	---	---	---	---	--->	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	6	---	---	---	---	---	---	---	--->	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	18	---	---	---	---	---	---	---	---	---	--->	0	0	0	0	0	0	0
10	0	0	0	0	0	0	18	---	---	---	---	---	---	---	--->	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	12	---	---	---	---	---	---	---	--->	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	124	---	---	---	---	---	---	---	---	---	---	---	---	---	--->	0	0	0
13	0	0	0	0	0	0	0	9	---	---	---	---	---	---	--->	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	76	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	--->
15	7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	--->
TOTAL	724	717	717	717	717	717	972	1034	1034	1034	1034	1034	1034	1034	1034	995	868	848	848	848	848	724	724	724

#1 → 4 COMPRESSORS
#15: LIGHTS

Month: JULY
Day Type: SAT&SUN & JUL 4

HOUR OF DAY (1=midnight to 1 am, 2=1 am to 2 am, etc.)

PEAK KW DEMAND

Equip. ID #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	216																							→
2	167																							→
3	167																							→
4	167																							→
15	7																							→
TOTAL	724																							→

Month____________

Day Type____________

Equip. ID #	HOUR OF DAY (1=midnight to 1 am, 2= 1 am to 2 am, etc.)																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	PEAK KW DEMAND																							

ENERGY MANAGEMENT CONTROLS

KWH CONTROL

PEOPLE

TIME CLOCKS

KW OR DEMAND CONTROL

1. SOLID STATE-LOW VOLTAGE (15-20%)(COST $2500 TO $8000)
   BUILT IN PROGRAM PERMITS
   PROGRAMMING THE ON/OFF OF LOADS
   KWH CONTROL - ON/OFF
   KW CONTROL - DUTY CYCLING

2. MINICOMPUTERS/MICROPROCESSORS ($10,000 UP)
   MORE MEMORY
   PROGRAMMING FLEXIBILITY
   BINARY PLUS ANALOG

ENERGY MANAGEMENT SYSTEMS

COMMAND SYSTEM

1. TIME CLOCKS -- EXISTING POWER LINES

2. SOLID-STATE DEVICES AND MINICOMPUTERS/MICROPROCESSORS

   A. EXISTING POWER LINES AND JUNCTION BOXES

   B. LOW VOLTAGE LINES

   C. EXISTING A.C. POWER LINES - CODED SIGNAL

   D. F.M. RADIO

   E. COAXIAL CABLE

ENERGY MANAGEMENT SYSTEMS

INTRODUCTION

The term "Energy Management Systems" (EMS) is generally used to describe equipment that can monitor and/or control energy use in a particular building or group of buildings. Other commonly used terms for Energy Management Systems are: Utility Control Systems, Utility Monitoring Systems, and Load Management Systems, or other related terms. Energy Management Systems can be used as a tool for conserving energy and reducing energy cost.

EMS vary from simple controls, such as time clocks, to sophisticated systems that use computer programs to monitor and control energy use and equipment operation. The factors that determine the type of EMS that can be used at a particular facility are:

- The amount of energy used
- The cost of energy per year
- The degree of monitoring and/or control necessary to operate the facility efficiently

Generally, facilities spending less than $100,000 per year on energy cannot justify the more sophisticated systems because of the relatively high initial cost of the monitoring and controlling equipment.

"ON-OFF" OPERATION OF EQUIPMENT

For buildings that contain energy use systems that can be controlled by either stopping or starting them, the installation of a time-clock system can perform those functions adequately. The type of building that would benefit from such a system is one in which the following conditions exist:

- Regular hours of operation
- Known occupancy rates
- Standard equipment for the building environmental conditions, such as air-conditioning, heating, lighting, etc.
- Small operating labor force.

An office building is an example where such conditions exist because the building is usually occupied during the day and vacant at night. The number of people in the building is fairly constant at any one time and the equipment used for controlling the environment is usually common equipment without complex controls for its operation. Finally, the labor force available for the maintenance of such a facility is usually small. With such conditions, it is feasible for a time-clock system to stop and start equipment at the desired times.

The equipment that can be shut down during unoccupied hours can usually be identified by a visit to the building when it is unoccupied. Many opportunities for "on-off" controls can be found by looking for lights that could be turned off and listening for equipment that is operating. If it is determined that the equipment is not needed during the unoccupied times, a device can be installed that will shut the equipment down at a prescribed time. If the only function of an EMS will be to turn equipment on and off, then the capital investment required for a complex EMS system cannot be justified.

An example of the potential magnitude of savings that can be achieved from the installation of time clocks for stopping and starting equipment can be seen from an office building that contained 1 million square feet. The annual electric cost to operate the building was $300,000 per year. During a tour of the building during unoccupied hours, it was discovered that most of the fans for the air distribution system were on. Upon investigation, it was learned that they ran 24 hours per day, 7 days per week; but the building was only occupied from 7 a.m. to 6 p.m. during the week and not at all on weekends.

An investment of $3,000 was made to install time clocks on the equipment to shut it down during non-use hours. The net result was that cost for electrical energy was reduced by $82,000 per year, a reduction of 26 percent.

Savings of this magnitude are not unusual. A more complex energy management system could have been installed and perhaps increased the savings in energy by 10 percent by monitoring and controlling temperatures throughout the building. This would have produced an annual savings of $108,000. However, to obtain the additional $26,000 savings per year, an investment of well over $100,000 would have been necessary. When compared to the actual $3,000 invested, there was no practical way to justify the additional expense.

Given this example, when is it advisable to investigate more sophisticated energy management systems for a building or group of buildings? The answer is when conditions exist which make simple "on-off" operations infeasible because of occupancy rates, required environmental conditions, or the existence of special equipment that cannot be simply turned on or off.

MONITORING AND CONTROLLING EQUIPMENT

There are capabilities that can be designed in energy management systems that include much more sophisticated controls than the simple "on-off" control functions. Some of these functions include:

- Monitoring and/or controlling the temperature and humidity of a designated room or area

- Monitoring and/or controlling interior air supply systems

- Monitoring equipment for speed, bearing temperature, pressure differential, etc., so that if a malfunction occurs, it can be acted upon quickly

- Monitoring and/or controlling the extent to which equipment is loaded

- Controlling the amount of outside air entering the building and providing the right mix of return air with the outside air so that the least amount of energy is used in conditioning the air (Enthalpy Control).

There are also other benefits that can be obtained from the more complex system that pertain to cost avoidance. They are:

- The ability of such systems to limit electrical demand to take advantage of electrical rate structures, thereby avoiding higher costs

- Providing a record system that can be used for equipment maintenance programs

- Sequentially starting and stopping equipment to avoid system overloads

- Monitoring and controlling special equipment

- Monitoring and controlling safety and security functions

The more complex EMS also provides for the monitoring and controlling of equipment from a central control console. This means that the console operator can monitor and control the status of all equipment from one location. The advantage of this is that it allows for better utilization of the existing labor force by reducing the amount of time taken to physically check the equipment. The monitoring systems also help to make the maintenance personnel aware of potentially large problems with the equipment before they occur.

Aside from the central console provided by the EMS discussed above, there are several other pieces of equipment used to make up the total system. In order for the console to receive the needed information, the desired functions are transmitted from the energy use equipment to data-gathering panels. These panels then transmit the information back to the console. The console operator can then make adjustments to the energy use system by remote control. The more common types of equipment that are available for use in such systems are:

- An intercommunications system that allows the console operator to speak to someone at a remote panel location. This allows for direct instruction and/or feedback from the console operator to a mechanic or other person.

· Teletypewriters and printers that log and print operational information that can be used for backup data, maintenance, records, or any use requiring a permanent operation record.

· A process controller, or mini-computer, may be added and programmed to start and stop equipment, make adjustments in controls, provide equipment efficiency profiles and a variety of other functions. Software programs for many different functions are commercially available from EMS manufacturers.

· Closed circuit TV can provide visual checks of critical areas of equipment from the central console panel; while a graphics display panel can project schematic drawings for any and all systems being controlled so that the operator can display directly on the console the system that he is concerned with.

· A Cathode Ray Tube (CRT) Terminal can issue equipment control instructions to other locations and, coupled with a typewriter can record information sent and received.

A diagram of a typical energy management system of this type is shown on the following page.

Energy Management Systems can be made simple or complex to match the job as required. Most EMS provide for future addition of equipment as needed and lend themselves easily to expansion. To determine whether or not a particular facility would benefit from an EMS that would perform more than simple "on-off" functions, the following questions should be answered:

- Is temperature or humidity monitoring or control needed for certain areas or pieces of equipment?
- Does the facility contain equipment that is too complex to be simply turned on and off?
- Is the facility always occupied but at varying levels?
- Is the cost of energy above $100,000 per year?
- Is the monitoring and controlling of equipment necessary to help avoid major maintenance expenditures?

If the answer to any of these questions is "yes," then the facility can be a candidate for an energy management system that can perform more than "on-off" functions. Suppliers of these systems should be contacted for cost estimates of their particular monitoring and control systems for the facility in question. They can also recommend the systems which should be included in the initial installation.

MINICOMPUTERS/MICROPROCESSORS

1. SCHEDULING (ON/OFF)
   OPTIMIZED START-UP AND SET BACK
2. DUTY CYCLING
3. LOAD SHEDDING
4. CHILLER CONTROL
   START/STOP/CHILLED WATER RESET
5. OUTSIDE AIR ECONOMIZER
6. SUPPLY AIR RESET
7. TERMINAL REHEAT
   SUPPLY AIR RESET
8. DUAL DUCT
   HOT AND COLD DUCT RESET

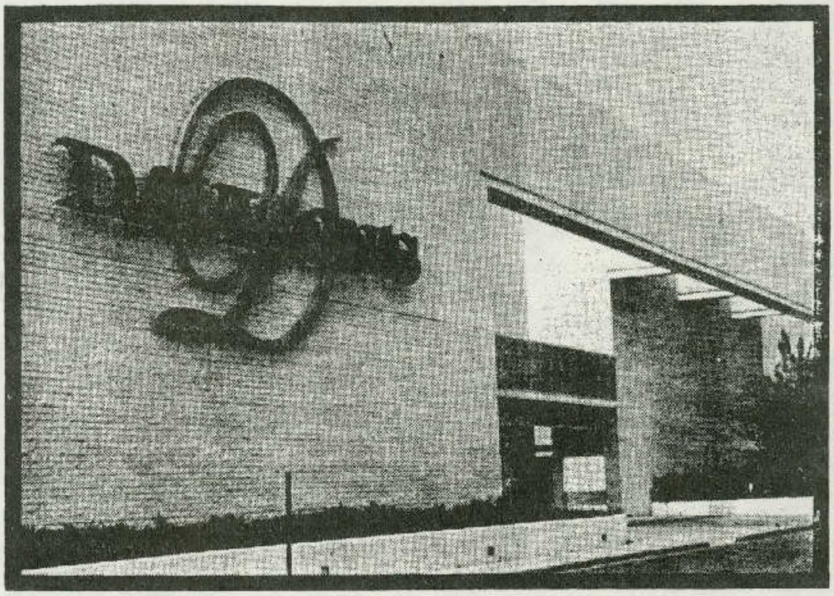
Case history

Davison's department store

CH3

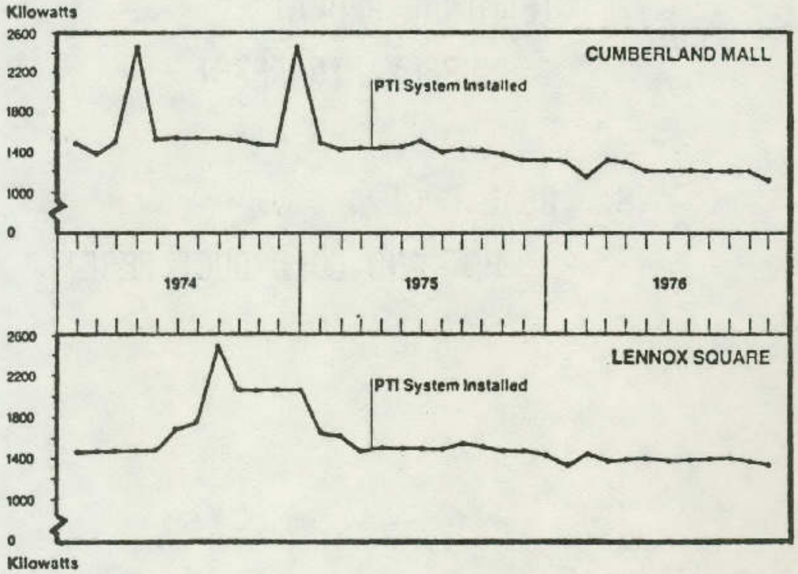
Davison's Stores
$82,000 annual savings—6 month payback

ATLANTA, GEORGIA. In April, 1975, two Model 414 Power Demand Controllers manufactured by Pacific Technology, Inc. were installed; one system in each of the Davison's Department Stores located in the Cumberland Mall and Lennox Square. These two systems were installed by Honeywell for use with their BOSS (building operation supervisory systems) Centers.



In each store, the PTI system controls four fans, one chiller (in two stages), four lighting circuits, a steam boiler and numerous duct heaters. In addition, the BOSS Center regulates environmental control of dampers on a time-shared basis for energy management service.

Gradually, a constant and increased reduction in demand resulted without customer discomfort. Both stores realized a combined savings of $82,000 during the first 12 months. Because of this tremendous savings, both systems and all installation costs were paid for within six months.



The two graphs show the monthly billed demand in kW for each store, both before and after the PTI systems were installed.

Energy management systems

Equipment data sheet — Power demand controller — Model 414

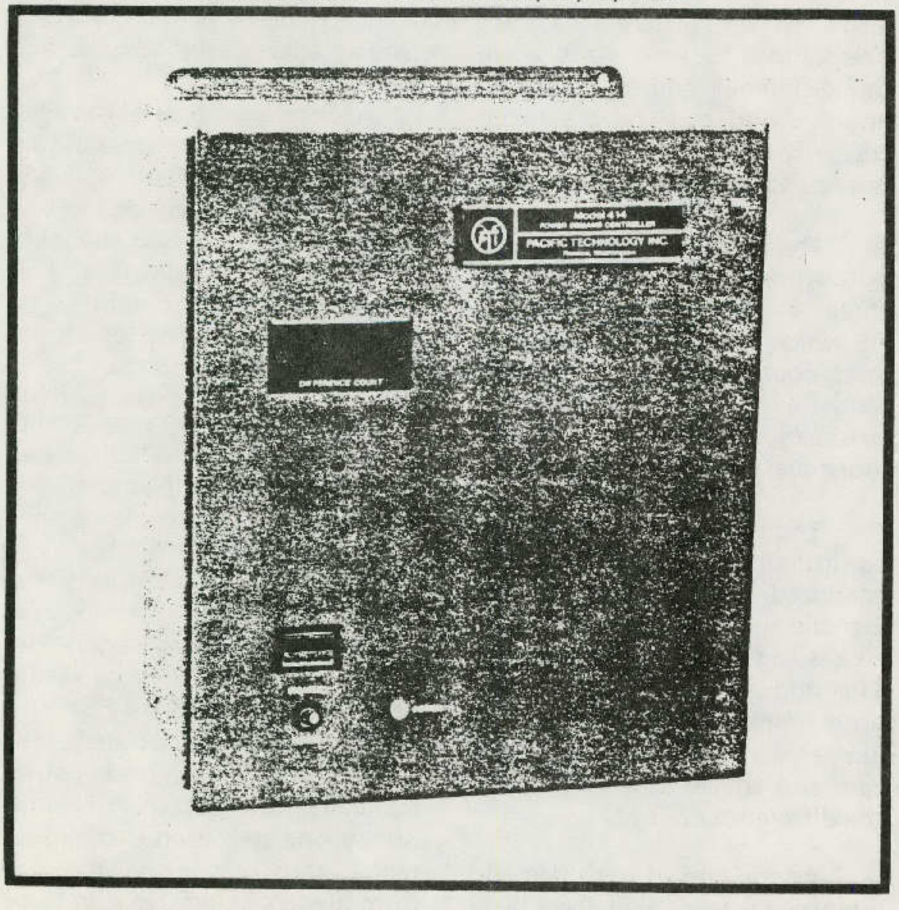
FEATURES

- ☐ Low cost, automatic control of one to 20 loads
- ☐ Load priority easily changed
- ☐ Compatible with utility pulse metering
- ☐ May be used when internal reset pulse is not available

APPLICATIONS

- ☐ HVAC systems in buildings and malls
- ☐ Furnaces and melters for metal reduction and forming
- ☐ Controls resistive heating, electric water boilers, heaters and motors
- ☐ Colleges, factories, hospitals, hotels, offices and schools

Model 414 AS/5 with difference count display option



The Model 414 Power Demand Controller is a digital control system designed to limit peak electrical demand through automatic control of preselected loads. This system finds application in commercial buildings or industrial plants where the total connected load is 300 kW or greater.

The Model 414 operates on the Ideal Curve concept. In this technique, the kilowatt-hour metering pulses are compared with pulses generated at an ideal rate which has been operator selected. Throughout each demand interval, the difference between the utility metering pulses and the internally generated pulses is continuously calculated and presented on an optional digital front panel display. (See figure 1, over.)

An initial offset in the ideal curve prevents crossover early in

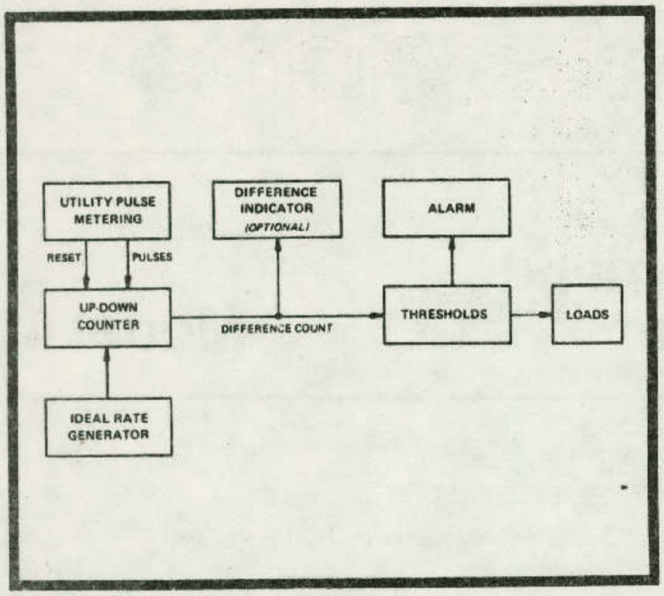


Figure 1

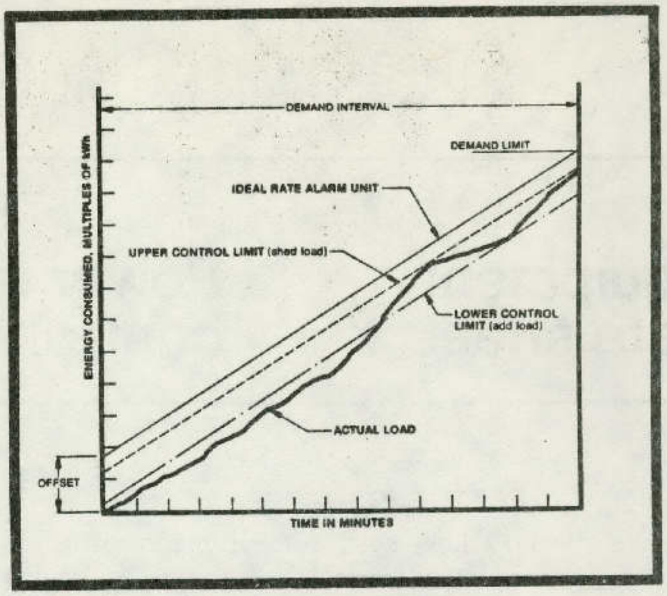


Figure 2

the demand interval before load trends have been established. The operating set point for the reference generator and the initial offset are selected by means of front panel digital thumbwheel switches. The demand limit is equal to the total of the offset and reference settings (see figure 2).

If the difference count were to decrease until it passed through zero (indicating cross-over of the actual load curve), an alarm circuit is activated to alert the operator that the preset demand limit will be exceeded if the rate of energy consumption is not decreased.

Control of loads may be accomplished automatically by one of three basic configurations of the Model 414.

The Model 414 AN develops a linear analog output voltage ranging between 0 and 10 volts dc. This voltage is proportional to the difference count. The output is zero volts when the difference count is zero or negative and may be set to increase to 10 volts dc at any difference count greater than five.

The Model 414 AS has relay output, on/off control. There are three versions of the Model 414 AS which offer either 5, 10 or 20 load control circuits. Thus the Model 414 AS/20 can be used to automatically control up to 20 individual control circuits.

The threshold at which each control circuit is energized or deenergized is independently adjustable so that load priority can be easily established or changed. The add or shed setpoints are programmed (see figure 3) by jumper wires on the logic control card and are set as a function of the difference count.

At the end of each demand interval, all loads that have been turned off during the interval are re-energized. To prevent simultaneously adding all loads, a selectable time interval of 1, 2½, 5 or 10 seconds will elapse between the addition of each load. As an option, either the Model 414 AS/10 or 414 AS/20 may be ordered with manual over-ride switches and load status indicators. This allows any control circuit to be manually switched on or off, or left on automatic control.

Many applications require that all the controllable loads equally share the load shedding responsibility rather than having the lowest priority off the longest time. This is particularly true when interfacing with HVAC systems in building as undue discomfort might otherwise result. The Model 414 AS may be purchased with an optional load cycler circuit which automatically advances the first load off by one step each demand interval, thus preventing one load from always being the first to be

Patent number 3,514,713 applies to some of the above equipment.

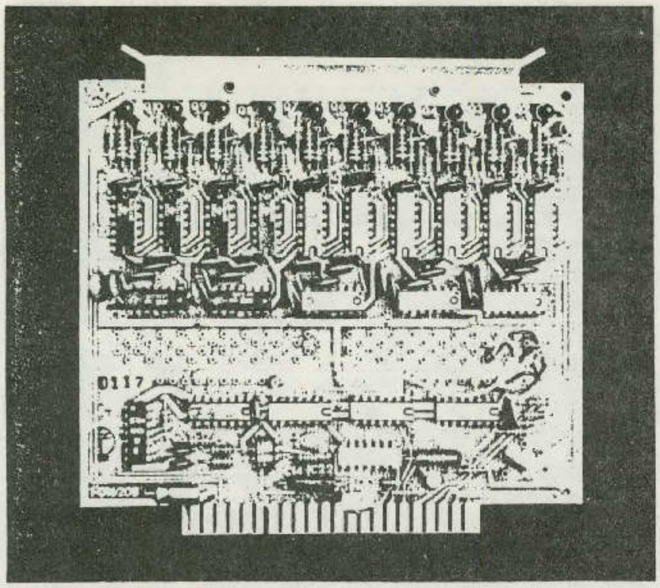


Figure 3

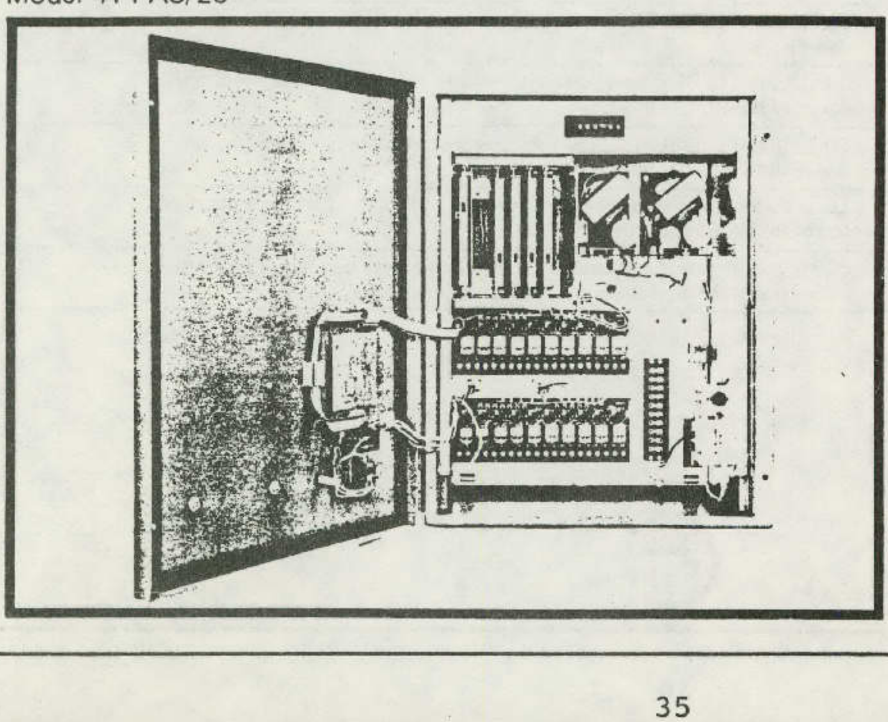
shed. The load cycler may also be used to rotate all loads one step with a selectable time base. These two features are independent and may be used separately or together. These options insure more equal distribution of the load shedding responsibility.

In some installations the utility metering may provide only the kWh pulses without the demand interval reset pulse. This may typically occur in smaller installations where a demand register has been fitted with a pulse generator for kWh pulses only.

A special version of this system, the Model 414R, is available for these applications. The 414-020 option (no additional cost) should be specified at the time of order. All of the standard system configurations listed are available with the model 414R as well as the standard Model 414.

The model 414R operates in an Ideal Rate mode. Loads are automatically controlled so that the rate of energy consumption is maintained at a predetermined level.

Model 414 AS/20



SYSTEM CONFIGURATIONS

414 AL	Alarm only
414 AN	Analog output, 0-10V dc
414 AS/5	Relay output with five control circuits
414 AS/10	Relay output with ten control circuits
414 AS/20	Relay output with twenty control circuits

Specifications

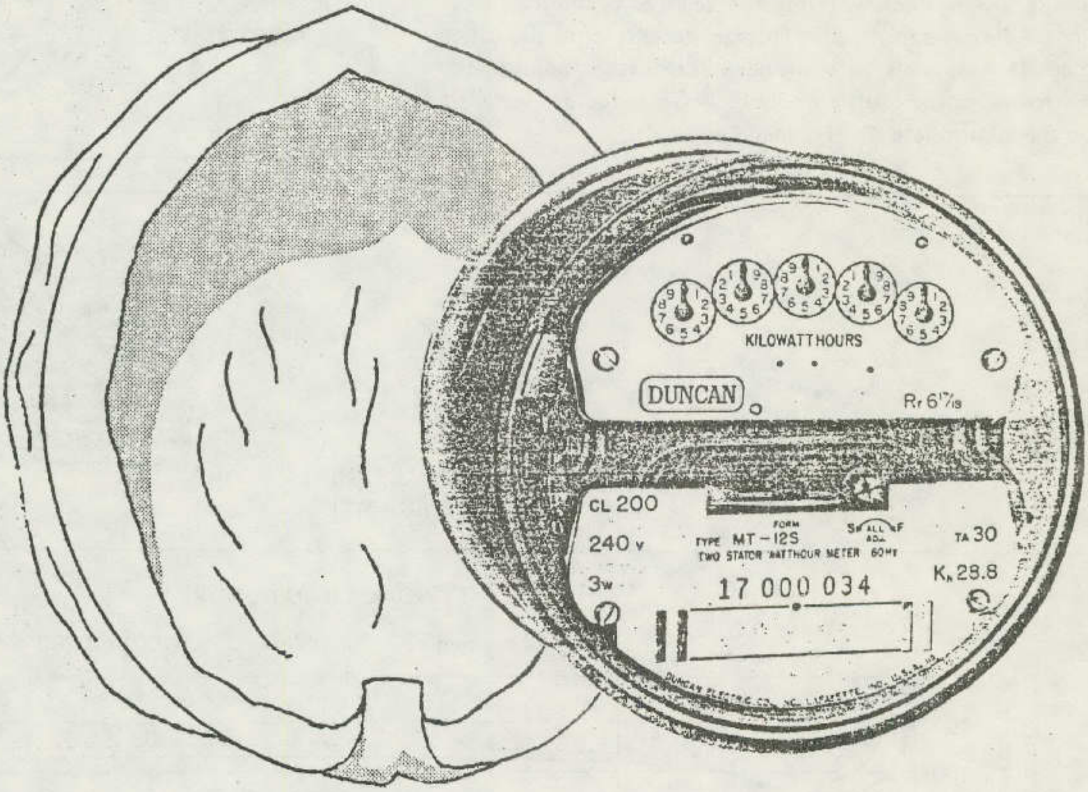
Maximum Pulse Count	999 (4999 Available as option)
AC Pulse Input	Standard 3-wire metering circuit, 115V ac, 60 Hz at 3600Ω nominal input impedance.
Maximum Rate	20 per second
Period Reset	2-wire, contact closure for 0.05 seconds minimum, 115V ac, 60 Hz at 3600Ω nominal input impedance.
DC Pulse Input	Standard 3-wire metering circuit, 24V dc at 500Ω nominal input impedance.
Maximum Rate	20 per second
Period Reset	2-wire, contact closure for 0.05 seconds minimum, 24V dc at 500Ω nominal input impedance.
Metering Period	15, 30 or 60 minutes
Displays	Alarm Alarm Disabled Load Status
Outputs	
Control	Isolated relay contacts, 5A resistive for each control circuit except in 414 AN which has 0 - 10V dc output, 5 mA maximum @ +10V.
Alarm	Isolated relay contacts, 5A resistive
Input Power	105V to 125V ac, 60 Hz, 50W nominal
Ambient Temperature	$0^{o}C$ to $50^{o}C$
Weight	414 AL, 414 AN, 414 AS/5 — Approx. 30 lb. 414 AS/10, 414 AS/20 — Approx. 45 lb.
Dimensions (in inches)	414 AL, 414 AN, 414 AS/5 — 14(H) x 12(W) x 9(D) 414 AS/10, 414 AS/20 — 20(H) x 16(W) x 9(D)

Options

414-001	Adds 4th digit to reference set point (4999 max.)
414-005	2-digit difference count display
414-010	Pulse-to-kilowatt converter
414-020	Adapts 414 to utility metering which does not have a period reset pulse.
414-021	10 ON/AUTO/OFF override switches and load status indicators on cover (414 AS/10 Only).
414-022	20 ON/AUTO/OFF override switches and load status indicators on cover (414 AS/20 Only).
414-025	Load Cycler to automatically advance load shedding sequence and/or to rotate all loads on timed basis.
414-030	50 Hz modification. Adapts unit to 50 Hz power but requires 2:1 step down transformer if used on 230V ac line voltage.

DUNCAN

MT METER . . .



in a nutshell

DUNCAN ELECTRIC COMPANY, INC. P. O. BOX 180 LAFAYETTE, INDIANA 47902

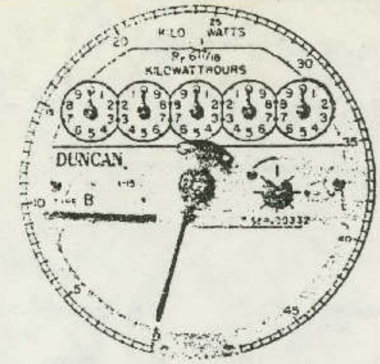
COMPATIBLE ACCESSORY PRODUCTS

Meters with mechanical demand registers, and watthour-thermal watt demand meters are available. An electronic pulse generator, Type PG-6MT or PG-6MTL, can be mounted on any of these meters, as well as on standard type MT watthour meters.

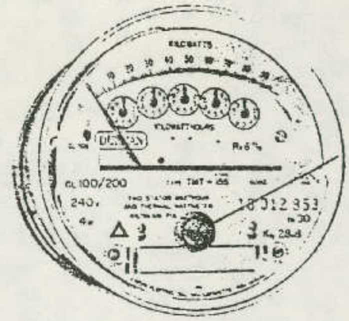
All meter features necessary to operate a pulse generator are standard on transformer rated meters, and are optional on self-contained. These features include:

1. pulse generator drive pinion on rotor spindle
2. P. G. power winding in left stator potential coil
3. KYZ terminals in baseplate (on 13 terminal types pre-wired from center terminals to side terminals).

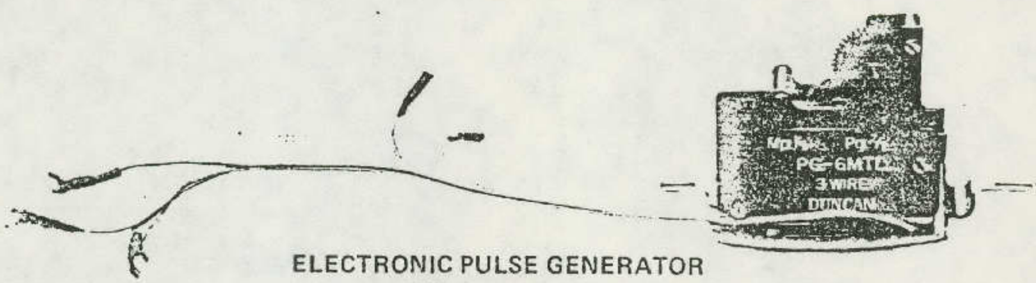
Mechanical demand registers are mounted to the meter by an intermediate gear unit which includes the first reduction (worm) gear. This makes it possible to accurately adjust worm mesh without the register obscuring visual access during adjustment. The register fits onto the intermediate gear unit without need for further adjustment. Thermal demand units are supplied only as factory installed on the appropriate KWH-demand meter.



BLOCK INTERVAL DEMAND REGISTER TYPE B



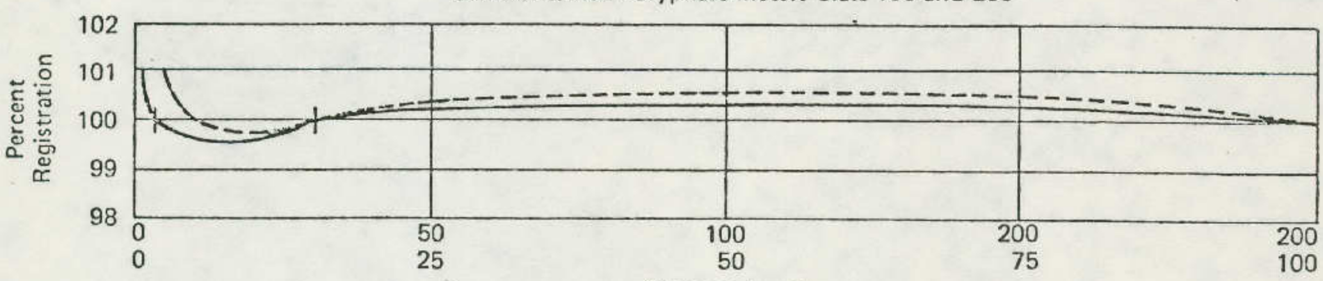
WATTHOUR THERMAL WATT DEMAND METER TYPE TMT



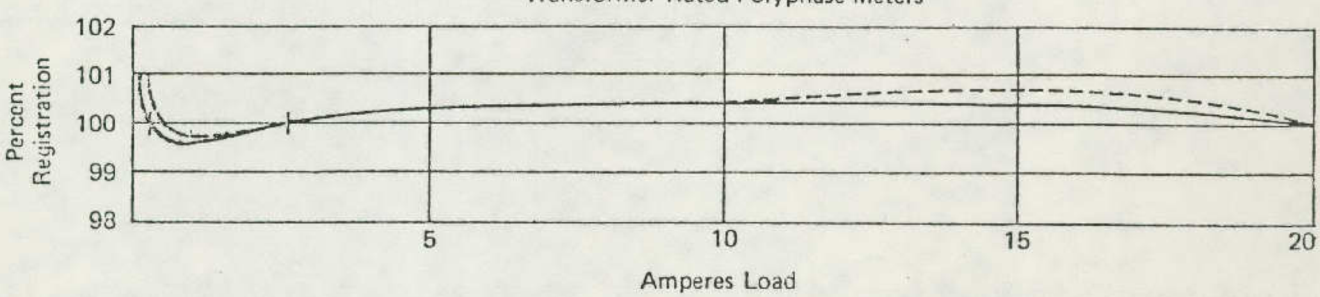
ELECTRONIC PULSE GENERATOR
TYPE PG-6MTL

TYPICAL LOAD CURVES

Self-Contained Polyphase Meters Class 100 and 200



Transformer-Rated Polyphase Meters



——— 1.0 Power Factor

— — — 0.5 Power Factor Lagging

Data Sheet: *PDS001-03/78*
Date: *1 March 1978*

product data from Texas Controls, Inc.

Power Management Master

General Description

The need for reducing the level of energy consumption, together with the problems of coping with ever-increasing energy costs, enhance the value of the Model 416 Power Management Master (PMM).

The PMM is a microprocessor-based master load controller pre-programmed for demand monitoring and load controlling, load scheduling and load cycling of electrical devices such as fans, compressors, heaters, lighting and etc.. The activation or deactivation of associated relays, contactors or motor starters by the PMM is the means of reducing energy consumption.

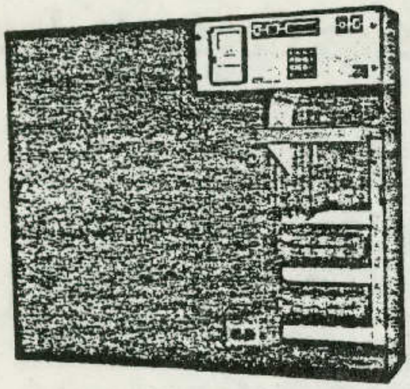
Unlike systems which continually meter pulses, the PMM utilizes the more sophisticated Predictive Demand Control (PDC) logic method. PDC employs a "sample and hold" technique, with the "hold" being the period between control points at which forecasts are made. The PDC system can accommodate a wide variety of load profiles and is highly accurate.

The PMM is available in two models; the wall-mounted, and a designer desk configuration. Each includes all required software, operator/display panel, relay outputs, battery back-up and options including a printer, strip chart recorder, output expansion and etc..

Advantages

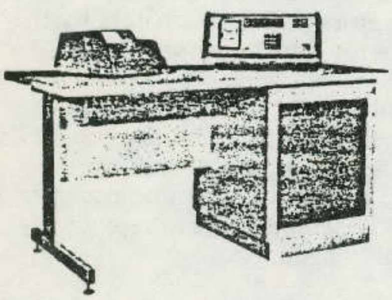
- U. L. Approved
- Eliminates telephone line installation and the related recurring costs.
- Low cost — Fast payout
- Minimal maintenance through self-testing and diagnosis

SALES & SERVICE CENTERS



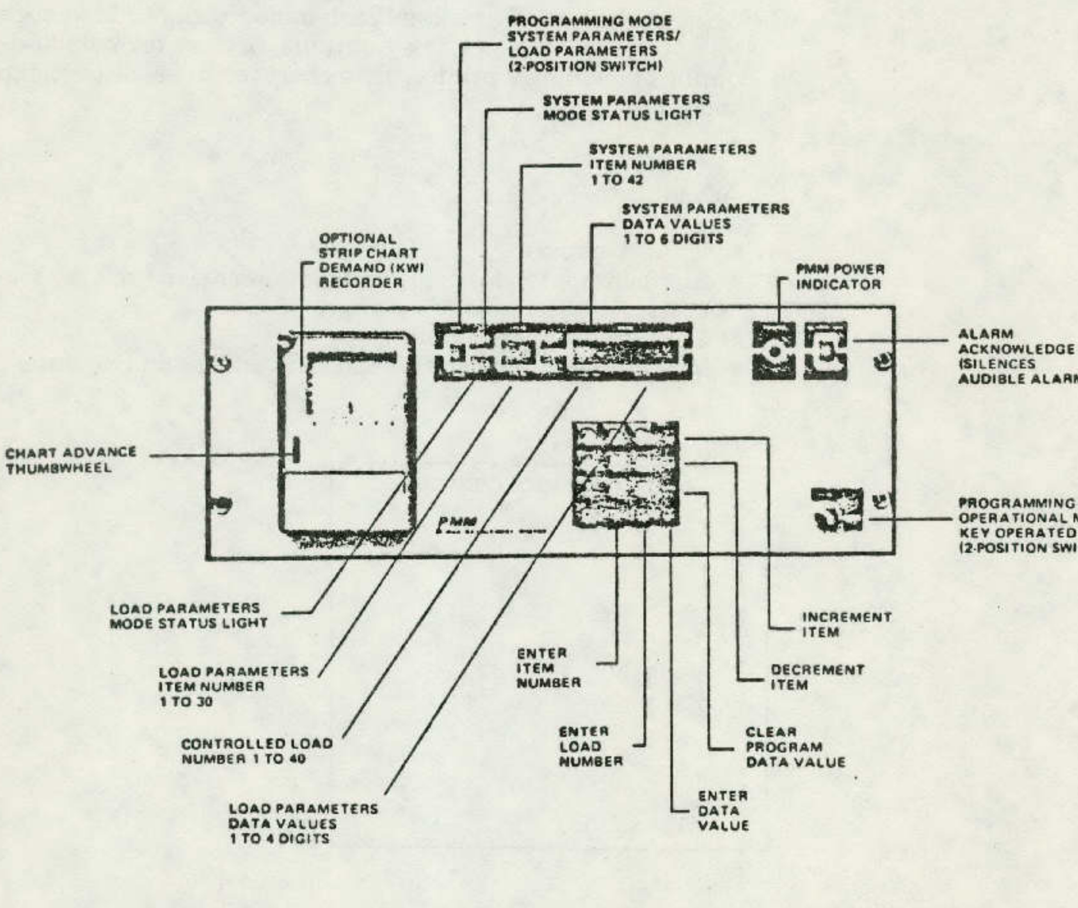
Model 416W

The Model 416W is a self-contained, indoor, wall-mountable, firmware driven master controller for energy management application. The base unit contains a power supply, battery back-up (for memory retention), watchdog timer, audio alarm and relay, 16 relay outputs, four digital status inputs, four demand meter contact inputs, 16-key keypad and operator/display panel. Options include up to 24 control relays and 40 override switch assemblies (both available in groups of eight (8) only), one analog output, KW demand strip chart recorder and a 40 column impact printer. A unique feature in the power management industry is the self-test and diagnostic abilities of the PMM.



Model 416D

The Model 416D base unit contains the same electronics as the Model 416W except they are housed in the designer desk pedestal. Pedestal space includes provisions for 24 additional relay outputs and up to 40 override switch assemblies (each in groups of eight). The keypad and operator/display is housed in an attractive and functional desk-top console.



System Description

The Power Management Master (PMM) is designed to optimize power consumption and limit demand in commercial and industrial buildings. Significant energy savings are made by:

- Monitoring demand, predicting future demand and controlling electrical loads to minimize demand peaks.
- Scheduling loads on an individual basis for any two periods of time during the day.
- Cycling any load on an individual on/off cycle schedule.

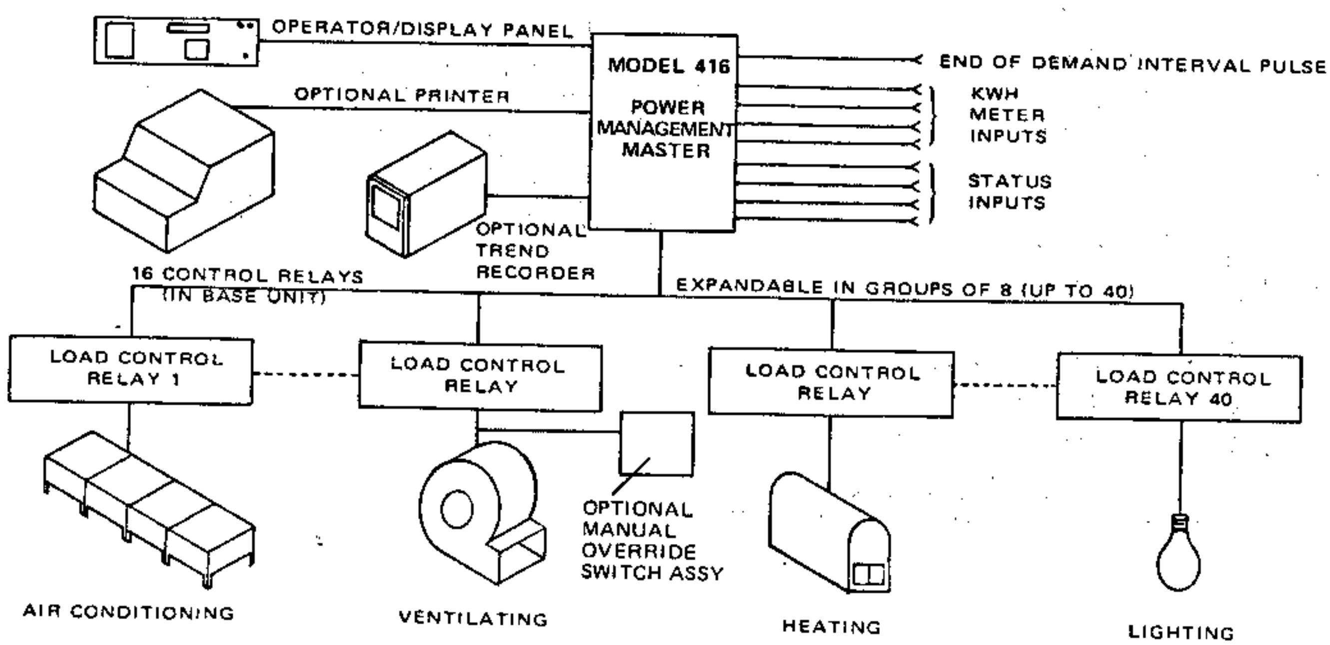
Inputs from four KWH meters and four status inputs, which can be used with thermostats and/or humidistats, are provided for truly adaptive control. The status inputs can be used to modify cycling strategy as a result of changing environmental conditions and etc..

Convenience and adapability of the PMM are considerably enhanced by the Operator/Display panel. It provides for the individual entry and display of all 42 system and 30 load parameters via a 16-key keypad.

Entry of this data is simplified with the 'fill in the blanks' approach. The input data is divided into two categories: system parameters and load parameters. Input data sheets are supplied to the user to aid in preparation of the data and provide a record of the data. A sample of the parameter items is shown on the following page. Initial variable entry on a typical 24 output system can easily be made in approximately 30 minutes.

The PMM refreshes the display values twice per second thereby insuring all values are current. Ten parameters are automatically updated by the PMM; date, time, most recent demand, maximum demand this month, most recent power company demand, power company maximum demand this month, resettable KWH totalizer, perpetual KWH totalizer, daily KWH totalizer and current day type.

The unique self-test and diagnostic abilities of the PMM require no user action unless there is a problem. Each morning at 9:00AM, the PMM automatically performs a self-test of its memory. Problem notification is given on the operator/display panel by displaying an item number of 99 and flashing an error code (1-14) in the data field. In addition to the displayed error code, the alarm relay is energized to announce an error. All load control action ceases when a self-test error occurs.



Parameters

Input data is divided into two categories which are: system parameters and load parameters. Input data sheets are supplied with the equipment to aid the user in preparation of input data and to provide a record of the data. Parameters can only be changed when PMM is in the program mode.

Up to 36 system parameters may be input to the PMM. These parameters plus six (6) other information parameters may be displayed on the operator/display panel when the equipment is in System mode. Also, up to 30 load parameters may be input to the PMM for each load. These parameters may be displayed on the operator/display panel when the load/system switch is in the load position.

There is a range of valid values defined for each system or load parameter. The system will not accept a parameter outside that range. A pre-programmed value is also specified for each system and load parameter. The PMM will use the pre-programmed value for any parameter not given another value by operator/display panel input.

SYSTEM PARAMETERS

01 DATE
02 TIME
03 CURRENT DAY OF WEEK
04 DEMAND INTERVAL
05 TARGET DEMAND
06 CONTROL BAND%
07 ALARM SETPOINT DEMAND
08 EMERGENCY SHED DEMAND

09 METER 1 METER FACTOR
10 METER 2 METER FACTOR
11 METER 3 METER FACTOR
12 METER 4 METER FACTOR

13 STATUS INPUT 1 OFF CYCLE MULTIPLIER
14 STATUS INPUT 2 OFF CYCLE MULTIPLIER
15 STATUS INPUT 3 OFF CYCLE MULTIPLIER
16 STATUS INPUT 4 OFF CYCLE MULTIPLIER

17 DAY TYPE OF SUNDAY
18 DAY TYPE OF MONDAY
19 DAY TYPE OF TUESDAY
20 DAY TYPE OF WEDNESDAY
21 DAY TYPE OF THURSDAY
22 DAY TYPE OF FRIDAY
23 DAY TYPE OF SATURDAY

24 SPECIAL DAY 1 DATA
25 SPECIAL DAY 2 DATA
26 SPECIAL DAY 3 DATA
27 SPECIAL DAY 4 DATA
28 SPECIAL DAY 5 DATA
29 SPECIAL DAY 6 DATA
30 SPECIAL DAY 7 DATA
31 SPECIAL DAY 8 DATA
32 SPECIAL DAY 9 DATA
33 SPECIAL DAY 10 DATA

34 PRINT MODE
35 CHART RECORDER FULL SCALE
36 RESETTABLE KWH TOTALIZER
37 KWH TOTALIZER
38 DAILY KWH TOTALIZER
39 MOST RECENT DEMAND
40 MAXIMUM DEMAND THIS MONTH
41 MOST RECENT POWER COMPANY DEMAND
42 POWER COMPANY MAXIMUM DEMAND THIS MONTH

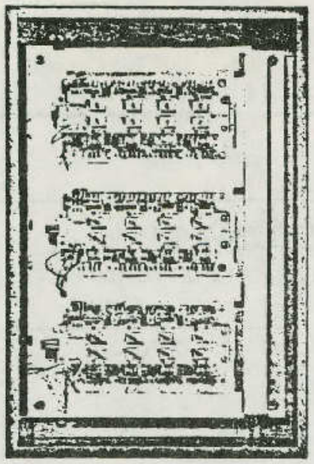
LOAD PARAMETERS

01 LOAD SIZE
02 PRIORITY LEVEL
03 MINIMUM ON/OFF TIMES
04 SHED/CYCLE OFF CONDITION STATEMENT NUMBER
05 SHED/CYCLE OFF CONDITION LOAD NUMBER(S)
06 OFF-CYCLE ASSOCIATED STATUS INPUT(S)

07 DAY TYPE 1 FIRST ON TIME
08 DAY TYPE 1 SECOND ON TIME
09 DAY TYPE 1 FIRST OFF TIME
10 DAY TYPE 1 SECOND OFF TIME
11 DAY TYPE 1 FIRST CYCLE START
12 DAY TYPE 1 FIRST CYCLE ON/OFF
13 DAY TYPE 1 SECOND CYCLE START
14 DAY TYPE 1 SECOND CYCLE ON/OFF

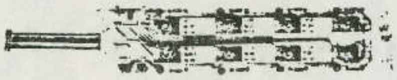
15 DAY TYPE 2 FIRST ON TIME
16 DAY TYPE 2 SECOND ON TIME
17 DAY TYPE 2 FIRST OFF TIME
18 DAY TYPE 2 SECOND OFF TIME
19 DAY TYPE 2 FIRST CYCLE START
20 DAY TYPE 2 FIRST CYCLE ON/OFF
21 DAY TYPE 2 SECOND CYCLE START
22 DAY TYPE 2 SECOND CYCLE ON/OFF

23 DAY TYPE 3 FIRST ON TIME
24 DAY TYPE 3 SECOND ON TIME
25 DAY TYPE 3 FIRST OFF TIME
26 DAY TYPE 3 SECOND OFF TIME
27 DAY TYPE 3 FIRST CYCLE START
28 DAY TYPE 3 FIRST CYCLE ON/OFF
29 DAY TYPE 3 SECOND CYCLE START
30 DAY TYPE 3 SECOND CYCLE ON/OFF



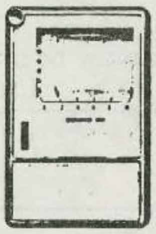
Expansion Unit

This unit contains eight to 24 output relays (in groups of eight) housed in a 35 pound indoor, wall mountable and lockable enclosure (24" X 16" X 7"D). It is available only with the Model 416W as no additional enclosure is required for expansion of the Model 416D.



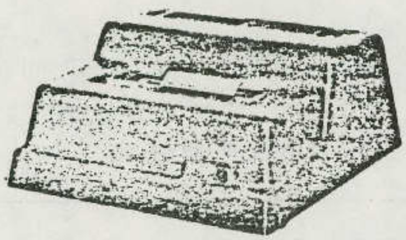
Override Switch Assembly

Eight to 40 switch assemblies are available (in groups of eight). Each includes one 3-position (on-off-automatic) switch and one status LED indicator for each output relay.



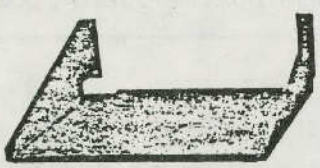
Trend Recorder

This is a 30-day, 1"/hour strip chart recorder mountable in the operator/display panel. It requires 115V AC ± 10% supplied by the base unit. 0–10V DC input option is required.



Printer

The 40 column, 64 character, 50 cps, six lines/inch recorder requires 115V AC ± 10%, 50-60 Hz at 1.5 amp. Overall dimensions are: 6.5" H X 13" W X 13" D. Weight is 10 pounds and estimated head life is 10 X 10^6 lines. Ribbon life: 4 X 10^6 characters and cable length: 72"



Printer Wall Mount Bracket

The wall mount bracket is included when printer is used with the Model 416W. The bracket is not required for Model 416D. 4.5" X 14.19" X 14.19"D

Specifications Summary

	416W BASE UNIT	416D BASE UNIT
OPERATING CHARACTERISTICS		
ENCLOSURE	SELF CONTAINED, INDOOR WALL MOUNTABLE WITH LOCK	DESK
KWH MOTOR INPUTS	1 to 4 DRY CONTACTS SELECTABLE NORMALLY OPEN OR NORMALLY CLOSED (FORM 'C'). EXCITATION VOLTAGE 5V DC @ .5 mA SUPPLIED BY BASE UNIT. PULSE RATE UP TO 10 PPS. METER FACTOR RANGE .00 - 99.99	
STATUS INPUTS	1 to 4 DRY CONTACTS SELECTABLE NORMALLY OPEN OR NORMALLY CLOSED (FORM 'C'). EXCITATION VOLTAGE 12V DC @ .5 mA SUPPLIED BY BASE UNIT.	
END OF DEMAND INTERVAL (IF DESIRED)	1 AT EITHER 5, 15, 30 OR 60 MINUTE INTERVALS. SELECTABLE EITHER NORMALLY OPEN OR NORMALLY CLOSED DRY CONTACT. EXCITATION VOLTAGE 5V DC @ .5 mA SUPPLIED BY BASE UNIT.	
DIGITAL OUTPUT RELAYS		
COIL VOLTAGE	12V DC @ 1.2 WATTS	
COIL IMPEDANCE	120 OHMS	
CONTACT RATING	ONE SET OF FORM 'C' CONTACTS RATED @ 10 AMPS @ 28V DC OR 240V AC	
POWER REQUIRED	115V AC (± 10%), 60 HZ, 5 AMP	
CUSTOMER CONNECTIONS	POWER & I/O FIELD CONNECTIONS	
PHYSICAL CHARACTERISTICS		
DIMENSIONS	36" X 21" X 9" DEEP (91.44 cm X 53.34 cm X 22.96 cm)	60" X 31" X 30" DEEP (152.40 cm X 78.74 cm X 76.20 cm)
NET WEIGHT (APPROX)	70 LBS (31.78 KG)	160 LBS (73.64 KG)
POWER CABLE	CUSTOMER FURNISHED 14 AWG, 3 CONDUCTOR CABLE OR LARGER	
PAINT COLOR	NITRO BLUE	DECORATOR WHITE TOP & PEDESTAL WITH NITRO BLUE PEDESTAL DOOR
ENVIRONMENTAL CHARACTERISTICS		
OPERATING TEMPERATURE RANGE	0° TO 50° C	
RELATIVE HUMIDITY	0 TO 95% NONCONDENSING	

Typical Questions & Answers

Q. How many times can a load be shed within a given demand interval?

A. Depends on the length of demand interval, minimum on/off times specified and availability for shedding based on demand, priority and scheduling.

Q. Describe the electrical energy management control strategy.

A. The PMM employs demand control, load scheduling and cycling strategies to attain its energy management goal.

Q. Can the 24-hour day be divided into contiguous time segments?

A. A 24-hour day can be divided into two contiguous or non-contiguous time segments (user selectable).

Q. Can startup and shutdown times be designated for each controlled load?

A. Each load can be independently programmed to two different cycle plans which can be started or stopped at two different sets of time of day.

Q. How many meters and loads can be connected to the system?

A. Up to four KWH pulse sources can be accommodated by the PMM and up to 40 load control relays are available.

Q. Does the PMM require constant attention after system and load parameters have been programmed by the user?

A. No, the PMM is designed to function unattended.

Q. Does the system produce a scheduled or operator requested hard copy data log?

A. The printer option records all system events as they occur. A daily summary is printed at midnight.

Q. Are there inputs other than KWH meter and end of demand interval? If so, how do they affect control strategy?

A. Yes, there are four (4) status inputs. The set state of these inputs are used, if selectd, to affect the off time (multiply by .0-99.99) set for each load/cycle period.

Q. Are there any provisions for facility load coordination within the system?

A. Yes, each load can be programmed so that its capability for shedding or cycling is a function of the state of up to two other loads. There are eight (8) facility coordination statements that can be selected for performing this function.

Q. In what sequence are loads shed and restored?

A. Priority one (1) loads are shed first, restored last and priority six (6) loads are shed last, restored first.

Q. What type of monitor/control device is incorporated in the energy management system.

A. A microprocessor programmable controller.

Q. Since the device is programmable, does the system include all requisite system and application software for energy management, i.e., must the user write any software?

A. User does not write any software. Equipment comes completely programmed. User inputs system and load parameter data via the 16-key keypad.

Q. Is 'brown out' and power failure detection and protection included?

A. Yes, a separate solid state adjustable AC voltage sensor for 'brown out' detection is included along with a battery backup in the base unit.

Q. What is the frequency of execution of the control algorithm?

A. Every 1/20th of the PMM demand interval. Demand interval is operator selectable at 5, 15, 30 or 60 minutes.

Q. Is synchronization with the power utility's demand interval required?

A. Not required, but may be used for synchronization with supplying utility if desired.

Q. When shedding action is initiated, are loads shed singly or in multiples?

A. Loads are shed singly or in multiples depending on load size and rate of consumption.

Q. Are loads shed by cumulative KW load depending upon either the magnitude of the computed excess demand or the time elapsed in the demand interval?

A. Loads available for shedding are checked for size, among several things, and actual shedding is then done on basis of loads required to change the slope of 'Demand Trend' to stay within deadband.

Q. Are all shed loads restored at the end of a demand interval and what are the criteria for load restoration?

A. Loads may and will be restored singly at any time during the demand interval. Restoration is based on the continuous predictive demand.

Q. How is short cycling of loads inhibited?

A. By use of minimum on/off times.

Q. Explain how loads are sequenced for shedding.

A. A combined priority/rotational method is used. There are actually eight (8) priority levels any load may be assigned to. Six (6) of these are used for establishing shedding priority. A priority zero (0) assigned load will remain off and a priority seven (7) load is not available for shedding, only scheduling and cycling.

Commitment to Industry

General

The main business of Texas Controls, Inc. is the design and production of data acquisition and control equipment. Because of this the company has made the large and necessary investment not only in extensive manufacturing facilities, but also in developing the necessary hardware and software products which inherently assure quality, performance and on-going support. It is this investment in facilities, products and people that provides our customers with the hard dollar "plus factors" that aren't available from job shops or rack-and-stack suppliers.

Because of the company's commitment to, and dependence upon, data acquisition and control business, you can rely on us to be around year after year and in the forefront of technological development.

Training

Texas Controls, Inc. maintains a complete, professionally staffed training center at its headquarters in Dallas, Texas. Comprehensive hardware courses are conducted at a level customers find interesting, informative and challenging. All training courses are conducted by instructors who have had extensive experience. Classroom instruction and practical equipment demonstrations are presented in a balanced curriculum for a maximum learning environment. Manuals and equipment documentation are made available to each student for his retention. A thirty (30) day advance notice for attendance is required and classes are on a 'first come-first serve' basis.

Test Equipment

The company's philosophy towards field test equipment is to keep all specialized test equipment requirements to a minimum and build those desired test features into the prime product. With this in mind we recommend each customer have access to general test equipment standard to the industry.

Sales and Service

Texas Controls, Inc., provides sales, service and applications assistance from its National Sales and Service Centers or headquarters in Dallas, Texas.

TEXAS CONTROLS, INC.

13735 Omega Road / P. O. Box 59469
Dallas, Texas 75229
(214) 386-5000

3

AUDITS AND COSTS

Audits, Costs, Tax Incentives

Table of Contents

WHAT IS AN ENERGY AUDIT

QUANTIFICATION OF ENERGY USE BY:

TYPE	-	ELECTRIC, OIL, GAS, L.P.
AREA	-	OFFICE, PLANT, PROCESS
SYSTEM	-	HEATING, VENTILATING, AIR CONDITIONING, LIGHTING, PROCESS
TIME	-	DUTY CYCLES, OCCUPIED/UNOCCUPIED, HOURS/YEAR

LIGHTING AUDIT

1. COUNT INCANDESCENT BULBS AND NOTE WATTAGE

2. COUNT FLUORESCENT BULBS, NOTE WATTAGE, MULTIPLY WATTAGE BY 120% (FOR BALLAST)

3. MULTIPLY BY OPERATING HOURS PER MONTH

EXAMPLE

$$\frac{200 \times 75 \times 1.20 \times 310}{1000} = 5580 \text{ KWH/MONTH}$$

ELECTRIC MOTOR AUDIT

1. CHECK NAMEPLATE FOR VOLTS AND FULL LOAD CURRENT (FLA)

2. ESTIMATE LOAD FACTOR (70%)

3. MULTIPLY BY OPERATING HOURS PER MONTH

EXAMPLE

$$\frac{115V \times 5.5A \times .7 \times 200 \text{ Hours}}{1000} = 88 \text{ KWH}$$

APPENDIX A-2

MOTORS - GENERAL FORMULAE AND SIZING

1.0 GENERAL FORMULAE.

	A. C. MOTORS Single Phase (a)	A. C. MOTORS Three Phase (b)	D. C. MOTORS (c)
(1) $P_{KW} =$	$\frac{V \times I \times PF}{1000}$	$\frac{V \times I \times 1.73 \times PF}{1000}$	$\frac{V \times I}{1000}$
(2) $P_{IHP} =$	$\frac{V \times I \times PF}{746}$	$\frac{V \times I \times 1.73 \times PF}{746}$	$\frac{V \times I}{746}$
(3) $P_{OHP} =$	$\frac{V \times I \times PF \times Eff}{746}$	$\frac{V \times I \times 1.73 \times PF \times Eff}{746}$	$\frac{V \times I \times Eff}{746}$
(4) $I =$	$\frac{P_{OHP} \times 746}{V \times Eff \times PF}$	$\frac{P_{OHP} \times 746}{1.73 \times V \times Eff \times PF}$	$\frac{P_{OHP} \times 746}{V \times Eff}$

(5) $P_{KW} = P_{IHP} \times .746$

(6) $P_{KW} = \frac{P_{OHP}}{Eff} \times .746$

(7) $P_{OHP} = Eff \times P_{IHP}$

SYMBOLS:

P = Power

P_{KW} = input power in KW

P_{IHP} = input power in HP

P_{OHP} = output power in HP

V = line voltage, e.g., 120, 208, 240, 480v.

I = amperage input to motor

PF = Power Factor (varies with I); obtained from mfgr.'s data.

Eff = Efficiency (varies with I); obtained from mfgr.'s data.

1 HP = 746w = 0.746 KW (by definition)

1 KW = 1000w (by definition)

2.0 SIZING. Motors should be sized to handle the horsepower requirement of the application, but should not be excessively oversized. An excessively oversized motor wastes energy because its efficiency is relatively low at low load. In general, the common A.C. induction motor will operate with only minor efficiency loss from 100% to 50% of its full load output horsepower. If the measured amperage input to the motor is approximately 25% or less of the full load amperage rating, then substitution of a smaller motor may save sufficient energy to pay back in a reasonable time. Use the following procedure to evaluate this ECO:

a. Obtain mfgr.'s literature for both the existing motor and the proposed motor. Data should include ratings of I, PF, and Eff for various percentages of full-load output.

b. Measure I for the existing motor at all ranges of capacity of the equipment that the motor serves; e.g., a pump will require a higher P_{OHP} from its motor when pumping against a lower head than usual. The highest I determined is I_M .

c. Calculate the percentage of full-load (%FL) that the existing motor is operating:

$$\%FL = (P_{KW}) \div (P_{KW} \text{ nameplate})$$

$$= \frac{I_M \times (PF)_M}{I_N \times (PF)_N} \times 100$$

where

I_M = measured amperage

$(PF)_M$ = PF @ I_M (mfgr.'s data)

I_N = nameplate amperage

$(PF)_N$ = nameplate PF (mfgr.'s data)

d. Calculate P_{OHP} of existing motor:

$$P_{OHP} = (\%FL) \times (\text{nameplate } P_{OHP})$$

e. From mfgr.'s data for the existing motor, interpolate as necessary and determine Eff at the %FL calculated in c. above. Use Equation (6) above to calculate P_{KW}.

f. Since the proposed motor will have to provide the same P_{OHP} to the machine served as the existing motor does, then

$$(P_{OHP} \text{ of proposed motor}) = P_{OHP} \text{ of existing motor})$$

g. Calculate %FL for proposed motor = $\dfrac{P_{OHP}}{\text{nameplate HP}}$.

From mfgr.'s data for proposed motor interpolate as necessary and determine Eff for the proposed motor.

h. Calculate P_{KW} for the proposed motor using Equation (6) above.

i. Is P_{KW} of proposed motor less than P_{KW} of existing? If so, its installation may pay back; proceed to j. below.

j. Payback Time: Calculate the annual $ savings from reducing the KWH consumption and the KW demand. Estimate the installed cost of the proposed motor.

$$\text{Payback Time} = \frac{\text{Installed cost of motor}}{\text{Annual \$ Savings}}$$

2.1 Example.

Given A 460v. 20 HP, three-phase motor with FLA = 26 amps and PF = 80%. Its measured amperage I_M = 5.2 amps. PF = 45% and Eff = 50% at this 5.2 amps.

Required: Examine benefits of installing a smaller motor. Last block KWH cost is $.02/KWH. Motor runs 2000 hrs./year.

Solution: Follow procedure of paragraph 2.0 above.

c. $\% FL = \dfrac{5.2 \text{ amps} \times .45}{26 \text{ amps} \times .80} \times 100 = 11\%$

d. $P_{OHP} = (\%FL) \times (\text{nameplate } P_{OHP})$

$= .11 \times 20$ HP

$= 2.2$ HP

e. Eff = .50

$$P_{KW} = \frac{P_{OHP}}{Eff} \times .746$$

$$= \frac{2.2}{.50} \times .746$$

$= 3.28$ KW

f. P_{OHP} of

proposed motor = 2.2 HP

Thus, a 3 HP motor is proposed.

g. % FL of
proposed motor $= \frac{2.2 \text{ HP}}{3 \text{ HP}} \times 100 = 73\%$

Eff @ 73% FL = 78% (from mfgr.'s data)

h. P_{KW} of
proposed motor $= \frac{P_{OHP}}{Eff} \times .746$

$$= \frac{2.2 \text{ HP}}{.78} \times .746$$

$= 2.10$ KW

i. $\Delta P_{KW} = 3.28$ KW $- 2.10$ KW

$= 1.18$ KW (reduction)

j. Annual KWH = 1.18 KW x 2000 hrs. = 2360 KWH

Annual KWH cost = 2360 KWH x $\frac{\$.02}{KWH}$ = $47.20

cost of 3 HP motor = $150.

Payback Time = $\frac{\$150}{\$47.20}$ = 3.2 years

(NOTE: 3.2 yr. payback time is for KWH $ savings only and does not include any $ savings for reducing KW demand.)

MONTHLY DETAILED ENERGY AUDIT-ELECTRICAL

DATE________________________

USAGE (EXCEPT MOTORS	RATED WATTS (1)	H	KWH	BTU
OFFICE LIGHTING				
OUTSIDE LIGHTING				
SPACE HEATING				
SOLDERING IRONS				
TANK HEATERS				
ETC.				

MOTORS	RATED WATTS (1)	WATTS (2)	H	KWH	BTU
VENTILATING FANS					
EXHAUST FANS					
AIR CONDITIONERS					
HAND TOOLS					
BIG MOTOR #1					
BIG MOTOR #2					
ETC.					

TOTALS ________ ________

DEMAND________KW POWER FACTORS__________________

NOTES: (1) NAME-PLATE DATA, WATTS EQUALS VOLTS TIME AMPERES. FOR FLUORESCENT TUBES, ADD 20 PERCENT FOR THE BALLAST; I.E., MULTIPLY THE RATING BY 1.20. FOR THREE-PHASE MOTORS, WATTS EQUALS VOLTS TIMES AMPERES TIMES 1.732.

(2) RATED WATTS TIMES THE FRACTION OF FULL LOAD, USUALLY ABOUT 70 PERCENT. IF THE OPERATING CURRENT HAS BEEN MEASURED, USE VOLTAGE TIMES THE MEASURED CURRENT (TIMES 1.732 IF IT IS A THREE-PHASE MOTOR.)

ELECTRICAL REQUIREMENT

Gross sq ft of area ____________   ______________________________ (Area Identification)   Floor_______

Electrical Equipment	1	2	3	4*	5	6	7
	No.	Watts	Tot. Watts (Col. 1 x Col.2)	Tot. Kw: See below	Number Hours per day	Number Days per year	Kwh Annual Requirements
Lights:							
Incandescent							
Fluorescent							
Other							
MOTORS							
Kw H.P. Use							
TOTAL							

*Lighting Multiplier: Incandescent = .001
Fluorescent: = .0012

Motors: Column 3 ÷ 1,000

ELECTRICAL REQUIREMENT (cont'd.)

Gross sq ft of area ____________ ______________________________ Floor______

(Area Identification)

Electrical Equipment	1	2	3	4*	5	6	7
	No.	Watts	Tot. Watts (Col. 1 x Col.2)	Tot. Kw: See below	Number Hours per day	Number Days per year	Kwh Annual Requirements
TOTAL							

*Lighting Multiplier: Incandescent = .001 Motors: Column 3 ÷ 1,000
Fluorescent: = .0012

THERMAL REQUIREMENTS

Location:________________

ITEMS	NO.	BTU	TOTAL BTU	NO. HRS/DAY	NO. DAYS/YR	ANNUAL REQMTS. BTU
TOTAL						

ENERGY INVENTORY
COMBINED RE-CAP

FACILITY	ELEC-TRICITY KWH	FUEL OIL GALLONS	NATURAL GAS THERMS	STEAM 1,000lbs.	OTHER	TOTAL BTU
GUEST ROOMS						
LOBBY						
OFFICE & COMM. SPACE						
BALLROOMS & MEETING ROOMS						
KITCHENS						
EQUIPMENT ROOMS						
BARS						
DINING ROOM-RESTAURANT						
HALLWAYS						
ELEVATORS-ESCALATORS						
HOUSEKEEPING ROOMS						
PUBLIC REST ROOMS						
LAUNDRY						
BUILDING EXTERIOR						
SWIMMING POOLS						
RECREATION FACILITIES						
OTHER						
TOTAL						

TEN MOST SIGNIFICANT FEATURES OF ENERGY CONSUMPTION IN BUILDINGS

1. HOURS OF OPERATION
2. HVAC SYSTEM TYPE
3. HVAC CONTROLS
4. VENTILATION
5. GLASS AREA
6. HEATING ENERGY TYPE
7. COOLING ENERGY TYPE
8. CLIMATE
9. LIGHTING
10. OTHER USES IN BUILDING

LIFE-CYCLE ANALYSIS FOR ENERGY MANAGEMENT DECISIONS

Del Fowler, P.E., Planergy, Inc.

For those who are serious about energy managment, energy use computations from past bills for a given building or facility are usually followed by a detailed energy audit of that building or facility. Observations during the audit and computations and analysis following the audit will provide a "shopping list" of energy conservation opportunities, or as I prefer to call them, Dollar Saving Opportunities (DSOs). To compile a list of such potential retrofit projects is not enough, however; we will need other information if we are to make good decisions based on sound economics. For example, we might want to know:

- should this project be done at all
- which of the many potential projects should be done first
- for my yearly budget of "X" dollars for such projects, which of those on the "shopping list" will provide me the greatest return on investment

This section discusses how to go about this analysis.

Simple Pay-back

Most of us would probably think of this analysis even if we had never heard of it. It is simply the first cost (estimated cost of labor and materials required for the retrofit project) divided by the net annual savings; in other words how many months or years will it take to recover the cost of the project.

$$\text{Payback Period} = \frac{\text{First Cost}}{\text{Net Annual Savings}}$$

In this case net annual savings would, in the simplest form, be the annual fuel or energy saving (computed using projected fuel or energy prices) less any additional operating cost which might be required for the energy-saving equipment installed.

$$\text{Payback Period} = \frac{FC}{(AFS \times PFP) - AAOC}, \text{ where}$$

FC = First Cost
AFS = Annual Fuel Saving
PFP = Projected Fuel Price
AAOC = Additional Annual Operating Cost

The payback period is then compared to the expected lifetime of the investment in order to make some rough judgement as to its potential for cost recovery. A payback period of less than one-half the life time of an investment would generally be considered profitable where the lifetime is ten years or less.

Return on Investment

Return on Investment (ROI) is somewhat superior to the above because it takes into account the depletion of the investment over its economic life by providing for renewal through a depreciation charge. Using a straight line depreciation charge (DC) where

$$DC = \frac{\text{FC (First Cost)}}{\text{EL (Estimated Lifetime)}}$$

the percent return on investment can be calculated using

$$\text{ROI, \%/yr} = \frac{\text{S-DC}}{\text{FC}} \times 100\%$$

S = Net Annual Savings

ROI has the advantage of putting investments with different life expectancies on a comparable basis. It is frequently used in the financial analysis of potential investments because of its simplicity of calculation.

These measures, payback period and return on investment, as measures of performance, give rise to problems, however. For instance, they do not consider debt service, price escalations, or energy cost increases. One cannot say, for example, that an initial capital investment of $100,000 which results in annual energy savings of $20,000 has a payback period of five years. To do so ignores the fact that interest must be paid on the loan of $100,000, or that -- if no loan is involved -- the $100,000 would otherwise be earning interest. So for the larger projects in particular, we need measures of performance which will incorporate the time value of money.

Life-Cycle Costing

Once we have taken the mental step of deciding to include the price of money from year to year, we have entered the world of life-cycle costing. To examine what we mean by life-cycle costing, we might look at how you might buy an automobile. If you decide you want a specific model of automobile, say based on style and appearance, then you are really going to base your decision to buy based only on first cost. You will most likely buy from a dealer which offers the lowest sales price, even though a second dealer with a slightly higher price might have a cheaper source of money which would finance your loan for the car purchase with a lower monthly payment. Buying without checking on the cost of money for the car loan is certainly buying on first cost alone, and without considering the principles of life-cycle costing.

Additionally, if you ignore gasoline mileage, other operating costs, maintenance costs, and "salvage value" or trade-in cost at the end of a certain period of time, you are ignoring the principles of life-cycle costing.

> DEFINITION -- The term "life-cycle cost" means the total costs of owning, operating, and maintaining a building or a piece of equipment over its useful life.

In the National Energy Conservation Policy Act of 1978, the Federal Government has directed that all federal agencies develop and establish methods for applying life-cycle costing for all federal buildings. This same act, to give you a picture of what the federal government is in the process of doing, requires that:

1. The Secretary of Energy and others shall establish and publish energy performance targets for all federal buildings.

2. Each federal agency must conduct a preliminary energy audit of all federal buildings with more that 30,000 square feet as soon as possible and report to Congress in 1979 on the accomplishments.

3. Similarly, they are to next conduct preliminary energy audits of all federal buildings with 1,000 or more but less that 30,000 square feet of floor space, and report to Congress in 1980 on the accomplishment.

4. In the first year, all federal agencies should retrofit 1% of the total gross square footage of floor space as recommended in the preliminary energy audits.

5. By 1990, all federal building will be retrofitted so as to assure their minimum life-cycle costs.

Because there are always alternative investment opportunities available for funds, a dollar held today is worth more than a dollar held at some future time. This is true even without continuing inflation, which promises to reduce the value of that future dollar even more. To bring into the analysis this cost of money we will use standard interest tables and present worth factors. In life-cycle costing, the most commonly included costs are first cost (in place), operating costs, maintenance costs, and interest on the investment. To use interest tables we must know the life of the system. This is one judgement we must make --that is, the useful life.

In addition we must make judgements on interest rates (i.e., the cost of money or capital), on inflation rates, and on rate increases in costs of energy and of maintenance.

Cost of Money

Let us examine this question, since it is probably the most important judgement or decision management will have to make.

Financial managers in any company will usually know what return in percent they want to realize on cash or capital which they spend from earned income. They arrive at their decision by looking at the various earning alternatives available for that same cash, to include investment in savings instruments of some kind, as well as the reinvestment of that cash in their own business. These alternate investment decisions can be based on the rate of return before taxes, but sound financial decisions must take into account corporate income and other taxes. We can take income taxes into account by setting the "before income tax rate" of return at a higher value than the "after income tax rate". If a 12% return is the minimum desired after taxes, the rate before taxes can be determined by

$$i_b = \frac{i_a}{1-I} = \frac{.12}{1-.48} = 23.1\%$$

where

i_b = before tax rate of return

i_a = after tax rate of return

I = income tax bracket (48% in above example)

At the 48% corporate tax level, it can be seen that the before tax rate of return must be about twice that of the desired after tax rate.

THE INCOME TAX CREDIT

Regular Investment Tax Credit

Investment tax credits encourage capital investments by reducing the income tax paid. Income tax to be paid may be reduced by 10% of the cost of equipment which qualifies up to a limit which is defined in IRS regulations:

1. If the tax due is $25,000 or less, an investment tax credit is permitted up to the total tax due.

2. If the total tax due is more than $25,000, then an investment tax credit is permitted which equals $25,000 plus 60% (1979 tax year) of the difference between the total tax due and $25,000.

3. In addition, any part of an investment tax credit you cannot use because it exceeds the tax due, may be carried back 3 years and forward 7 and may be used to the extent permissable with the limitations applicable in those years.

1978 TAX LAW CHANGES

In 1978 significant changes were made in the tax system which provide new tax incentives to commercial businesses for certain energy management measures. Both incentives take the form of an investment tax credit:

— The Revenue Act of 1978 extends the regular 10% investment tax credit to building rehabilitation expenditures for buildings which qualify.

— The Energy Tax Act of 1978 provides a new 10% investment tax credit for certain energy conservation equipment classified as "energy property." This credit is in addition to the regular investment tax credit of 10%, to the extent that the "energy property" also qualifies as regular investment credit property under existing law. As discussed in greater detail below, "energy property" includes, among other things, automatic energy control systems and economizers, two items of particular interest to the commercial sector.

— The Energy Tax Act of 1978 also provides for a 10% refundable energy tax credit for solar or wind energy property; all other tax credits are non-refundable. Refundable means that the credit can exceed the tax due, and the limits on investment tax credits discussed earlier do not apply. In fact if this tax credit exceeds the tax due, the government pays the taxpayer the difference.

BUSINESS ENERGY TAX CREDITS

The Energy Tax Act of 1978 contains changes in the tax system to create incentives for energy conservation by businesses and to penalize certain business investments that would increase usage of oil or gas. For the most part these take the form of tax credits. A new 10% investment tax credit may be claimed on property classified as "energy property" acquired or constructed and placed in service after September 30, 1978, and before December 31, 1982. The business energy tax credit is determined separately from the regular investment tax credit. It may be claimed in addition to the regular investment tax credit if the property meets the qualifications for both. The business energy tax credit rate drops to 5%, however, when the eligible property is financed with tax exempt industrial development bonds.

Eligible Property

Energy property, as defined in the law, is any of the following:

1. Alternative energy property -- includes equipment for producing synthetic fuel and geothermal energy; does not include hydroelectric and nuclear equipment and structures

2. Solar or wind energy property -- includes equipment using such energy to heat, cool, or provide hot water in a structure, or to generate electricity; "passive" solar equipment is not included

3. Specially defined energy property -- includes:

   *recuperators
   *heat wheels
   *regenerators
   *heat exchangers
   *waste heat boilers
   *heat pipes
   *automatic energy control systems
   *turbulators
   *preheaters
   *combustible gas recovery systems
   *economizers
   Other items specified by the Secretary of Energy that reduce the amount of heat wasted or energy consumed in existing commercial or industrial processes and facilities will also be eligible. In March of 1979 no list of "other items" was yet available.

4. Recycling equipment

5. Shale oil equipment

6. Equipment for producing natural gas from geopressured brine

Equipment must be new, depreciable property with a useful life of at least 3 years. Equipment can be a structural component or used in connection with lodging (unlike eligible equipment under the regular investment tax credit). All property must meet quality and performance standards, if any, prescribed by the Treasury which are in effect when the property is acquired. At present there are no such regulations and some Treasury sources indicate it may be this summer before they are issued.

The final legislation omitted from the business energy property tax credit two types of expenditures included in both the House and Senate versions of the bill: cogeneration equipment and business insulation expenditures for items like storm doors, weatherstripping, structural insulation, etc. Therefore, businesses cannot obtain tax credits for insulation of offices, apartment buildings, shopping centers and other buildings under this section of the Act. However, it does appear that most equipment in a coal-fired cogeneration system, except the turbines generating electricity, may qualify for the credit.

Limitation

The business energy tax credit is limited to 100% of tax liability except for solar or wind energy property on which the tax credit is refundable (i.e., the credit can exceed the taxpayer's tax liability).

IRS Forms and Publications

1. The non-refundable energy tax credit for investment in energy property (other than solar and wind energy property) is computed in Part I of Schedule B (Form 3468) and is then entered on Form 3468 (Computation of Investment Credit) to determine the allowable credit for the year.

2. The refundable energy tax credit for investment in solar or wind energy property is computed in Part II of Schedule B (Form 3468) and is then entered on the specified line of Form 1040, Form 1120, or the appropriate line on other returns.

Samples of these forms are shown on the following pages. For more information concerning the business energy credit, see IRS Publication 572, Tax Information on Investment Credit (not available in March 1979).

1978 Department of the Treasury Internal Revenue Service

Instructions for Form 3468

Computation of Investment Credit

(References are to the Internal Revenue Code)

New Tax Law Provisions

1. The Energy Act of 1978 provides a refundable energy investment credit of 10% for solar and wind energy property and a nonrefundable energy investment credit of 10% for other energy property. The credits are in addition to the regular 10% investment credit if the energy property also qualifies as regular investment credit property under existing law without considering the energy credit provisions. New Schedule B (Form 3468) will be made available to provide for the computation of the energy credits.

2. For tax years ending in 1979, the tax liability limitation as figured on line 12(b) was increased to 60%. Public utilities, railroads and airlines, see section 46(a)(7) and (8) concerning revised limitations.

3. The 10% credit rate and the $100,000 limitation on used property are made permanent.

4. See new section 48(a)(1)(D) concerning certain single purpose agricultural or horticultural structures which qualify for the investment credit.

5. For tax years ending after 10/31/78, cooperative organizations described in section 1381(a) may claim the investment credit to the same extent it is available for taxpayers in general. In addition, new section 46(h) provides that any credit the cooperative cannot use because of the tax liability limitation (section 46(a)(3)) shall be allocated to the patrons of the cooperative.

6. Generally, pollution control facilities are eligible for 100% investment credit for tax years ending after 1978. See section 46(c)(5).

7. New section 48(a)(1)(E) extends the investment credit to rehabilitation expenditures for all types of business and productive buildings, except those, such as apartments, which are used for residential purposes. This provision is effective for qualified expenditures paid or incurred after 10/31/78 for buildings which have been in use for at least 20 years.

8. The investment credit is denied for certain air conditioning or heating units as well as certain boilers fueled by oil or gas which are placed in service after September 30, 1978. See sections 48(a)(1)(A) and 48(a)(10) for details.

9. Commuter highway vehicles having a useful life of 3 years or more are eligible for 100% investment credit. See section 46(c)(6).

General Instructions

A. Who Must File.—Any individual, estate, trust, or corporation claiming an investment credit must attach this form to its income tax return.

Partnerships and small business corporations are not required to file this form because the credit is claimed by the partners and shareholders. They, however, must complete Schedule K on their returns showing the amount of investment credit property and qualified progress expenditures that is to be divided among the partners or shareholders.

This credit does not apply to a Domestic International Sales Corporation (DISC) and is not divided among DISC shareholders.

An estate or trust is allowed a credit for its share of the investment in depreciable property with an estimated useful life of 3 or more years. An estate or a trust that divides the qualified investment among itself and its beneficiaries must attach to this form a statement showing the allocation of the investment among its beneficiaries. The statement must show each beneficiary's allocable share of the basis of the new property, the cost of used property, and the life years assigned to the property. If the estate or trust has made an election under section 46(d)(6), the statement must show each beneficiary's portion of the qualified progress expenditures.

B. When Allowed.—The credit is allowed for the first year in which the qualified property is placed in service or for the year in which progress expenditures are taken into account (see section 46(d)(4)(F) for exceptions).

C. Property Defined.—(See New Tax Law Provisions above which add and delete certain properties from the listing below depending on when the item is acquired, constructed, or placed in service.) You are allowed a credit against your tax for investment in depreciable property with an estimated useful life of 3 years or more. For qualifying progress expenditures, you are allowed this credit for property with a useful life of 7 years or more. The credit is applicable to:

(1) Tangible personal property,

(2) Elevators and escalators,

(3) Other tangible property, including certain real property (except buildings and their structural components and land) if used as an integral part of manufacturing, production, or extraction, etc., or used as a research facility or bulk storage facility for fungible commodities for these activities, and

(4) Livestock (other than horses) if substantially identical livestock (not subject to recapture tax) is not disposed of or sold during the one-year period beginning 6 months before the acquisition date. Reduce the cost of the acquired livestock by the amount realized on the disposition of the substantially identical livestock.

This credit does not apply to property:

(1) Used mainly outside the U.S.;

(2) Owned by or leased to a tax-exempt organization, unless the unrelated business income tax applies;

(3) Owned by or leased to governmental units;

(4) Used for lodging or for furnishing the lodging unless—

- (a) The property, such as a restaurant, is used and located in commercial facilities,
- (b) The property is used by a hotel or motel, or
- (c) The property is a coin-operated vending machine, washing machine, or dryer; and

(5) Amortized over a 5-year period such as railroad rolling stock, rehabilitation of low income rental housing, or child-care facilities (see sections 184, 167(k), or 188 respectively).

D. Election for Leased Property.—A lessor may elect to treat all or part of an investment in new property as if it were made by the lessee. (See section 48(d).) For limitation on availability of the credit to certain lessors, see section 46(e)(3).

E. Recomputed Tax on Early Disposition of Property.—If you dispose of property prior to the life-years category used in figuring investment credit, recompute the credit. You may use Form 4255 to compute the tax increase.

F. Carryback and Carryover of Unused Credits.—Any part of an investment credit you cannot use because it exceeds the amount allowable (including any unused credit created by the carryback of a net capital loss or a net operating loss) may be carried back 3 years and forward 7 and may be used to the extent permissible within the limitations applicable in those years.

Special Rule for Carryover of Unused Credits from Tax Years Ending Before 1971.—Any unused credit which originated before 1971 which can be carried over to any year after 1970 may be carried forward 10 years. Also, any credit unused because of the 20% limitation on carryover and carryback for any year after 1968 but before 1971 may be carried forward 10 years.

You may make a claim for refund based upon the carryback of an unused investment credit by filing Form 1040X (individuals) or Form 1120X (corporations) for the year to which the unused credit is carried. For a tentative (quick) refund, file Form 1045 (individuals) or Form 1139 (corporations).

Priority of Application of Credits.—The limitation is first absorbed by:

(1) Investment credit carryovers to current year, then by

(2) Investment credit earned in current year, and then by

(3) Investment credit carrybacks.

G. Basis and Cost.—The credit for new property applies to the basis of the property. The credit for used property applies to the cost of the property. The cost of used property does not include the basis of any property traded in unless the trade-in resulted in the recapture of all or any portion of an investment credit previously allowed or resulted in a reduction of an investment credit carryback or carryover.

No adjustment for additional first-year depreciation or salvage value is required.

For purposes of the investment credit, the useful life of the qualifying property must be the same as the useful life used for depreciation or amortization.

H. Qualified Progress Expenditures.—You may elect under section 46(d) to increase your qualified investment for a year by the allowable qualified investment in progress expenditures property as defined in section 46(d)(2) and (3). This election is made by attaching a statement to this form and shall apply to the tax year for which it is made and to all subsequent tax years.

The amount of qualified progress expenditures which may be taken into account in a tax year beginning in 1978 is the sum of (a) 80% of the qualified progress expenditure made in a tax year beginning in 1978 plus (b) 20% of the qualified progress expenditures made after January 21, 1975, in tax years beginning in 1974, 1975, 1976, and 1977, providing a proper election as prescribed in section 46(d)(6) was in effect for such years.

I. 11%–11.5% Investment Credit (Corporations Only).—A corporation may elect an 11% (or 11.5%) investment credit for qualified investment in property that is otherwise eligible for the 10% credit providing it meets the requirements of section 46(a)(2)(B) and section 301(d) of the Tax Reduction Act of 1975 (as amended).

A corporation may elect the additional credit by attaching a statement to this form.

J. Public Utilities, Railroads, or Airlines.—The alternative limitation under section 46(a) will apply to a public utility, a railroad or an airline, if the amount of qualified investment attributed to public utility property (or railroad property) (or airline property) is 25% or more of the total of its qualified investment for the year. For public utilities this applies to any year ending before 1981; for railroad and airlines this applies to any year ending after 1976 and before 1983. See section 46(a)(7) for public utilities and 46(a)(8) for railroads, airlines, and manufacturers who lease railroad property.

K. Ships.—An investment credit equal to 50% of the normal investment credit is allowed for certain vessels. See section 46 (g)(1) through (6) for additional details.

Note: *If you claim 100% instead of 50%, you are required to check the block in the instruction for line 1 on the front of this form.*

L. Movies and Television Films.—See section 48(k) for special rules on the computation of investment credit for movies and television films.

M. Mutual Savings Institutions, Regulated Investment Companies, Real Estate Investment Trusts, and Cooperatives.—The qualified investment for investment credit property and the $25,000 amount in line 12(a) are limited for the above organizations. See section 1.46–4 of the regulations to determine these limits.

N. 7% Property (4% for Public Utilities).—Property acquired or constructed prior to January 22, 1975, and placed in service during the taxable year must be reported on line 4 of Form 3468. The investment credit rate for this property is 7% (4% for public utilities).

Specific Instructions

Lines 1(a)–(c). New Property.—Enter on the appropriate line the basis of new property placed in service during the year. (See instructions C and G.)

Lines 1(d)–(e). Qualified Progress Expenditures.—Enter on line 1(d) column (2), the amount of qualified progress expenditures made in 1974, 1975, 1976, and 1977. Enter on line 1(e), column (2), the amount of qualified progress expenditures made in 1978. (See instruction H and section 46(d)(7).)

Do not take any qualified progress expenditures for the year in which the progress expenditure property is placed in service or for the year for which recapture is required for the property. The investment credit allowed for the year in which the property is placed in service is based on the entire qualified investment in the property reduced by the progress expenditures that were included as qualified investment in previous years.

Lines 1(f)–(h). Used Property.—Enter on the appropriate line the cost (subject to the dollar limitation) of used property placed in service during the year. (See instruction G.) Property inherited, received as a gift, or acquired from certain related parties does not qualify for the investment credit.

Dollar Limitation on Used Property.—In general, the amount of used property that you may take into account may not exceed $100,000. This amount is determined without regard to the applicable percentages based on useful life.

If a husband and wife file separate returns, each may claim up to $50,000. If one of them has no qualifying used property, the other may claim up to $100,000.

The amount of used property placed in service by a partnership, small business corporation, estate, or trust that may be taken into account cannot exceed $100,000. The $100,000 limitation also applies to each partner, shareholder, and beneficiary.

A controlled group of corporations (see section 48(c)(3)(C)) must apportion the $100,000 limitation among the component members of the group. The apportionment is based on the total cost of used property that each member placed in service. The $100,000 limitation and the applicable percentages based on useful life are not considered in making the apportionment.

Estates and Trusts.—For an estate or trust the amount of qualified investment is apportioned among the estate or trust and the beneficiaries. The apportionment is based on the income of the estate or trust allocable to each.

Line 5(a).—The additional 1% credit on line 5(a) is allowable to the extent the corporation makes the required contribution of stock or cash to a qualified employee stock ownership plan (ESOP). This required contribution must equal 1% of the qualified investment (line 2) less any portion of the additional credit carried over to a later year.

Line 5(b).—The credit to be entered on line 5(b) is limited to a maximum of .5% multiplied by the qualified investment for investment credit property acquired, constructed, or erected after 1976. To determine the qualified investment to be used in the above computation, reduce line 2 by the qualified investment for property acquired, constructed, or erected before 1977. (For example, if any part of the qualified investment on line 2 is attributable to 1974, 1975 or 1976 progress expenditure property (line 1(d)), then line 2 would have to be reduced by such qualified investment.) The resulting figure is multiplied by the appropriate percentage (see instruction I) and that figure is entered on line 5(b). Do this computation on a separate sheet of paper and attach to this form. (See section 46(a)(2)(B) and (D).)

Line 9(c). Tax on Lump-sum Distributions.—Individuals, estates, or trusts which are recipients of lump-sum distributions from qualified employees' trusts or annuity plans are to enter the amount of partial tax included in line 8. This partial tax is computed on Form 4972 and Form 5544.

Line 12. Limitation.—If the tax liability (line 11) is $25,000 or less, the investment credit may not exceed the amount of the tax liability.

If the tax liability exceeds $25,000, the credit may not exceed $25,000 plus 50% (60% for tax years ending in 1979) of the excess for calendar year taxpayers.

If you and your spouse file separate returns and both are entitled to an investment credit, compute the limitation by substituting $12,500 for the $25,000 shown in line 12(a).

Controlled corporate groups (see section 46(a)(6)) must divide the $25,000 among all component members.

An estate or trust must reduce the $25,000 amount to (a) $25,000 multiplied by (b) the qualified investment apportioned to the estate or trust, divided by (c) the total qualified investment apportioned among the estate or trust and its beneficiaries.

☆U.S.GPO 1978-0/263-150 E.I.#430814328

Form **3468**

Department of the Treasury
Internal Revenue Service

Computation of Investment Credit

▶ Attach to your tax return.

1978

Name	Identifying number as shown on page 1 of your tax return

1 Use the format below to list qualified investment in new and used property acquired or constructed and placed in service during the tax year. Also list qualified progress expenditures made during the 1978 tax year and qualified progress expenditures made in 1974, 1975, 1976, and 1977 if you made the proper election prescribed in section 46(d)(6) for those tax years. If progress expenditure property is placed in service during the tax year, do not list qualified progress expenditures for this property. See instruction for line 1.

If you are claiming 100% investment credit on certain ships, check this block ▶ ☐. See instruction K for details.

Note: *Include your share of investment in property made by a partnership, estate, trust, small business corporation, or lessor.*

Type of property		Line	(1) Life years	(2) Cost or basis (See instruction G)	(3) Applicable percentage	(4) Qualified investment (Column 2 x column 3)
New property		(a)	3 or more but less than 5		33⅓	
		(b)	5 or more but less than 7		66⅔	
		(c)	7 or more		100	
Qualified progress expenditures	1974, 1975, 1976 and 1977	(d)	7 or more		20	
	1978	(e)	7 or more		80	
Used property (See instructions for dollar limits)		(f)	3 or more but less than 5		33⅓	
		(g)	5 or more but less than 7		66⅔	
		(h)	7 or more		100	

2 Qualified investment—Add lines 1(a) through (h) (see instruction M for special limits)

3 10% of line 2

4 7% (4% for public utility property) of certain property (see instructions M and N)

5 Corporations electing the additional investment credit for contributions to Employee Stock Ownership Plans—Attach election statement (see instruction I and instruction for line 5)

(a) Additional 1% credit—Enter 1% of line 2

(b) Additional credit (not more than .5%)—Enter allowable percentage times adjusted line 2 (attach schedule)

6 Carryback and carryover of unused credit(s)—Attach computation (see instruction F)

7 Tentative investment credit—Add lines 3 through 6

Limitation

8 (a) Individuals—Enter amount from Form 1040, line 37, page 2

(b) Estates and trusts—Enter amount from Form 1041, line 27 or 28, page 1

(c) Corporations—Enter amount from Schedule J (Form 1120), line 9, page 3

9 (a) Credit for the elderly (individuals only)

(b) Foreign tax credit

(c) Tax on lump-sum distributions (see instruction for line 9(c))

(d) Possession tax credit (corporations only)

(e) Section 72(m)(5) penalty tax (individuals only)

10 Total—Add lines 9(a) through (e)

11 Subtract line 10 from line 8

12 (a) Enter smaller of line 11 or $25,000. See instruction M for special limits. (Married persons filing separately, controlled corporate groups, estates, and trusts, see instruction for line 12.)

(b) If line 11 is more than line 12(a) and your tax year ends in 1978, enter 50% of the excess (if your tax year ends in 1979, enter 60% of the excess). (Public utilities, railroads, and airlines, see instruction J.)

13 Total—Add lines 12(a) and (b)

14 Enter smaller of line 7 or line 13

15 Subtract line 14 from line 11

16 Enter energy property credit from line 3 of Schedule B (Form 3468)

17 Enter smaller of line 15 or line 16 (if there is no entry on line 16, enter zero)

18 Total Investment Credit—Add lines 14 and 17. Enter here and on Form 1040, line 41; Schedule J (Form 1120), line 10(b), page 3; or the appropriate line on other returns

Schedule A If any part of your investment in line 1 or 4 above was made by a partnership, estate, trust, small business corporation, or lessor, complete the following statement and identify property qualifying for the 7% or 10% investment credit.

Name (Partnership, estate, trust, etc.)	Address	Property: Progress expenditures	Property: New	Property: Used	Life years
		$	$	$	

If property is disposed of prior to the life years used in figuring the investment credit, see instruction E.

Form 3468 (1978)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—0-263-356 :58-040-1110

SCHEDULE B (Form 3468)
(November 1978)
Department of the Treasury
Internal Revenue Service

Computation of Business Energy Investment Credit

▶ Attach to your tax return.

To be Used ONLY for Tax Years Ending After 9/30/78

Name	Identifying number

Note: *All filers are to attach a schedule showing the computation of total basis and total qualified investment for each category (lines 1(a) through 1(e) and line 4) of energy property. See instructions.*

Part I Nonrefundable Energy Credit

	(a) Basis	(b) Qualified investment
1 Enter total amounts from attached schedule(s) for each category of energy property below:		
(a) Alternative energy property		
(b) Specially defined energy property		
(c) Recycling equipment		
(d) Shale oil equipment		
(e) Equipment for producing natural gas from geopressured brine		
2 Add lines 1(a) through 1(e), columns (a) and (b)		
3 Nonrefundable energy credit—Enter 10% of line 2, column (b), here and on Form 3468 (see Instructions)		

Part II Refundable Energy Credit

	(a) Basis	(b) Qualified investment
4 Enter total amounts for solar and wind energy property from attached schedule		
5 Refundable energy credit—Enter 10% of line 4, column (b), here and on the appropriate line of Form 1040, Form 1120, and other returns as explained in the instruction for line 5		

Part III If Any Part of Your Investment in Parts I and II Above was Made by a Partnership, Estate, Trust, Small Business Corporation, or Lessor, Complete the Following Statement:
(Under "Category," indicate which line applies—1(a), (b), (c), (d), (e) or line 4.)

Name (Partnership, estate, trust, etc.)	Address	Property			
		Category	Life years	Progress expenditures	Basis
				$	$

Highlights of the Energy Act of 1978

(References are to the Internal Revenue Code)

Refundable Energy Credit

(a) The Act provides for a refundable energy credit (i.e. the credit can exceed the taxpayer's tax liability) for investment in solar and wind energy property acquired or constructed after September 30, 1978.

(b) The credit is equal to 10% of the qualified investment in solar or wind energy property as defined in section 48(l)(4). The credit is computed in Part II of Schedule B (Form 3468) and is then entered on the appropriate line of Form 1040, Form 1120, etc., as indicated in the instruction for line 5.

Nonrefundable Energy Credit

(a) The Act provides for a nonrefundable energy credit for investment in energy property (other than solar and wind energy property) acquired or constructed after September 30, 1978.

(b) The credit is equal to 10% of the qualified investment in energy property as defined in sections 48(l)(3) and 48(l)(5) through (8).

(c) The credit is limited to 100% of tax liability as defined in section 46(a)(4) reduced by the allowable credit for regular investment credit property. The credit is computed in Part I of Schedule B (Form 3468) and is then entered on Form 3468 to determine the allowable credit for the year (see instruction for line 3).

Energy Credit is in Addition to Regular Investment Credit

(a) Generally, the refundable or nonrefundable energy credit is in addition to, and not instead of, the regular 10% investment credit to the extent that the energy property also qualifies as regular investment credit property under existing law. The property must qualify as regular investment credit property without regard to the special energy credit provision contained in section 48(l)(1). For example, solar and wind energy property which is considered under existing law to be a structural component of a building would not qualify as regular investment credit property because of the structural component rule of section 48(a)(1)(B). Accordingly, such solar or wind energy property would qualify for the refundable energy credit, but not for the regular investment credit.

(b) If energy property qualifies for the energy credit and the regular investment credit, such property would be listed on line 1, Form 3468, and also on the appropriate line of Schedule B (Form 3468). If the property qualifies only as energy property, it would be listed only on Schedule B (Form 3468).

General Instructions

A. Who Must File.—Any individual, estate, trust, corporation, or organization (including exempt organizations if the energy property is used predominantly in an unrelated trade or business the income of which is subject to tax under section 511) claiming the refundable or nonrefundable energy credit must attach Schedule B (Form 3468) to its income tax return.

B. Energy Property Defined.—Energy property means property which is:
(1) alternative energy property,
(2) solar or wind energy property,
(3) specially defined energy property,

(Continued on page 2)

235-320-1

(4) recycling equipment,
(5) shale oil equipment, or
(6) equipment for producing natural gas from geopressured brine.

To qualify for the energy investment credit, energy property must:

(1) Meet the requirements of regular investment credit property except that the provisions of sections 48(a)(1) and 48(a)(3) do not apply to energy property,

(2) Be constructed after September 30, 1978, or acquired after September 30, 1978, if the original use commences with the taxpayer,

(3) Meet certain performance and quality standards which are in effect at time of acquisition (section 48(l)(9)), and

(4) Have a useful life of three years or more at the time the property is placed in service.

See sections 48(l)(1) through (12) for details.

C. Special Rules.—The following special rules apply:

(1) Alternative energy property, solar or wind energy property, and recycling equipment do not include property which is public utility property. In addition, specially defined energy property does not include property which is public utility property because specially defined energy property must be installed in connection with an existing industrial or commercial facility,

(2) The energy credit is limited to 5% in the case of property which is financed in whole or part by the proceeds of an industrial development bond (section 48 (l)(11)),

(3) Solar equipment does not include "passive solar" equipment,

(4) Specially defined energy property must be installed in connection with an existing industrial or commercial facility. See section 48(l)(10) for a definition of the term "existing," and

(5) If property qualifies under more than one category of energy property, the taxpayer is limited to a single 10 percent energy credit for that property.

Specific Instructions

Lines 1(a) through 1(e) and Line 4.—Enter the total basis and total qualified investment for each category of energy property on lines 1(a) through 1(e) and line 4. See sections 46(c) and 48(b). Basis and qualified investment are computed for energy property acquired or constructed after September 30, 1978, and placed in service in the tax year. Basis and qualified investment are computed for qualified progress expenditures incurred after September 30, 1978.

A separate schedule showing the computation of basis and qualified investment for each category of property must be attached. The schedule must contain all items of information as shown in the Sample Computation Schedule located at the end of these instructions. See sections 48(l)(1) through (12) for details about items within each category of property.

If any part of your investment was made by a partnership, estate, trust, small business corporation, or lessor, be sure to complete Part III of Schedule B (Form 3468).

If qualified progress expenditures are involved, see section 46(d)(1) through (7) and the Instructions for Form 3468 for details concerning qualified progress expenditures.

Line 3.—

1978 Calendar and Fiscal Year Taxpayers (1978 Form 3468).—These taxpayers may claim the nonrefundable energy credit by entering the amount from line 3 of Schedule B (Form 3468) on line 16 of the 1978 Form 3468 and completing Form 3468 as applicable.

1977 Fiscal Year Taxpayers With Tax Years Ending After September 30, 1978 (1977 Form 3468).—These taxpayers should determine and claim the nonrefundable energy credit as follows:

(1) Computation to determine the credit—

(a) Enter the amount from line 11 of the 1977 Form 3468	
(b) Enter the smaller of line 7 or line 13 of the 1977 Form 3468	
(c) Tax liability limitation—Subtract line (b) from line (a)	
(d) Allowable credit—Enter the smaller of line (c) or line 3 of Schedule B (Form 3468)	

(2) Enter the amount from (d) above in the margin to the right of line 14 of the 1977 Form 3468 and identify it as "Energy Credit."

(3) Combine the energy credit with the regular investment credit (the lesser of line 7 or line 13 of the 1977 Form 3468) and enter the combined total on line 14 of the 1977 Form 3468.

Line 5.—Individuals, estates, trusts, corporations, and other organizations (including exempt organizations if the energy property is used predominantly in an unrelated trade or business the income of which is subject to tax under section 511) are to claim the refundable energy credit (refundable if this credit is in excess of the tax liability or if there is no tax liability) on their respective returns.

The refundable energy credit is allowable only for tax years ending after September 30, 1978. If your tax year ends after this date and you have not filed your income tax return by the time you read these instructions, include the refundable credit in the total amount to be entered on the line referenced below and write in the margin next to the total amount the amount of the energy credit and the words "refundable energy credit."

(1) 1977 Form 1040, line 62, page 2; 1978 Form 1040, line 62, page 2.

(2) 1977 Form 1041, line 41, page 1; 1978 Form 1041, line 37, page 1.

(3) 1977 Form 1120, line 32, page 1; 1978 Form 1120, line 32, page 1.

(4) 1977 Form 1120F, line 6, page 1; 1978 Form 1120F, line 6, page 1.

(5) 1977 Form 990-C, line 34, page 1; 1978 Form 990-C, line 32, page 1.

(6) 1977 Form 990-T, line 21, page 1; 1978 Form 990-T, line 21, page 1.

(7) 1978 Form 1120L, line 22, page 1.

(8) 1978 Form 1120M, line 20, page 1.

If you have filed your income tax return without claiming a refundable or nonrefundable energy credit that you're entitled to, you should file Form 1040X or Form 1120X, or an amended income tax return, whichever applies.

As this schedule is printed, business energy property regulations are being prepared by the Internal Revenue Service. When these regulations are final, they will be printed in the Internal Revenue Bulletin and the Federal Register. The Service is also revising **Publication 572**, Tax Information on Investment Credit, to reflect the new business energy investment credit. You may want to obtain the regulations or **Publication 572** when they are published for more detailed information on the business energy investment credit.

Sample Computation Schedule

Line (1)	Description Of Asset Within Each Category of Properties (2)	Life years (3)	Basis (4)	Applicable percentage (5)	Qualified investment (column 4 × column 5) (6)
(a)		3 or more but less than 5		33⅓	
(b)		5 or more but less than 7		66⅔	
(c)		7 or more		100	
(d)		1978 qualified progress expenditures		80	
(e)		1977 qualified progress expenditures*		60	
Total—Add lines (a) through (e), columns 4 and 6					

*Applies only to years ending 10-31-78 and 11-30-78.

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235-320-2

INVESTMENT TAX CREDITS FOR BUILDING REHABILITATION

Most types of buildings have not been eligible for investment tax credit since the credit was first enacted. Investment tax credit will now be available to partially offset rehabilitation expenditures for certain existing structures. The Revenue Act of 1978 extends the 10% investment tax credit to rehabilitation expenditures for all kinds of commercial buildings, including hotels. However, renovation costs for apartments and other residential structures are not eligible.

Rehabilitation expenditures are defined as capital expenditures incurred after October 31, 1978, effective for taxable years ending after that date. Such expenditures may qualify for the credit if:

1. The building was placed in service before the rehabilitation began;

2. The building previously has been in service for at least 20 years and has not been the object of a rehabilitation project within the prior 20 years;

3. At least 75% of the existing external walls are retained in place as external walls, although they can be reinforced or receive a new cover; and

4. The property or the additions or improvements to the property have a useful life of 5 years or more.

Additions with a 5 or 6-year life will be eligible only for two-thirds of the 10% investment credit rate. The cost of acquiring a building or enlarging a building will not qualify for the credit. Rehabilitation expenditures will be considered new property and thus not subject to the $100,000 used property limitation of the investment tax credit.

It appears that capital expenditures such as those for the replacement of heating or air conditioning systems (including temperature control systems), insulation, plumbing, electrical wiring, flooring, and permanent interior partitions and walls would qualify as rehabilitation expenditures when incurred in connection with a rehabilitation.

IRS Forms and Publications

The investment tax credit is computed on Form 3468 (Computation of Investment Credit) to determine the allowable credit for the year.

For more information on the investment credit for building rehabilitation, see IRS Publication 572, Tax Information on Investment Credit (not available in March 1979 at this printing).

INVESTMENT TAX CREDITS NON-REFUNDABLE

PROBLEM: You install "an automatic energy control system" costing $50,000 with an expected life of 10 years. What is your investment tax credit?

SOLUTION:

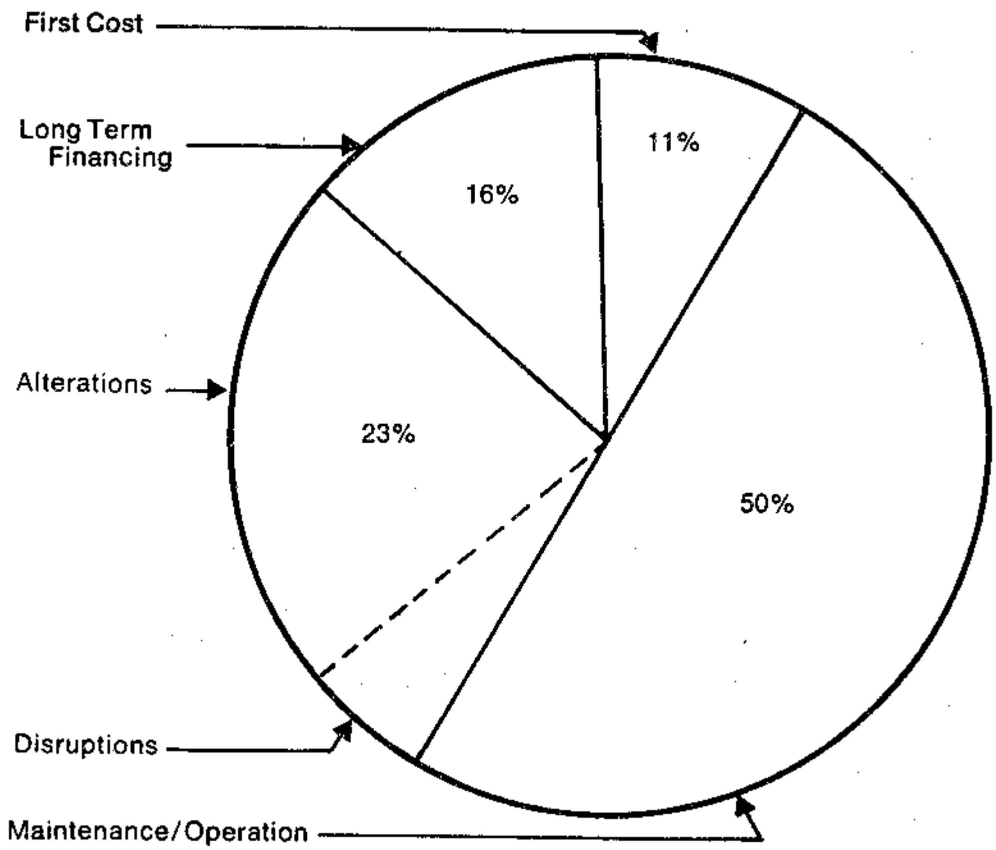
1. Consult your tax specialist to find out if this system qualifies for the regular investment tax credit of 10%. If it does, enter $50,000 on line 1(c) of Form 3468

2. It does qualify as "specially defined energy property" and is therefore also eligible for the 10% business energy tax credit. So also enter $50,000 on line 1(b) of Schedule B to Form 3468. Enter 10% of $50,000 on line 3 and on line 16 of Form 3468

3. Line 18 will be sum of the $5,000 regular tax credit, if the system qualifies, and the $5,000 business energy tax credit.

WHY LIFE CYCLE COSTING?

The Educational Facilities Laboratories, Inc., of Menlo Park, California, portrays the lifetime cost of a building as shown below.



With the first cost representing only 11% of the total, the reason for considering all costs seems obvious. And since maintenance and operations are 50% of the total, again the logic in designing a facility to minimize energy use and operating costs is obvious.

Present Value Analysis

If all the factors involved in life-cycle costing did not change with time from year to year and if every energy investment were for the same number of years, there would be no need to reduce what happens from year to year to a common base. But as we know only too well, things do change, and the useful life of various energy projects are quite different. The rate of inflation as measured by the cost of living index or the wholesale price index, or any other such index, has varied in the past few years from month to month from 6 or 7 percent for year to as much as 14 percent. This rate obviously affects maintenance costs where the provision of supplies and services is involved.

We also know that energy prices are going to escalate for several years at a rate greater than those in the rest of our economy, primarily since price controls on energy are to be removed gradually, so as to bring our domestic energy supplies up to free world prices. So we need some analytical method of comparing these different investment opportunities.

Life-cycle costing in terms of present worth or present values provides us such a tool. Life-cycle costing extends our decision-making time frame from one year and first costs to a time frame of future years and all costs. Present worth or present value analysis does for the future of an analysis what a telescopic lens does to distance. It brings the future up to the present, allowing future costs to be reflected in their true value today, considering that all money will be invested in some area every year. Just as first costs have been compared and decisions made according to the lowest or first-cost bid, now we will begin using life-cycle costing and present worth or present value concepts to compare pieces of equipment or hardware, or in our case, alternative energy saving and dollar saving opportunities.

The concept of present worth or present value in life-cycle costing is based on the assumption that funds that are borrowed always carry interest charges for their use; in similar manner, if cash on hand is to be used, that cash, if not used, could be invested in some manner and earn interest. Present value analysis provides us a tool to reduce future annual savings to a common, or equilvalent, basis with current savings or current costs. Such a reduction is necessary because a dollar saved today is worth considerably more than a dollar saved some years from now, because a dollar available today can be invested and earn interest whereas the future dollar cannot so earn interest in any year prior to its receipt. What we are able to do is answer this type of question:

> "I want to invest $10,000, which I either have in cash, or will borrow. Should I reinvest it in my business in added inventory, in added sales space, in the stock market, or in an energy and dollar saving opportunity? In other words, will my energy saving investment provide me with the highest equivalent interest rate of all the investment opportunities available?"

We are all accustomed to thinking in interest terms; for example, we readily understand and can compute or find in interest tables what $1.00 invested today at 10% will be worth ten years from now. This so-called future value would be

$$\$1.00\,(2.57) = \$2.57$$

The future value factor of 2.57 is shown below under column A opposite year 10.

PRESENT VALUE ANALYSIS

A Future Value of $1.00 at 10%	Years (n)	B Present Value of $1.00 at 10%	C Present Value of $1.00 Received Annually for each of "n" years at 10%
1.10	1	.91	.91
1.21	2	.83	1.74
1.33	3	.75	2.49
1.46	4	.68	3.17
1.61	5	.62	3.79
1.77	6	.56	4.35
1.94	7	.51	4.87
2.13	8	.46	5.33
2.34	9	.43	5.76
2.57	10	.38	6.14
2.83	11	.35	6.49
3.11	12	.31	6.80
3.42	13	.29	7.09
3.76	14	.27	7.36
4.14	15	.24	7.60
4.55	16	.22	7.82
5.01	17	.20	8.02
5.51	18	.18	8.20
6.06	19	.16	8.36
6.67	20	.15	8.51

Present worth or present value analysis just "turns this upside down" or reverses the process. In other words the $2.57 ten years from now has a present value of $1.00 if invested at 10%. We could actually do most of our present value analysis from interest tables like that in column A, but it could be awkward and we would constantly be interpolating between figures in the table. So we have constructed tables which are based on the same interest principles, but which give us a quickly read present value factor instead of the future value factor we got from interest tables. For example, we can look in column B at 10 years and get the present value factor of .38; that factor used with the earlier $2.57 will give us the original $1.00.

$2.57 (.38) = $1.00

What this says is that $2.57 received 10 years from now has a present value of $1.00 if it were invested at 10%.

But with some energy-saving investments, we will be saving an amount each year, in contrast to the previous example when the saving was only in year 10. Referring to column B we can see that if $1.00 were saved in year 1, it's present value is .91, and another $1.00 in year 2 has a present value of .83. Note now that column C is the sum of these two. In other words the figure 1.74 opposite year 2 in column C reflects the present value of $1.00 saved in year 1 and another $1.00 saved in year 2. And in similar manner the 8.51 in column C opposite year 20 reflects the present value of $1.00 saved each of the 20 years, and is the collective sum of all the present values in column B between year 1 and year 20, both inclusive. Another way of looking at this same set of numbers is that if $8.51 were invested now at 10%, the return or yield would be $1.00 for the next 20 years.

The very simple table above covers only an interest rate of 10%. We will obviously use a range of possible interest rates in our life-cycle cost computations. Such a range is provided in Table I; note that the figures in column C of the illustrative example are identical to those in the 10% column of Table I.

Benefit/Cost or Savings/Investment Ratio

At this point, we need to look at a simple illustrative problem. And in doing so we are now returning to the energy audit and the "shopping list" of energy saving or dollar saving opportunities (DSOs) we mentioned in the introduction to this section. In this illustrative problem, we want to compare two alternatives.

	Alternative A	Alternative B
First Cost	$100,000	$100,000
Annual Energy Savings	3.0 billion BTUs	2.7 billion BTUs
Energy Cost	$11.72/million BTUs	$14.65/million BTUs
Useful life	15 years	15 years
Cost of money (or desired return on investment before taxes)*	20%	20%

*In general, a 20% return before taxes is necessary for a 10% return after taxes.

The best analysis of such alternatives will be one which provides for each alternative or option a single number which reflects both benefits and costs. Public or governmental agencies normally use these two and produce a benefit/cost ratio. The same principle is used in the business world with what is called a savings/investment ratio. Keeping in mind all the earlier discussion on life-cycle costs and present value, what we need to do for both System A and System B is to determine the present value of the savings for both alternatives A and B, and the present value of the necessary investment for both.

	Alternative A	Alternative B
Investment cost (present value)	$100,000	$100,000
Energy Savings (present value)		
Millions BTUs saved/year	3000	2700
Cost per million BTU	x 11.72	x 14.65
	$35,160	$39,555
Cumulative Present Value Factor	x 4.67	x 4.67
	$164,197	$184,722
Savings/Investment Ratio	$\frac{164,197}{100,000} = 1.64$	$\frac{184,722}{100,000} = 1.85$

The cumulative present value factor of 4.67 used was obtained from the 20% column (opposite 15 years) of Table I.

As can be seen, both alternatives A and B have Saving/Investment ratios greater than 1.0, indicating that both will return all funds invested at a rate greater than the desired rate of return of 10%. The greater the savings/investment ratio (SIR), the higher the rate of return and the more effective the investment. Thus Alternative B with a SIR of 1.85 is a better investment than Alternative B, a fact which was not obvious even in this rather simple illustration.

Energy and Maintenance Differential Cost Escalation

As was mentioned earlier it is quite possible that maintenance costs may increase at a higher rate from year to year than other costs, and it is a certainty that energy prices will rise at a more rapid rate than other elements of our economy. Actual rates of increase in costs of energy are being projected as high as 15 or 20%. Any differential increase, even 2%, materially affects normal present value computations. For example, in the illustrative situation just discussed, the present value factor for energy saving would have been 10.86 instead of the 4.67 if an annual energy price increase of 15% had been factored in. Because of the need to include these annual increases in our computations, Tables II and III have been included, for desired returns of 10% and 20%. Respectively, the 10.86 figure just quoted is obtained from the 15% column of Table III opposite 15 years.

To illustrate the effects of these factors, let us go back to the illustrative problem and add an annual energy price increase of 15% and an annual price increase in maintenance costs of 4%. In this illustration the maintenance cost is that which is required on the new energy-saving devices being installed. Hence the present value of the added maintenance cost must be subtracted from the present value of the energy savings to obtain the overall net saving.

	Alternative A	Altermative B
First Cost	$100,000	$100,000
Annual Energy Savings	3.0 billion BTUs	2.7 billion BTUs
Energy Cost	$11.72/million BTUs	$14.65/million BTUs
Added Annual Maintenance Cost	$1500/year	$2000/year
Useful Life	15 years	15 years
Desired Return on Investment	20%	20%
Annual Energy Price Increase	15%	15%
Annual Maintenance Price Increase	4%	4%

Our savings/investment ratio previously looked like this:

$$\frac{\text{present value of energy savings}}{\text{present value of investment}}$$

With maintenance costs added to the equation, the SIR will now be:

$$\frac{\text{(present value of energy savings) - (present value of added maintenance)}}{\text{present value of investment}}$$

In addition, we will need to refer to Table III for present value factors for both energy and maintenance, rather than Table I.

	Alternative A	Alternative B
Investment Cost (present value)	$100,000	$100,000
A. Energy Savings (present value)	$35,160	$39,555
Cumulative Present Value Factor	10.86	10.86
	$381,838	$429,567
B. Added Maintenance Costs	$1500	$2000
Cumulative Present Value Factor	5.74	5.74
	$8,610	$11,480
A - B	$373,228	$418,087
Savings/Investment Ratio	$\frac{373,228}{100,000} = 3.73$	$\frac{418,087}{100,000} = 4.18$
Earlier SIR (w/o energy & maintenance cost escalation)	1.64	1.85

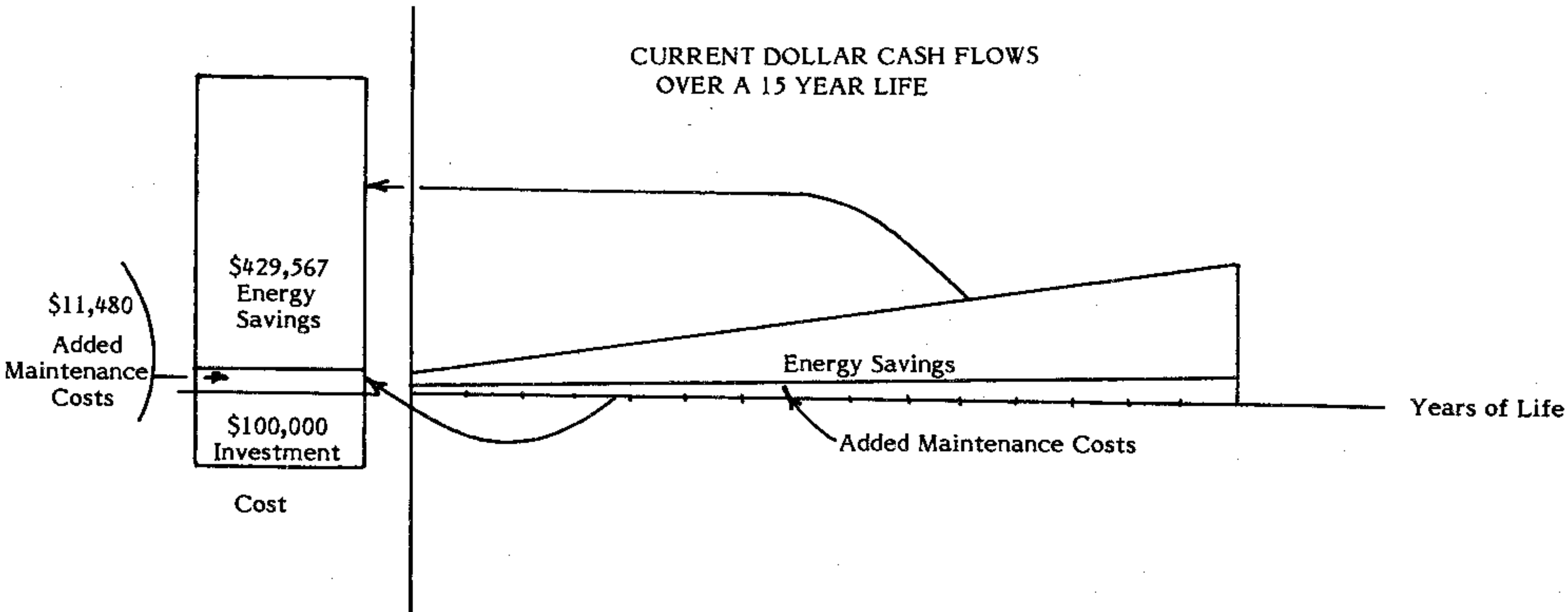
The effect of escalating energy prices on this analysis is unmistakable, and points out that this factor should be included in all computations for all such energy decisions.

This type of problem can be shown graphically as an aid in visualizing the time and relationships involved; such a graphical portrayal of Alternative B alone is at Figure 1.

Energy Audits

The only requirement which remains is how to pack all this knowledge into something more compact for an energy audit report. For each of the energy conserving Dollar Saving Opportunities (DSOs) we fill out a one page form like the one shown at the end of this section, and secondly we set priorities, based on the SIRs for each DSO, on a second one page form, a copy of which is also included at the end of this section.

FIGURE 1



$$\text{Savings/Investment Ratio} = \frac{\text{Energy Saving (PV) - Added Maintenance Costs (PV)}}{\text{Investment Costs (PV)}}$$

$$= \frac{\$418{,}087}{100{,}000}$$

$$= 4.18$$

TABLE I

CUMULATIVE PRESENT VALUE OF $1.00 RECEIVED ANNUALLY FOR n YEARS

Years (n)	6%	8%	10%	12%	14%	16%	18%	20%
1	0.94	0.93	0.91	0.89	0.87	0.86	0.85	0.83
2	1.83	1.78	1.74	1.69	1.65	1.61	1.57	1.53
3	2.67	2.58	2.49	2.40	2.32	2.24	2.17	2.11
4	3.46	3.31	3.17	3.04	2.91	2.80	2.69	2.59
5	4.21	3.99	3.79	3.61	3.43	3.27	3.13	2.99
6	4.92	4.62	4.35	4.11	3.89	3.68	3.50	3.33
7	5.58	5.21	4.87	4.56	4.29	4.04	3.81	3.60
8	6.21	5.75	5.33	4.97	4.64	4.34	4.08	3.84
9	6.80	6.25	5.76	5.33	4.95	4.61	4.30	4.03
10	7.36	6.71	6.14	5.65	5.21	4.83	4.49	4.19
15	9.71	8.56	7.60	6.81	6.14	5.56	5.09	4.67
20	11.47	9.82	8.51	7.47	6.62	5.93	5.35	4.87
25	12.78	10.67	9.08	7.84	6.87	6.10	5.47	4.95
30	13.76	11.26	9.43	8.05	7.00	6.18	5.52	4.98
40	15.05	11.92	9.78	8.24	7.10	6.23	5.55	5.00

$$\text{Present value} = \frac{(1 + i)^n - 1}{i(1 + i)^n} \quad \text{where}$$

n = number of years

i = interest rate, 6%, 8%, 10%, etc.

TABLE II

CUMULATIVE PRESENT VALUE OF $1.00 SAVED EACH YEAR WHEN THE COST OF MONEY IS 10% (C) AND ENERGY COSTS INCREASE AT 0, 2, 4, 6, 8, 10, 12, 15, OR 20% ANNUALLY

OR

CUMULATIVE PRESENT VALUE OF $1.00 SAVED (OR SPENT) EACH YEAR WHEN THE COST OF MONEY IS 10% (C) AND MAINTENANCE COSTS INCREASE AT 0, 2, 4, 6, 8, 10, 12, 15, OR 20% ANNUALLY

	ANNUAL INCREASE (AI)								
Year (n)	0%	2%	4%	6%	8%	10%	12%	15%	20%
1	.91	.93	.94	.96	.98	1.00	1.01	1.05	1.09
2	1.74	1.79	1.84	1.89	1.94	2.00	2.07	2.14	2.28
3	2.49	2.58	2.68	2.79	2.89	3.00	3.14	3.29	3.58
4	3.17	3.32	3.48	3.65	3.82	4.00	4.20	4.49	4.99
5	3.79	4.01	4.24	4.48	4.73	5.00	5.28	5.73	6.54
6	4.35	4.64	4.95	5.28	5.63	6.00	6.38	7.04	8.23
7	4.87	5.24	5.63	6.05	6.51	7.00	7.50	8.40	10.07
8	5.33	5.78	6.27	6.80	7.37	8.00	8.68	9.82	12.07
9	5.76	6.29	6.87	7.51	8.22	9.00	9.86	11.32	14.26
10	6.14	6.76	7.44	8.20	9.05	10.00	11.06	12.88	16.64
15	7.60	8.64	9.86	11.30	12.99	15.00	17.38	21.80	32.26
20	8.51	9.93	11.69	13.87	16.59	20.00	24.30	32.96	56.39
25	9.08	10.82	13.07	16.00	19.87	25.00	31.87	46.87	93.66
30	9.43	11.43	14.11	17.78	22.86	30.00	40.15	64.29	151.25
40	9.78	12.13	15.49	20.48	28.08	40.00	59.14	113.11	377.64

$$\text{Present Value} = \frac{1 + AI}{C - AI}\left[1 - \left[\frac{1 + AI}{1 + C}\right]^n\right] \quad \text{where}$$

C = Cost of money (10% for this table)

AI = Annual Increase in Energy Costs or Maintenance Costs

n = Number of years (life of energy-saving item)

TABLE III

CUMULATIVE PRESENT VALUE OF $1.00 SAVED EACH YEAR WHEN THE COST OF MONEY IS 20% (C) AND ENERGY COSTS INCREASE AT 0, 2, 4, 6, 8, 10, 12, 15, OR 20% ANNUALLY

OR

CUMULATIVE PRESENT VALUE OF $1.00 SAVED (OR SPENT) EACH YEAR WHEN THE COST OF MONEY IS 20% (C) AND MAINTENANCE COSTS INCREASE AT 0, 2, 4, 6, 8, 10, 12, 15, OR 20% ANNUALLY

	ANNUAL INCREASE (AI)								
Year (n)	0%	2%	4%	6%	8%	10%	12%	15%	20%
1	.83	.85	.86	.89	.90	.91	.94	.97	1.00
2	1.53	1.57	1.62	1.67	1.71	1.76	1.81	1.89	2.00
3	2.11	2.19	2.27	2.35	2.44	2.53	2.62	2.76	3.00
4	2.59	2.71	2.83	2.96	3.10	3.23	3.37	3.61	4.00
5	2.99	3.15	3.32	3.50	3.69	3.88	4.09	4.42	5.00
6	3.33	3.53	3.74	3.98	4.22	4.48	4.75	5.18	6.00
7	3.60	3.85	4.11	4.39	4.77	5.02	5.36	5.93	7.00
8	3.84	4.13	4.43	4.76	5.13	5.51	5.94	6.65	8.00
9	4.03	4.35	4.71	5.10	5.52	5.97	6.48	7.31	9.00
10	4.19	4.55	4.95	5.38	5.86	6.39	6.97	7.98	10.00
15	4.67	5.17	5.74	6.39	7.15	8.02	9.03	10.86	15.00
20	4.87	5.45	6.13	6.94	7.90	9.08	10.47	13.41	20.00
25	4.95	5.57	6.32	7.23	8.35	9.75	11.51	15.07	25.00
30	4.98	5.62	6.41	7.39	8.62	10.19	12.24	16.58	30.00
40	5.00	5.66	6.48	7.55	8.87	10.66	13.12	18.81	40.00

$$\text{Present Value} = \frac{1 + AI}{C - AI} \quad 1 - \frac{1 + AI}{1 + C}^{n} \quad \text{where}$$

C = Cost of money (20% for this table)

AI = Annual Increase in Energy or Maintenance Costs

n = Number of years (life of energy-saving item)

Planergy, Inc.
901 W. M.L.K. Blvd.
Austin, Texas 78701
512/477-8012

ENERGY AUDIT

FIRM/BUSINESS: ____________________

TYPE OF FIRM/BUSINESS: ____________________

FACILITY: ____________________

LOCATION: ____________________

ADDRESS: ____________________

DATE OF AUDIT: ____________________

AUDITORS: ____________________

____

____

DOLLAR SAVINGS OPPORTUNITY (DSO) NO. ________

DESCRIPTION:

SPECIFIC ASSUMPTIONS:

USEFUL LIFE ________ yrs.

ADDED (OR REDUCED) MAINTENANCE $________

COST OF MONEY ______%

ANNUAL ENERGY COST INCREASE ______%

ANNUAL MAINTENANCE INCREASE ______%

COST SAVINGS:

INVESTMENT COST NEEDED TO REALIZE COST SAVINGS:

$$\text{SAVINGS/INVESTMENT RATIO} = \frac{\text{(PRESENT VALUE OF ENERGY SAVINGS)} \pm \text{(PRESENT VALUE } \tfrac{\text{ADDED}}{\text{REDUCED}} \text{ MAINTENANCE COST)}}{\text{PRESENT INVESTMENT COST}}$$

SAVINGS/INVESTMENT RATIO ____________ SIR =

SIMPLE PAYBACK PERIOD ____________ SPB =

Planergy, Inc.
901 W. M.L.K. Blvd.
Austin, Texas 78701
512/477-8012

ENERGY AUDIT

DOLLAR SAVINGS OPPORTUNITIES (DSOs) PRIORITIES

FIRM/BUSINESS: ______________________

TYPE OF FIRM/BUSINESS: ______________________

FACILITY: ______________________

LOCATION: ______________________

ADDRESS: ______________________

DATE OF AUDIT: ______________________

AUDITORS: ______________________

____

____

ASSUMPTIONS FOR ESTABLISHING PRIORITIES:

COST OF MONEY ________%

ANNUAL ENERGY COST INCREASE ________%

ANNUAL MAINTENANCE INCREASE ________%

PRIORITY	DSO NO.	DESCRIPTION	USEFUL LIFE (Yrs.)	COSTS SAVED (PRESENT VALUE)		PRESENT INVESTMENT COST	SAVINGS / INVESTMENT RATIO	SIMPLE PAYBACK
				ENERGY	ADDED OR REDUCED MAINTENANCE (±)			

REMARKS:

4

LIGHTING

Lighting

Table of Contents

Energy

- A Watt Is Not *A Unit Of Light,*
  But *A Unit Of Work,* Which
  Releases 3.4 BTU Of Heat/Hour
  - 100 Watts = 341 BTU
  - 1000 Watts = 3,413 BTU
- A 100 Watt Light Bulb, . . . A 100 Watt TV And A 100 Watt Heating Pad, . . . All Produce 341 BTU Of Heat

Effect of Lighting Load on Air Conditioning

Lighting Load Watts/Sq. Ft.	Energy Cost/Yr.	A/C Capacity Tons	A/C Capital Cost	A/C Operating Cost/Yr.
3	$71,886	171	$308,000	$15,000
6	$143,772	342	$615,000	$31,000

For: 200,000 Sq./Ft. Store - Boston Area
Based on $.032/KWH for 3,700 Hrs./Yr.
A/C Sizes for Lighting Only

Lighting Energy Compared To Total Energy 1976

Total Fuel Consumed *All Types*		100%
Total Fuel Consumed *Electrical* 1525 10^9 KWH		25%
Total Fuel Consumed *Lighting* 313 10^9 KWH		5%

	TOTAL LIGHTING KWH 10^9	LIGHTING % of TOTAL
Industrial	63.95	1.05%
Street Lighting	12.20	.20%
Residential	92.05	1.53%
Commercial	144.72	2.40%
TOTAL	312.92	5

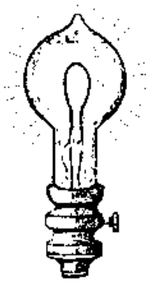
Total Lighting Represents About 5% Of The Total Fuels Consumed

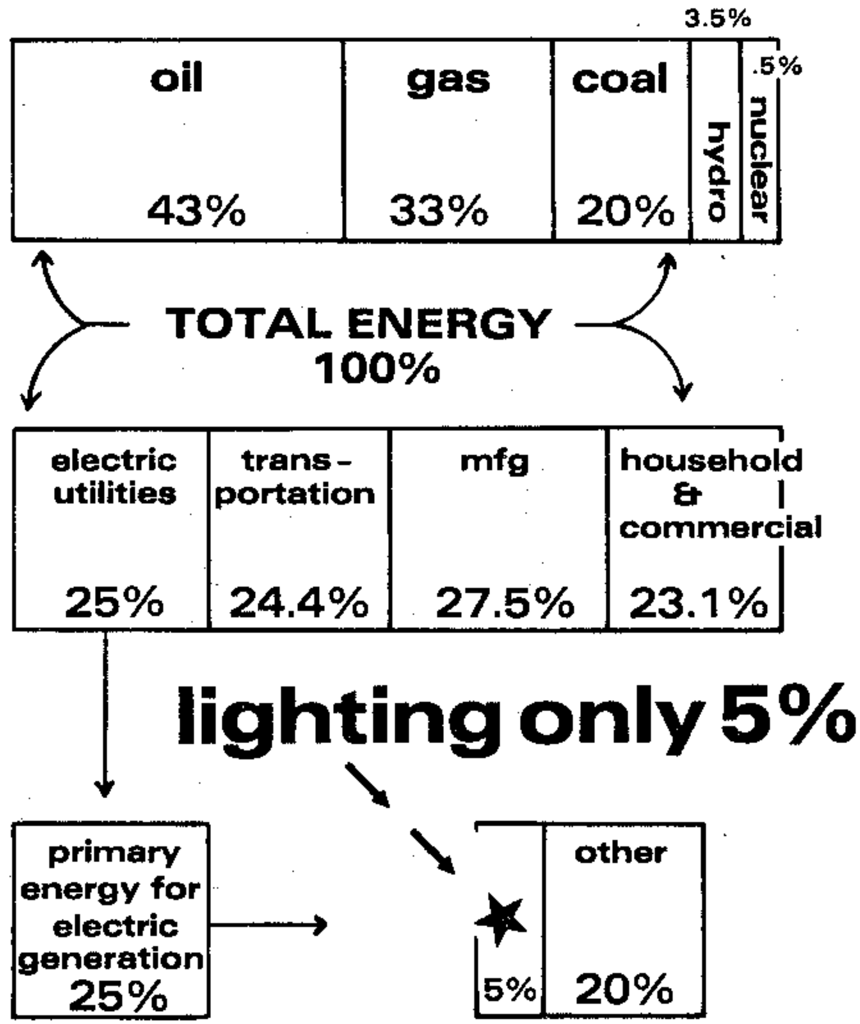
U.S.A. Heat Energy Consumption

1. Transportation	25%	6. Refrigeration	6%
2. Process Heat	24%	7. Water Heating	5%
3. Space Heat	19%	8. Lighting	5%
4. Electric Drive	8%	9. Others	3%
5. Air Conditioning	6%		

Industry Estimates Of Fuel Input To The NEAREST %

electric energy uses





ENERGY FOR LIGHTING

RETAIL FACILITIES	60%
HOTELS & MOTELS	11%
SUPERMARKETS/GROCERIES	20%
OFFICE BUILDINGS	25%
RESTAURANTS	8.2%

WHAT YOU CAN DO

SURVEY WITH LIGHT METER

- REMOVE BULBS AND BALLASTS
- REMOVE FIXTURES
- REWIRE SWITCHES

CLEAN BULBS

CLEAN FIXTURES

SET UP RELAMP SCHEDULE

SET UP MANUAL LIGHTING SCHEDULE

USE TIMERS

ILLUMINATION LEVELS

FOOTCANDLES

	IES	FEA
MERCHANDISE, REQUIRING CLOSE INSPECTION		30 - 100
GENERAL MERCHANDISE AREAS		30 - 50
MERCHANDISING AREAS		
SERVICE	100	
SELF-SERVICE	200	
SHOWCASES AND WALL CASES		
SERVICE	200	
SELF-SERVICE	500	
FEATURE DISPLAYS		
SERVICE	500	
SELF-SERVICE	1000	

RETAIL STORES
ILLUMINATION LEVELS

WATTS/SQUARE FOOT

CALIFORNIA (OPTIONAL)

(2.5 WATTS/SQ.FT.)(A_1) + (1 WATT/SQ.FT.)(A_2) + SHOWCASE AND DISPLAY WATTS

A_1 = PRIME SALES AREAS (DO NOT INCLUDE SHOWCASE AND DISPLAY AREAS) IN SQUARE FEET

A_2 = CIRCULATION AREAS IN SQUARE FEET

MASSACHUSETTS (MANDATORY)

3 WATTS/SQ.FT. OF SALES AREA
1 WATT/SW. FT. OF STORAGE AREA

THERE IS MORE TO LIGHTING THAN

FOOTCANDLES!

DEFINITION

1 LUMEN PER SQUARE FOOT = 1 FOOTCANDLE

DESIGN

NUMBER OF FIXTURES REQUIRED =

$$\frac{\text{(SQUARE FEET TO BE LIGHTED) (FOOTCANDLES)}}{\text{(LAMPS/FIXTURE) (LUMENS/LAMP)(C.U.)(M.F.)}}$$

WHERE C.U. = COEFFICIENT OF UTILIZATION

M.F. = (L.L.D.)(L.D.D.)

L.L.D. = LAMP LUMEN DEPRECIATION

L.D.D. = LUMINAIRE DIRT DEPRECIATION

DESIGN EXAMPLE

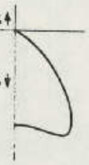
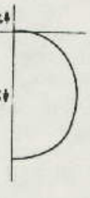
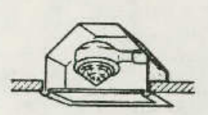
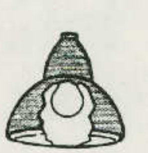
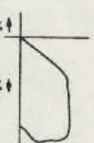
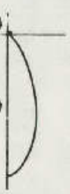
LIGHT REQUIRED: 100 FOOTCANDLES OVER
50,000 SQUARE FEET

LAMP TO BE USED: 50,000 LUMENS PER LAMP
90% LAMP LUMEN DEPRECIATION (L.L.D.)

LUMENS TO BE USED: 1 LAMP PER LUMINAIRE
.74 COEFFICIENT OF UTILIZATION (C.U.)
.85 LUMINAIRE DIRT DEPRECIATION (L.D.D.)

$$\text{NUMBER FIXTURES} = \frac{(50{,}000)\ (100)}{1 \times 50{,}000 \times .74 \times .90 \times .85} = 177$$

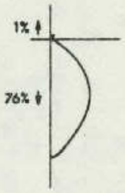
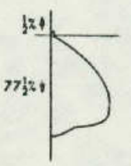
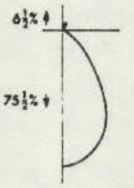
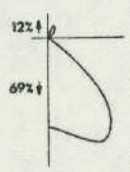
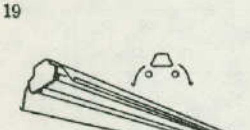
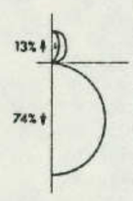
TABLES OF COEFFICIENTS OF UTILIZATION

Typical Luminaire	Typical Distribution and Per Cent Lamp Lumens			ρ_{CC}[a] →	80			70			50			30			10			0	WDRC[e] ↓
				ρ_W[b] →	50	30	10	50	30	10	50	30	10	50	30	10	50	30	10	0	
		Maint. Cat.	Maximum S/MH Guide[d]	RCR[c] ↓	Coefficients of Utilization for 20 Per Cent Effective Floor Cavity Reflectance (ρ_{FC} = 20)																
10  Wide distribution unit with lens plate and inside frost lamp	0% ↑  53½% ↓	V	1.4	0	.63	.63	.63	.62	.62	.62	.59	.59	.59	.56	.56	.56	.54	.54	.54	.53	
				1	.58	.56	.54	.57	.55	.54	.54	.53	.52	.52	.51	.50	.50	.50	.49	.48	.14
				2	.53	.50	.48	.52	.49	.47	.50	.48	.46	.48	.47	.45	.47	.45	.44	.43	.13
				3	.48	.45	.42	.47	.44	.42	.46	.43	.41	.44	.42	.40	.43	.41	.40	.39	.12
				4	.44	.40	.37	.43	.40	.37	.42	.39	.37	.41	.38	.36	.40	.38	.36	.35	.12
				5	.40	.36	.33	.39	.36	.33	.38	.35	.33	.37	.35	.32	.36	.34	.32	.31	.11
				6	.36	.32	.30	.36	.32	.29	.35	.32	.29	.34	.31	.29	.33	.31	.29	.28	.11
				7	.33	.29	.26	.33	.29	.26	.32	.28	.26	.31	.28	.26	.30	.28	.26	.25	.10
				8	.30	.26	.23	.30	.26	.23	.29	.26	.23	.28	.25	.23	.28	.25	.23	.22	.10
				9	.27	.23	.21	.27	.23	.21	.26	.23	.21	.26	.23	.20	.25	.22	.20	.19	.09
				10	.25	.21	.18	.25	.21	.18	.24	.21	.18	.24	.20	.18	.23	.20	.18	.17	.09
11  Recessed unit with dropped diffusing glass	1½% ↑  50½% ↓	V	1.3	0	.61	.61	.61	.60	.60	.60	.57	.57	.57	.54	.54	.54	.51	.51	.51	.50	
				1	.53	.51	.48	.52	.50	.47	.49	.47	.46	.47	.45	.44	.45	.44	.42	.41	.23
				2	.46	.42	.39	.45	.42	.39	.43	.40	.38	.41	.39	.37	.39	.37	.35	.34	.20
				3	.40	.36	.33	.40	.35	.32	.38	.34	.31	.36	.33	.31	.35	.32	.30	.29	.18
				4	.36	.31	.28	.35	.31	.28	.34	.30	.27	.32	.29	.26	.31	.28	.26	.25	.16
				5	.32	.27	.24	.31	.27	.24	.30	.26	.23	.29	.25	.23	.28	.25	.22	.21	.15
				6	.29	.24	.20	.28	.24	.20	.27	.23	.20	.26	.22	.20	.25	.22	.19	.18	.13
				7	.26	.21	.18	.25	.21	.18	.24	.20	.17	.23	.20	.17	.22	.19	.17	.16	.12
				8	.23	.19	.16	.23	.18	.15	.22	.18	.15	.21	.18	.15	.20	.17	.15	.14	.11
				9	.21	.17	.14	.21	.16	.14	.20	.16	.13	.19	.16	.13	.19	.15	.13	.12	.11
				10	.19	.15	.12	.19	.15	.12	.18	.14	.12	.18	.14	.12	.17	.14	.12	.11	.10
12  Clear HID lamp and glass refractor above plastic lens panel	0% ↑  66% ↓	V	1.3	0	.78	.78	.78	.76	.76	.76	.73	.73	.73	.70	.70	.70	.67	.67	.67	.65	
				1	.71	.69	.68	.70	.68	.66	.67	.66	.64	.65	.64	.62	.62	.62	.61	.59	.17
				2	.65	.62	.59	.64	.61	.58	.62	.59	.57	.60	.58	.56	.58	.56	.55	.54	.16
				3	.59	.55	.52	.58	.55	.52	.57	.53	.51	.55	.52	.50	.53	.51	.49	.48	.15
				4	.54	.50	.47	.54	.50	.46	.52	.49	.46	.51	.48	.45	.49	.47	.45	.43	.14
				5	.50	.45	.42	.49	.45	.41	.48	.44	.41	.47	.43	.41	.46	.43	.40	.39	.13
				6	.46	.41	.37	.45	.40	.37	.44	.40	.37	.43	.39	.37	.42	.39	.36	.35	.13
				7	.41	.37	.33	.41	.36	.33	.40	.36	.33	.39	.35	.33	.38	.35	.32	.31	.12
				8	.38	.33	.30	.38	.33	.30	.37	.33	.30	.36	.32	.29	.35	.32	.29	.28	.12
				9	.35	.30	.27	.34	.30	.27	.34	.29	.26	.33	.29	.26	.32	.29	.26	.25	.11
				10	.32	.27	.24	.31	.27	.24	.31	.27	.24	.30	.26	.24	.30	.26	.23	.22	.11
13  Enclosed reflector with an incandescent lamp	0% ↑  71½% ↓	V	1.4	0	.85	.85	.85	.83	.83	.83	.79	.79	.79	.76	.76	.76	.73	.73	.73	.71	
				1	.78	.76	.74	.76	.74	.73	.73	.72	.70	.71	.69	.68	.68	.67	.66	.65	.17
				2	.71	.68	.65	.70	.67	.64	.68	.65	.63	.65	.63	.61	.63	.62	.60	.59	.16
				3	.65	.61	.57	.64	.60	.57	.62	.59	.56	.60	.57	.55	.59	.56	.54	.53	.16
				4	.60	.55	.51	.59	.54	.51	.57	.53	.50	.55	.52	.50	.54	.51	.49	.48	.15
				5	.54	.49	.45	.54	.49	.45	.52	.48	.45	.51	.47	.44	.50	.46	.44	.43	.14
				6	.49	.44	.40	.49	.44	.40	.47	.43	.40	.46	.42	.40	.45	.42	.39	.38	.14
				7	.44	.39	.35	.44	.39	.35	.43	.38	.35	.42	.38	.35	.41	.37	.35	.33	.14
				8	.40	.35	.31	.40	.35	.31	.39	.35	.31	.38	.34	.31	.38	.34	.31	.30	.13
				9	.37	.31	.28	.36	.31	.28	.36	.31	.28	.35	.31	.28	.34	.30	.27	.26	.13
				10	.33	.28	.25	.33	.28	.25	.32	.28	.25	.32	.28	.25	.31	.27	.24	.23	.12
14  Narrow distribution ventilated reflector with clear HID lamp	1½% ↑  77% ↓	III	0.7	0	.92	.92	.92	.90	.90	.90	.86	.86	.86	.82	.82	.82	.78	.78	.78	.76	
				1	.87	.85	.83	.85	.83	.82	.81	.80	.79	.78	.77	.76	.75	.75	.74	.72	.11
				2	.81	.79	.76	.80	.77	.75	.77	.75	.73	.75	.73	.72	.72	.71	.70	.69	.10
				3	.77	.73	.71	.76	.72	.70	.73	.71	.69	.71	.69	.67	.70	.68	.66	.65	.10
				4	.73	.69	.66	.72	.68	.65	.70	.67	.64	.68	.66	.64	.67	.65	.63	.62	.09
				5	.69	.65	.62	.68	.64	.61	.66	.63	.61	.65	.62	.60	.64	.61	.59	.58	.09
				6	.65	.61	.58	.64	.61	.58	.63	.60	.57	.62	.59	.57	.61	.58	.56	.55	.09
				7	.62	.57	.54	.61	.57	.54	.60	.56	.54	.59	.56	.53	.58	.55	.53	.52	.09
				8	.58	.54	.51	.58	.54	.51	.57	.53	.51	.56	.53	.51	.55	.52	.50	.49	.09
				9	.55	.51	.48	.55	.51	.48	.54	.50	.48	.53	.50	.48	.53	.50	.48	.47	.08
				10	.53	.49	.46	.52	.48	.46	.52	.48	.46	.51	.48	.45	.50	.47	.45	.44	.08

[a] ρ_{CC} = per cent effective ceiling cavity reflectance.
[b] ρ_W = per cent wall reflectance.
[c] RCR = Room Cavity Ratio.
[d] Maximum *S/MH* guide—ratio of maximum luminaire spacing to mounting or ceiling height above work-plane.

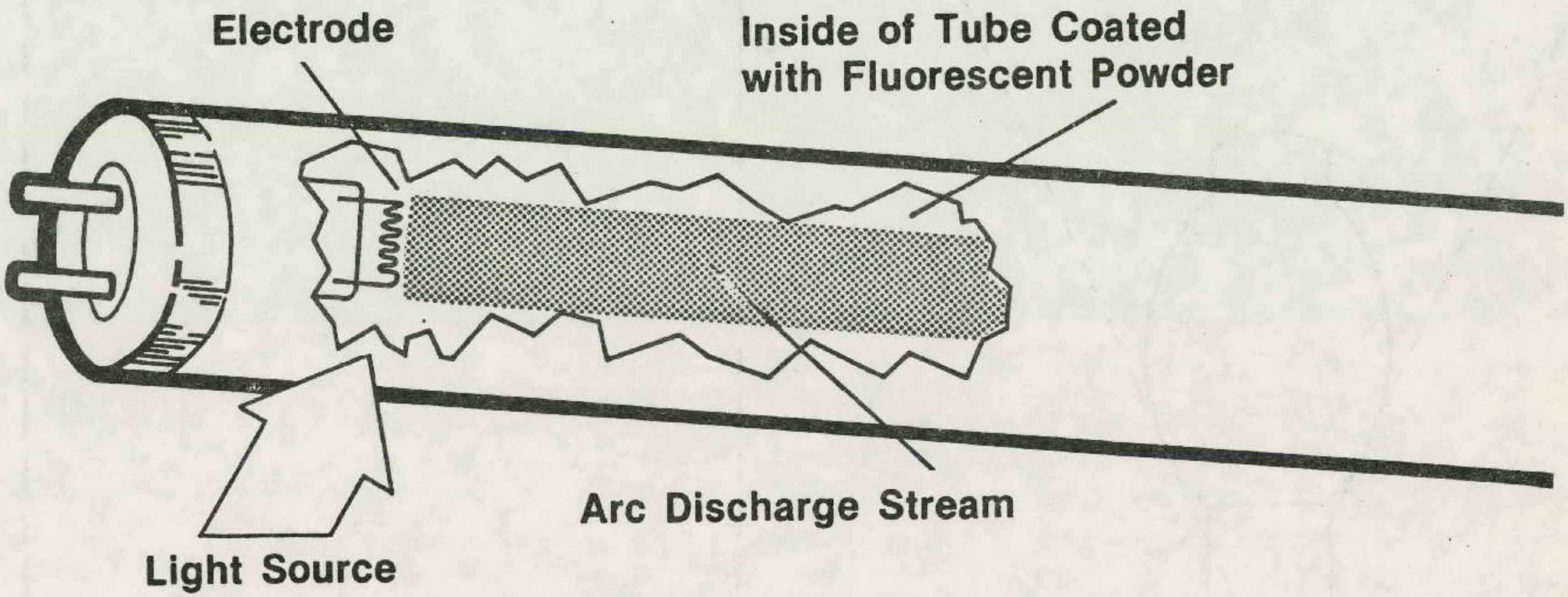
Courtesy IES Handbook

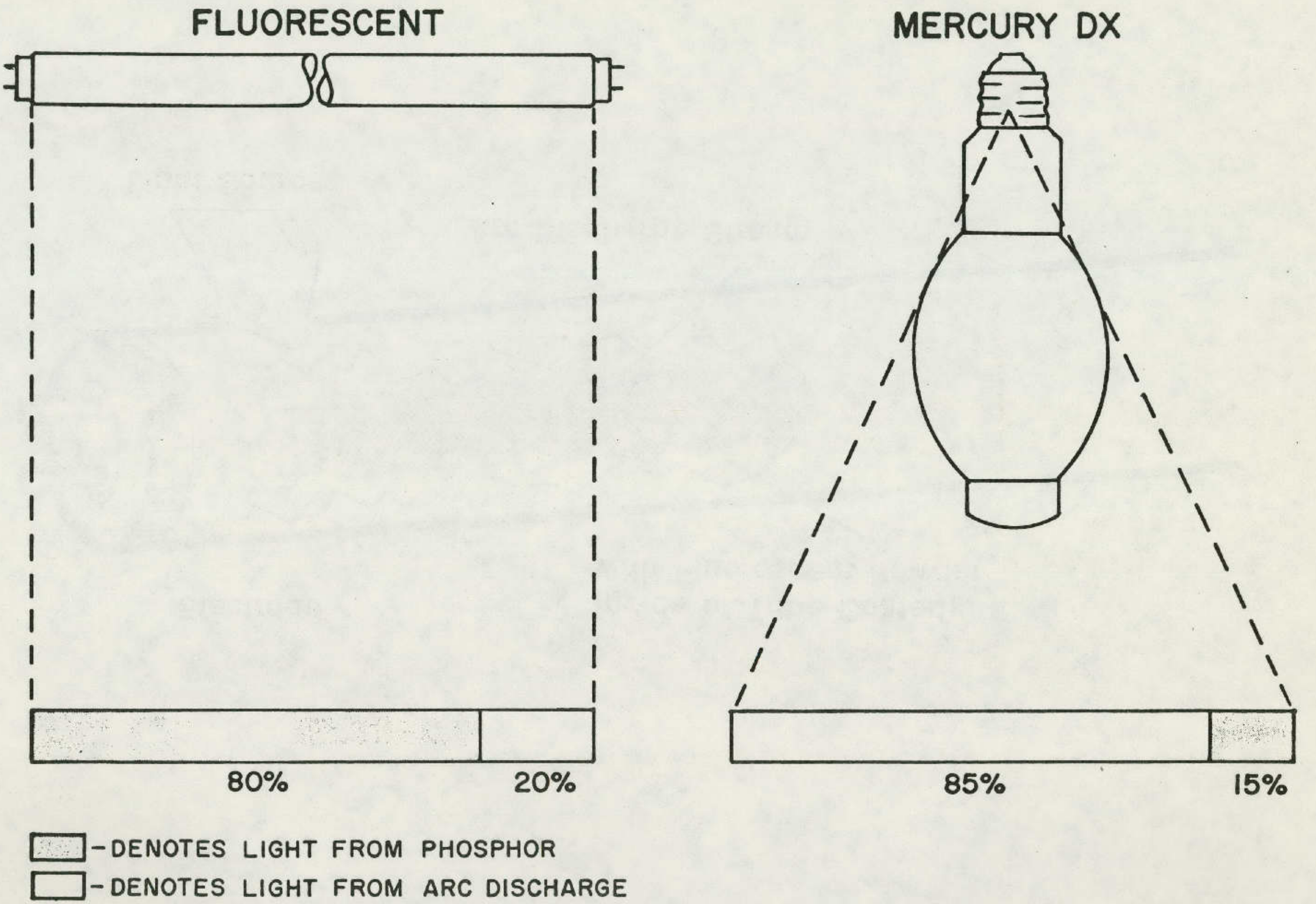
TABLES OF COEFFICIENCY OF UTILIZATION

Typical Luminaire	Typical Distribution and Per Cent Lamp Lumens: Maint. Cat.	Maximum S/MH Guide[d]	ρcc[a] → / ρw[b] → / RCR[c] ↓	80			70			50			30			10			0	WDRC[e] ↓
			ρw[b] →	50	30	10	50	30	10	50	30	10	50	30	10	50	30	10	0	
				Coefficients of Utilization for 20 Per Cent Effective Floor Cavity Reflectance (ρ_{FC} = 20)																
15	III	1.0	0	.91	.91	.91	.89	.89	.89	.84	.84	.84	.81	.81	.81	.77	.77	.77	.75	
			1	.84	.81	.79	.82	.80	.78	.79	.77	.76	.76	.74	.73	.73	.72	.71	.69	.16
			2	.77	.73	.70	.76	.72	.70	.73	.70	.68	.70	.68	.66	.68	.66	.65	.63	.16
			3	.71	.66	.63	.69	.65	.62	.67	.64	.61	.65	.62	.60	.63	.61	.59	.57	.15
			4	.65	.60	.56	.64	.59	.56	.62	.58	.55	.60	.57	.54	.59	.56	.54	.52	.15
			5	.59	.54	.50	.59	.54	.50	.57	.53	.50	.56	.52	.49	.54	.51	.48	.47	.14
			6	.54	.49	.45	.54	.49	.45	.52	.48	.45	.51	.47	.44	.50	.47	.44	.42	.14
			7	.50	.44	.40	.49	.44	.40	.48	.43	.40	.47	.43	.39	.46	.42	.39	.38	.14
Intermediate distribution ventilated reflector with clear HID lamp			8	.45	.40	.36	.45	.40	.36	.44	.39	.36	.43	.39	.35	.42	.38	.35	.34	.13
			9	.41	.36	.32	.41	.36	.32	.40	.35	.32	.39	.35	.32	.38	.35	.32	.30	.13
			10	.38	.33	.29	.37	.32	.29	.37	.32	.29	.36	.32	.29	.35	.31	.28	.27	.12
16	III	1.5	0	.92	.92	.92	.90	.90	.90	.86	.86	.86	.82	.82	.82	.79	.79	.79	.77	
			1	.85	.82	.80	.83	.81	.79	.79	.78	.76	.76	.75	.74	.74	.72	.71	.70	.19
			2	.77	.73	.70	.75	.72	.69	.73	.70	.67	.70	.68	.66	.68	.66	.64	.63	.19
			3	.70	.65	.61	.68	.64	.60	.66	.62	.59	.64	.61	.58	.62	.59	.57	.56	.18
			4	.63	.58	.53	.62	.57	.53	.60	.56	.52	.58	.55	.52	.57	.54	.51	.49	.18
			5	.57	.51	.47	.56	.51	.47	.55	.50	.46	.53	.49	.46	.52	.48	.45	.44	.17
			6	.51	.45	.41	.51	.45	.41	.49	.44	.40	.48	.43	.40	.47	.43	.40	.38	.16
			7	.46	.40	.35	.45	.39	.35	.44	.39	.35	.43	.38	.35	.42	.38	.34	.33	.16
Wide distribution ventilated reflector with clear HID lamp			8	.41	.35	.31	.41	.35	.31	.40	.34	.31	.39	.34	.30	.38	.33	.30	.29	.15
			9	.37	.31	.27	.37	.31	.27	.36	.30	.27	.35	.30	.27	.34	.30	.26	.25	.15
			10	.33	.27	.24	.33	.27	.23	.32	.27	.23	.31	.27	.23	.31	.26	.23	.22	.14
17	III	1.0	0	.96	.96	.96	.93	.93	.93	.87	.87	.87	.82	.82	.82	.77	.77	.77	.75	
			1	.89	.87	.84	.86	.84	.83	.82	.80	.79	.78	.76	.75	.74	.73	.72	.70	.14
			2	.82	.79	.76	.80	.77	.74	.76	.74	.72	.73	.71	.69	.70	.68	.67	.65	.13
			3	.76	.72	.68	.74	.70	.67	.71	.68	.65	.68	.66	.63	.66	.63	.61	.60	.13
			4	.70	.66	.62	.69	.65	.61	.66	.63	.60	.64	.61	.58	.62	.59	.57	.55	.13
			5	.65	.60	.56	.64	.59	.56	.62	.58	.54	.60	.56	.53	.58	.55	.52	.51	.12
			6	.60	.55	.51	.59	.55	.51	.57	.53	.50	.56	.52	.49	.54	.51	.48	.47	.12
			7	.56	.51	.47	.55	.50	.46	.53	.49	.46	.52	.48	.45	.50	.47	.44	.43	.12
Intermediate distribution ventilated reflector with phosphor coated HID lamp			8	.52	.47	.43	.51	.46	.43	.50	.45	.42	.48	.44	.41	.47	.43	.41	.40	.11
			9	.48	.43	.39	.47	.42	.39	.46	.42	.39	.45	.41	.38	.44	.40	.38	.36	.11
			10	.45	.40	.36	.44	.39	.36	.43	.39	.36	.42	.38	.35	.41	.37	.35	.34	.10
18	III	1.5	0	.93	.93	.93	.89	.89	.89	.83	.83	.83	.77	.77	.77	.71	.71	.71	.68	
			1	.85	.83	.81	.82	.80	.78	.77	.75	.74	.72	.71	.69	.67	.66	.65	.63	.15
			2	.78	.74	.71	.76	.72	.69	.71	.68	.66	.67	.65	.63	.63	.61	.60	.58	.14
			3	71	.67	.63	.69	.65	.62	.65	.62	.59	.62	.59	.57	.58	.56	.54	.53	.14
			4	.65	.60	.56	.64	.59	.55	.60	.56	.53	.57	.54	.51	.54	.52	.50	.48	.13
			5	.60	.54	.50	.58	.53	.49	.55	.51	.48	.53	.49	.46	.50	.47	.45	.43	.13
			6	.54	.49	.45	.53	.48	.44	.51	.46	.43	.48	.45	.42	.46	.43	.40	.39	.13
			7	.49	.44	.40	.48	.43	.39	.46	.41	.38	.44	.40	.37	.42	.39	.36	.34	.12
Wide distribution ventilated reflector with phosphor coated HID lamp			8	.45	.39	.35	.44	.38	.35	.42	.37	.34	.40	.36	.33	.38	.35	.32	.31	.12
			9	.41	.35	.31	.40	.34	.31	.38	.33	.30	.36	.32	.29	.35	.31	.28	.27	.12
			10	.37	.31	.27	.36	.31	.27	.34	.30	.26	.33	.29	.26	.32	.28	.25	.24	.11
19	III	1.3	0	1.00	1.00	1.00	.96	.96	.96	.89	.89	.89	.82	.82	.82	.76	.76	.76	.73	
			1	.88	.85	.82	.85	.82	.79	.79	.77	.74	.73	.72	.70	.68	.67	.66	.63	.27
			2	.78	.72	.67	.75	.70	.66	.70	.66	.62	.65	.62	.59	.61	.58	.56	.53	.26
			3	.69	.62	.57	.66	.60	.56	.62	.57	.53	.58	.54	.51	.54	.51	.48	.46	.23
			4	.61	.54	.48	.59	.52	.47	.55	.50	.45	.52	.47	.43	.49	.45	.42	.39	.22
			5	.54	.46	.41	.52	.45	.40	.49	.43	.39	.46	.41	.37	.43	.39	.36	.33	.20
			6	.48	.41	.35	.47	.40	.35	.44	.38	.34	.41	.36	.32	.39	.34	.31	.29	.19
			7	.43	.36	.31	.42	.35	.30	.40	.34	.29	.37	.32	.28	.35	.31	.27	.25	.17
			8	.39	.32	.27	.38	.31	.26	.36	.30	.25	.34	.28	.24	.32	.27	.24	.22	.16
Porcelain-enameled reflector with 14°CW shielding			9	.35	.28	.23	.34	.27	.23	.32	.26	.22	.30	.25	.21	.28	.24	.20	.19	.15
			10	.32	.25	.20	.31	.24	.20	.29	.23	.19	.28	.22	.19	.26	.21	.18	.17	.14

[a] ρ_{CC} = per cent effective ceiling cavity reflectance.
[b] ρ_W = per cent wall reflectance.
[c] RCR = Room Cavity Ratio.
[d] Maximum *S/MH* guide—ratio of maximum luminaire spacing to mounting or ceiling height above work-plane.

Courtesy IES Handbook


Electrode
Inside of Tube Coated with Fluorescent Powder
Arc Discharge Stream
Light Source


FLUORESCENT
MERCURY DX
80%
20%
85%
15%
-DENOTES LIGHT FROM PHOSPHOR
-DENOTES LIGHT FROM ARC DISCHARGE

What light Sources are available?

Light sources	Typical lumens per watt: Lamp only	Typical lumens per watt: Including ballast
☐ Incandescent	20	20 (no ballast)
☐ Self-ballasted mercury	25	25
☐ Fluorescent	100	85
☐ Std. mercury	63	58
☐ Metalarc (metal-halide)	125	115
☐ Lumalux (std. HPS)	140	127
☐ Unalux (easy start HPS)	116	97
☐ Low pressure sodium	183	150

COLOR RENDERING INDEX
(CRI)

LAMP TYPE	CRI
NATURAL LIGHT	100
INCANDESCENT	97
FLUORESCENT	
COOL WHITE	67
DELUXE COOL WHITE	86-89
WARM WHITE	56
WARM WHITE DELUXE	71
DAYLITE	75
VITA-LITE	91
ULTRALUME	85
ENERGY EFFICIENT	
LITE-WHITE	48
ECONO-O-WHITE	51
MERCURY	22-52
METAL HALIDE	65-70
HIGH PRESSURE SODIUM	20
LOW PRESSURE SODIUM	0

COMPARISON OF COMMON LIGHT SOURCES

LAMP TYPE	DESIGNATION	NOMINAL WATTAGE	INITIAL LUMENS	INITIAL LPW (1)	INITIAL LPW (2)	COLOR TEMP. °K	COLOR RENDERING INDEX	RATED AVE. LIFE (3)
METALARC CLEAR	M400	400	34,000	85	75	4,500	65	15,000
METALARC COATED	M400/C	400	34,000	85	75	3,800	70	15,000
SUPER METALARC CLEAR	MS400	400	40,000	100	88	4,500	65	15,000
SUPER METALARC COATED	MS400/C	400	40,000	100	88	3,800	70	15,000
MERCURY CLEAR	H33CD-400	400	20,500	51	46	5, 00	22	24,000
MERCURY DELUXE WHITE	H33GL-400/DX	400	23,000	57	51	4,000	45	24,000
MERCURY WARMTONE	H33GL-400/N	400	19,500	48	43	3,300	52	24,000
LUMALUX CLEAR	LU400	400	50,000	125	107	2,100	20	24,000
LUMALUX COATED	LU400/D	400	47,500	119	102	2,100	20	24,000
UNALUX CLEAR	ULX360	360	38,000	105	95	2,060	20	16,000
UNALUX COATED	ULX360/D	360	36,000	100	90	2,060	20	16,000
LOW PRESSURE SODIUM	SOX-180	180	33,000	183	136	1,750	0	18,000
FLUORESCENT	F40CW	40	3,150	78	67	4,300	67	26,000
FLUORESCENT	F96T12CW	75	6,300	84	63	4,300	67	18,000
FLUORESCENT	F96T12CWX	75	4,400	59	44	4,100	86	18,000
INCANDESCENT	300/IF	300	6,000	20	20	2,900	97	1,000

(1) Lamp only

(2) Lamp and ballast losses, where applicable

(3) At 10 hrs. per start

NEW

Sylvania Product Information Bulletin

FLUORESCENT

SuperSaver II "Lite White" Fluorescent Lamps reduce energy use while maintaining high levels of lighting efficiency.

FL-22

SUPERSAVER II FLUORESCENT LAMPS

A blend of new phosphors provides the principle means by which Sylvania is able to introduce two new SuperSaver lamps with significant increases in efficacy. The phosphor which makes this possible, provides a lamp color slightly different from Cool White which will be identified as "Lite White". In order to minimize confusion in the industry, lamps with the Lite White phosphor will be known as SuperSaver II. The lamps in which this new phosphor will be used initially are the F40/LW/RS/SS and the F96T12/LW/SS, the two most commonly used sizes.

The Lite White phosphor provides a color with more energy in the green/yellow portions of the spectrum than Cool White. For those applications where color rendition is not critical, standard F40 or F96T12 lamps can be replaced with reduced energy use of 15% or 20% respectively and lumen reductions of 5% or less. It is estimated that Lite White SuperSaver II lamps will provide satisfactory color rendition for most applications where Cool White is currently being used. Size for size, SuperSaver II lamps provide the same wattage reduction characteristics as the standard SuperSaver lamps.

SuperSaver II lamps can be used indoors where temperatures are 60° F or higher. They should not be used where exposed to direct drafts from air diffusers sufficient to cause flickering or striations. The F40/LW/RS/SS should be used only in luminaires equipped with high power factor single lamp or two-lamp series, rapid start ballasts meeting ANSI specifications. The F96T12/LW/SS is recommended for use only with two-lamp, instant start ballasts meeting ANSI specifications.

Lamp performance specifications are as follows:

Ordering Abbreviation	Rated Watts	Color	Approx. Lumens	Avg. Life Hours*	NAED Code No.
F40/LW/RS/SS	35	Lite White	3050	20,000+	24520
F96T12/LW/SS	60	Lite White	6000	12,000	29850

Lite White — Color Temperature	4150° K
Color Rendering Index	48

Engineering estimates indicate lumen maintenance equal to Cool White phosphor.

*Engineering estimates based on three hour burning cycle.

GTE SYLVANIA

LIGHTING CENTER, DANVERS, MASS. 01923

TABLE III

REFERENCE DATA ON SYLVANIA FLUORESCENT LAMPS

Lamp[2] Designation	Nominal Watts	Nominal Length (inches)[3]	Base	Lamp Operating	
				Amps.	Volts
Preheat					
F4T5	4	6	Min. Bipin	0.170	29
F6T5	6	9	Min. Bipin	0.160	42
F8T5	8	12	Min. Bipin	0.145	57
F13T5	13	21	Min. Bipin	0.165	95
F14T12	14	15	Med. Bipin	0.380	39
F15T8	15	18	Med. Bipin	0.304	56
F15T12	15	18	Med. Bipin	0.330	46
F20T12	20	24	Med. Bipin	0.380	56
F25T12	25	33	Med. Bipin	0.445	64
F30T8	30	36	Med. Bipin	0.350	100
F90T17	90	60	Mog. Bipin	1.500	62
Rapid Start – Preheat[4]					
F40T12	40	48	Med Bipin	0.430	102
Rapid Start					
F30T12	30	36	Med. Bipin	0.430	78
High Output					
F24T12/HO	32	24	Rec. D.C.	0.800	42
F36T12/HO	44	36	Rec. D.C.	0.800	
F48T12/HO	60	48	Rec. D.C.	0.800	79
F72T12/HO	85	72	Rec. D.C.	0.800	116
F72T12/HO	100	72	Rec. D.C.	1.000	105
F96T12/HO	110	96	Rec. D.C.	0.800	152
Very High Output					
F48T12/VHO	115	48	Rec. D.C.	1.500	83
F72T12/VHO	165	72	Rec. D.C.	1.500	124
F96T12/VHO	215	96	Rec. D.C.	1.500	161
Circline					
FC8T9	22	8" Diam.	4 – Pin	0.380	60
FC12T10	32	12" Diam.	4 – Pin	0.430	82
FC16T10	40	16" Diam.	4 – Pin	0.415	108
Curvalume					
FB40/6"	40	24	Med. Bipin	0.430	100
Instant Start[5]					
F40T12/IS	40	48	Med. Bipin	0.420	104
F40T17/IS	40	48	Mog. Bipin	0.420	107
Slimline[6]					
F42T6	25	42	Single Pin	0.200	145
F64T6	38	64	Single Pin	0.200	225
F72T8	38	72	Single Pin	0.200	218
F96T8	51	96	Single Pin	0.200	290
F48T12	39	48	Single Pin	0.425	100
F72T12	55	72	Single Pin	0.425	149
F96T12	75	96	Single Pin	0.425	197

Reference Notes

[1]Rated initial lumens, mean lumens and rated life are not included in this bulletin because frequent improvements in lamp performance continuously obsoletes published data. Refer to other engineering bulletins for current ratings.

[2]"T" stands for tubular bulb; number indicates diameter of tube in eighths of an inch.

[3]Indicates length of lamp plus two standard lampholders.

[4]Electrical values are slightly different for preheat operation.

[5]Base pins shorted inside base.

[6]T-6 and T-8 Slimline lamps are also operated at 0.100 amp. and 0.300 amp.

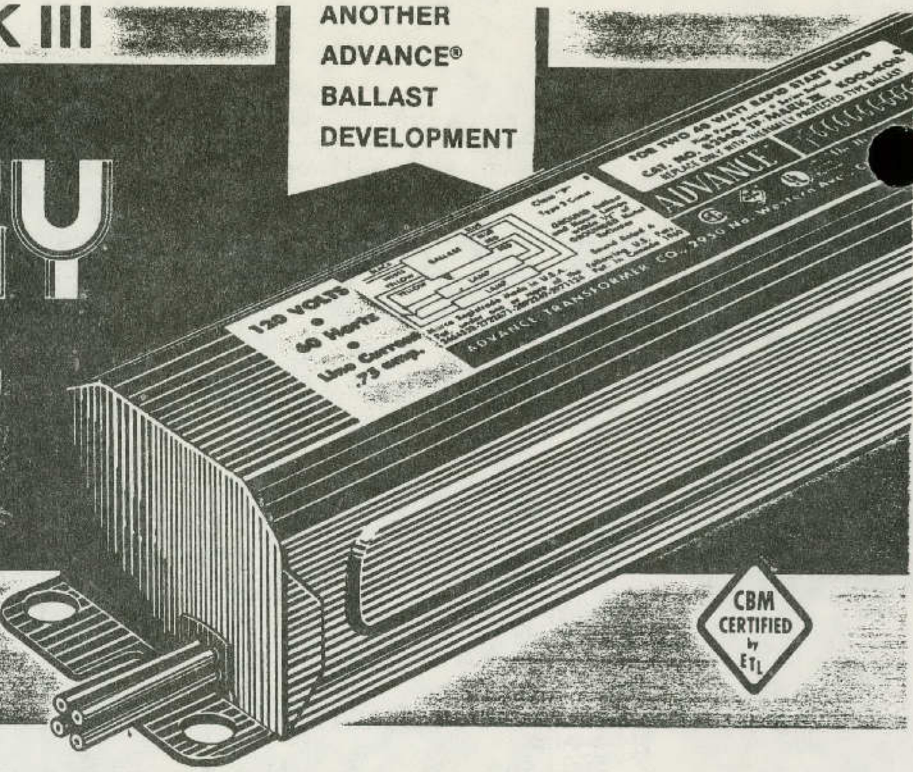
New, Improved MARK III

ANOTHER ADVANCE® BALLAST DEVELOPMENT

ENERGY SAVER

OF RAPID START LAMPS

FULL LIGHT OUTPUT



ADVANCE® Mark III Rapid Start Ballasts . . .

• Reduce Energy Costs • Operate 25°C Cooler than Standard • Provide Longer Life
• Maintain Full Light Output • Also Compatible with Energy-Saving Lamps

- ADVANCE® Full Light Output, Energy Saving Ballasts are available for both 120V and 277V operation of two (2) F40T12/RS (430 MA.) fluorescent lamps.
- Full light output is provided. Ballasts are CBM Certified.
- Input *at full light output* is reduced by approximately 10 watts compared to standard ballasts used in the same application. This energy savings translates directly into significant savings in operating costs. These ballasts truly pay for themselves many times over during normal life.
- Unique ADVANCE Mark III ballast design operates approximately 25°C cooler in fixture than standard ballasts. Result: should easily provide up to four times longer ballast life; reduced maintenance because of less change-out cost for replacement ballasts and labor; and lower air conditioning load.
- Physically interchangeable with standard ballasts. Ideal for both new and existing installations.
- ADVAN-guard® automatic resetting thermostat is included to afford Class P ballast protection.
- High power factor and sound rated "A" for widest possible use.
- Listed by Underwriters' Laboratories, Inc.

Energy Savings Become More Important Every Year

Energy costs have increased substantially in recent years, and industry forecasts call for continued increases—perhaps *three times today's rates* in the next 15 years. These higher power costs make the ADVANCE Full Light Energy Saving Ballasts a wise choice now—and an even wiser choice for every year they operate at reduced watts input.

Compute Your Savings

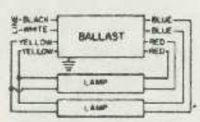
See tables on the reverse side of this bulletin to compute the savings you will gain with ADVANCE Mark III ballasts. You'll save with reduced energy, longer ballast life and reduced maintenance.

Depending on energy costs, total life savings up to $89.00 per ballast can be expected.

Full Light Energy Saving Ballasts 60Hz

Lamp Data		Circuit (Volts)	Min. Starting Temp. (°F.)	Catalog Number (Class P)	Electrical Data		Sound Rating	Dimensions (Inches)				Shipping Data	
Description	Watts				Line Current (Amps.)	Input* (Watts)		Length	Width	Height	Mounting	No. of Units Per Std. Ctn.	Wt. Std. Ctn. (Lbs.)
(2) F40T12/RS	40	120 277	50°	R2S40-1-TP V2S40-1-TP	.73 .32	86/82	A	9½	2⅜	1½	8 29/32	10	40

Wiring Diagram



*Higher figure for Bare Lamp Fixture
Lower figure for Enclosed Fixture.

Specify ADVANCE® Mark III Ballasts For Full Light Energy Savings

ADVANCE®
TRANSFORMER CO.
2950 N. Western Avenue, Chicago, Ill. 60618
A NORTH AMERICAN PHILIPS COMPANY

Form No. 1286 Rev. 10/77 Printed in U.S.A.

Specifications and data in this bulletin are subject to change without notice.

How ADVANCE® Mark III Ballasts Save You $$$ 3 Ways while Maintaining Full Light Output

The three factors which contribute to substantial savings with ADVANCE Mark III Full Light Output Ballasts are: 1) Reduced energy consumption; 2) Longer ballast life; and 3) Reduced maintenance costs. The modest list price premium of a Mark III ballast is far outweighed by the savings tabulated below.

1. Significant Savings in Energy Costs

Input has been reduced by10watts compared to standard ballasts used in the same application. Compute your *annual* cost savings in energy alone by referring to the power rate for your area in the following table.

Power Rate	Annual Energy Savings Per Ballast (Based on 3000 Hr. Operation @ 10 Watt Reduction or 30 KWHr)
2¢/KWHr	$ .60
3¢/KWHr	.90
5¢/KWHr	1.50
8¢/KWHr	2.40
10¢/KWHr	3.00

The annual savings computed above add up to substantial savings when considered over the life of a standard ballast. Using an average standard ballast life of 10 to 12 years the savings will be:

Power Rate	Full-Life Energy Savings Per Mark III Ballast (Over average life of standard ballast—10 to 12 years)
2¢/KWHr	$6.00 to $7.20
3¢/KWHr	$9.00 to $10.80
5¢/KWHr	$15.00 to $18.00
8¢/KWHr	$24.00 to $28.80
10¢/KWHr	$30.00 to $36.00

Keep in mind that energy costs are likely to increase in the future so savings over the life of the ballast would be even greater.

2. Longer Ballast Life Multiplies Energy Savings

Ballast life is a function of ballast operating temperature. Standard ballast operating temperature of 90°C results in an expected ballast life of 10 to 12 years according to accepted industry standards.

Mark III ballasts are designed to operate at a much cooler temperature-easily resulting in an average life of at least 25 years.

The following table shows the energy savings based on a conservative 25-year life with Mark III ballasts. Again, there is the strong probability of future rate increases which would make the savings even greater.

Power Rate	Full-Life Energy Savings Per Mark III Ballast (based on conservative ballast life of 25 years)
2¢/KWHr	$15.00
3¢KWHr	22.50
5¢/KWHr	37.50
8¢/KWHr	60.00
10¢/KWHr	75.00

3. Additional Savings from Reduced Maintenance

This table shows the savings you will gain when Mark III ballasts are used in a lighting unit over a 25-year period. The longer life provided by Mark III ballasts will reduce the number of change-outs required.

Ballast Type	No. of Change-Outs	Cost Each (Ballast plus Labor)	Total Cost
Standard	2*	$17.00	$34.00
Mark III	1	$20.00	$20.00
Mark III Ballast Maintenance Savings =			$14.00*

*Conservative—actual is 2.5 change-outs.

Mark III Energy & Maintenance Savings Add Up To Significant Extended Life Savings

Using an example of a power rate of 5¢/KWHr over a 25-year life, the following table shows how each Mark III ballast will return tremendous savings to you. The savings in energy costs, plus longer life and reduced maintenance, make Mark III ballasts today's most logical choice. And the continually increasing power rates will mean even greater savings for you in the future.

TOTAL SAVINGS (over 25-year period)	
Energy Savings (based on 5¢/KWHr rate)	$37.50
Maintenance Savings	14.00
Total per Ballast	$51.50

For various power rates, refer to this table for total savings

Total Savings per MARK III Ballast (over 25-year period)	
Power Rate	**Total Savings**
2¢/KWHr	$29.00
3¢/KWHr	36.50
5¢/KWHr	51.50
8¢/KWHr	74.00
10¢/KWHr	89.00

To Compute Your Savings . . .

You can readily compute the savings you will gain with Mark III ballasts. Simply multiply the number of ballasts in your installation by the total savings shown for each unit in the above table, using the power rate in your area.

Example: If you have a lighting installation requiring 320 ballasts and your power rate is 5¢/KWHr, your total savings would be:

320 × $51.50 = $16,480 Total Savings

Mark III ballasts are compatible with energy-saving lamps, permitting additional cost savings.

Typical Specifications for Full Light Output Energy Saving Rapid Start Ballasts

The Advance Transformer Co. Mark III Full Light Output Energy Saving Ballast catalog number ________. The ballast shall be CBM certified for full light output and have an average input wattage of 86 watts when operating two (2) non-enclosed F40T12 Rapid Start Fluorescent Lamps in ambients of 77°F. It shall not exceed 90°C operating temperature in a 73°C heat box. Tests shall be conducted at a minimum of 33°C over CBM and U/L testing procedures. Ballast shall be guaranteed not to overheat capacitor insulating oil beyond manufacturer's warranty limits.

LAMP PERFORMANCE WHEN 40-WATT BIPIN
FLUORESCENT LAMPS ARE INTERCHANGED
WITH TYPICAL BALLASTS

Ballast Type	Bipin-Lamp Type		Lamp Performance
Preheat	Preheat	OK	Normal rated life.
	Instant-Start	NG	Won't start. Filament is short-circuited inside lamp base. Starter will keep trying to strike an arc until failure occurs or the lamp is disconnected.
	Rapid-Start	OK	Normal rated life.
Instant-Start	Preheat	NG	May start. Very short life because primary current flows through one filament, causing early darkening and early failure.
	Instant-Start	OK	Normal rated life.
	Rapid-Start	NG	May start. Very short life because *high* primary current flows through one filament designed for *low* heating current.
Rapid-Start	Preheat, only	NG	Not recommended. Might start with best grounding and high line voltage, but starting is doubtful and unreliable under usual field conditions.
	Instant-Start	NG	Will not start. Short-circuited filament across heater winding will overheat ballast and could cause burnout.
	Rapid-Start	OK	Normal rated life.

TABLE IV

APPROXIMATE WATTS LOSS IN TYPICAL FLUORESCENT LAMP BALLASTS

Lamp Designation	Nominal Watts	118 Volts[1]			277 Volts[2]		
		Single Lamp	Two – Lamp Series	Two – Lamp Lead-Lag	Single Lamp	Two – Lamp Series	Two – Lamp Lead-Lag
Preheat							
F4T5	4	2	–	–	–	–	–
F6T5	6	2	–	–	–	–	–
F8T5	8	2	–	–	–	–	–
F13T5	13	6	–	–	–	–	–
F14T12	14	6	–	–	–	–	–
F15T8	15	5	–	8	–	–	–
F15T12	15	5	–	8	–	–	–
F20T12	20	6	–	10	–	–	–
F25T12	25	6	–	–	–	–	–
F30T8	30	10	–	17	–	–	–
F40T12	40	10	–	16	10	–	16
F90T17	90	20	–	33	–	–	33
Rapid Start							
F30T12	30	52[3]	75[3]	–	52[3]	–	76[3]
F40T12	40	52[3]	94[3]	–	52[3]	–	94[3]
High Output							
F24T12	32	70[3]	100[3]	–	65[3]	100[3]	–
F48T12	60	85[3]	154[3]	–	85[3]	150[3]	–
F72T12	85	135[3]	210[3]	–	135[3]	210[3]	–
F96T12	110	140[3]	246[3]	–	140[3]	246[3]	–
Very High Output							
F48T12/VHO	115	138[3]	247[3]	–	140[3]	247[3]	–
F72T12/VHO	165	200[3]	360[3]	–	200[3]	360[3]	–
F96T12/VHO	215	235[3]	450[3]	–	230[3]	450[3]	–
Circline							
FC8T9	22	29[3]	–	–	–	–	–
FC12T10	32	45[3]	–	–	43[3]	–	–
FC16T10	40	56[3]	–	–	56[3]	–	–
Instant Start							
F40T12/IS	40	20	20	25	23	21	24
F40T17/IS	40	20	20	25	23	21	24
Slimline							
F42T6[4]	25	16	–	16	16	–	16
F64T6[4]	38	17	–	30	–	–	–
F72T8[4]	38	17	–	30	12	–	25
F96T8[4]	51	19	–	30	18	–	30
F48T12[5]	39	20	20	25	23	21	24
F72T12[5]	55	26	27	33	25	26	27
F96T12[5]	75	26	27	33	25	26	27

Reference Notes

[1]Ballast range, 110-125 volts.

[2]Ballast range, 255-290 volts.

[3]Total input watts to ballast, including lamp and ballast watts.

[4]Operating lamp at 200 ma.

[5]Operating lamp at 425 ma.

Comparison Of Typical Discharge Lamp Performance

Lamp Type		Initial			End of Life**		Rated Average Life
			Lumens Per Watt				
		Lumens	Lamp	Lamp/Ballast	Lumens	Lumens per Watt*	
Low Pressure Sodium	180W	33,000	180	150	33,000	117	18,000
High Pressure Sodium	400W	50,000	125	106	35,000	76	24,000
Super Metalarc	400W	40,000	100	88	27,200	60	15,000
Metalarc	400W	34,000	85	75	22,500	50	20,000
Mercury	400W	23,000	57	51	15,700	35	24,000
Fluorescent VHO	2/215W	32,000	74	71	21,760	48	15,000

*Includes ballasts losses.

**Operated on 10 Hour Burning Cycle.

Energy-Savings Guide

ENERGY EVALUATION OF SYLVANIA HID LIGHT SOURCES
September 1978

Light Source	Average (000) Life*	Color Temp. in Degrees Kelvin (Coated)	Color Rendering Index (Coated)	Initial Lumens (LPW)**
Incandescent (REF)	1.0	3000-K	97	(20)
F40CW (REF)	25.0	4300-K	67	(79)
MERCURY — 40-50-75-100-175-250-400-700-1000 Watts			**Good**	**Fair**
175 DX	24.0	4,000	45	8,500 (49)
400 DX Deluxe	24.0	4,000	45	23,000 (58)
400/N Warm Tone	24.0	3,300	52	19,500 (49)
Self-Ballasted (By Others)	16.0	4,000	45	POOR (10-26)
METALARC LEAD PEAK BALLAST			**Excellent**	**Good/Excellent**
M-175 BU/BD	7.5	4,400 (4,000)	65 (70)	14,000 (80)
M-250 BU/BD	10.0	4,500 (3,900)	65 (70)	20,500 (82)
M-400 BU/BD (15,000 Hrs/Horiz)	20.0	4,000 (3,700)	65 (70)	34,000 (85)
M-1000 BU/BD	10.0	3,900 (3,400)	65 (70)	100,000 (100)
M-1500 BU/BD	3.0	3,700	70	155,000 (103)
MM-400 (Mercury CWA Ballast)	12.0	4,000 (3,700)	65 (70)	34,000 (85)
SUPER METALARC LEAD PEAK BALLAST			**Excellent**	**Excellent**
MS-175 Horizontal Only	10.0	4,700 (4,200)	65 (70)	15,000 (86)
MS-400 Horizontal Only	20.0	4,500 (3,800)	65 (70)	40,000 (100)
MS-400 BU or BD Only	15.0	3,700	65 (70)	40,000 (100)
MS-1000 BU or BD Only	10.0	3,500 (3,100)	65 (70)	125,000 (125)
LUMALUX HPS "BURN ANY POSITION"			**Fair**	**Excellent**
LU-70	24.0	2,100	20	5,800 (83)
LU-70/D (Coated)	24.0	2,100	20	5,400 (77)
LU-100	24.0	2,100	20	9,500 (95)
LU-100/D (Coated)	24.0	2,100	20	8,800 (88)
LU-150/100	24.0	2,100	20	16,000 (107)
LU-150/55	24.0	2,100	20	16,000 (107)
LU-150/55/D (Coated)	24.0	2,100	20	15,000 (100)
LU-200	24.0	2,100	20	22,000 (110)
LU-250	24.0	2,100	20	27,500 (110)
LU-250/D (Coated)	24.0	2,100	20	26,000 (104)
LU-250/S	24.0	2,100	20	30,000 (120)
LU-310	24.0	2,100	20	37,000 (119)
LU-400	24.0	2,100	20	50,000 (125)
LU-400/D (Coated)	24.0	2,100	20	47,500 (119)
LU-1000	24.0	2,100	20	140,000 (140)
UNALUX HPS "RETROFIT" LAG BALLAST			**Fair**	**Excellent**
ULX-150 (175W Merc. Ballast)	12.0	1,800	20	13,000 (87)
ULX-150/D (Coated)	12.0	1,800	20	12,000 (80)
ULX-215 (250W Merc. Ballast)	12.0	2,000	20	20,000 (93)
ULX-360 (400W Merc. Ballast)	16.0	2,060	20	38,000 (106)
ULX-360-D (Coated)	16.0	2,060	20	36,000 (100)
ULX-880 (1000W Merc. Ballast 480 Volt Reactor)	12.0	2,100	20	102,000 (116)

* Average life based on 10 hours per start. Values are approximate, consult your Sylvania Representative or IES Handbook.

** (LPW) stands for LUMENS PER WATT, a common denominator for comparing energy efficiency. Ballast loss not included.

CHARACTERISTICS OF SYLVANIA LAMPS[(1)]

	TUNGSTEN HALOGEN INCANDESCENT	FLUORESCENT	MERCURY	METALARC	LUMALUX	LOW PRESSURE SODIUM
LUMENS PER WATT	6-23	25-84	30-63	68-125	77-140	137-183
LUMENS	40-33,600	96-15,000	1,200-63,000	12,000-155,000	5,400-140,000	4,800-33,000
MAINTENANCE %	75-97	75-91	70-86	73-83	90-92	75-90*
WATTAGE RANGE	6-1,500	4-215	40-1,000	175-1,500	70-1,000	35-180
LIFE	750-8,000	9,000-20,000	16,000-24,000+	1,500-15,000	20,000-24,000	18,000
COLOR TEMPERATURE	2,400-3,100	2,700-6,500	3,300-5,900	3,200-4,700	2,100	1,780
COLOR RENDITION	95-99	55-95	22-52	65-70	21	0
COLOR BREADTH OF APPLICATION	Good	Good	Fair	Good	Fair	Poor
CONTROL	Excellent	Poor	Fair	Fair to Good	Good	Poor
INITIAL COST (PER LAMP)	Low	Moderate	Moderate	High	High	Moderate
OPERATIONAL COST (POWER)	High	Moderate	Moderate	Low	Low	Low
BREADTH OF APPLICATION	Wide	Wide	Medium	Medium to Wide	Narrow	Narrow

(1) General Lighting Types

*Lumen per watt maintenance

APPLICATIONS
LIGHT SOURCE SELECTOR GUIDE

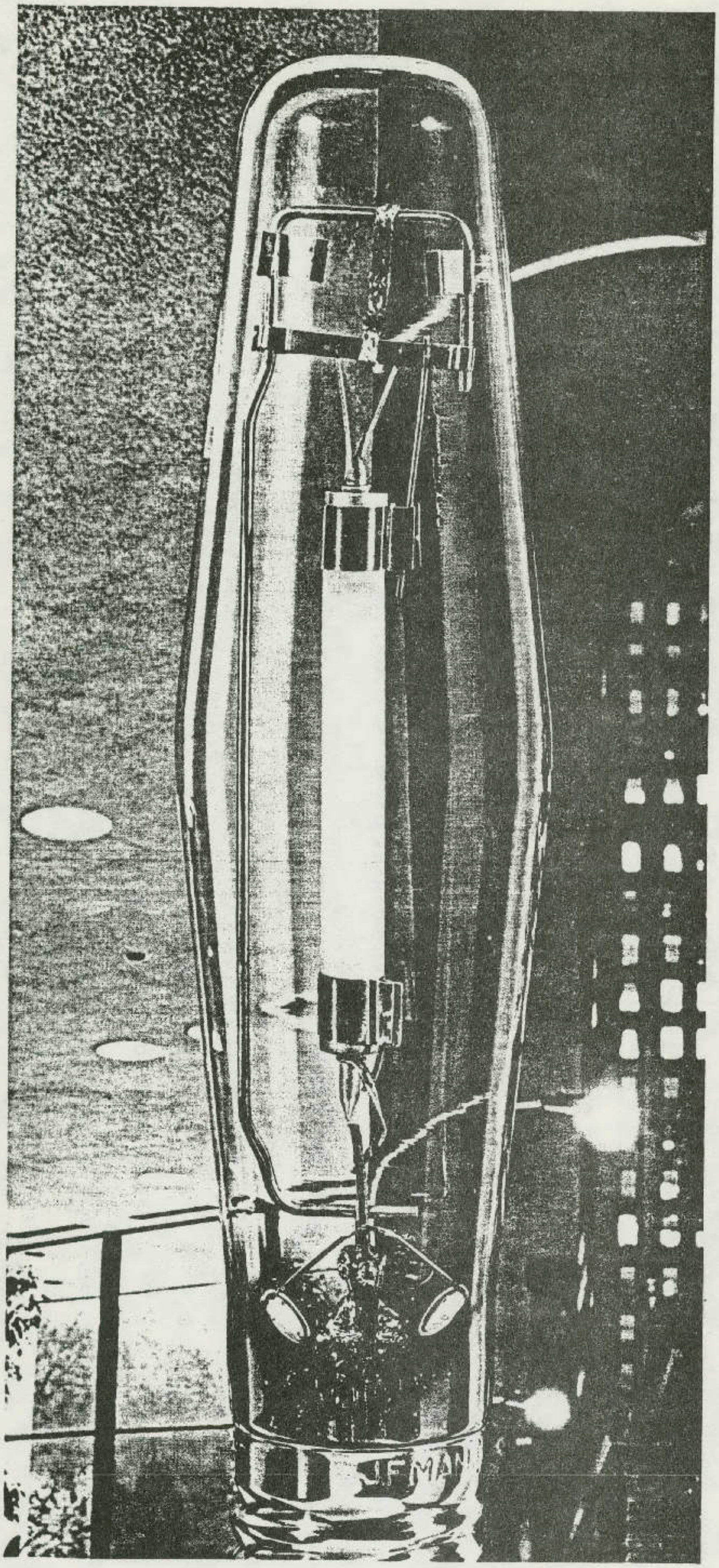
CHARACTERISTICS OF SOURCES ➧	HIGH COLOR FIDELITY (color rendering)			EFFICIENCY (lumens per watt) (initial)			LUMEN MAINTENANCE (mean lumens)			RATED AVG. LIFE (hours)			DEGREE OF LIGHT CONTROL			INPUT POWER REQ'D. (for equal light)				SYSTEM OPERATING COST (for equal light)			INITIAL EQUIPMENT COST (for equal light)			TOTAL OWNING & OPERATING COST		
RELATIVE RATINGS OF SOURCES ➧	VERY IMPORTANT	IMPORTANT	UNIMPORTANT	HIGHEST (80 UP)	MEDIUM (50-80)	LOWEST (15-50)	HIGHEST (85% UP)	MEDIUM (75-85%)	FAIR (65-75%)	SHORTEST (5000 or less)	INTERMEDIATE (5000-15000)	LONGEST (15000-25000)	HIGHEST	INTERMEDIATE	LOWEST	HIGHEST	HIGH	INTERMEDIATE	LOWEST	HIGHEST	INTERMEDIATE	LOWEST	HIGHEST	INTERMEDIATE	LOWEST	HIGHEST	INTERMEDIATE	LOWEST
INCANDESCENT	●					●		●		●			●			●				●					●	●		
TUNGSTEN-HALOGEN	●					●	●			●			●			●				●					●	●		
FLUORESCENT	●				●			●				●			●			●			●			●			●	
CLEAR MERCURY			●		●			●				●	●				●				●			●			●	
COATED MERCURY		●			●			●				●		●			●				●			●			●	
CLEAR METALARC	●			●				●			●		●						●			●		●				●
COATED METALARC	●			●					●		●			●					●			●		●				●
CLEAR LUMALUX			●	●			●					●	●						●			●	●					●
COATED LUMALUX			●	●			●					●		●					●			●	●					●
CLEAR UNALUX			●	●			●				●		●						●			●		●				●
COATED UNALUX			●	●			●				●			●					●			●		●				●

NOTE: DOT INDICATES THAT THE LIGHT SOURCE EXHIBITS THE LISTED CHARACTERISTICS

HOW TO USE THE SELECTOR GUIDE:

1. Determine which characteristics are important.
2. Example . . . "How important is good color rendition (high color fidelity)"?
3. Repeat this procedure for each characteristic which you feel is necessary or desirable for your application.
4. Select the source or sources which exhibit most or all of the characteristics which you have specified.
5. Make trade offs; i.e., longer life for lower efficiency or poorer color fidelity for higher efficiency, when you feel this makes more sense.

NOTE: The selector guide does not cover all lamps in each product family but rather indicates characteristics of those sources most widely used in commercial and industrial application.



Westinghouse Lamp Information Bulletin

CERAMALUX 4 Lamp

The indoor light with outdoor economy.
The outdoor light with indoor color.
TM

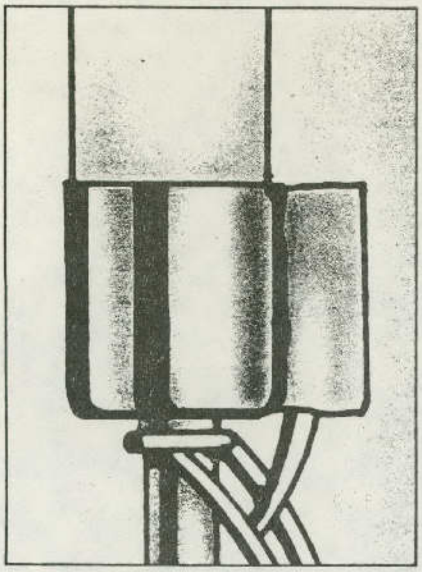
The Ceramalux-4™ high pressure sodium lamp features good color rendition in addition to the high efficacy normally associated with Ceramalux™ lamps, making it a highly desirable new light source for a wide variety of applications both indoors and outdoors.

The HPS lamp that breaks the "color barrier."

The C250S50/DX4 lamp, the first of a line of Ceramalux-4 lamps, exhibits superior color rendering properties. Its color rendering index (CRI) is 65, compared to 25 for standard Ceramalux lamps. The CRI is about equivalent to the value of the Cool White fluorescent lamp with CRI of 67, and superior to the Warm White fluorescent lamp with a CRI 53. It surpasses other HID type lamps. For example, the deluxe mercury lamp has a CRI about 50 and the metal halide lamp about 55.

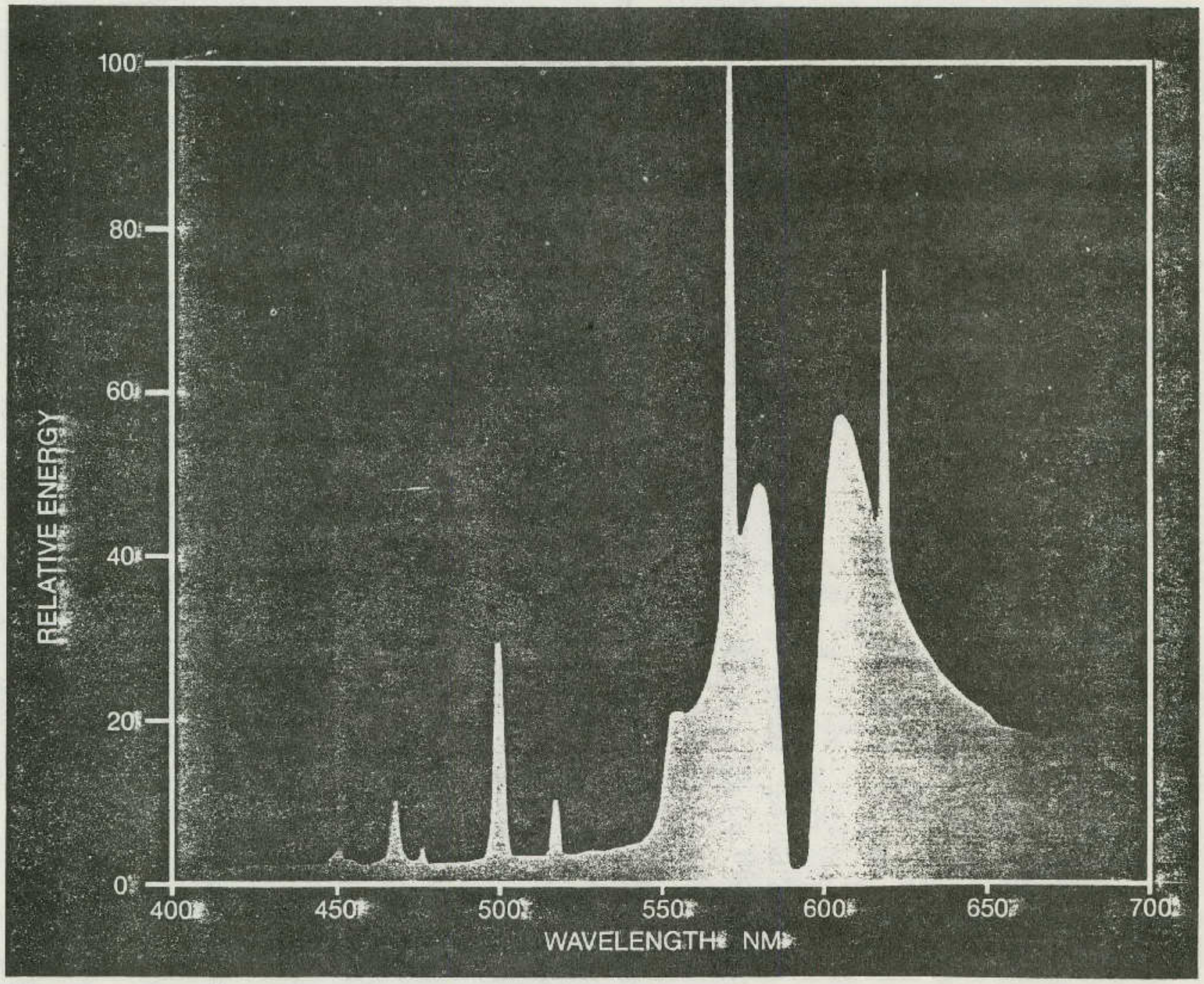
This very favorable CRI, coupled with an initial rated output of 25,000 lumens, or 100 LPW, and an initial rated average life of 7,500 hrs. are what make the new Ceramalux-4 lamp such an ideal and versatile light source.

Ideal for interior *and* exterior use in a wide variety of applications: industrial operations, schools, commercial buildings, institutions, public buildings, merchandising, sports fields, arenas, parking lots, floodlighting, streets and highways, and security.



Improved Color Rendition: The Secret's in the Seal.

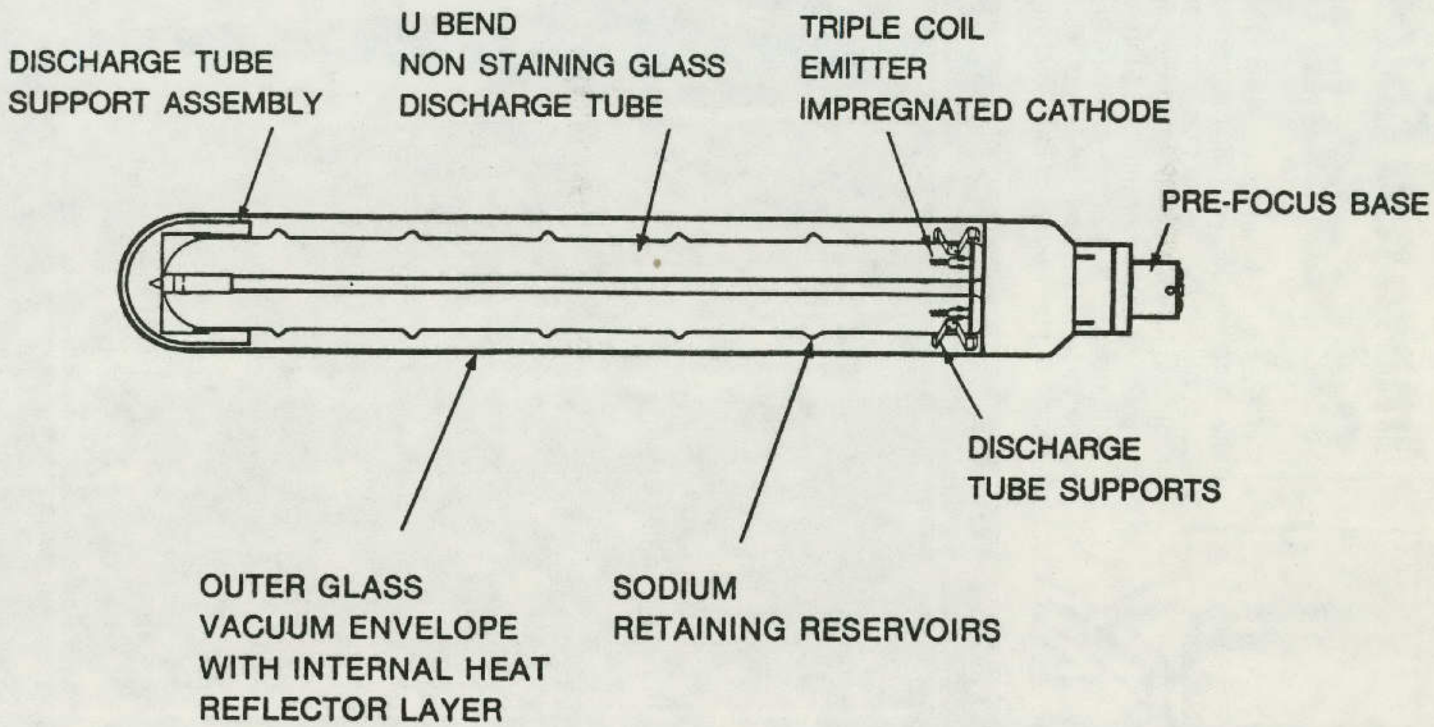
Ceramalux-4 lamps appear very similar in construction to the standard line of Ceramalux lamps. However, there is one very significant built-in difference that is not immediately apparent to the eye. This involves a major breakthrough in the seal joint between the aluminum oxide, ceramic arc tube material and the niobium metal conductor. This major improvement permits the higher temperature operation of the seal that is required to achieve the improved color rendering properties of the Ceramulux-4 lamp without seal failure.



Spectral Power Distribution

This chart graphically illustrates the improved color rendering properties of the Ceramalux-4 high pressure sodium lamp. The increased energy content in the violet, blue, green and particularly the orange and red portions of the spectrum relative to the yellows, materially improves the CRI of the Ceramalux-4 lamp.

Low Pressure Sodium



HIGH PRESSURE SODIUM LAMPS—SON

Product Code	Abbreviated Symbol	Standard Packaging Qty	Standard Packaging Wt. Lbs.	Description	Life	Approximate Lumens Initial	Approximate Lumens Mean
70 WATTS							
09350	LU70°	24	9.5	Clear—Burn any Position	24,000	5,800	5,250
09349	LU70D/D°	24	9.5	Diffuse Coated—Burns any Position	24,000	5,450	4,930
100 WATTS							
09319	LU100	24	9.5	Clear—Burn any Position	24,000	9,500	8,550
09314	LU100/D	24	9.5	Diffuse Coated—Burn any Position	24,000	8,700	8,040
150 WATTS							
09320	LU150/55	24	9.5	Clear—Burn any Position	24,000	15,800	14,850
09313	LU150/55/D	24	9.5	Diffuse Coated—Burn any Position	24,000	14,850	13,960
09321	LU150/100	12	7.0	Clear—Burn any Position	24,000	15,400	14,000
200 WATTS							
09307	LU200°	12	7.0	Clear—Burn any Position	24,000	22,000	19,800
250 WATTS							
09305	LU250	12	7.0	Clear—Burn any Position	24,000	27,500	25,500
09309	LU250/D	12	7.0	Diffuse Coated—Burn any Position	24,000	25,500	23,500
310 WATTS							
09360	LU310°	12	7.0	Clear—Burn any Position	24,000	37,000	33,300
400 WATTS							
09306	LU400	12	7.0	Clear—Burn any Position	24,000	50,000	46,500
09310	LU400/D	6	6.0	Diffuse Coated—Burn any Position	24,000	47,500	43,500

RETROFIT HIGH PRESSURE SODIUM LAMPS—SON-H

These lamps are designed for direct replacement of existing mercury vapor lamps in installations employing lag type autotransformer ballasts or 240V-277V reactor ballasts.

Product Code	Abbreviated Symbol	Standard Packaging Qty	Standard Packaging Wt. Lbs.	Description	Life	Approximate Lumens Initial	Approximate Lumens Mean
150 WATTS (for 175 watt mercury circuits)							
09372	LU150-H	12	7.0	Clear—Burn any Position	12,000	12,000	10,400
09365	LU150-H/D	12	7.0	Diffuse Coated—Burn any Position	12,000	11,000	9,400
215 WATTS (for 250 watt mercury circuits)							
09366	LU215-H°	12	7.0	Clear—Burn any Position	12,000	20,000	18,000
09367	LU215-H/D°	12	7.0	Diffuse Coated—Burn any Position	12,000	18,500	16,500
360 WATTS (for 400 watt mercury circuits)							
09368	LU360-H°	6	6.0	Clear—Burn any Position	16,000	38,000	35,000
09369	LU360-H/D°	6	6.0	Diffuse Coated—Burn any Position	16,000	36,000	32,600

°Available after March 1, 1979

LOW PRESSURE SODIUM LAMPS—SOX

Product Code	Abbreviated Symbol	Standard Packaging Qty	Standard Packaging Wt. Lbs.	Description	Life	Approximate Lumens Initial	Approximate Lumens Mean
18 WATTS							
09299	SOX 18	20	8.0	Clear	10,000	1,800	1,800
35 WATTS							
09300	SOX 35	12	10.0	Clear	18,000	4,800	4,800
55 WATTS							
09301	SOX 55	9	10.75	Clear	18,000	8,000	8,000
90 WATTS							
09302	SOX 90	9	15.00	Clear	18,000	13,500	13,500
135 WATTS							
09303	SOX 135	9	24.00	Clear	18,000	22,500	22,500
180 WATTS							
09304	SOX 180	9	39.75	Clear	18,000	33,000	33,000

Printed in U.S.A.

CS-222

North American Phillips Lighting Corporation
Bank Street, Hightstown, N.J. 08520 (609) 448-4000

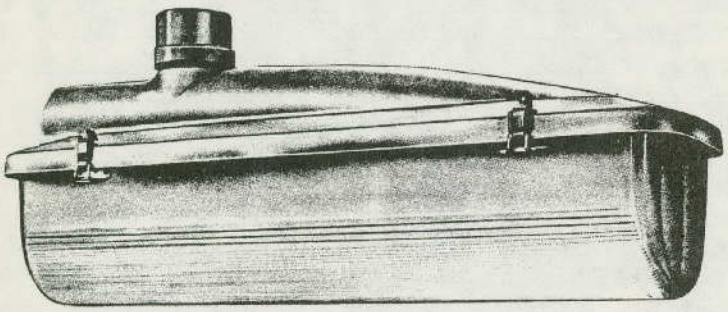
Norelco®

SPECIFICATION SHEET

NORTH AMERICAN PHILIPS LIGHTING CORPORATION

Type: Low Pressure Sodium Roadway Luminaire (SRX-114)

35/55 WATT SOX 4800/8000 LUMENS



Made in U.S.A.

Norelco Low Pressure Sodium SRX-114 luminaire combines attractive appearance with outstanding optical performance. Fixtures are cast aluminum construction with prismatic polycarbonate refractors.

HOW TO ORDER

Wattage	Ordering[a] Code	Lamp Lumens	Volts[b]	Ballast Type	Fixture[c] Wt. Lbs.
35/55	33155	4800/8000	120/240	HX-HPF	16
35[d]	09300	4800	SOX-35 LOW PRESSURE SODIUM LAMP		
55	09301	8000	SOX-55 LOW PRESSURE SODIUM LAMP		

(a) Jumper cap is included for continuous operation of fixture.
(b) 120/240 volt units are factory wired 120 volts; fixtures can be reconnected easily in field for 240 volts. Other voltages available on request.
(c) including ballast assembly, less lamp.
(d) Sox 35W and Sox 55W lamps are electrically interchangeable.

Note: Lamps must be ordered separately.

HOW TO SPECIFY

LUMINAIRE HOUSING shall be of high quality, corrosion resistant die cast aluminum providing mounting for all electrical components as well as Tenon (mounting arm) securing.

LUMINAIRE FINISH shall be aluminum gray.

HARDWARE shall be stainless steel or cadmium plated.

REFLECTOR shall be high gloss white enamel internal surface of housing.

REFRACTOR shall be moulded prismatic polycarbonate, hinged and secured with spring clips for rainwater water tightness.

LAMP SOCKET shall have spring-loaded nickel plated contacts.

GASKET shall be of high temperature neoprene rubber providing continuous interface between housing and refractor.

BALLAST shall be H.P.F. type, suitable for high ambient temperature operation and mounted on luminaire housing for maximum heat dissipation and ease of field maintenance.

SLIPFITTER shall allow leveling adjustment and provide two position securing by means of locking screws. Suitable for minimum 5" straight Tenon of 1-5/8" O.D. to 2-3/8" O.D.

MAXIMUM PROJECTED SQUARE AREA shall be 1.55 square feet.

Luminaire is supplied with an EEI-NEMA standard three terminal twist lock type photoelectric control receptacle and jumper cap.

OPTIONAL SPECIFICATIONS: Photoelectric control — voltage to be specified.

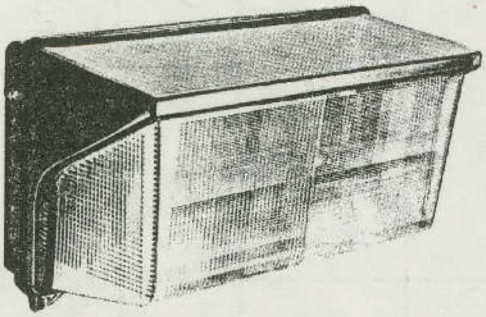
Norelco®

SPECIFICATION SHEET

NORTH AMERICAN PHILIPS LIGHTING CORPORATION

Type: Low Pressure Sodium Wall-Pack (SWP-465)

35/55 WATT SOX 4800/8000 LUMENS



Norelco Wall Packs are virtually maintenance free moulded polycarbonate and heavy die-cast aluminum construction.
The housing and refractor is one piece moulded prismatic polycarbonate material hinged and secured weather-resistant to rear aluminum mounting plate.
The luminaire is engineered for maximum utilization of light output and provides a wide area "Down and Out" type distribution.
The ballast is located on the rear mounting plate and concealed within fixture housing, eliminating unslightly external ballast housing.
The rear mounting plate provides access for surface conduit wiring and cast-in knock-outs for thru wall wiring as well as luminaire mounting points.
Standard finish is bronze.

Made in U.S.A.

HOW TO ORDER

Wattage	Ordering Code	Lamp Lumens	Volts (a)	Ballast Type	Fixture (b) Wt. Lbs.
35	33825	4800	120/240	HX-HPF	14
55	33826	8000	120/240	HX-HPF	15
35(c)	09300	4800	SOX 35 LOW PRESSURE SODIUM LAMP		
55	09301	8000	SOX 55 LOW PRESSURE SODIUM LAMP		

(a) 120/240 volt units are factory pre-wired for 120 volts; fixtures can be reconnected easily in field for 240 volts. Fixtures also available pre-wired for 208, 277 or 480 volts.
(b) Including ballast, less lamp.
(c) Sox 35W and Sox 55W lamps are electrically interchangeable.

NOTE: LAMP MUST BE ORDERED SEPARATELY.

HOW TO SPECIFY

LUMINAIRE HOUSING AND REFRACTOR: Shall be one piece moulded polycarbonate material with integral prismatic design for precise beam control. Housing and refractor shall be hinged and secured to rear mounting plate by means of screws for water tightness.

REAR MOUNTING PLATE: Shall be precision Die Cast corrosion resistant aluminum providing mounting for all electrical components.

LUMINAIRE FINISH: Shall be bronze, being internally applied to housing and externally applied to rear mounting plate.

REFLECTOR: Shall be of textured anodized aluminum.

LAMP SOCKET: Shall have spring-loaded nickel plated contacts.

GASKET: Shall be of high temperature neoprene rubber providing continuous interface between housing and rear mounting plate.

BALLAST: Shall be H.P.F. type, suitable for high ambient temperature operation, mounted on rear plate for maximum heat dissipation and ease of field maintenance.

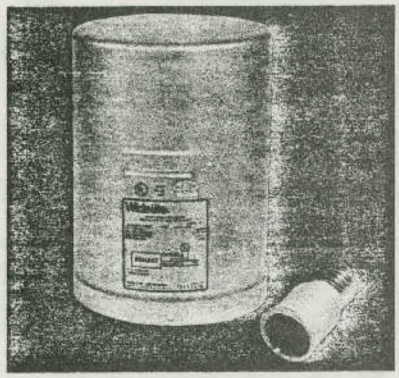
MOUNTING PROVISIONS: The rear mounting plate shall provide two side access holes tapped ½" NPS suitable for surface conduit wire entry. Shall also provide cast in knock-outs for alignment to standard recessed boxes for thru wall wiring.

Interchangeability of Lamps and Ballasts

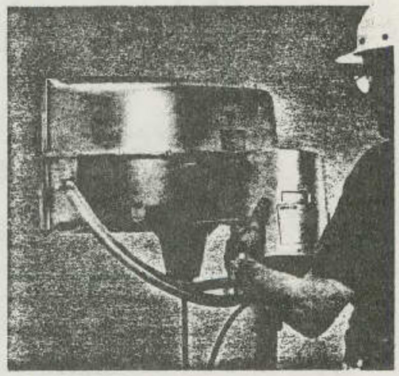
Ballast Types	LAMP TYPES: Lumalux	Unalux	Metalarc	Metalarc Swingline	Super Metalarc	Mercury
Standard HPS	OK	High Wattage Short Life	Unreliable Short Life	Unreliable Short Life	Unreliable Short Life	High Wattage Reduced Life
Metal Halide	NO	Short Life	OK	OK	OK	OK
CW or CWA no start capacitor	NO	Short Life or NO	NO	OK	NO	OK
CW or CWA with start capacitor	NO	Short Life or NO	NO	NO	NO	OK
Lag Mercury autotrans-former	NO	OK	NO	NO	NO	OK
Mercury reactor	NO	OK	OK*	NO	OK*	OK

*Only on 480 Volt Reactor, down to +50°F for 1000 Watt Lamps to -20°F for 175, 250, 400, Watt Lamps.

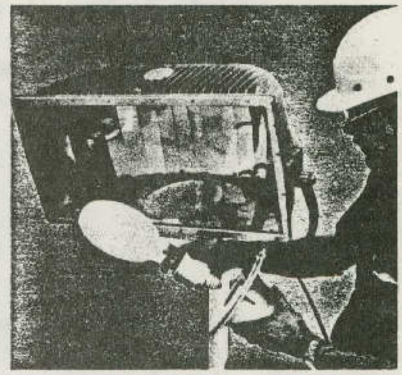
Retrofit kit converts F Series mercury floodlights to lower wattage HPS quickly, economically.



The retrofit kit consists of a replacement ballast for diffuse high pressure sodium lamp. (Socket extender provided for 400w HPS lamp only.)



All you do is remove three screws, replace the old ballast enclosure with the new, and make electrical connections . . .



. . . remove the flower pot, discard old mercury lamp. Then screw in the new HPS lamp, and replace the flower pot. That's it.

Now you can easily convert any F-1000 or F-400 mercury vapor floodlight to lower wattage high pressure sodium. Cut your power load 60% with equal light ouput with 400w HPS compared to 1000w mercury. Or replace 400w mercury with 250w HPS and get 50% more light for 40% less load.

Fast payback

Savings add up fast. This chart indicates what you save at different KWH/rates.

Savings Fixture/Year

KWH/Rate	400w HPS vs. 1000w mercury	250w HPS vs. 400w mercury
$.025	$ 60.50	$ 15.00
.030	72.60	18.00
.035	84.70	21.00
.040	96.80	24.00
.045	108.90	27.00
.050	121.00	30.00

(Savings based on 4000 hr/yr operation)

Excellent distribution

The diffuse HPS replacement lamp works equally well with any type F Series reflector. (See isolux diagrams.) A socket extender is provided for 400w HPS lamp for proper photometric alignment; none is required for 250w HPS lamp.

Ordering Guide

400w	250w
400-RKS-QV*	250-RKS-QV*
400-RKS-480v	250-RKS-480v

*120/208/240/277v taps

400w kit includes socket extender (not required for 250w).

Lamp Requirement

Kit requires one of the following diffuse HPS lamps for proper light distribution. (Lamp not included.) G.E. LU400D/BD or LU250D/BD Sylvania LU400/D or LU250/D

3-Year Warranty

Ballast is covered by Wide-Lite's standard published three-year limited warranty.

Wide-Lite®

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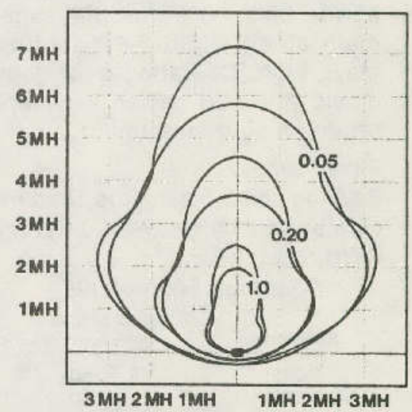
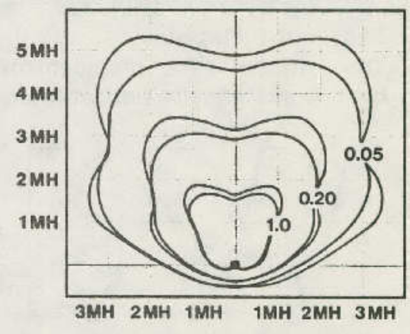
Isolux diagrams

Based on mean lumens

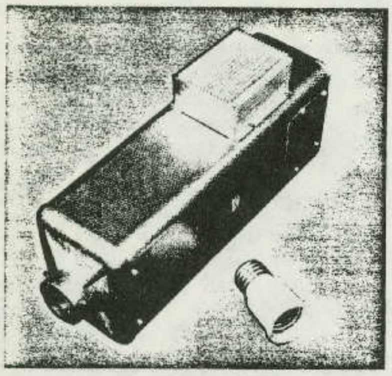


F-1000-B with 1000w DX mercury lamp
F-1000-B with 400w diffuse HPS lamp
Mt. Ht.: 40' Aiming Point: 120'

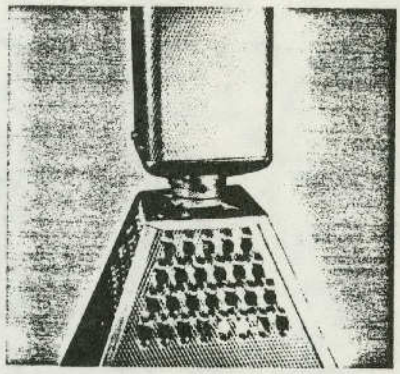


F-1000-A with 1000w DX mercury lamp
F-1000-A with 400w diffuse HPS lamp
Mt. Ht.: 40' Aiming Point: 80'

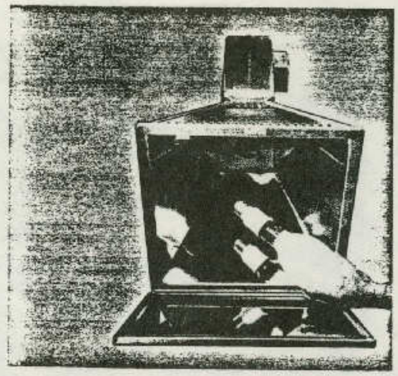
Retrofit kit converts ID and IL Series Luminaires from 1000w mercury to 400w HPS quickly, economically.



Retrofit kit consists of replacement ballast and socket extender for the 400 watt diffuse high pressure sodium lamp. (Lamp is not included.)



Keyed, slip-in ballast-to-fixture contact makes ballast change-out simple. Just slide in the new ballast, secure three locking set screws and reconnect branch circuit wiring.



The hinged lens assembly permits relamp from below. Because the optical assembly is sealed from the atmosphere, merely clean the outer lens surface to restore fixture to like-new condition.

Now you can easily convert any ID-1000 or IL-1000 mercury vapor luminaire to 400 watt high pressure sodium and reduce your power bills 60% for the same maintained light. Production stays high. Operating cost goes down. And you get an excellent return on your investment.

Fast Payback

Savings add up fast. This chart indicates what you save at different KWH/rates.

Savings Fixture/Year

KWH/Rate	400w HPS vs. 1000w mercury
\$.025	\$ 60.50
.030	72.60
.035	84.70
.040	96.80
.045	108.90
.050	121.00

(Savings based on 4000 hr/yr operation)

Excellent Distribution

The diffuse HPS replacement lamp works equally well with any type IL or ID Series reflector - specular or diffusing. A socket extender is provided for proper photometric alignment.

Ordering Guide

Catalog No./ Voltage	Ballast Type
400-IDS-120-RKS	Regulating, HPF
400-IDS-208-RKS	Regulating, HPF
400-IDS-240-RKS	Regulating, HPF
400-IDS-277-RKS	Regulating, HPF
400-IDS-480-RKS	Regulating, HPF
400-IDS-480R-RKS	Reactor, HPF

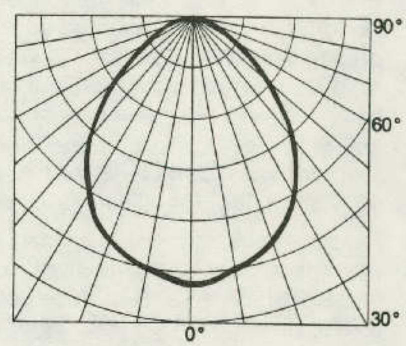
Lamp Requirement

Kit requires a G.E. or Sylvania LU400/D diffuse high pressure sodium lamp. Lamp is not included.

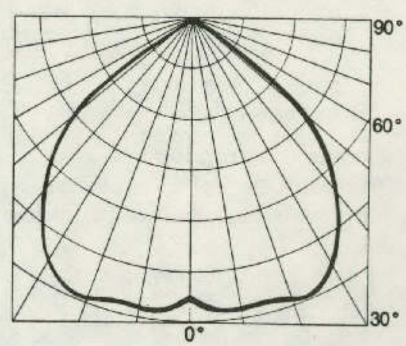
3-Year Warranty

Replacement ballast is covered by Wide-Lite's standard published three-year limited warranty.

Typical Candlepower Distribution



ID-1000-A (specular reflector) with 400 watt diffuse HPS lamp



ID-1000-C (diffusing reflector) with 400 watt diffuse HPS lamp

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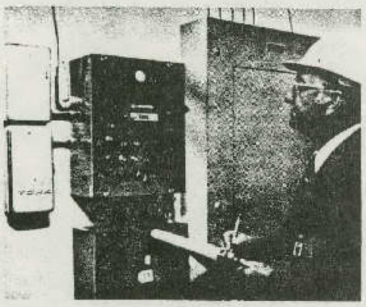
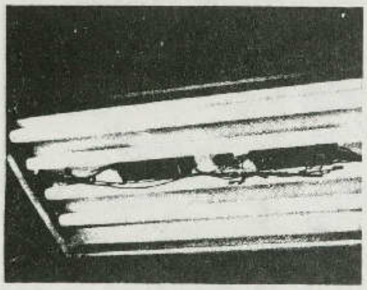
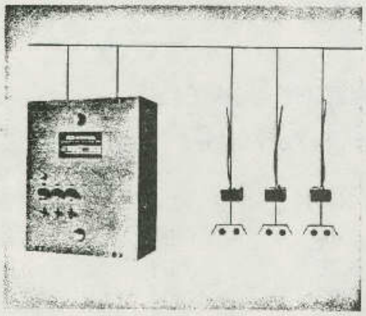
System Components*



Transmitter with timer control



Fixture modified with receiver



Existing lighting circuitry carries control signal from transmitter to receiver.

* All components UL listed

Energy Control Device Operational Instructions

Manual Operation:

Consists of using the toggle switches located on the E.C.D. control panel or a convenient remote location, for on/off operation of fixtures having E.C.D. control.

Automatic Operation:

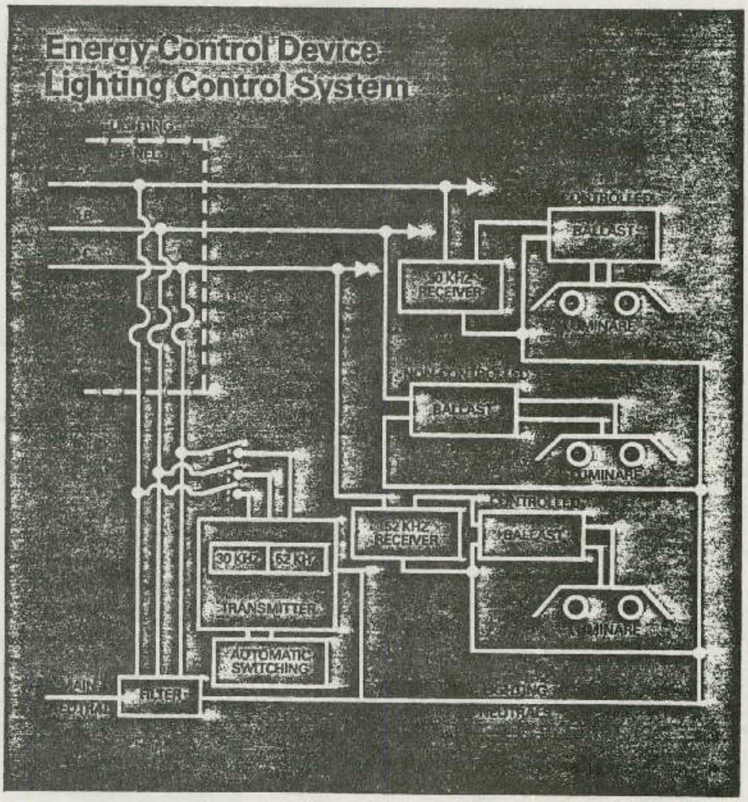
Consists of controlling on/off operation by use of automatic devices:

1. Timing devices are set to trigger the fixtures having E.C.D. control on/off at your choice of hourly operation. Time changes are easily accomplished should your hours of operation change.
2. Computer control gives maximum utilization of the E.C.D. system with exact timing, flexibility to control power increases and load shedding capability.

Override Capabilities

1. In all methods of automatic operation, if the E.C.D. controlled lighting should be off, manual override is possible with the toggle switch at the control panel.
2. Should the lights be on (in the automatic mode) they can be turned off by use of the manual switch on the control panel.

Note: Any change from the automatic mode must be corrected before automatic switching is again in control.



Energy Control Device Savings on F40 Lamps

I. 2-F40CW Lamps & 1 Ballast = 92W

ECD Controlled (5.5 Days/Wk)		Annual Savings Per Fixture				
Hrs/Day	Hrs/Yr	(KWH)	3¢/KWH	4¢/KWH	5¢/KWH	6¢/KWH
5	1430	131.6	3.95	5.26	6.58	7.90
7	2002	184.2	5.53	7.37	9.21	11.05
9	2574	236.8	7.10	9.47	11.84	14.21
11	3146	289.4	8.68	11.58	14.47	17.36

II. 4-F40CW Lamps & 2 Ballast = 184W

ECD Controlled (5.5 Days/Wk)		Annual Savings Per Fixture				
Hrs/Day	Hrs/Yr	(KWH)	3¢/KWH	4¢/KWH	5¢/KWH	6¢/KWH
5	1430	263.2	7.90	10.52	13.16	15.79
7	2002	368.4	11.06	14.74	18.42	22.10
9	2574	473.6	14.20	18.94	23.64	28.42
11	3146	578.9	17.37	23.15	28.94	34.73

III. 2-F40CW/SS Lamps & 1 Ballast = 78 W (Super Savers)

ECD Controlled (5.5 Days/Wk)		Annual Savings Per Fixture				
Hrs/Day	Hrs/Yr	(KWH)	3¢/KWH	4¢/KWH	5¢/KWH	6¢/KWH
5	1430	111.5	3.35	4.46	5.58	6.69
7	2002	156.2	4.69	6.25	7.81	9.37
9	2574	200.8	6.02	8.03	10.04	12.05
11	3146	245.4	7.36	9.82	12.27	14.72

IV. 4-F40CW/SS Lamps & 2 Ballast = 156W (Super Savers)

ECD Controlled (5.5 Days/Wk)		Annual Savings Per Fixture				
Hrs/Day	Hrs/Yr	(KWH)	3¢/KWH	4¢/KWH	5¢/KWH	6¢/KWH
5	1430	223.1	6.69	8.92	11.16	13.39
7	2002	312.3	9.37	12.49	15.62	18.74
9	2574	401.5	12.05	16.06	20.08	24.09
11	3146	490.8	14.72	19.63	24.54	29.45

LIGHTING

DOLLAR SAVING OPPORTUNITIES

NO/LOW COST

SURVEY WITH LIGHT METER

-REMOVE BULBS AND BALLASTS

-START USING ENERGY EFFICIENT BULBS

CLEAN BULBS

CLEAN FIXTURES

SET UP MANUAL LIGHTING SCHEDULE

RETROFIT

REMOVE FIXTURES

REWIRE SWITCHES

RETROFIT WITH ENERGY EFFICIENT BALLASTS

REPLACE INCANDESCENT FIXTURES WITH HID OR FLOURESCENT

REPLACE MERCURY WITH METAL HALIDE HPS, LPS

USE PHOTOCELLS

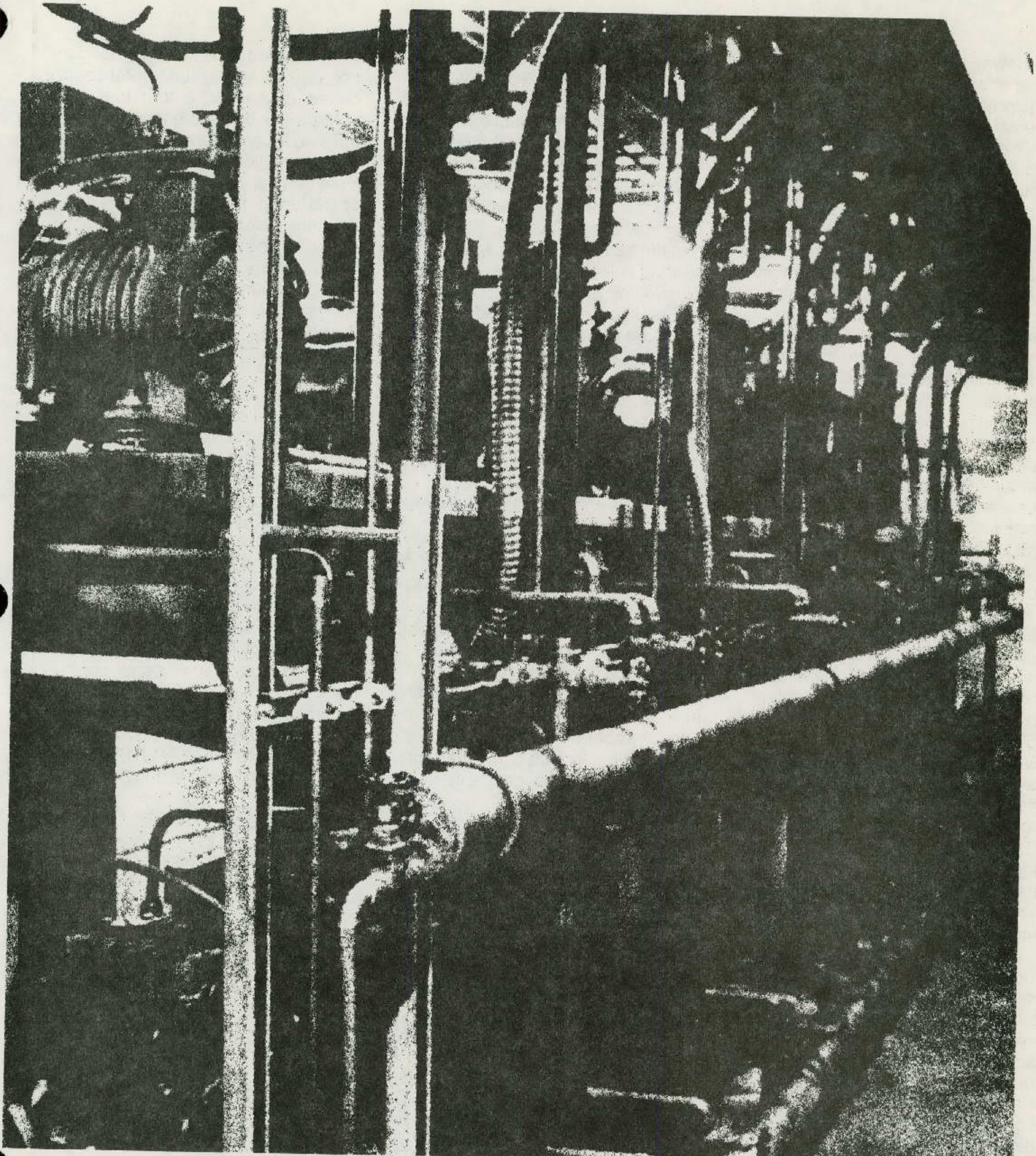
USE TIMERS

5

HVAC

HEATING, VENTILATING, AIR CONDITIONING

TABLE OF CONTENTS



Between 60 and 80 percent of your energy bill is attributable to equipment operated for environmental control—refrigeration, humidification, and heating, ventilating, and air-conditioning (HVAC) equipment. On the average, refrigerators and freezers alone account for 45 percent of your bill; refrigerator fans and anti-sweat heaters, another 12.5 percent; and HVAC equipment, 12.5 percent more.[1] While this equipment is responsible for the greatest energy use and demand charges on your electric bill, it also has the greatest potential for energy savings.

Retail grocery stores have special and costly environmental control needs. They are unique in that at certain times they must simultaneously heat the building and refrigerate food. In addition, refrigeration and HVAC equipment must meet the requirements of local and State building, health, and fire codes. Despite these complex and energy-using requirements, the potential for energy savings is significant, even for simple operations that cost almost nothing to carry out. For example, lowering your thermostat from 72° to 65°F in the winter will reduce your HVAC energy use by 18 percent per day. You can save 5 percent of the energy you now use just by adjusting your refrigerators. The OPERATION section of this chapter provides specific ideas on how to save energy by operating your environmental control equipment more efficiently on a daily basis.

The largest potential for energy and cost savings lies in maintaining your refrigeration and HVAC systems to prevent inefficiencies and costly breakdowns. A dirty air filter or coil can reduce HVAC efficiency by 50 percent or more. Dirty grilles in refrigerated cases can result in a rise of as much as 10°F in the temperature of stored products. The MAINTENANCE section of this chapter provides ideas and a list of items that should be cleaned, checked, or replaced periodically.

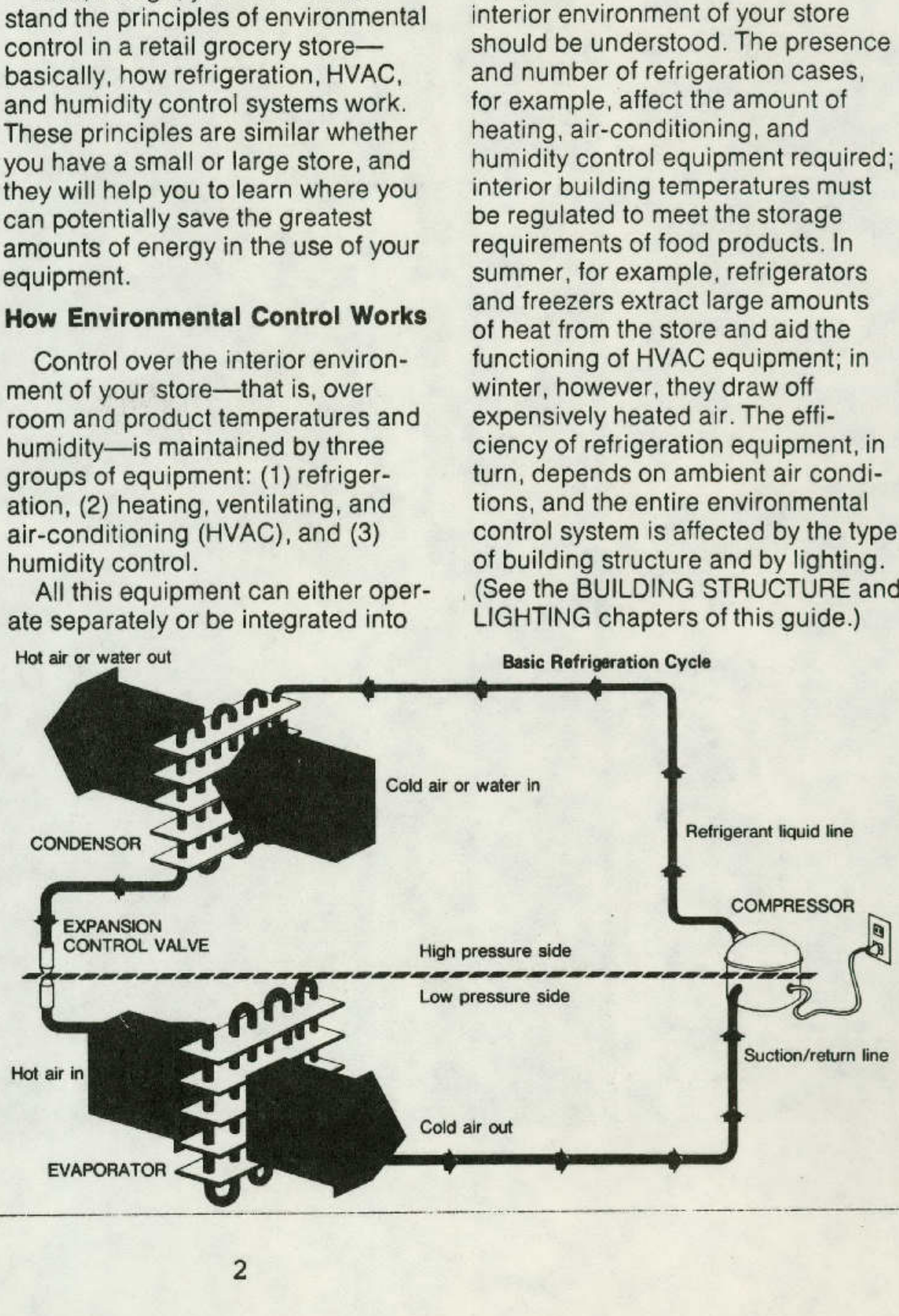
In the PLANNING section you will find energy-saving ideas having short payback periods; they should be looked into when you are conducting a major alteration or designing a new store. For example, environmental control systems that can reclaim heat can reduce winter heating bills up to 100 percent, depending on geographic location.

First, though, you should understand the principles of environmental control in a retail grocery store—basically, how refrigeration, HVAC, and humidity control systems work. These principles are similar whether you have a small or large store, and they will help you to learn where you can potentially save the greatest amounts of energy in the use of your equipment.

How Environmental Control Works

Control over the interior environment of your store—that is, over room and product temperatures and humidity—is maintained by three groups of equipment: (1) refrigeration, (2) heating, ventilating, and air-conditioning (HVAC), and (3) humidity control.

All this equipment can either operate separately or be integrated into what is called an environmental control system. An environmental control system is an HVAC system that controls not only store temperature but also humidity and air flow. This system provides an in-store environment that permits the most efficient operation of refrigerated cases. Whether your equipment operates separately or as a system, however, the interrelated nature of HVAC, humidification, and refrigeration equipment and their effects on the interior environment of your store should be understood. The presence and number of refrigeration cases, for example, affect the amount of heating, air-conditioning, and humidity control equipment required; interior building temperatures must be regulated to meet the storage requirements of food products. In summer, for example, refrigerators and freezers extract large amounts of heat from the store and aid the functioning of HVAC equipment; in winter, however, they draw off expensively heated air. The efficiency of refrigeration equipment, in turn, depends on ambient air conditions, and the entire environmental control system is affected by the type of building structure and by lighting. (See the BUILDING STRUCTURE and LIGHTING chapters of this guide.)



Refrigeration

Refrigeration equipment is the single most energy-using component of environmental control in retail grocery stores. Single-deck and/or multideck produce and meat display cases; delicatessen, dairy, and closed meat cases; walk-in coolers for dairy, meat, and produce; and low-temperature cases for frozen foods and ice cream—several or all of these may line store aisles. Furthermore, each case may have a different temperature requirement, which may mean as many as 15 to 20 different requirements in one store.

The simplest type of refrigerator consists of an evaporator, the refrigerant, a compressor, and a condenser. The drawing opposite shows a typical refrigeration cycle. A liquid refrigerant enters the evaporator, where it absorbs heat from the air and food products stored within the case. As it absorbs heat, the refrigerant turns from a liquid to gas. A compressor draws the heated gaseous refrigerant from the evaporator, compresses, and pumps it into the condenser. The condenser transfers the heat from the refrigerant to water or air and converts the refrigerant back to a liquid. The cooled liquid refrigerant is then metered by an expansion control valve into the evaporator coils. The lower pressure in these coils allows the liquid refrigerant to expand to a gas or evaporate. Because evaporation is a cooling process, the coils become cold and absorb heat from the refrigerator case and food products.

While actual refrigeration systems in retail grocery stores are considerably more complex than the system illustrated and may vary from it in detail, the operating principles are the same. Most large commercial refrigeration units have individually programmed defrost cycles, evaporator pressure regulators, and temperature controls. The refrigerant may be condensed by air-cooled units in separate air-cooled machine rooms, remote air-cooled condensers, closed water-cooling systems, or cooling towers. Common defrosting methods include condensing units or system shutoff, electric heat, vapor defrost, and air defrost.

HVAC Systems

Today, a majority of retail grocery stores are centrally air-conditioned by means of combined heating and cooling equipment. A typical central HVAC system draws in a small amount of fresh, outside air proportioned with air returning from the store. This air is drawn into ducts by a blower, then through filters to be cleaned of dust and other particles. The blower next forces air through a furnace when heating is required or through cooling coils when cooling and/or dehumidification is required. This conditioned air travels through ducts and enters the store through air-supply diffusers or vents.

Actual HVAC systems in retail grocery stores may be considerably more complex than the system just described. Several separately controlled HVAC systems may operate simultaneously, and heating or cooling may occur in several stages.

Humidity Control

Humidity is the water vapor or moisture content always present in the air. Controlling humidity is important to the energy-efficient and economical operation of a store. The increased demands on refrigeration, defrosting, and HVAC equipment caused by increased humidity raise operating costs and shorten product life. High humidity causes refrigeration equipment to "sweat," or accumulate moisture on exterior windows and other cold surfaces.

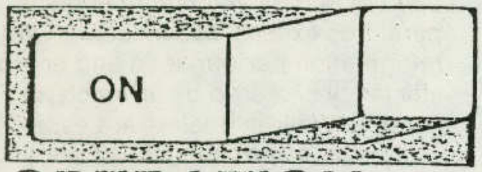
When relative humidity exceeds 55 percent and/or when ambient temperatures exceed design conditions, refrigeration performance and energy efficiency can drop by as much as 50 percent. Walk-in coolers are especially sensitive to humidity change: high relative humidity increases the possibility of bacteria growth; low relative humidity causes dehydration of stored food.

Customer and employee comfort is influenced by the humidity of the air as well. At comfortable shopping temperatures (65° to 75°F), relative humidities in the store should range between 20 and 55 percent. At temperatures greater than 75°F, high humidity makes the air feel warmer; at low temperatures, high humidity makes the air feel colder.

Environmental Control Systems

An environmental control system is no more than refrigeration, HVAC, and humidity control equipment integrated to utilize energy efficiently. Most present-day environmental control systems use reclaimed heat from refrigeration systems, underfloor duct returns for proper air distribution, and cooler floor-level air recirculated, to reduce air-conditioning requirements. Most often, an environmental control system reduces the energy required to operate the refrigeration equipment by providing the most efficient environment for operating refrigerated cases.

The heat reclaimed from the cases may then be used to heat the interior of the store, reheat chilled and dehumidified air, heat vestibules and water, and defrost the cases. Captured cold air may be used to cool the store and then to cool the attic space.



OPERATION

The following ideas can help you operate your environmental control equipment to save energy and substantially reduce your HVAC and refrigeration costs. Also, review manufacturer's operating instructions for your equipment; keep in mind the particular requirements of your store.

HVAC Systems

- Set thermostats* according to the following schedule:

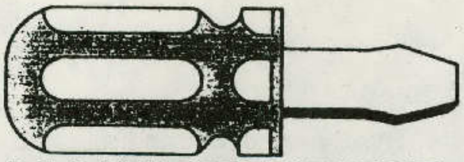
Location	Heating Months	Cooling Months
Sales Area	65°F when store is open unless your store is humidity controlled; if humidity controlled, lower the thermostat another few degrees. 60°F when store is closed.	75°F and 55 percent maximum relative humidity.
Back Rooms and Storage Areas	60°F maximum.	If air-conditioned, set the temperature not higher than 75°F.
Offices	68°F during working hours. 60°F after working hours.	78°F during working hours. 75°F after working hours.

- Install locked cages or other locking devices on thermostats.
- Do not let merchandise block heat ducts or registers.
- Maintain relative humidity between 20 and 55 percent.
- Turn off local exhaust fans, such as those used above a grill or fryer in a delicatessen when not required to save both the energy need to run the fan and the load on the HVAC system.
- Check the thermostat in your store against a correctly operating thermometer to insure that the heating and cooling systems reflect actual store temperatures.
- Adjust duct registers to give the most efficient air flow and balanced air distribution. Check especially that air is not blowing into refrigerated cases. For complex systems, the adjustment should be made by a professional service representative.
- Stagger startup times for individual HVAC units in order to reduce electrical demand and eliminate unnecessary cooling or heating during the hours before your store opens.

* Recommended settings are for thermostats positioned 7 feet above the floor; raise the setting 1°F for each additional foot above the floor.

- To moderate heating and cooling demands on the HVAC system, operate a dehumidifier in conjunction with the cooling system in the summer. Drier air can be tolerated at higher temperatures than humid air.
- Avoid firing up the entire heating system when heating is required only for short periods each day. Often, heat from lighting and customer movement will satisfy these requirements. Sensors in the heating system that sense the rate of outdoor temperature change are especially effective in avoiding unnecessary HVAC startup.
- Keep air supply diffusers and return air grilles free of litter. Blockage impairs the store's air distribution pattern.
- On warm days, when outdoor temperatures are greater than 75°F, start the cooling system early to avoid the simultaneous demand changes likely to occur when major energy-using equipment is started simultaneously upon opening.

By lowering temperatures in its stores, offices, and distribution centers, a New Jersey grocery chain has reduced its use of natural gas sufficiently to heat 160 single-family homes.



MAINTENANCE

Attention to seemingly trivial maintenance items can save substantial quantities of energy and dollars. Small, growing stores in particular may face financial collapse if their equipment breaks down for a day or two and ruins the stock of expensive perishable products—meat, frozen foods, produce, ice cream. Consulting manufacturers' recommendations for the proper maintenance of environmental control equipment and following through on these recommendations will prove to be the greatest asset to your energy and cost savings. Instituting a preventive maintenance program to keep your refrigeration, HVAC, and humidification equipment in the most energy-efficient operating condition will reduce your costs. Instructing store personnel and maintenance contractors to be on the lookout for energy-using abnormalities will also help. You should contact equipment manufacturers for maintenance guidelines and schedules for your own particular pieces of equipment; in addition, the following energy-saving maintenance suggestions are provided for your review. They are divided into two sections: refrigeration and HVAC.

Refrigeration Units

- Clean display fixtures, air- and water-cooled condensers, and cooling towers regularly. Change air filters monthly. Cleaning should include coils, fans, grilles, fins, plates, and waste outlets. Obtain and follow manufacturers' cleaning recommendations and maintenance schedules. Dirty fixtures and condensers increase compressor operating times and condensing temperatures and decrease cooling capacity. The reduction in air flow caused by dirty grilles can increase defrosting requirements and product temperatures by as much as 10°F.
- Remove discharge grilles in order to clean both sides.
- After cleaning, allow a case to return to normal operating temperature before replacing products.
- Regularly flush drains with pressure to prevent blockage and consequent ice buildup in the bottoms of fixures.
- Check all door seals and gaskets for cracks or other damage. A dollar bill inserted between the gasket and door frame should resist withdrawal when the door is closed. Make this test around all sides of the door, even the hinge side. Wash door seals regularly to prevent accumulation of debris and to keep gaskets resilient, lubricate door hinges and latches with food-grade oil monthly to enable doors to close easily.
- Check the operation of fan motors in all fixtures, especially multishelf equipment where broken motors can easily go unnoticed.
- Check the operation of all expansion valves; they should fully feed the evaporator. Check temperatures, bulb location, and head pressures.

- Check refrigerant; systems that have an insufficient amount of refrigerant will cause the compressor to run excessively. Insufficient refrigerant also indicates the presence of a leak that will ultimately cause a failure and possible product loss if not detected.
- If the unit has an automatic defrost cycle, periodically ask a trained service technician to adjust it to operate only when necessary. If you have a timed defrost system, set the defrost cycle so the freezer will defrost after operating hours when electrical demand is low and so that different units do not turn on simultaneously. If the unit does not have an automatic defroster, defrost as often as necessary to keep the evaporator free of frost.
- Level refrigerators and freezers so that (1) doors close automatically from an open position, (2) refrigerators operate properly, and (3) drains do not back up.
- Keep thermostats set to maintain desired temperatures; be sure thermometers read correctly.
- Periodically, and frequently for a new unit, feel the outside walls for cold spots. A cold spot indicates that the insulation has shifted or is waterlogged. Contact the manufacturer if you detect this problem.

HVAC

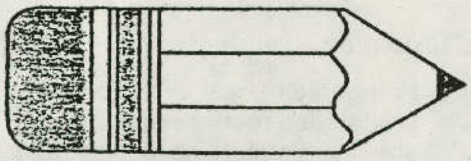
HVAC breakdowns and substandard performance are so costly in terms of energy and dollars—and their prevention so easy—that a checklist similar to the one provided here should be consulted monthly and the dates of these maintenance checks recorded.

Although this guide cannot show you precisely where to look and how to check your particular HVAC system, if you do not know how to locate and check the items noted on the list below, you can find instructions in the service manual for your system. Before doing any work on your HVAC system, DO NOT FORGET TO SHUT IT OFF! If possible, disconnect the electrical source.

HVAC MAINTENANCE CHECKLIST*

Monthly	Quarterly	Semiannually	Annually
change HVAC air filters	lubricate motors and bearings, including blower and fans, if required	check pulleys on all V-belts and fans for alinement and correct tension	check and repair all weatherstripping, caulking and glazing around HVAC casings; tape all joints and cracks in duct system
clean fresh air intake screens, supply diffusers, return air grilles	clean heating and cooling coils, duct systems, burners	have entire cooling system checked before summer use, and heating system checked before winter use	clean and vacuum blower compartment and assembly
check fan belts for frays, cracks, nicks	check blower compartment for dirt, and vacuum if necessary	check fan blades and drive couplings	check and tighten all bolts and screws, cabinets, brackets, and other HVAC components
brush off air-conditioner condenser coil	check and repair or replace damaged insulation around HVAC ducts, pipes, and vents	check for proper burner adjustments (air-to-fuel ratio)	check the ventilation to compressors and motor—these areas should be kept cool to reduce power use and increase equipment life
clean room thermostat bulbs or elements	check duct thermostats and remote sensoring bulbs for accuracy, and clean if necessary		adjust and balance system to avoid overheating and underheating various areas of store
	check operations or fans, dampers, and controls		
	check cooling towers for proper water and flows and operation		

* Maintain a file on all components of your HVAC system: serial number, purchase dates, and length of warranties.

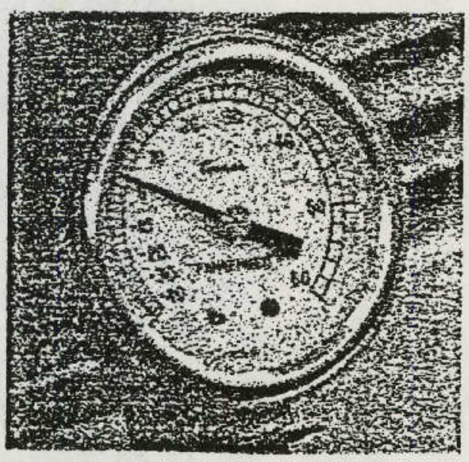


PLANNING

The following suggestions should be considered when you are replacing a piece of equipment, planning a renovation, or designing or building a new store. Energy considerations have the greatest payback at the planning stage because once your structure exists and your equipment is purchased, they largely determine the pattern of energy use. (See also the BUILDING STRUCTURE chapter of this guide.) Review trade journals for the last several years, obtain ideas from several manufacturers, and contact your trade association for information on the latest energy-saving innovations. The important thing to remember is that if your profits as a percentage of sales are 1 percent, then every dollar saved by energy conservation planning is equivalent to selling $100 of product.

According to many independent retailers, new construction or major remodeling presents the major opportunity for saving energy. A Platteville, Wisconsin, independent retailer is incorporating heat reclamation systems as its stores are remodeled, and significant savings in heating costs are expected.

The following energy-conserving suggestions are broken down into three categories: refrigeration, HVAC, and environmental control systems.



Refrigeration

Compressor/Condensing Units

- Locate refrigerators as close to compressors as possible. In long pipe runs, the resistance of the refrigerant to flow raises the head pressure and temperature, the result being a reduction in refrigeration capability and an increase in power requirements and operation cycles.
- Locate air-cooled condensers in areas where cool, fresh air is available. For each 10°F increase in air temperature, a unit loses 6 to 10 percent of its cooling capacity.
- Use individual compressors only to refrigerate cases and coolers operating at the same temperatures. A compressor used to run cases at different temperatures is usually less efficient than one that runs equipment at the same temperature.
- Consult manufacturer's engineering data for the most economical compressor size for each application.
- Investigate the economies of multiplexing or parallel refrigeration systems. When more than one compressor is used on a system, it is sometimes possible to shut off one of the compressors automatically and thereby reduce running times. The availability of qualified maintenance and engineering personnel is essential with this type of system.
- Eliminate electric condensate evaporators, like those found in self-contained cases, where possible. One energy-efficient alternative is a small condensate pump and a floor drain. If you have an entire section of self-contained cases, install one connecting drain line to a condensate pump or a floor drain. The energy saved will offer a quick payback.

Refrigerant Piping

- Keep in mind that correctly sized refrigerant lines are essential to the energy-efficient operation of refrigeration systems. Consult appropriate line-sizing charts and the refrigerator manufacturers' recommendations when purchasing new equipment.
- Allow for long radii in refrigeration lines for new pits and trenches, and eliminate as many extra right-angled elbows as possible. Sharp turns cause pressure to drop and thus waste energy.
- Check with manufacturers' representatives about insulating suction and liquid lines together to reduce power use and alleviate condensate drip.

Defrost

The most commonly used defrost methods are:

Condensing unit or system off-time, which simply shuts off the unit and allows it to remain off until the evaporator reaches a temperature that permits defrosting; in this way there is ample time for condensate to drain. The method is usually limited to those fixtures that maintain temperatures of 28°F or above.

Electric defrost, which employs a heater to warm, and thus defrost, the evaporator externally.

Vapor (or hot gas) defrost, which uses waste heat from the gaseous refrigerant to defrost the evaporator.

Air defrost, which uses warm store air forced by fans directly on to the evaporator.

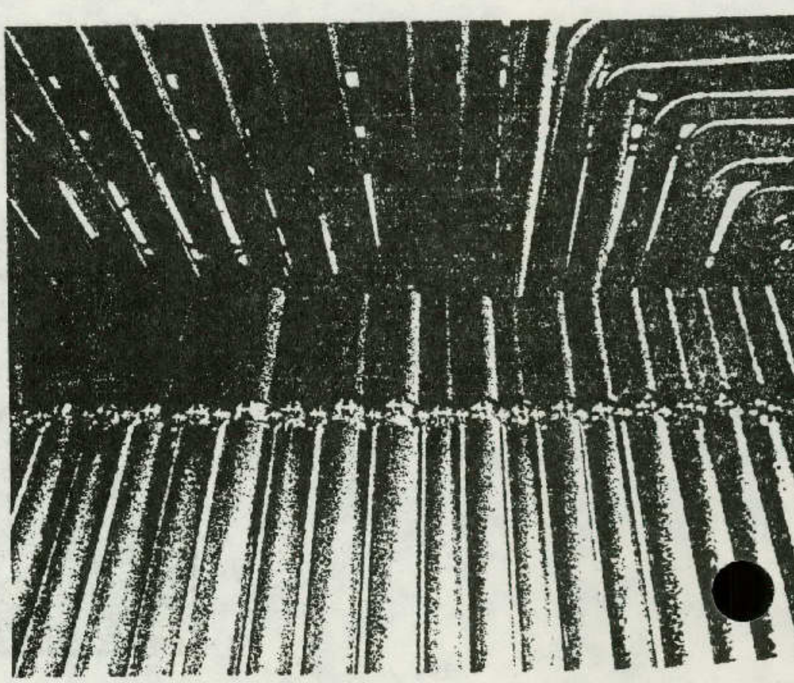
- Use demand defrost if your store is humidity controlled. Demand defrost is a method that automatically senses frost buildup and turns on the defrost system only when necessary. Consult the fixture manufacturer before specifying demand defrost. To avoid overdefrosting individual fixtures, use an automatic defrost-terminating device.
- On timed defrost systems, also use a defrost-terminating thermostat on each fixture.
- When refrigerating products that require temperatures of 32°F or higher, use off-time defrost rather than an added heat source where possible to do so without impairing product life. With existing equipment, disconnect the heater and reset the controls. Energy will be saved because the compressor does not operate and no electricity is used for defrost heaters.[5]

New Jersey stores have installed demand defrost units in their four-deck frozen food cases. This device has cut defrost requirements during winter months from one cycle every 8 hours to one every day and a half.

Insulation

- Refrigerated meat and produce preparation room ceilings, walls, and floors should have insulation adequate to reduce refrigeration costs. (See BUILDING STRUCTURE.)
- A variety of insulating materials is used for refrigerated equipment. Factors to consider when evaluating insulation are: overall heat transfer, water absorption, strength, fire retardation, and special bonding requirements.

Included in a new supermarket in Harleysville, Pennsylvania, are eight prefabricated walk-ins. "We specified walk-ins assembled from 4-inch thick, metal clad, solid core urethane panels and doors," the owners explain. "Three-inch thick panels normally used for supermarkets prefabs consume one-third more electricity than the thicker insulation because of temperature losses through the walls alone. Two-and-a-half inch panels require even more electricity."



HVAC

Items to consider when installing new HVAC equipment are enumerated below. However, as their application depends on factors specific to your type of facility and location, you should seek the advice of an HVAC engineer before choosing a new system. And, because HVAC systems for retail food stores pose unique problems and demands, you should find an engineer who specializes in HVAC design for these facilities.

Heating and cooling systems are usually designed on the basis of the worst weather conditions of the year in a locality. As these conditions are seldom reached, the systems are usually running at less than full capacity, which means they are not running efficiently.

The selection of heating and cooling systems for a particular facility is made primarily on the basis of its use. Before investing in any HVAC unit, attention should also be given to the following important factors:

- heat losses and gains through and around windows and building walls. (Refer to the BUILDING STRUCTURE chapter of this guide.)
- the heat added to the store when occupied by people.
- the type of external building materials. For instance, a flat-roofed building painted a dark color will absorb heat from the sun, possibly lowering heating costs in the winter, but adding to cooling costs in the summer.
- the heat added by lighting. (Refer to the LIGHTING chapter of this guide.)
- the heat removed by refrigeration.

With these factors in mind, consider the applicability of the following recommendations for your HVAC system.

- Moderate air in vestibules to temperatures slightly lower than that of the sales area in winter and slightly higher in summer. Vestibule air may be warmed by heaters, refrigeration waste heat, or heat trapped between the ceiling and the roof.
- In cooking and baking areas, install air supply and exhaust systems that are separate from the main HVAC system. Rather than exhausting air outdoors, install a filter where permitted. In areas where exhausts are required, supply balanced makeup air to the immediate area of the exhaust system.
- Selectively block off air-supply diffusers that blow directly into refrigerated cases, then rebalance the heating and cooling system.
- Carefully size and locate diffusers where they will not interfere with the operations of refrigerated fixtures. Locate outlets near the highest heating and cooling loads.
- Isolate storage rooms from the sales area by construcing a tight partition from roof to floor. Install return ductwork directly to the air handler from the sales area.
- Size return air ducts to accommodate the load. Undersized ducts impair efficiency and affect blower power.
- Install timing devices on heating and cooling equipment to prevent the simultaneous start of major pieces of equipment and to cut down on your electric demand charges.
- Consider insulating all heating and air-conditioning supply ducts to reduce power use and eliminate condensate drip from ducts in summer months. Seek the advice and experience of an insulation contractor.
- Consider attaching a dehumidification unit to your HVAC system to eliminate strain that high relative humidities place on display fixtures. Recovering and using waste heat from refrigeration systems as part of the dehumidification system will substantially reduce energy use.
- Deliver at least 75 percent of the total air supply to the front half of the sales area. Because of its large glass area, entrances, and concentration of customers at checkout stations, this section of the store has the greatest HVAC load.
- If you operate a large building or a facility that has simultaneous heating and cooling needs, consider installing several small HVAC units instead of a single large one for zone control over temperatures in various parts of the facility.
- Investigate the use of evaporative cooling units in place of a central HVAC system where the climate is dry. Because these units use water to cool the air, they do not require as much energy to operate as does a standard air-conditioner. Caution: Overhumidifying your store will cause refrigerators to use excess energy. The lower you set your humidistat, the less energy will be used.

- When purchasing window and other small, space-type air-conditioners, look for the Btu-per-watt or "Energy Efficiency Ratio" (EER) rating tag now required on all units. The rating indicates the efficiency: the higher the EER number, the better the efficiency.
- To improve air distribution, locate return air grilles near the floor, not on the ceilings or high on the walls. Sometimes, existing refrigeration trenches can be used as effective return air ducts to facilitate making this change during a renovation.
- Consider reclaiming a portion of the already conditioned air that is exhausted out of the building.
- Shorten compressor running times by installing economizer controls, which employ sensors inside HVAC ducts that are responsive to changes in outdoor temperatures and automatically open and shut dampers. This reduces ventilation in cold weather and increases it when warm.
- Consider installing thermostats having a fan position that allows the ventilation system to operate together with heating and cooling cycles. Increased air circulation can reduce the running times of heating and cooling systems.

Environmental Control and Heat Recovery

Environmental control systems, which integrate refrigeration and HVAC equipment, reduce energy use through efficient system design. They can also incorporate newly developed heat recovery devices designed to recover and use heat that has been expensively produced and would otherwise be wasted as it is expelled outdoors by cooling or refrigeration systems. Heat recovery devices are increasingly popular with retail grocery stores; most commonly recovered is waste heat from refrigeration systems, which can be used for both humidity control systems and winter heating.

This heat reclamation can save 30 percent and possibly as much as 100 percent, depending on heating costs, on the type of refrigeration system, heat recovery system, and climate. You should calculate payback for your particular facility based on realistic factors, including the number of hours your store operates, the complexity of the particular system, the quality of the building's insulation, and the local climate.

- Review with an HVAC expert the potential for installing heat reclamation systems to reclaim and recycle waste heat from refrigeration units for in-store winter heating, summer humidity control, and water heating.
- Reuse the cold air that is given off by open refrigerated cases by directing it through underfloor ducts to the air-conditioning handling unit, where it can be heated or further cooled as required and redistributed to air diffusers.
- Use a humidistat, and integrate it into the environmental control function of the HVAC.
- In stores where heat recovery from refrigeration equipment is not practical, try to relocate air-cooled condensers so that hot air from the condenser can be directed to building ducts. Because the existing condenser fan will probably not be large enough to circulate the additional air, a second fan may be required. Ducts and dampers may also be rearranged to direct cool exhaust air from the building to the condenser for cooling in summer.
- Consider ventilating ceiling plenums (the area between the roof and a dropped ceiling) in a way that exhausts the hot air that forms in these spaces in summer and reuses it in winter to heat back rooms or sales areas.
- Provide a means to control heat given off by lighting fixtures. Use lighting fixtures that have slots for drawing the return air into the ceiling plenum. This air can be exhausted in the summer and used for supplemental heat in the winter.

Demand Control Systems

Demand control systems are electrical devices (either computerized or noncomputerized) that control the power used in your store. They are designed to turn off equipment in order to lower peak electric demands. Demand control systems are being used experimentally in many large grocery stores in several major areas of the country. Contact grocery store trade associations and demand control system manufacturers for advice when considering this expenditure.

HVAC Systems

(N) 1. Avoid firing entire HVAC systems when only required for short periods of the day.

(N) 2. Investigate feasibility of changing environmental set points. Remember to make sure this does not have an adverse effect on your refrigeration equipment.

(L) 3. Establish a regular efficient maintenance schedule on all air handling equipment.

(C) 4. Consider reclaiming a portion of the already conditioned air that is exhausted out of the building.

(C) 5. When purchasing small units look for Btu-per watt or energy efficiency ratio.

(L) 6. Adjust outside air intake so as to only bring in minimum required by codes.

(C) 7. Insulate all ducts.

(N) 8. Keep temperature and humidity set points at optimum for refrigerator case and walk-in cooler operation.

Heating, Ventilating, and Air-Conditioning (HVAC Systems)

The environmental control system in a supermarket can take many forms. It may be a central system or it may be one or more rooftop-type units. The goal of this system is to maintain the store environment at specific levels for not only the people in the store, but also for the store's refrigeration equipment. This equipment may have been sized according to specific environmental temperature and humidity settings. If a change is made to that environment it may put a load on the refrigeration cases that they cannot handle.

Whatever the design of the environmental control system, its purpose is to provide treated air to the store's environment. This air must be cleaned, heated or cooled, and dehumidified.

In each system outside air is brought into the store. The requirement for outside air is necessary for ventilation. Generally speaking, proper ventilation requires about 10 percent outside air and about one complete air change in an hour. The outside air intake is usually a great energy waster in most stores due to the problem of improper adjustment or setting of the outside air dampers. The air brought in goes through a filtering section to be cleaned. After being cleaned the air passes through a heating and cooling section.

Proper humidity control is very important to the store's refrigeration equipment. Excessive humidity will cause increased running of defrost and anti-sweat equipment on the display cases. Humidity levels are kept down when excessive humidity is apparent by dehumidification of the air. Dehumidifying is a function of cooling air. As air is cooled the moisture condenses out of it because the air has been cooled to its dewpoint temperature.

The environmental control system in a store is very important and should be operated and maintained properly to be energy efficient. Filters should be kept clean, the fan should be in proper running condition, and the heating and cooling coils should be free of dirt so as to allow maximum heat transfer.

Supermarkets and the Triangle for Energy Efficiency

The modern supermarket is a highly specialized operation. It is unlike any other type of retail establishment and has its own unique heating and cooling requirements. This uniqueness is emphasized by the fact that supermarkets in some parts of the U. S. can obtain as much as 100% of their heating needs with "recycled" heat from refrigeration. Cooling and dehumidification needs are just as singular. These needs cannot be compromised. If the "conservators of energy" suggest—or even dictate— that thermostats be raised during the cooling season, the net result will be totally counterproductive. Why? The problem lies in generalization. What is true generally can be totally false for a specific situation.

ART PEREZ
Member ASHRAE

THE development of food store equipment is the result of the demand-supply cycle. Store owners have always purchased the display equipment that could do the most effective job. Many a commercial refrigerator style has fallen by the wayside because it would not sell. Either it was a merchandising dud ("ahead of its time"), or it had outlived its usefulness. Over the years, this interplay resulted in the evolution and predominance of open-style display cases.

Those who advocate a return to closed refrigerator cases in the name of energy conservation are as practical as those who want to bring back trolley cars. Trolleys were viable as long as they satisfied the needs of those who rode them. Similarly, today's open-design supermarket equipment reflects the present needs of the food distribution system. Changes are dictated by need. *And changes within the framework of present needs are essential in order to conserve energy.* It is, therefore, important to make every facet of supermarket energy management as relevant as possible. This article presents three interdependent steps toward this goal:

- Store environment control;
- Condensing unit efficiency;
- Display temperature control.

One way of thinking about the three above elements is in a figurative triangle (Fig. 1). It is useful to emphasize the influence of store environment on case load; condensing temperature on condensing unit capacity; and capacity imbalance on refrigerator temperature.

There is an inseparable relationship among the three items. In the interest of achieving a cooling job with minimum energy, these items must be used to their greatest advantage.

A. Perez, P.E., is Vice President, Engineering, Tyler Refrigeration Corp., Niles, MI.

STORE ENVIRONMENT

Display Case Load

An open refrigerated display case gains from 80% to 95% or more of its load from the display opening. The balance is made up of product and service load from fan motors and lights, and leakage load through the insulated walls of the case (Fig. 2). These elements are the reason display cases are so sensitive to the store's temperatures and humidity.

Store Envelope

Fig. 3 is a graphic presentation using a standard ASHRAE psychrometric chart as a base.

The "envelope of operation" depicts a range of temperatures and humidities found in supermarkets. The industry's accepted standard case-rating condition of 75 F and 55% rh is the 100% load line. This sloping line and the other parallel lines above and below it on the enthalpy scale represent equal heat-load conditions (taking into account both sensible temperature and latent heat load). Higher enthalpy means heavier frost accumulations on case evaporator coils and subsequent need for more frequent and longer defrosts. In this kind of situation, the condensing units must work harder to maintain temperature. These additional loads have been theoretically calculated as shown on the chart. The shaded area in the table shows case loads greater than 100%. It's evident that in extreme conditions, the envelope loads are increased greatly. This explains why open cases do not funciton well in uncontrolled stores or in tropical or semitropical conditions.

Fig. 1 Triangle for energy efficiency

Reduced Loads

The most important advantage of the "envelope of operation" is that at low ambient conditions, the imposed load on an open refrigerator is substantially reduced.

Obviously, during the winter, controlling the environment of a store to a lower temperature and humidity level is a conservation idea in itself. By lowering controls, the loads on the open refrigerators are reduced.

In the summer, however, the question becomes, "Is conservation better served by letting the air conditioning depress the dry bulb and wet bulb, or will energy be better conserved by raising the thermostat and requiring the open refrigerator to work under higher load conditions?" In considering this point, it is necessary to deal specifically with the food store. Combination stores, having substantial space for items other than foods, need to be examined separately. However, in a supermarket, with a conventional mix of open refrigerators in the store, the horsepower involved is substantially larger than that required to air condition the building. The reason, in part, is that the open refrigerators remove a great deal of heat from the store in the first place.

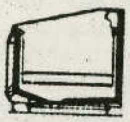
System Efficiency

It is basic to air conditioning systems that, owing to relatively low compression ratios, they operate at a level where they are able to produce cooling at the rate of 9 Btu's per watt, or more. This means that any cooling or dehumidification done by the air conditioning equipment will be performed at that level of efficiency.

On the other hand, if thermostats are raised in the interest of energy conservation, the net result is that the cooling which is not done by the air conditioning system will be attempted—unsuccessfully—by the display cases. However, the latent load and the sensible load will be absorbed by the display cases to the degree possible, but at a different level of performance. A low-temperature display, case, for example, operates at

OPEN CASE HEAT LOAD DATA

12' WELL TYPE FROZEN FOOD CASE



Book Rating & @75F & 55% RH .... 4,400 Btuh

Heat Load Tabulation

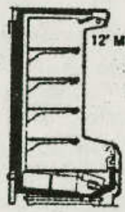
- 3 Fan Motors @ 35 Watts (105W x 3.41) .... 109.9 Btuh
- Case Body Insulation $\frac{144" \times (39 + 24 + 24)}{144} \times \frac{.14}{2} \times 80^{\Delta} T$ ..... 487.2 Btuh
- Case End Insulation $\frac{33 \times 24}{144} \times \frac{.14}{2} \times 80^{\Delta} T \times 2$ .... 61.6 Btuh

TOTAL LOAD OTHER THAN OPENING ..... 907.1 Btuh — 907.1 Btuh

LOAD ATTRIBUTABLE TO OPENING .... 3,492.9 Btuh

PERCENTAGE OF LOAD ATTRIBULABLE TO OPENING (3492.9 ÷ 4400 x 100) .... 79.38 %

12' MULTISHELF DAIRY CASE



Book Rating @75F & 55% RH .... 18,600 Btuh

Heat Load Tabulation

- 3 Fan Motors @ 45W (135W x 3.41) .... 460.8 Btuh
- Case Body Insulation $\frac{144" \times (72 + 30 + 39)}{144} \times \frac{.14}{2} \times 60^{\Delta} T$ ..... 592.2 Btuh
- Case End Insulation $\frac{72 \times 30}{144} \times \frac{.14}{2} \times 60^{\Delta} T \times 2$ .... 126.0 Btuh

TOTAL LOAD OTHER THAN OPENING ..... 1179.0 Btuh — 1,179 Btuh

LOAD ATTRIBUTABLE TO OPENING .... 17,321 Btuh

PERCENTAGE OF LOAD ATTRIBUTABLE TO OPENING (17,321 ÷ 18,600 x 100) .... 93.62 %

NOTE: Product load is considered neglible. Case wall is 2" of urethane foam with an R of .14.

Fig. 2

5 Btu's per watt or, as low as 4 Btu's per watt under more adverse conditions. Meat cases operate at approximately 6.5 Btu's per watt and so on. None of the refrigerating systems will operate as efficiently on an energy to cooling ratio as an air conditioning system. The basic factor involved here is compression ratio. An air conditioning system works at the lowest compression ratio of any refrigeration system in a food store. Therefore, it will be the most efficient in terms of cooling work for energy use.

NATURE COOLS CONDENSERS

Condenser Environment

The first step has been to design a more favorable environment for display cases, using controls and other available equipment. *The second step is to take advantage of a favorable environment which may already exist around a condenser.* This has not been done.

Condensing units and condensers are sized on the basis of summer design conditions. These conditions exist during only a relatively short

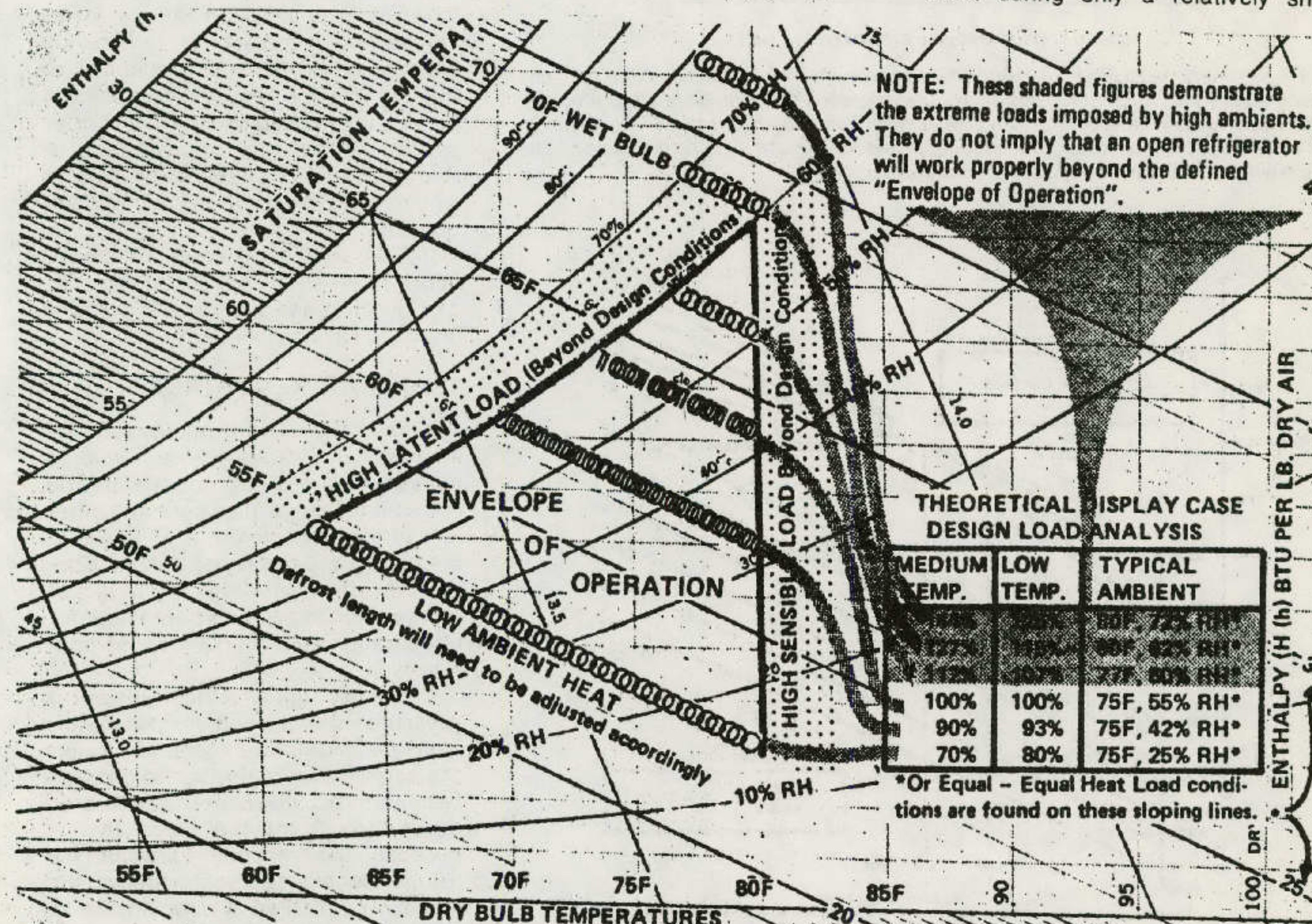
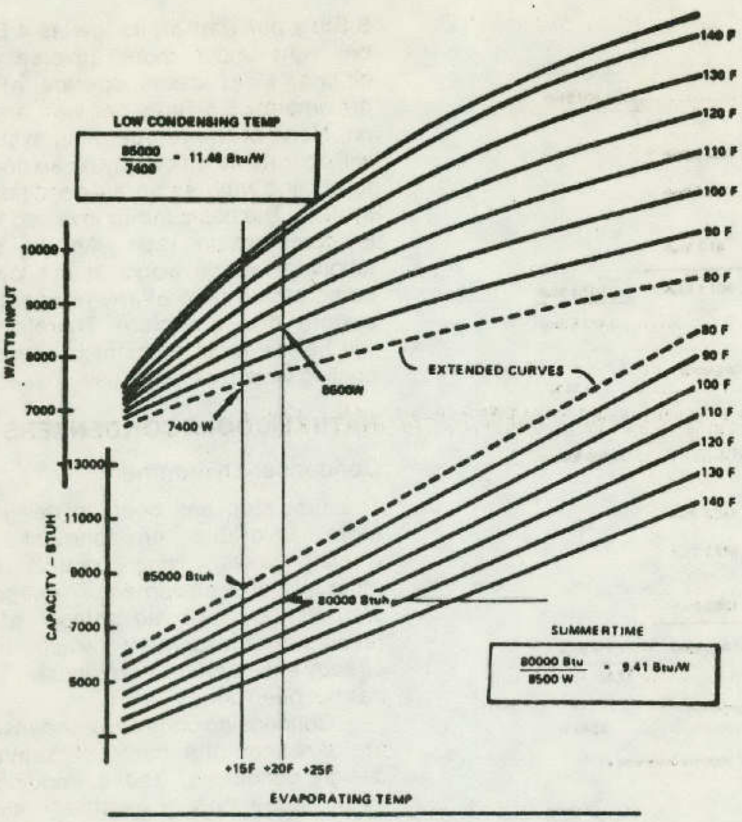
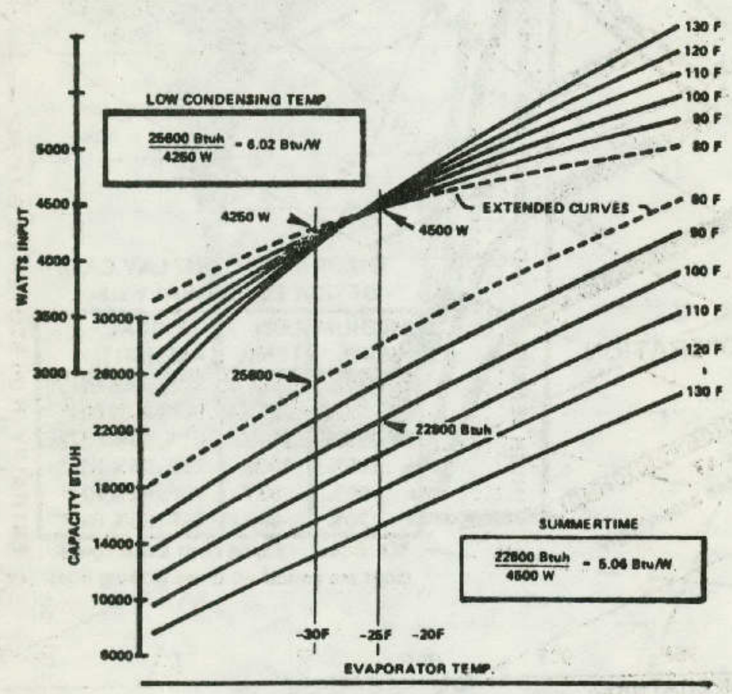


Fig. 3 The triangular area labeled "ENVELOPE OF OPERATION" on this abbreviated psychrometric chart delineates the ambient conditions in which refrigerated display cases are designed to operate. The labeled border areas outside of the boundaries tell in what way design limitations have been exceeded. Note that the High Latent Load boundary is the 60% r.h. line, and that the High Sensible Load boundary is the 80F (dry bulb) line. The Low Ambient Heat line is a less critical condition which may require longer defrost times on timed off-cycle defrost. This is because ambient heat alone is generally the source of defrost heat for dairy, deli and meat cases. Although defrosts may have to be lengthened, less frequent defrosting will be required



MEDIUM TEMP COMPRESSOR CAPACITY/DATA SHEET

Fig. 4 Summertime Btu/W figure is derived from the standard conditions of 100F Condensing and +20F Suction for this 10 HP compressor. A substantially more efficient Btu/W figure is obtained from the Low Condensing Temp conditions of 80F Condensing and +15F Suction. (The lower suction temp allows for the unavoidable pulldown of the system when it has surplus capacity for this application.)



LOW TEMP COMPRESSOR CAPACITY/DATA SHEET

Fig. 5 Summertime Btu/W figure is derived from the standard conditions of 100F Condensing and –25F Suction for this 5 HP compressor. A substantially more efficient Btu/W figure is obtained from the Low Condensing Temp conditions of 80F Condensing and –30F Suction. (The lower suction temp allows for the unavoidable pulldown of the system when it has surplus capacity for this application.)

period of the year. In considering refrigeration systems of all types, past thought has suggested that heat pressures must be constantly maintained at summer conditions in order to assure consistent, uniform refrigeration performance throughout the year. "You must maintain uniform feed through the metering device in order to avoid difficulty in controlling the refrigeration because of *capacity imbalance*," is the essence of the argument.

"Balanced Systems"

Balancing the heat load with refrigeration capability is an old idea. It is so much a part of the industry that compressor manufacturers show capacities within only a narrow range, with the lowest level frequently being 90 F. condensing temperature.

While the idea of "balanced systems" is valid, the quest for energy conservation makes it necessary to create, by design, a surplus of refrigeration capability throughout most of the year. Operating the condensing unit at a lower head pressure during the greater portion of the year in which it is possible, allows lower condensing temperatures, effectively increasing the Btu/watt capability of the unit (Figs. 4 and 5). When used to provide the needed cooling in a shorter period of time, this improvement in Btu/watt permits stopping the motors which drive such a system's compressor.

The sum of greater efficiency (more Btu/Watt) plus less running time can, when properly handled, produce dramatic savings in energy use.

TEMPERATURE CONTROL

The third step toward energy savings involves coordinating the benefits derived from the first two steps. The operation of the display case and other refrigeration equipment is essential to the storing and displaying of food. Controlling the created surplus of refrigeration capacity is paramount for refrigeration quality and intended conservation.

Controlling the refrigerator with a pressure device and following the ideas described here, generally cause the surplus of refrigeration to produce temperatures which are colder than desired much of the time. This is because the reduced load on the refrigerator places a lighter load on the coil. With a smaller coil loading, the ΔT will be reduced. With a given pressure setting, the refrigerator temperature will be lower than when the coil is at full load. There are no savings in running colder-than-required temperatures. Ideally, refrigerators should be controlled to produce as much

Table 1

AN ENERGY USE COMPARISON—COMPARING
•100% Case Load and Summertime Condensing Temperature Efficiency
WITH
•Reduced Case Load and Low Condensing Temperature Efficiency.

MULTI-SHELF DAIRY CASE

Published 100% Load on Multi-Shelf Dairy Case (12')	18,500 Btuh
Summertime Compressor Capacity (9.41 Btu/W from Fig. 4) WATT LOAD (18,500 ÷ 9.41) =	1966.0 W/h
REDUCED LOAD AT 70F & 35% RH STORE (Fig. 3) = 70% FOR MEDIUM TEMP CASES (.70 × 18,500) =	12,950 Btuh
LOW CONDENSING TEMP Capacity (11.48 Btu/W from Fig. 4) WATT LOAD (12,950 ÷ 11.48) =	1128.0 W/h
WATT/HOUR LOAD SAVINGS WITH LOW CONDENSING TEMP COMBINED WITH REDUCED LOAD IN 70F & 35% RH STORE	838.0 W/h
PERCENTAGE REDUCTION IN OPERATING COST POSSIBLE (838.0 ÷ 1966.0 × 100) =	42.6%

MULTI-SHELF LOW TEMP CASE

Published 100% Load on Multi-Shelf Frozen Food Case (12')	18,300 Btuh
Summertime Compressor Capacity (5.06 Btu/W from Fig. 5) WATT LOAD (18,300 ÷ 5.06) =	3616.6 W/h
REDUCED LOAD AT 70F & 35% RH STORE (Fig. 3) = 80% FOR LOW TEMP CASES (.80 × 18,300) =	14,640 Btuh
LOW CONDENSING TEMP Capacity (6.02 Btu/W from Fig. 5) WATT LOAD (14,640 ÷ 6.02) =	2431.9 W/h
WATT/HOUR LOAD SAVINGS WITH LOW CONDENSING TEMP COMBINED WITH REDUCED LOAD IN 70F & 35% RH STORE	1184.7 W/h
PERCENTAGE REDUCTION IN OPERATING COST POSSIBLE (1184.7 ÷ 3616.6 × 100) =	32.7%

Table 2

Btus Per Watt Efficiency	
12	
11	Air Conditioning Units
10	
9	Produce
8	Dairy Units
7	Meat-Deli
6	
5	Frozen Food Units
4	Ice Cream Units

compressor motor off-time as possible within the framework of the mechanical needs of the rest of the refrigeration system.

Methods of Control

Historically, there has been a variety of ways of dealing with excess refrigeration capacity compared to refrigeration load. Among the typical ways are:

•Compressor unloading—mechanical or gas bypass;
•Evaporator pressure-regulating valves;
Temperature-controlled evaporator regulating valves;
•Conventional pressure controls;
•Thermostats.

Unloading devices have the essential quality of being driven by a motor at substantially less than their total capability. All of the friction work involved remains constant while the work of pumping refrigerant is unloaded. The net result is that the energy consumed is greater than that which is possible by stopping the pumping and friction work.

Evaporator regulation, whether by pressure or temperature sensing, unloads a refrigerating system in a different way. However, the net result is the same as described above. This is because the compressor motor remains in operation much, if not all, of the time, albeit at a lower suction pressure (unloaded) condition.

Controlling refrigeration systems with conventional pressure devices is an extremely questionable procedure with highly variable load to capacity relationships. This is due to the detail already discussed regarding evaporator pressures and variable temperatures with variable loads. Other drawbacks involve the erratic and/or short cycling which may occur.

Controlling with temperature-sensing devices has its drawbacks too. The difficulties are essentially mechanical, and relate to the capability of controlling certain types of components in a way that satisfies their needs and the needs of the rest of the system. Controlling by temperature sensing, however, has the inherent advantage of knowing the conditions to be produced in a refrigerator. With the proper application of the proper controller, the refrigerator's needs may be satisfied and the compressor motor can be stopped. By its very nature, the thermostat appears to be the only type of device that can satisfy the needs of the refrigerator and achieve maximum energy conservation.

As with all systems, proper correlation and sizing of components is vital. This needs to be done by people skilled in the specialties involved. When the correlation and sizing are done properly, calculated results (Table 1) show the amount of savings possible, when both store environment and condenser cooling medium permit.

SUMMARY

The three items on the triangle must be coordinated with the store's master plan. For example, the heating needs of the store and the ability to recover heat from the refrigeration system for the purpose of heating the store are also essential to conservation.

Using the concept of lower condensing temperatures must be reconciled with the idea of recovering heat. The ability to recover heat has a great deal to do with the sizing of the heat recovery coils and the air handler. Therefore, while this article emphasizes the great interrelationship among the three elements in the triangle, the relationships do not end there. Furthermore, legislation or regulation to control one element can have a substantial negative domino effect on numerous other factors in a given specialized situation. □□

The supermarket uses more electric power per square foot of sales area than any other retail business. With reasonable power rates of the past the cost of energy was of little concern to the store operator.

For well over two years, now, Americans have been living with an "energy crisis." The main effect of the "energy crisis" has been the explosion of energy costs to the food store operator. This rise in energy cost has caused the operator to re-think his approach to store design and operation. In short, "ENERGY COST IS NOW ONE WHICH MUST BE CONTROLLED JUST AS LABOR AND INVENTORY ARE CONTROLLED."

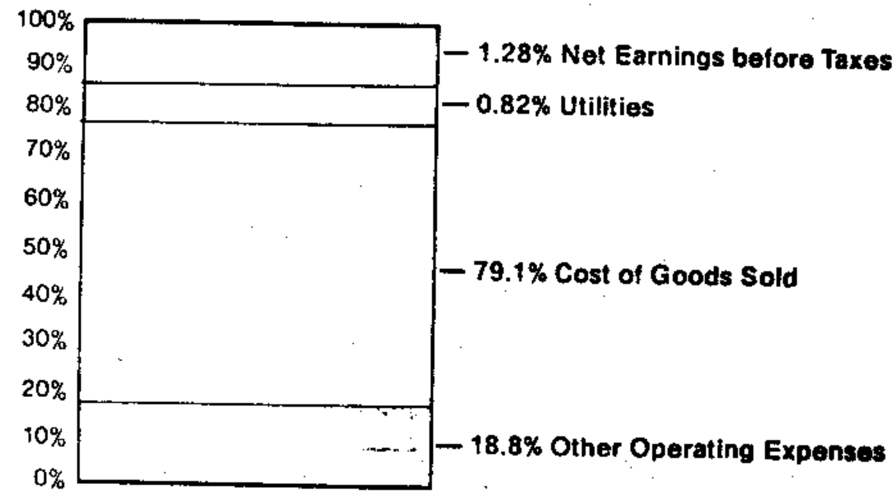
To aid our customers in planning new stores and operating existing stores we have performed extensive storewide testing in three separate stores to establish credibility for our recommendations. Hussmann has designed and equipped Tarpy's Market in Columbus, Ohio, to be a proving ground for our ideas. The store is being monitored in 130 locations so that even minute differences in store or local environment, power consumption or refrigerated case temperatures can be detected, stored in a computer and analyzed for their effect.

We have found no magic answers to the problem of energy costs; but we did find a number of solutions, each of which is part of a "big picture." The food store is a complete environmental system. Any action will effect other parts of the store either positively or negatively. We have determined that an orderly approach to energy management can save from 4% to 21% of the total energy use depending on the relative efficiency of the store.

In this booklet we want to discuss the areas of energy savings we have found to be most beneficial and to give the store operator the facts with which to make energy decisions.

Not all verifying information contained herein is from Tarpy's, but all Tarpy's tests are so identified.

Before you proceed in this booklet study the bar graph below. The data comes from the 1975 Progressive Grocer "42nd Annual Report of the Grocery Industry." (April 1975, Page 94.)



CONTEMPLATE THESE FACTS

1. *Utilities* equal 62% of *net earnings before taxes.*
2. *Utilities* exceed *total net earnings after taxes* by 28%.
3. Of the expenses listed, utilities rank 5th, exceeded only by payroll, property rentals, services purchased and supplies.
4. Every dollar saved through utilities conservation equals $78.12 in sales ($1.00/.0128 = $78.125).

HOW DOES YOUR STORE COMPARE WITH OTHERS IN ENERGY USE?

The Free Enterprise System thrives on using its resources efficiently. With respect to energy in the supermarket, this means: (a) "How efficiently are you using the kilowatts in your store?" (b) "How much do you sell with the kilowatts you use?"

We have analyzed information on 543 stores ranging from 4,000 to 26,000 sq. ft. The data indicates two helpful ways to measure your store's energy efficiency. They are discussed below.

1. Store sales expressed in terms of energy use.

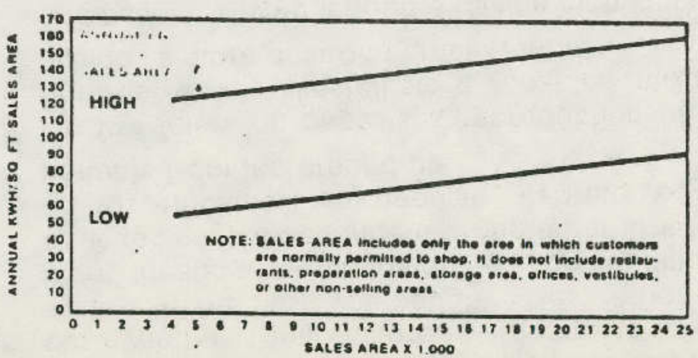
$$\frac{\text{Annual Sales—Dollars}}{\text{Annual Kilowatt-hour Usage}} = \frac{\$}{\text{KWH}}$$

Based on 1974 sales figures, a ratio of 3-$/KWH is good, 2-$/KWH is poor. The current rate of inflation indicates values of 3.3-$/KWH and 2.2-$/KWH will be more appropriate for this year.

2. Electrical usage expressed in terms of sales area.

$$\frac{\text{Annual Kilowatt-hour Usage}}{\text{Square Feet—Sales Area}} = \frac{\text{KWH}}{\text{Sq. Ft.}}$$

The two curves, HIGH and LOW, represent extremes in energy usage as indicated by the data. This graph should be used in conjunction with the "Sales-Energy Efficiency Value" above. We found "2's" and "3's" on both the HIGH curve and the LOW curve.



Example: Tarpy's is a "HIGH" due to its 7-day operation, instore bakery, high lighting level and concentration of multi-deck cases. Sales efficiency (a confidential value) is consistently higher than "good". From this you can conclude that Tarpy's is managing their resources well, but there is prob-

WHAT MAKES A STORE A "HIGH" OR A "LOW" ENERGY USER?

HIGH:

1. Electric resistance heat.
2. Sales area lighting level = 5 watts/square foot.
3. 7-day, 24-hour operation.
4. Instore bakery and/or restaurant with electrical appliances.
5. High density of multi-deck cases.

(One foot of open multi-deck medium and low temperature case per 45 square feet of sales area. A store with very little general merchandise.)

LOW:

1. Heat reclaim or gas heat.
2. Sales area lighting level = 2 watts/square foot.
3. 6-day, 12-hour operation, no night stocking.
4. No instore bakery or restaurant (if so, using gas appliances).
5. Low density of multi-deck cases.

(One foot of open multi-deck medium and low temperature case per 80 square feet of sales area. A store with a large area devoted to general merchandise.)

These two "indicators" of store energy efficiency were produced with data from 543 stores. This represents less than 2% of the supermarkets in the United States. While the data base is limited, it is our opinion that it represents a good beginning in trying to assess the "Supermarket Energy Problem—U.S.A."

We believe in sharing data, and would welcome the opportunity to exchange energy information with any supermarket interested in improving the accuracy of these "indicators."

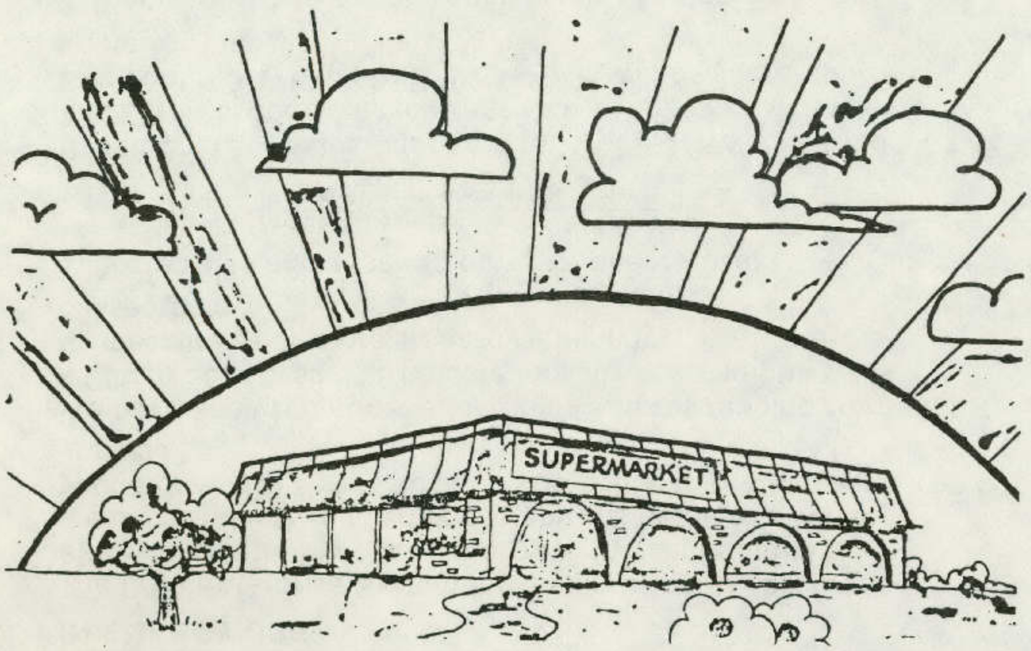
After all, if you don't know where you are, how do you know where to start?

As we have said in the introduction, the Tarpy test proved our hypothesis that a store is a complete interdependent system. In the past, you bought cases, refrigeration equipment, heating, air conditioning, lighting and store construction each independent of the other. But for maximum energy efficiency, you need to integrate your store components from the ground up.

On the following page is a reproduction of a computer print-out which takes all store variables into account and designs a store environmental system.

The accompanying legend explains highlights of the print-out.

This service is available now from Hussmann and will be expanded in the future. Each store is designed for its own particular climate, construction, display fixture, lighting and other variables.



To assist those concerned with realistic energy cost control, we offer our latest figures on the breakdown of store electrical consumption.

AVERAGE ANNUAL ENERGY USAGE	
•1. Low Temperature Compressors	21%
•2. Sales Area Ceiling Lights	19
3. Medium Temperature Compressors	18
4. Case Fans & Lights	9
5. Heating (Electric)	8
6. Back Room, Office, Sign Lights	6
7. Case Anti-Sweat Heaters	6
8. Air Handler Blower	5
9. Air Conditioning	4
10. Miscellaneous Store Operations	3
11. Meat Cutting Room	1
TOTAL	100%

The above figures are an average of three actual store measurements (including Tarpy's) and four confirmed power estimates taken from all parts of the country. Two stores had heat reclaim. Equivalent electric heat values were used.

1. Front glass area will have a significant effect on heating and air conditioning as will the direction of front glass.

2. Solar radiation also was shown at Tarpy's to affect store heating conditions.

3. Lights can play a significant role in store environment. Built into the computer is an automatic allowance for different numbers and types of store lighting systems.

4. Any store bakeries or ovens would show in this column.

5. An allowance is made for the number of people who will be occupying the store at any one time.

6. This number is taken from the store legend and accounts for store fixtures.

7. Weather information supplied by the U.S. Weather Bureau.

8. This is the number of credits accrued through using cold air returns as in the Tarpy Store. If no "free" air conditioning is used, purchased air conditioning would make up this number with a proportionate increase in the size of the air conditioning unit.

9. This is the air conditioning tonnage required given the store exactly as it appears with any energy saving equipment.

10. This is your free heat which again would need to be made up in purchased heat if heat reclaim were not used.

11. The furnace required for the store.

```
                                   ***STORE  LAYOUT DATA***

   WALL LENGTHS-FT              WALL LENGTHS-FT            WALL LENGTHS-FT         1. GLASS AREA SQFT
 OUTSIDE TO SALES AREA       OUTSIDE TO BACKROOM       SALES AREA TO BACKROOM     OUTSIDE TO SALES AREA

    ..... S.....               ..... S.....              ..... S.....               ..... S.....
    .     0    .               .   170    .              .   154     .              .     0    .
    E          W               E          W              E           W              E          W
   131         0              30         161             0          131             0          0
    .          .               .          .              .           .              .          .
    .    154   .               .    16    .              .     0     .              .    400   .
    ..... N.....               ..... N.....              ..... N.....               ..... N.....

2. ROOF OUTSIDE TO SALES AREA = 20,175 SQFT     WALL HEIGHT SALES AREA = 12 FEET   'U' FACTORS WALL   .34  ROOF  .20
   ROOF OUTSIDE TO BACKROOM   =  7,195 SQFT     WALL HEIGHT BACKROOM   = 12 FEET              GLASS 1.10  (SHADED)

3. INCANDENSENT LIGHTS =  5,000  WATTS (NOT RECESSED)    4. ** EXTRA APPLIANCE HEAT LOADS **
   FLOURESCENT  LIGHTS = 65,000 WATTS (NOT RECESSED)        SENSIBLE  17,000 BTU/HR  LATENT  11,000 BTU/HR

                                    ***STORE DESIGN DATA***

5. MAXIMUM NO OF PEOPLE =     200          SUMMER OUTSIDE DRY BULB = 093   WET BULB = 077   WINTER DRY BULB =  5
   OUTSIDE CFM          =   4,000          SUMMER INSIDE  DRY BULB =  75   WET BULB = 62.5  WINTER DRY BULB = 70
   GROSS OPEN CASE LOAD = 396,080 BTU/HR   WEATHER  DATA   06 21 40 N
                      6.                               7.

                                  *** AIR CONDITIONING DATA ***

  SENSIBLE HEAT   WALLS =      27,441  INCAD LIGHTS =    17,050     LATENT HEAT                        VENTILATION DATA
     BTU/HR       ROOF  =     216,897  FLURO LIGHTS =   277,063        PEOPLE        =     40,000     VENT CFM  =     4,0
                  GLASS =      11,840  PEOPLE       =    50,000        EXTRA+SAFETY=      16,100     SENSIBLE  =    79,2
                  FANS  =      35,560  EXTRA APPL   =    17,000        CASE CREDITS=      39,608     LATENT    =   137,5
            CASE CREDITS   8. 257,452  BACKROOM LOAD=    18,810
** TOTALS   SENSIBLE HEAT =    493,409 LATENT HEAT =   154,060  TOTAL BTU/HR=   647,467
9. TONS REQUIRED =  53.96 SENS HT-RT=   .76  NET SQFT PER TON =  373.88  GROSS SQFT PER TON=  256.32

                                      *** HEATING DATA ***

  GLASS  =      28,600   ROOF       =      262,275   VENTILATION    =     280,800
  WALLS  =      66,742   PERIMETER  =       79,440   SAFETY FACTOR  =      71,786

  WEATHER TOTAL =      789,643 CASE LOAD =       257,452  TOTAL HEATING LOAD =   1,047,095
  POSSIBLE CREDITS FURNACE SIZING  LIGHTS =      277,063 HEAT RECLAIM =  10. 347,560
11. NET FURNACE =   422,472
```

Reclaiming the heat from the refrigeration compressors to heat the store pays for itself in both new and existing stores. The chart below shows actual costs from Tarpy's, a new store with electric heat, and a large chain store, an existing store with gas heat.

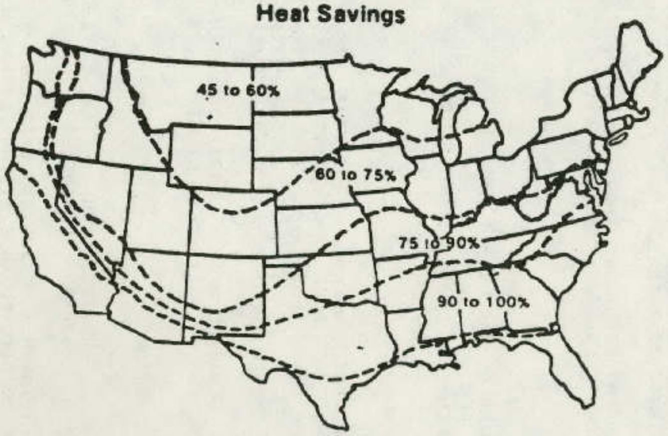
	NEW STORE TARPY'S (Electric) @ 1.5¢/ KWH	EXISTING STORE LARGE CHAIN (Gas)
Cost of Heat Reclaim Installed	$4,843	$7,800
Annual Savings from Heat Reclaim	$6,159	$2,944
Payback (Assuming no rate increase)	Less Than One Year	2.6 Years

Installation of heat reclaim requires only the following modifications:

1. Three-way valve on the compressor unit
2. A thermostat and relay panel
3. A heat coil

Heat reclaim can be used on any new or remodeled store using Hussmann refrigeration equipment from conventional condensing units to the largest new system.

Heat Savings

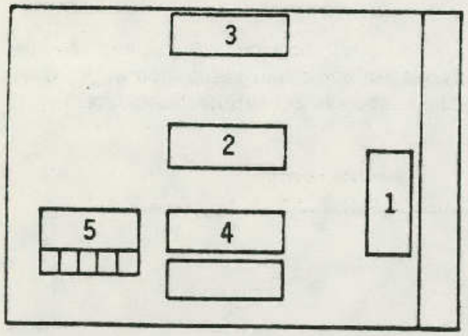


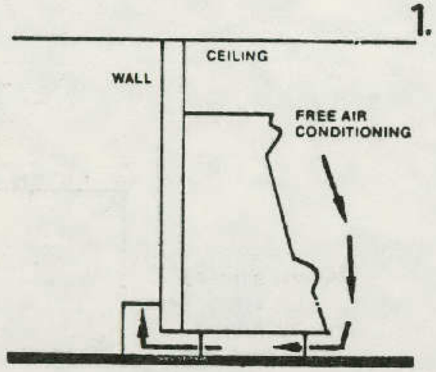
Just as free heating is available to warm a store, so too, free air conditioning is available to cool the store. The problem of cold aisles is a solution to rising air conditioning costs. In planning Tarpy's display case and air conditioning requirements, we decided that the cold display air which mixes with the store air could be used as "free" air conditioning. By using this free air conditioning we would also be controlling the cold aisle problem. All we had to do was to properly capture the free air conditioning and redistribute it to the store.

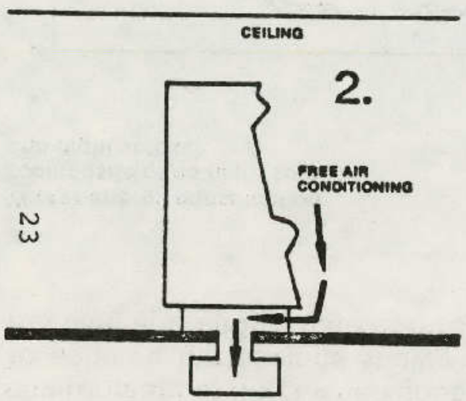
Conquering the cold aisle problem is a major help to merchandisers also, because a person standing in front of an open multi-deck frozen food case is subject to as much as a 10° variation in temperatures which can dip to 55°. It's no wonder shoppers hurried past many high margin frozens.

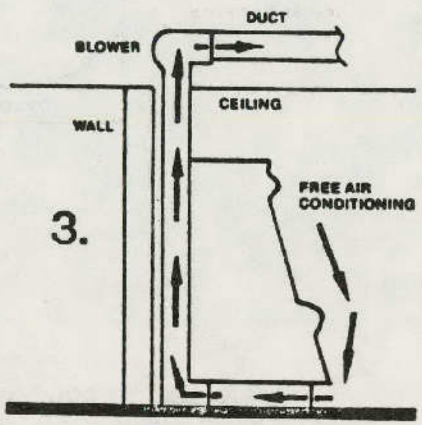
With a "free" air conditioning system the cold air is directed away from shoppers and redistributed to warmer areas of the store to create uniform store temperatures and humidity.

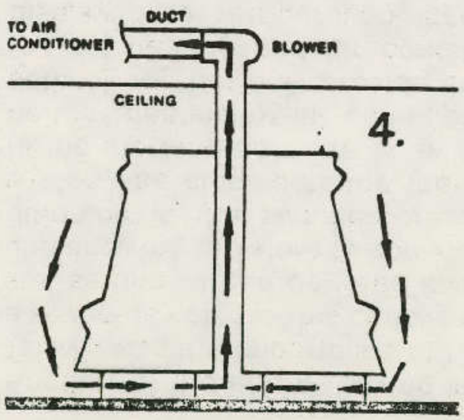
Free air conditioning can be used in new and existing stores. The drawings on right show five types of duct systems used to capture the free air conditioning.

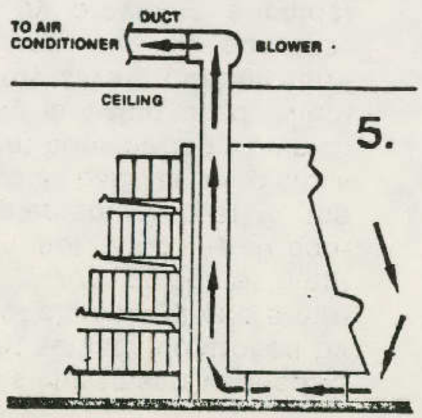




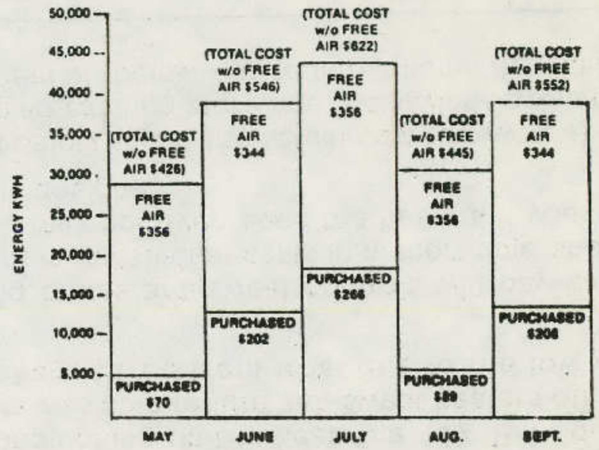








This graph shows the cooling requirements for the summer months at Tarpy's. As you can see, August was an exceptionally cool month. Without "free" air conditioning the cost would have been $2,591. to cool the store over the five-month period. With the Hussmann-designed free air conditioning system Tarpy's paid $835.



Five-Month Total Purchase	$ 835
Five-Month Total Free	1,756
Cost w/o Free Air Conditioning	$ 2,591
Five-Month Savings	$ 1,756

NOTE: Tarpy's paid 1.5¢ per KWH at time of tests.

Of course, the cost of duct systems varies widely according to type system and store location, so any payoff figure is difficult.

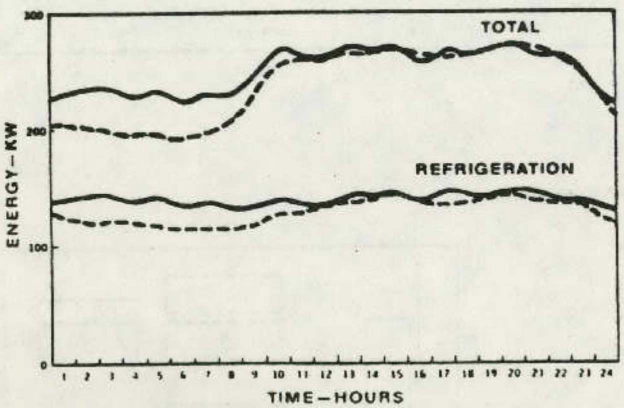
Return air duct-systems vary widely. At Tarpy's the duct system was also used for the refrigeration lines. Comparing the cost of the larger duct system at Tarpy's to the traditional pipe chase and pit system, the extra cost was $2,326.

TO SUMMARIZE

Additional Cost of Underfloor Ducts	$2,326
Reclaimed Air Conditioning	$1,756
Payback	1.3 Years

Another of the energy saving ideas Hussmann verified at Tarpy's was the importance of night setback controlled by a seven-day clock. This consisted of changing the thermostat setting fifteen degrees lower at ten o'clock at night and allowing the store to cool down, not using any air conditioning in the summer or supplementary heat in the winter. The clock sets the thermostat back at six o'clock in the morning so there is an eight-hour period in which neither heating or air conditioning is being used. Night setback will not only provide energy saving through turning off heating and air conditioning, but will decrease display case refrigeration loads by providing a colder environment at night when shopper comfort is not a factor. To achieve the savings shown the store must have Heat Reclaim and appropriate control of booster heaters.

Winter energy consumption "composite of no night setback and night setback."



This graph demonstrates the savings realized with night setback. In both cases the lower line shows savings due to night setback

Annual Savings $624

Extra Fixture in Control Panel Costs $378 Payoff 6 Months

As shown earlier in this booklet, case anti-sweat heaters account for 6% of store energy consumption. This, of course, is a substantial figure, but it becomes even bigger when it is realized that these heaters are not always needed.

In most areas of the country relative humidity never exceeds 40% or exceeds it only one-half of the year.

Hussmann has offered a humidity control for anti-sweat heaters which turns the heaters off when store humidity is lower than 40%. This control can mean a 50% energy reduction on the case fans and anti-condensate heaters circuit during periods of lower humidity. This saves you 3% of your power bill

Hussmann can design air conditioning units to operate at 40% RH maximum. Your anti-sweat heaters are not needed at all. This means a 6% reduction in your store power bill. In some stores there may be a small increase in the size of the air conditioning unit to keep the 40% RH figure. The Tarpy store was able to turn anti-sweat heaters off and still keep packages free from frost due to the low relative humidity.

In existing stores anti-sweat controls will pay back your investment in installation costs in a short time and in new stores you may not even need the heaters if your AC unit is properly designed

The chart below shows the actual cost to rewire anti-sweat heaters in an existing store and the savings available from turning them off below 40% relative humidity (R.H.).

Field Wiring Cost	$1,656
Annual Savings @ 1.32¢/KWH	$ 604
Payback	2.7 Years

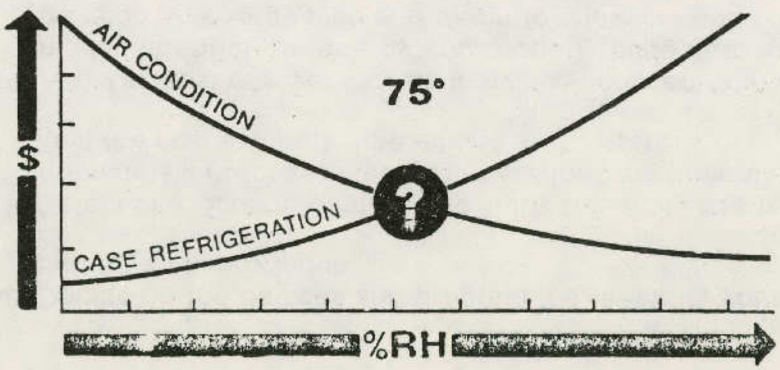
Lowering the store temperature and relative humidity will lower the open display case operating costs. In addition the number of defrosts can be reduced.

	75° F 50% R.H.	75° F 30% R.H.
Medium Temp.	100%	70%
Low Temp.	100%	85%
No. of Defrost	100%	50%

At Tarpy's we have varied store temperature and humidity by operating the air conditioning longer than normal and learned that the optimum operating condition in that store is 75° F and 30% R.H. Lowered operating costs for the refrigeration offset the higher air conditioning costs.

	75° F 50% R.H.	75° F 30% R.H.
Increased Air Conditioning Cost	$835	0
Medium Temp. Savings	0	$540
Low Temp. Savings	0	$314
TOTALS	$835	$854

Additional benefits are reduction of defrosts by half and minimum frost in low temp cases.



Energy conservation is not a familiar task for supermarket operators, but it can save more "bottom line" dollars than any other area of supermarket management. In today's environment of conflicting claims, gadgets and computers, it is difficult to plan a complete energy program.

This section outlines what we believe to be an intelligent, calculated program to save energy. We feel that a sum equal to 4% of your energy bill is needed for an energy program, which could save your store from 4% to 21% of your present energy costs.

1. Look at your energy cost for the last 12 months and calculate 4% and 21%. Ask yourself, "Is that much money worth saving?"
2. Allocate a budget of 10% of your annual energy cost. (4% x 2.5 years = 10% assuming a 2.5 year payback.)
3. Assign full time responsibility of energy management to one man, and give him the budget mentioned above. This person should have an electrical utilities background and understand computer application and programming.
4. Prepare energy history of all stores (see sample chart on next page).
5. Rate stores with the energy efficiency" graph on Page 4 and isolate the inefficient stores.
6. Make contact with local utility for counsel.
7. Discuss energy saving suggestions with equipment manufacturers and local utilities. Become familiar with energy management devices on the market; load shedders, computers, heat reclaim, demand defrost and humidity controls. Demand cost justification of products.

8. Decide on the devices and program that best fits your budget and knowledge.

9. Select one "Example" store and study the utility use in great detail. Purchase electrical measuring instruments. Test the cost justified suggestions in the store.

10. Allow at least one year for an individual, concentrating his full attention on energy and properly budgeted, to develop an energy plan and begin to show savings.

11. Show the stockholders what has been saved.

ELECTRICAL ENERGY LEDGER*
(Based on Total of 14 Stores)

STORE AREA**		ENERGY USE			DEMAND	ENERGY COST				AVERAGE RATE	ANNUALIZED DATA SUMMARY	
TOTAL	SALES***	KWH/ Mo.	BILLING PERIOD DAYS	KWH/ Week	KW	TOTAL BILL $	USAGE $	DEMAND $	FUEL ADJUST $	$/KWH	COST/ Sq. Ft. SALES	KWH/ Sq. Ft. SALES
30,000	24,000	297,600	30	69,440	384	7,440	6,034	290	1,116	0.025	$3.72	148

*This ledger lists basic information required for energy management on a monthly basis. An annual summary should be maintained (previous 12 months or calendar summary). The ledger should be maintained on a frequency that is related to store sales data.

Major remodels should be noted. A ledger comparing data to the previous year can show progress.

**There is some question in the industry regarding which area is more pertinent in comparing energy efficiency. Hussmann recommends carrying both figures until agreement is reached.

***Sales area includes only the area in which customers are normally permitted to shop. It does not include restaurants, preparation areas, storage areas, offices, vestibules or other non-selling areas.

The table below draws together all the energy saving ideas discussed in this booklet. Taken together these steps form the basis for an energy management program for one store or 1,000 stores. As the information shows, by taking these steps we have reduced the utility bill by 21.5%, the payback on the extra energy saving equipment is only 8.6 months; and, most importantly, the money saved in energy costs is the equivalent of $507,391 in extra sales.

SUMMARY

	ELECTRICAL SAVINGS	INITIAL COST
Heat Reclaim	6,159	4,843
Air Conditioning	1,756	2,326
Night Setback	624	378
Anti-Sweat Heaters	2,277	0
Display Refrigeration	854	835
TOTALS	11,670	8,382

$$\text{Savings} = \frac{11{,}670}{42{,}600 + 11{,}670} = 21.5\%$$

$$\text{Payback} \quad \frac{8{,}382}{11{,}670} = 8.6 \text{ months}$$

$$\text{Annual Sales Equivalent} \quad \frac{11{,}670}{.023} = \$507{,}391$$

Hussmann Refrigeration can provide all the energy saving equipment and ideas presented here.

We aren't offering gimmicks and short term answers. This is a complete program designed for today and tomorrow, for small and large stores, for independents and chains. In the supermarket—Hussmann is the INDUSTRY LEADER and ENERGY SAVER.

Lennox Food Store HVAC and Heat Reclaimer Unit

A. General Description

One piece air to air DX cooling unit. Heat section to be gas fuel, electric or hot water. Unit to be designed for single zone application and include factory mounted heat reclaim coil. Operation of heat reclaimer coil is to use all available condenser heat rejected from condenser coils from store refrigeration unit for space heating purposes and humidity control of store area. The humidity control between 45%-50% is required to prevent frost build-up on food package units. The food refrigeration system has a second condenser coil located on the roof which is used when the condenser heat reclaim coil in the HVAC unit is not in use.

Food chain store estimates are that with the lighting, occupant level and HVAC heat reclaim coil provides approximately 60% of the space heating requirements.

B. Companies Involved in Food Chain Store Reclaim Systems

With the exception of the Melco Company, no major manufacturer has provided a packaged HVAC system with factory mounted heat reclaim coil.

Refrigeration package manufacturer such as Haussman Company, have available condenser coils that can be field applied to HVAC along with their food package refrigeration equipment.

There are presently three major manufacturers in the country of refrigeration packages:

1. Haussman
2. Tyler Refrigeration Company
3. Hill Company

Companies such as Haussman have available engineering data which gives sizing recommendations of heat reclaim condenser coils that meet the various requirements of the food package refrigeration equipment.

The average food chain store takes about 125 h.p. of food package refrigeration equipment. Reclaims heat from the heat reclaim coils carry the store's space heating requirements down to about 25° outside temperature. The control of humidity in the store is very important to prevent frost build-up on food package equipment.

C. Marketing of Product

It is important that the sizing of this reclaim coil match the specific food package refrigeration equipment capacity. This type of information is only available from the specific food chain store. Most of the food chain stores have set up different packages for their different size stores.

Information required would be type of refrigerant used, installed h.p. and names of manufacturers of food package refrigeration equipment used.

A special E.H.B. Sheet or sales piece will be made available that outlines the specific design features of this equipment as applied to the food market business. This sheet also could be used as a direct mailer to the food market people. This sales piece would indicate that this particular unit has been designed specifically for food chain store application covering the following features as applied to a food market.

1. Heat reclaim features.
2. Completely factory packaged equipment.
3. Energy conservation features in addition to heat reclaim from food package refrigeration equipment.

    a. Two speed compressors.
    b. Load sensor control.
    c. Enthalpy control.
    d. Power saver with positive exhaust through use of return air blower.
4. Humidity control.

At this time there is no other manufacturer of HVAC equipment who has made any major effort to have available to the food marketing people a unit designed to meet their specific needs with a factory packaged heat reclaim coil.

SEQUENCE OF OPERATION

CALL		HEAT		COOL	UNIT COND. HEAT		DAMPERS	
COOL	D-HUMD.	RECLAIM	UNIT	COMPRESSOR			FIRST	SECOND
		1st Stage 2nd Stage	3rd Stage				H-M	H-M
X				As Needed			C-M	C-M
	X			1st Stage	X		M	F-C
	X	As req. w/hi-limit cutout	3rd Stage As Req.	1st Stage	X		H-M	F-C
X	X			As Needed	On Until 2nd Stage cool comes on		C-M	F-C

F – FULL
M – MOD.
H – HEAT
C – COOL

SEQUENCE OF OPERATION

HEATING CYCLE

On a call for heat: Heat reclaimer will come on in two stages. First stage 3 way valve will be energized allowing 1/2 of reclaim coil to heat. If this is not enough heat to satisfy space then 2nd stage 3 way valve will be energized allowing the full reclaim coil to be operative. At extreme temperatures possibly auxiliary heat will be required to maintain space temperature, then 3rd stage heat, which is the gas burner, electric, etc. will be energized to heat the space.

FREE COOLING OR POWER SAVER CYCLE

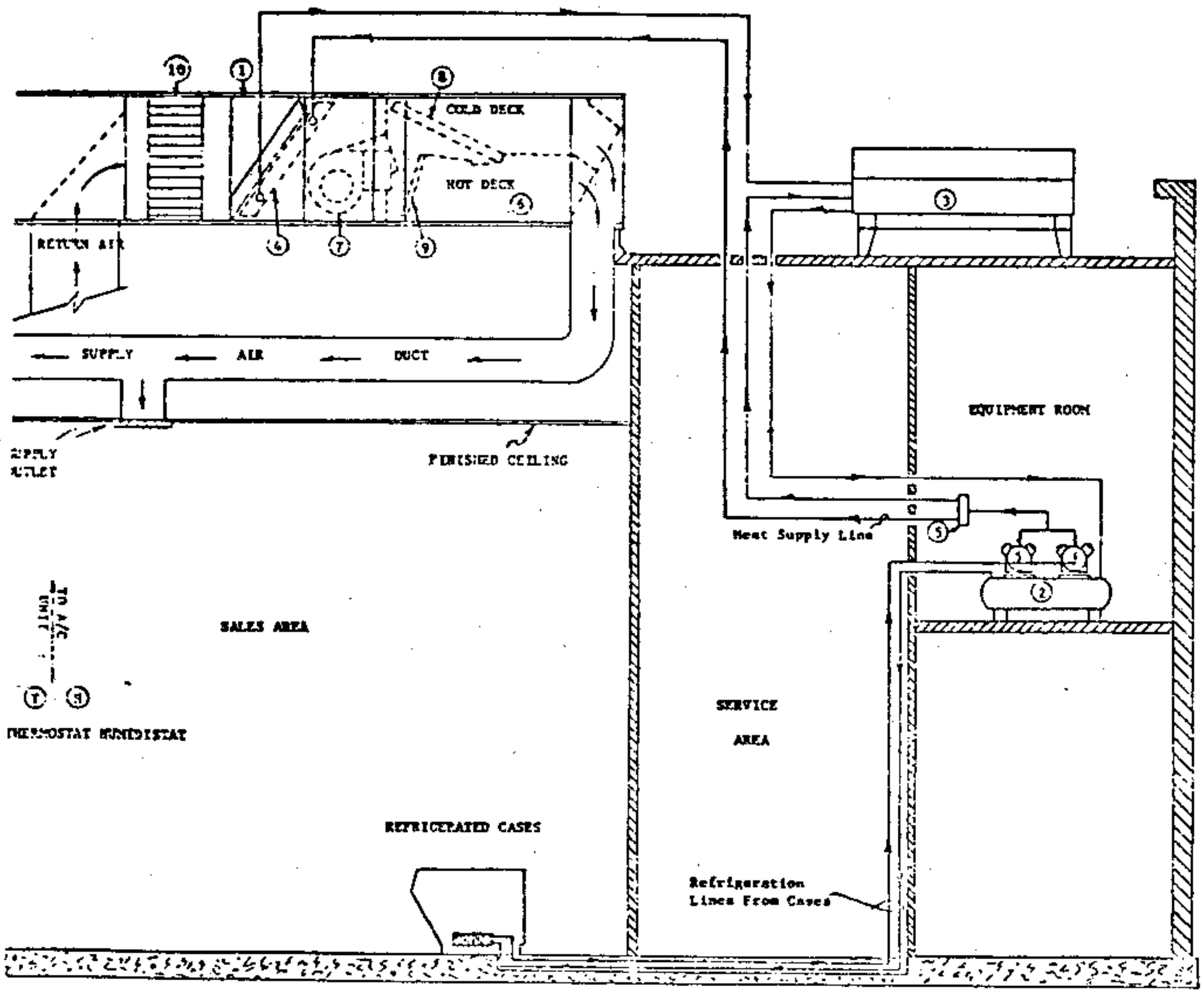
When conditions permit, free cooling is utilized by admitting outdoor air into the system instead of mechanical cooling. When conditon of outdoor air is no longer advantageous for cooling, outdoor air damper closes to a minimum and mechanical cooling is used.

COOLING CYCLE

On a call for cooling: Providing outdoor conditions permit the utilization of free cooling, the outdoor air dampers would open admitting outdoor air into the system. If this is not sufficient to cool the space, then compressor No. 1 would come on to utilize mechanical cooling, compressors would stage on with response to space demand.

DEHUMIDIFICATION CYCLE

When space temperature is satisfied and dehumidification is required, Humidistat will energize first stage cooling, unit condenser reheat coil, and position heat and cool dampers to a 50/50 position, and lock out heat reclaim coil. Under extreme dehumidification conditions, reclaim coil can briefly operate to maintain control of space sensible temperature. Under these conditions, reclaim coil is locked out when entering air temperature to the evaporator coil reaches 95° or the second stage compressor is energized.



LENNOX HEAT RECLAIMER - FOOD CHAIN UNITS

(1) Lennox roof-top unit factory assembled including heat reclaim coil and supplemental heater (gas, electric or hot water coil)

(2) Refrigeration units absorb heat from display cases through the medium of a refrigerant which is compressed into a high temp. gas and discharg into an air cooled condenser.

(3) Air cooled condenser dissipates heat to atmosphere when heat is not required in store.

(4) Heat reclaim coil - when heat is required in store, hot gas from refrigeration units goes directly to heat reclaim coil in roof-top unit to heat air passing across coil.

(5) Hot gas reversing valve diverts hot gas to heat reclaim coil when heat is required in store and to air-cooled condenser when heat is not require in store. Operated automatically by store thermostat.

(6) Supplemental heater - either gas, electric or hot water coil. Controlled by second stage of store thermostat. At extremely low outside temperatures-store may require heat in addition to heat reclaimer.

(7) Fan circulates air from store to roof-top unit where it passes across heat reclaim coil and supplemental heater into supply air duct.

(8) Cooling coil. When thermostat energizes coolin cycle, air passing across coil is cooled and dehumidified. (Hot gas is diverted to air-cooled condenser).

(9) Roof-top unit condenser heat coil - used for dehumidification.

(10) Power Saver controls fresh air entry and "Free" cooling with outdoor air. When conditio permit "Free" cooling is utilized by admitting outdoor air into the system instead of Mechanical cooling. When condition of outdoor air is no longer advantageous for cooling outdoor air damper closes to a minimum and Mechanical cooling is used.

(TH) Store thermostat and humidistat controls heatin cooling and dehumidification cycles for total environmental system. See sequence of operatio LENNOX HEAT RECLAIMER - FOOD CHAIN UNITS.

(I) Dehumidification cycle: when space temperature satisfied, dehumidistat will energize 1st stage cooling, unit condenser heat coil, close outdo air dampers and position heat and cool dampers to a 50-50 position. If space temperature is calling for cooling and dehumidistat is calling for dehumidification, unit condenser heat coil will be energized, heat and cool dampers will assume a 50-50 position, and Outside Air Damper will be closed.

6

REFRIGERATION

REFRIGERATION

TABLE OF CONTENTS

REFRIGERATION EQUIPMENT IN A SUPERMARKET

Most of the energy consumed in a supermarket is in the area of refrigeration for storage and display cases (about 50 percent). An overall understanding of how this equipment operates is important before you can start applying energy conservation measures.

The refrigeration in single-deck or multi-deck cases, closed cases, and walk-in coolers is attained by a refrigeration unit consisting of a compressor, condensor, and evaporator. The refrigerant enters the evaporator in a liquid form. The heat from the air and food products is absorbed by the refrigerant causing it to boil and change from a liquid to a gas. This gaseous refrigerant is then drawn into a compressor where it is compressed to a high pressure and high temperature. This high pressure temperature gas travels to the condensor where the heat of the refrigerant is transferred to the air or water surrounding the condensor. The refrigerant changes from a gas to a liquid in the condensor and is available for reuse in cooling in the evaporator. Generally, these three components will make up the refrigerator system but additional controls on each case will add to the complexities of the equipment.

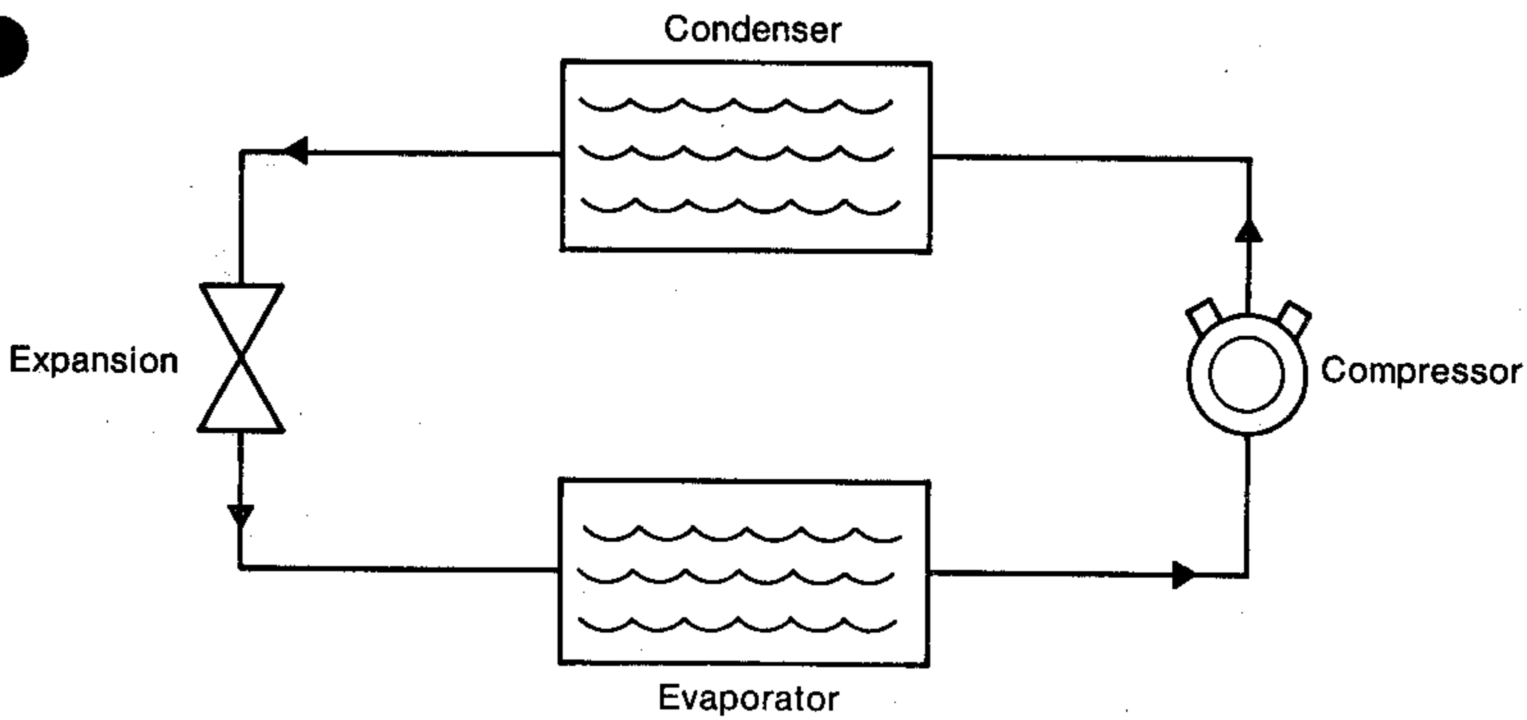
A defrosting system is also part of the equipment found on display cases. Why defrost? Frost buildup on the evaporator coils which will impinge the efficient operation of the refrigeration unit is caused by a number of things. If the humidity in the store is high that means that the moisture content of the air is high. When air is cooled to its dewpoint temperature the moisture in the air will condense on the evaporator coil. Defrosting the coil is necessary to maintain operation and keep foods fresh. But humidity is not the only thing that causes frost buildup; case overloading or improper loading will cause frost buildup. When a case is overloaded or improperly loaded the products break the air curtain on the unit causing warm environmental air to get into the unit and a resulting buildup of frost. More frequent defrosting is the result.

The most commonly used defrost methods are condensing unit or system off-time, electric defrost, hot gas defrost, and air defrost. The condensing unit or system off type of defrost is usually found on those units which maintain temperatures of 28°F or above. Defrosting is obtained by shutting the unit off and allowing it to remain off until the evaporator reaches a temperature which permits defrosting. Electric defrost employs a heater to warm up the evaporator to defrost. Hot gas defrost uses the waste heat from the gaseous refrigerant to defrost the evaporator. Air defrost uses fans which blow the warm air from the store over the evaporator to defrost. Whatever the type of defrost method, it can either be controlled in a time of day set mode or by demand. On timed set defrost the controls are set so as to automatically defrost a certain time of the day. This is an energy consuming type of control because it has to be set for worst case conditions. For example, the time set will be controlled so as to defrost every eight hours because it was found that during high humidity times of the year that was necessary to take care of frost buildup. Actually this worst case condition happens only a minimum number of days; therefore, you are using excess energy at all other times of the year. A better way of controlling defrost is by demand. Demand defrost is a method that automatically senses frost buildup and turns on the defrost cycle only as necessary. The advantages of demand defrost are fewer thermal shocks to the product and saving of energy because of fewer defrost cycles.

All display cases also have anticondensate heaters which prevent condensation from forming on cold surfaces, on rails, the discharge, and especially on glass door cases. Formation of condensate, "sweat", on these areas is dependent on the humidity, moisture content of the surrounding air, and dewpoint temperature. Typically these units are set to maintain a temperature of 55°F. This 55°F setting will accommodate worst case conditions. In reality, the dewpoint temperature is very rarely even close to 55°F unless humidity in the store environment is high. Therefore, maintaining surface temperature of 55°F is unnecessary and energy wasteful. Anti-sweat heaters are typically on all the time. You can save energy by controlling the anti-sweat heaters. One way is to turn them off or use a rheostat type of control whenever worst case conditions are not apparent. They may be controlled automatically to vary the surface temperature according to dewpoint temperature. In this type of control a sensor senses dewpoint and humidity of the surrounding air temperature and maintains only the surface temperature necessary to eliminate condensate by cycling the heaters.

These basically are the major functions and equipment that are associated with your refrigeration equipment. In order to understand each piece of equipment thoroughly manufacturers specifications should be studied.

Refrigeration Diagram:



Refrigeration

Refrigeration equipment is the single most energy-using component of environmental control in retail grocery stores. Single-deck and/or multideck produce and meat display cases; delicatessen, dairy, and closed meat cases; walk-in coolers for dairy, meat, and produce; and low-temperature cases for frozen foods and ice cream - several or all of these may line store aisles. Furthermore, each case may have a different temperature requirement, which may mean as many as 15 to 20 different requirements in one store.

The simplest type of refrigerator consists of an evaporator, the refrigerant, a compressor, and a condenser. The drawing opposite shows a typical refrigeration cycle. A liquid refrigerant enters the evaporator, where it absorbs heat from the air and food products stored within the case. As it absorbs heat, the refrigerant turns from a liquid to gas. A compressor draws the heated gaseous refrigerant from the evaporator, compresses, and pumps it into the condenser. The condenser transfers the heat from the refrigerant to water or air and converts the refrigerant back to a liquid. The cooled liquid refrigerant is then metered by an expansion control valve into the evaporator coils. The lower pressure in these coils allows the liquid refrigerant to expand to a gas or evaporate. Because evaporation is a cooling process, the coils become cold and absorb heat from the refrigerator case and food products.

While actual refrigeration systems in retail grocery stores are considerably more complex than the system illustrated and may vary from it in detail, the operating principles are the same. Most large commercial refrigeration units have individually programmed defrost cycles, evaporator pressure regulators, and temperature controls. The refrigerant may be condensed by air cooled units in separate air-cooled machine rooms, remote air-condensers, closed water-cooling systems, or cooling towers. Common defrosting methods include consensing units or system shutoff, electric heat, vapor defrost, and air defrost.

Humidity Control

Humidity is the water vapor or moisture content always present in the air. Controlling humidity is important to the energy-efficient and economical operation of a store. The increased demands on refrigeration, defrosting, and HVAC equipment caused by increased humidity raise operating costs and shorten product life. High humidity causes refrigeration equipment to "sweat," or accumulate moisture on exterior windows and other cold surfaces.

When relative humidity exceeds 55 percent and/or when ambient temperatures exceed design conditions, refrigeration performance and energy efficiency can drop by as much as 50 percent. Walk-in coolers are especially sensitive to humidity change: high relative humidity increases the possibility of bacteria growth; low relative humidity causes dehydration of stored food.

Customer and employee comfort is influenced by the humidity of the air as well. At comfortable shopping temperatures (65° to $75^{\circ}F$), relative humidities in the store should range between 20 and 55 percent. At temperatures greater than $75^{\circ}F$, high humidity makes the air feel warmer; at low temperatures, high humidity makes the air feel colder.

Environmental Control Systems

An environmental control system is no more than refrigeration, HVAC, and humidity control equipment integrated to utilize energy efficiently. Most present-day environmental control systems use reclaimed heat from refrigeration systems, underfloor duct returns for proper air distribution, and cooler floor-level air recirculated, to reduce air-conditioning requirements. Most often, an environmental control system reduces the energy required to operate the refrigeration equipment by providing the most efficient environment for operating refrigerated cases.

The heat reclaimed from the cases may then be used to heat the interior of the store, reheat chilled and dehumidified air, heat vestibules and water, and defrost the cases. Captured cold air may be used to cool the store and then to cool the attic space.

OPERATION

Refrigeration Unit

* Do not exceed manufacturer's load specifications. An overloaded or underloaded display case will decrease product quality and increase energy use by as much as 10 to 20 percent by increasing (1) the amount of store air that mixes with refrigerated air, (2) compressor running time, (3) case temperature, (4) refrigerated air losses from a case, (5) the heat needed to warm cold store aisles, and (6) defrost requirements.

* Adjust shelves to the positions and sizes recommended by the manufacturer. Dummy up the back parts of shelves when large quantities of display products are not required and large shelves are needed for proper refrigeration. Investigate the possibility of staggering shelves from one case to the next to accommodate the various sizes of packages displayed efficiently.

* Load cases neatly. Jumbled loading and dumping reduces energy efficiency because the extra air turbulence caused by the uneven surface stimulates heavier frost deposits, more frequent defrosts, and loss of refrigerated air.

* Do not stack products over the return air grilles to avoid causing a flow of refrigerated air out of the case and into the aisle.

* Keep food displays below refrigerator loadlines and straighten throughout the day.

* Keep drain-clogging litter out of cases. Each day, remove loose bits of wrappers and other debris to decrease the frequency of shutdowns required for major cleaning and to insure proper performance.

* Position advertising or display cards where they will not interfere with refrigerated case air flow.

* Do not open refrigerator and walk-in cooler doors any more than necessary. Use reminder signs, automatic door closers, buzzers, lights, and similar devices as aids in observing this rule. Try to plan ahead and take out or replace several items at one time. Clearly label stored items; place those frequently used near the front of the unit to reduce the time the doors are open. Be sure that items are not jammed against closed doors where they can damage gaskets and create air leaks.

* If night covers on cases are recommended by the manufacturer, use them strictly according to directions. Night covers can reduce compressor running time, product temperatures, and energy used. NOTE: improper placement can strain or damage compressors and promote frost buildup. Instruct personnel on correct use of this equipment.

* Shut down cutting and preparation rooms when not in use in conjunction with good sanitation practices. Be on the lookout, however, for any deterioration of cutting surfaces and operational problems with conveyors and scales, which may not tolerate frequent temperature changes.

* Turn off anti-sweat heaters on glass door assembly perimeters, and open display cases when temperature or humidity levels are low (less than 35 percent relative humidity). Perimeter heaters on individual glass doors should not be turned off because they prevent doors from freezing shut.

* Transfer food products rapidly from trucks to storage coolers and cases. Allowing products to warm up in aisles or loading docks will cause the use of unnecessary energy for re-cooling and possible product damage. Display case fixtures are designed only to maintain temperatures of products as they come from storage, not to lower temperatures.

* When restocking display cases, remove from storage freezers only as much frozen food as can be placed in the refrigerator in 30 minutes or less.

* Adjust case and cooler temperatures to the highest temperature that still allows food to be preserved correctly; follow applicable health code requirements.

* Set timed electric defrosts to occur during low electrical demand periods, if possible.

* Have your service representative adjust compressors to maintain the lowest head pressure at which the refrigeration system can operate without short-cycling or impairing expansion valve and coil efficiency.

* If possible, avoid stocking frozen foods and ice cream in the same refrigerator because they have different storage environment requirements.

* Open only one carton of frozen food at a time for price marking, then place the packages in the freezer cases immediately in order to reduce temperature gain.

* When loading glass door reachins, lock open only one door at a time, load the new product promptly, and close the door quickly.

* To check the correct operation of your refrigeration equipment, ask the manufacturer's representative to give it an energy conservation inspection. Also check the reference section at the end of this guide for other helpful publications.

* Use 24-hour alarm systems to alert store personnel to refrigeration malfunctions.

MAINTENANCE

Attention to seemingly trivial maintenance items can save substantial quantities of energy and dollars. Small, growing stores in particular may face financial collapse if their equipment breaks down for a day or two and ruins the stock of expensive perishable products - meats, frozen foods, produce, ice cream. Consulting manufacturers' recommendations for the proper maintenance of environmental control equipment and following through on these recommendations will prove to be the greatest asset to your energy and cost savings. Instituting a preventive maintenance program to keep your refrigeration, HVAC, and humidification equipment in the most energy-efficient operating condition will reduce your costs. Instructing store personnel and maintenance contractors to be on the lookout for energy-using abnormalities will also help. You should contact equipment manufacturers for maintenance guidelines and schedules for your own particular pieces of equipment; in addition, the following energy-saving maintenance suggestions are provided for your review.

Refrigeration Units

* Clean display fixtures, air-and water-cooled condensers, and cooling towers regularly. Change air filters monthly. Cleaning should include coils, fans, grilles, fins, plates, and waste outlets. Obtain and follow manufacturers' cleaning recommendations and maintenance schedules. Dirty fixtures and condensers increase compressor operating times and condensing temperatures and decrease cooling capacity. The reduction in air flow caused by dirty grilles can increase defrosting requirements and product temperatures by as much as 10°F.

* Remove discharge grilles in order to clean both sides.

* After cleaning, allow a case to return to normal operating temperature before replacing products.

* Regularly flush drains with pressure to prevent blockage and consequent ice buildup in the bottoms of fixtures.

* Check all door seals and gaskets for cracks or other damage. A dollar bill inserted between the gasket and door frame should resist withdrawal when the door is closed. Make this around all sides of the door, even the hinge side. Wash door seals regularly to prevent accumulation of debris and to keep gaskets resilient, lubricate door hinges and latches with food-grade oil monthly to enable doors to close easily.

* Check the operation of fan motors in all fixtures, especially multishelf equipment where broken motors can easily go unnoticed.

* Check the operation of all expansion valves; they should fully feed the evaporator. Check temperatures, bulb location, and head pressures.

Refrigeration

Display Fixtures and Walk-in Coolers

When replacing frozen food cases, refrigerators, and cold display case cabinets, select equipment based on lifetime cost and merchandising capability. Consider the most efficient and appropriate fixture for the application. Know the cooling efficiency as well as purchase, installation, and maintenance costs. Consult fixture manufacturers for data. Items to consider in refrigerations specifications include:

* Type and use of cases.
* Normal operating temperature of cases.
* Btu requirements of each system.
* Total Btu-horsepower requirements.
* Merchandising volume of each case and display area.
* Btu requirement per square foot for each walk-in cooler and preparation room.
* Total yearly energy requirement for each type of case.

Other considerations when selecting refrigeration units include reliability, quality of food preservation, labor requirements, merchandising capability (will it hold turkeys?) and owner-merchandiser-customer satisfaction. When selecting cases for new or existing stores, compare the total energy requirements of various models. Comparisons of Btu per cubic foot, Btu per square foot, or Btu per linear foot are not valid if one type of case requires more space than another, or if the quantity of product that can be physically or visually displayed in cases differs.

* Provide night covers where recommended for open cases to reduce heat load on the refrigerator. The energy saved will vary with each type of cabinet. However, be certain to contact your manufacturers first because night covers can damage some types of equipment.
* Where merchandising permits, disperse multideck cases throughout the store rather than bunching them into one area. This evens the load on the heating and cooling systems.
* Before buying open, multideck frozen food cases, consider the entire store plan and the volume of sales expected.

Generally, single-deck and reach-in display cases are the most economical. Although open multideck cases are more expensive to purchase and operate, they use less floor space and hold more food than the other case styles. Therefore, when deciding between an open multideck case and a glass-door reach-in case, consider initial cost, case volume, stocking and restocking labor, and product type. The relative amount of power used by glass-door versus open multideck cases depends most on sales volume. For high-volume use, multideck cases draw less energy than glass-door cases. For medium-volume use, however, the power required for glass-door cases can be 17 percent less than open multideck cases; for infrequent use, as much as 25 percent less. The decision whether to use glass-door or open multideck cases is not simple. You should consult several equipment manufacturers before deciding.

* Install separate wiring circuits for anti-sweat heaters, which are high energy users, to allow them to be turned off when humidity is low or to be regulated by a humidistat or other modulating controllers. The fan circuit should be wired to function the same as it did before the anti-sweat heaters were rewired.

REPLACE COLD CABINET INTERNAL LIGHTS BY EXTERNAL LIGHTS

Cold cabinet internal lights heat the cold air and increase the load on the refrigerating machine. In many cases, the internal lights can be removed and the contents of the cabinet lit either from repositioned existing fixtures or from new fixtures positioned to shine into the cabinet.

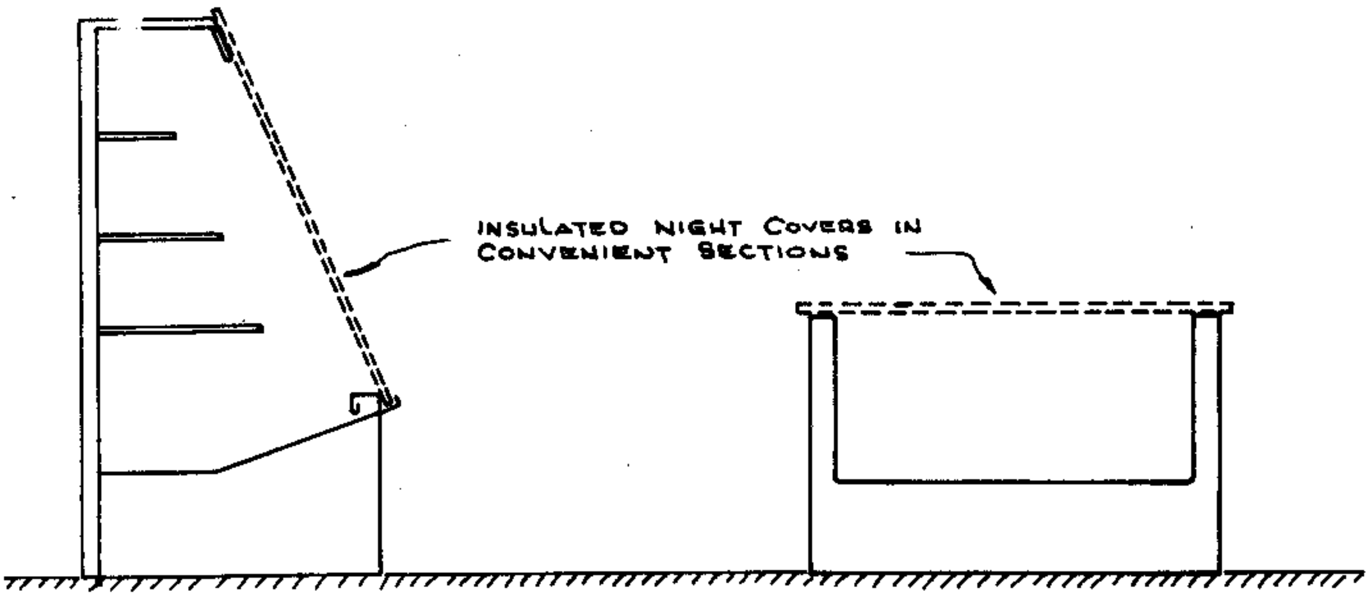
The reduction in load is in direct proportion to the wattage of the lamp removed, and is affected by type (fluorescent lamps give off 65% of their rating as heat, incandescent lamps give off 90% of their rating as heat). Each KW of "lighting heat" removed will reduce the refrigeration load by 0.28 tons.

Some reduction in display effectiveness will result when internal lights are removed and the trade off between this and the energy saved should be considered in stores and supermarkets.

The cost of removing internal lights and replacing them with external lights will vary with the circumstances for each case,and quotations should be obtained from local contractors. Order of magnitude costs, however, may be derived from the appropriate lighting sections of this Manual.

PROVIDE NIGHT COVERS FOR OPEN COLD CABINETS

Some existing cold cabinets and deep freeze chests in stores and supermarkets, because of their design, have to be open to allow visual display and public access to the produce. Heat exchange takes place at the interface between the warm room air and the cold freezer air due to mixing and cold air spill. While this heat exchange or gain must be tolerated during occupied hours, access and display are not required in unoccupied hours, and the cabinet can be modified to close by installing custom-made thermally insulated covers.



COLD CABINETS WITH NIGHT COVERS

Construct night covers in easily handled sections with sufficient thermal insulation to prevent condensation.

Institute a regular routine to cover all cold cabinets and freezers at night and during weekends both summer and winter.

The cost of night covers will vary with the configuration of cabinets. Obtain estimates from local contractors or cabinet manufacturers.

The energy savings obtained by fitting night covers will vary with each type of cabinet and will be greatest on vertical display cabinets where the cold air tends to spill over the bottom lip and spread over the floor. Subjective judgments can be made by observing near floor temperatures adjacent to the cold cabinets or by using a smoke tracer to show the magnitude of air spill.

When assessing the energy savings, bear in mind that the heat transfer into the cabinets results in a reduction of building space temperature, thus increasing the building heating load.

REPLACE EXISTING OPEN COLD CABINETS

Vertical display type cold cabinets and freezers are available as totally closed units with self-closing glass doors to provide visibility and access. These units have considerably lower heat gains than the open types, but still provide acceptable access and display.

Their initial cost does not warrant replacing new or almost new open types but where existing equipment is at or near the end of its useful life or where remodeling is contemplated, closed cabinets should be used in preference to open. Select new equipment on the basis of efficiency and seasonal COP.

MOVE CONDENSERS CLOSE TO COMPRESSORS

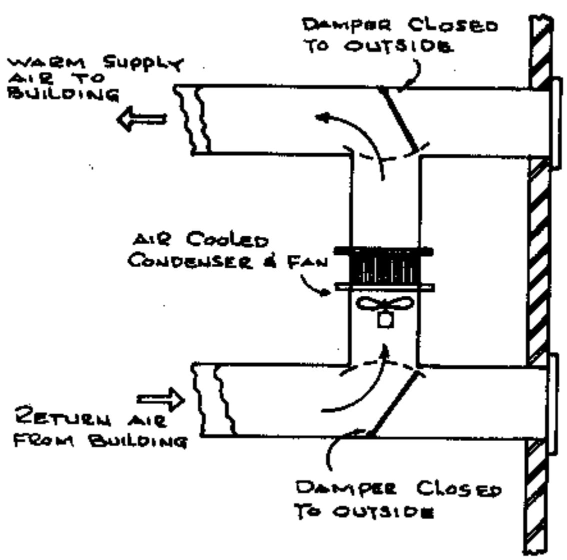
The resistance to refrigerant flow in long pipe runs between the compressor and condenser raises the head pressure and temperature. This results in less refrigeration output, increased power input, and longer cycles of operation to meet a given load.

To increase the efficiency of the refrigerating machines, relocate air-cooled condensers to minimize length of pipe runs. Check that oil return will not be impaired.

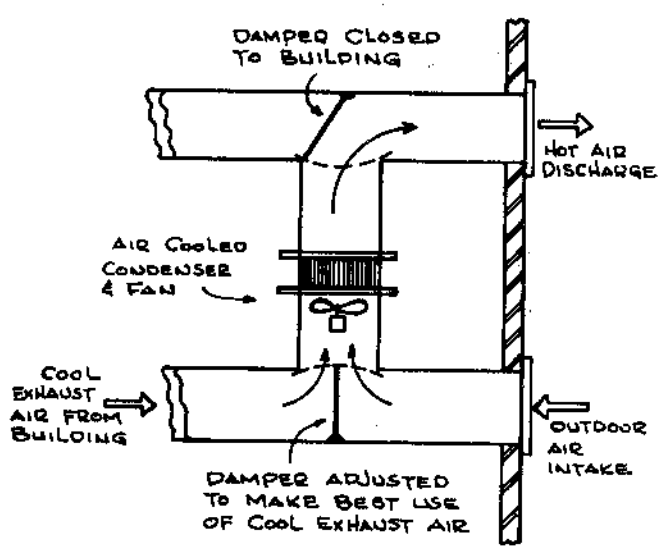
RELOCATE CONDENSERS TO RECAPTURE WASTE HEAT

In winter the hot air from air-cooled condensers can be usefully employed to meet part of the heating load.

In conjunction with ECO # 95 relocate air-cooled condensers so that hot air off the coil can be ducted into the building. Depending on the configuration, the existing condenser fan may have sufficient capacity reserve to provide adequate air flow through the new duct system or an additional fan may be required. If possible, arrange duct and dampers so that cold exhaust air from the building can be directed through the condenser coil in summer.



WINTER OPERATION



SUMMER OPERATION

GUIDELINES TO REDUCE ENERGY USED FOR COMMERCIAL REFRIGERATION SYSTEMS

Refer to ECM1, Section 4, "Commercial Refrigeration Systems" for specific measures which apply, and to all other Sections in both Manuals which address compressors and condensers.

Analyze and consider the following measures to conserve additional energy:

a) Convert air-cooled compressor and condenser installations to water-cooled systems when ambient wet bulb temperatures on a seasonal basis are favorable.

b) Install a heat reclamation system to salvage heat rejected from condensers for use in space heating.

c) When replacing frozen food cases, refrigerators and cold display cabinets, select equipment based on cooling efficiency rather than first cost.

d) When replacing refrigeration equipment, select equipment to give the highest seasonal COP.

e) Replace cold cabinet internal lights with external lights.

f) Provide night covers for open cold cabinets

g) Use closed cabinets when replacing existing open type cold cabinets.

h) Move condensers close to compressors to minimize length of pipe runs.

i) Relocate condensers to utilize hot air off the coil.

Flexible Vinyl Heat Barriers Sell Briskly

By JOHN SCHNEIDAWIND

NEW YORK — Sales of flexible vinyl-strip doorway barriers for industrial use in retaining heat and meeting noise standards have increased an average of 450 percent since their introduction to the American market in 1973, said several manufacturers of the product.

Despite the fast-paced sales, however, manufacturers do not foresee price increases or supply shortages in the near future.

The vinyl strips are hung like curtains so that vehicles and personnel can pass freely through openings, and the suppliers claim the product can retain from 80 to 95 percent of the heated or refrigerated air that would normally be lost everytime a warehouse door is opened.

Most common applications include use in spray particle containment (from sandblasters or grinders), temperature control between rooms and in loading dock receiving doors, and as tinted transparent welding curtains.

"That last application results from a federal regulation that prohibits employees from being exposed to eye-damaging glare and sparks," according to Stephen Grove, president of Metalglas Products Inc. of Atlanta. He said the product's main applications are for temperature control in a warehouse or plant, containment of dust resulting from a bagging-off of a dry material, and deadening of sound emissions in areas requiring strict noise standards. He stated that the product has a 95 percent efficiency, meaning that 95 percent of refrigerated or heated air normally lost without the strips will be saved.

"I would be sure that the product will pay for itself

See VINYL, Page 10

ENERGY TECHNOLOGY

Vinyl Heat Barriers Net Steep Sales Rise

Continued From Page One

within the first year of its use," he said. Metalglas Products has marketed the product since the fall of 1976, "but this is the first big push we are giving it," stated Grove. With normal care and use, he added, the product could last as long as ten years.

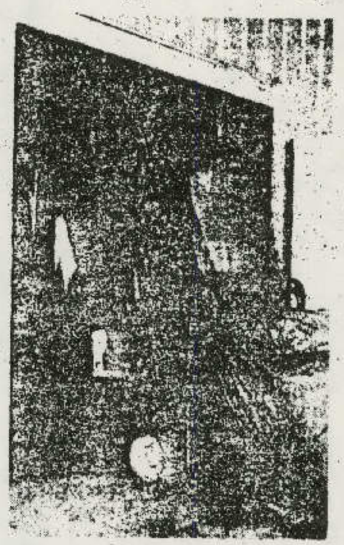
"It can be used for temperature control anywhere between a maximum temperature of 150 degrees F. to a minimum of 40 degrees F," he said. Metalglas quotes the price of the material at between $5.50 and $6.50 per square foot, and includes all hardware in the specifically designed application. The product is available within a week to ten days of order.

McGuire Co. Inc. of Hudson, N.Y., also manufactures the strips. Since introduction to the American market in 1973, sales of the strips have increased "almost 400 to 500 percent," according to Ray Wicks, sales engineer at the company.

"Efficiency will vary depending on application," cautions Wicks. "I would hesitate to claim an efficiency of 95 percent if the strips are located in an area exposed to wind velocities of 30 to 40 m.p.h. Also, negative pressure resulting from pumps used to circulate air within a plant, for example to remove sparks from a grinding wheel, will prevent the strips from remaining stationary, resulting in a slight loss of temperature retention."

For noise reduction implementation, McGuire has conducted tests at Riverbank Acoustical Laboratories in Geneva, Ill., that have resulted in a reduction in decibel ratings of almost 50 percent. "Because decibel ratings are measured logarithmically, a 100 decibel rating reduced by ten to 90 is not a 10 percent reduction, but a 50 percent reduction," said Wicks.

McGuire prices the material in various thicknesses, and sells it in 150 to 250 foot linear roles. For its 8-inch thickness the price is $1.40 per linear foot; 12-inch thickness, $2.20 per linear foot; 16 inch



Flexible vinyl barriers have cut heat and refrigeration losses by up to 90 percent, manufacturers say, while cutting down noise. Since their introduction four years ago, sales have increased rapidly.

thickness, $3.20 per linear foot. These prices refer to U.S.D.A. approved, non-toxic materials for use mainly in supermarket refrigeration.

The company also offers toxic, non-approved commercial-grade material in 12 and 16 inch thicknesses, priced respectively at $1.80 and $2.65 per linear foot. These applications would include use in plants where food is not manufactured or processed. McGuire has a three-week lead time from order to shipment of the product..

Twice The Sales

A spokesman for Nieco Corp. of Burlingame, Calif., essentially echoes the analysis of market demands offered by McGuire Co. and Metalglas Products. "Let me put it this way, states Doug Power, vice president of the company. "Since we first began marketing the product a year and a half ago, from the first month of sales, we are doing twice as much per day in sales. We have doubled our production capacity and are automating our packaging line to find more efficient ways to package the product."

The company projects a lead time of between four and seven days, including hardware made to specification. Nieco offers the strips in 8-and 12-inch thicknesses, and quotes a price of $190 for a typical 5 by 6 foot opening, with some overlap, for the 8-inch thickness, and a $204 price for the same size with a 12-inch thickness. The company claims that its product will save between 90 and 92 percent of air that is normally lost.

The company feels that noise reduction claims of 50 percent are not accurate. "According to tests we have made at San Jose State University's acoustical laboratories," states Power, "we have experienced a reduction on the average of between 9 and 10 decibels. That 50 percent figure is a meaningless figure because decibel ratings are measured logarithmically, and a 50 percent reduction is very hard to claim. We have experienced decibel reductions of as much as 15 or 16 decibels, but the average figure amounts to 9 and 10."

Metalglas Products Inc. is located at 3400 Oakcliff Road, Atlanta, GA, 30340. McGuire Co. is located at 100 Hudson Ave., Hudson, N.Y. 12534. Nieco Corp. is located at 88[illegible] Mitten Road, P.O. Drawer 4506, Burlingame, Calif. 94010.

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-- REPAIR WARPED OR DAMAGED DOORS
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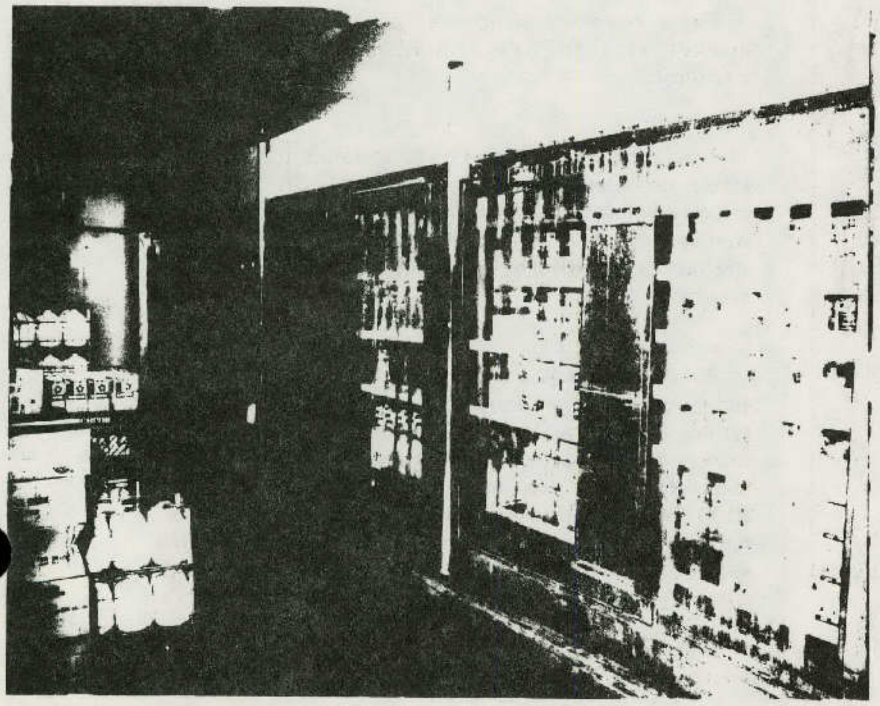
-- MAINTENANCE CONTRACT SERVICE

PRODUCTS

-- OVERLAPPING CLEAR PLASTIC STRIP DOORS FOR WALK-IN OR REACH-IN COOLERS
 . STRIPS PART DURING ENTRY TO THE COOLER AND THEN FALL IN PLACE AND SEAL BY STATIC FORCES
 . WILL NOT CRACK OR BREAK DUE TO COLD TEMPERATURES
 . COST -- $65 REACH-IN, $150 WALK-IN



SAVINGS

. 30-35% OF THE ENERGY FOR EACH COOLER WITH PROPER MAINTENANCE AND PLASTIC STRIP DOORS

CUSTOMERS

. SAFEWAY
. TOM THUMB
. FED MART

PLASTIC STRIPS ON LOADING SIDE OF REACH-IN COOLER. ←

ENERGY MANAGEMENT IN THE SUPERMARKET

A supermarket is a unique energy management application. Most commercial applications only require some form of conventional comfort control, but the supermarket requires further substantial consideration.

First, the heating, ventilation and air conditioning (HVAC) controls must provide ambient conditions that keep the employees and customers comfortable. These are the environmental controls.

The refrigeration system must maintain proper display case temperatures to keep merchandise in a saleable condition.

Without systemized controls, these systems frequently oppose each other when combined in the same supermarket area. Cold air spillage from the refrigeration cases causes need for additional heat to maintain the ambient temperature. Likewise, the difference between the store ambient and individual case temperatures (plus store humidity) dictates the refrigeration compressor's need to work harder. The energy management opportunity is to reduce the disharmony between the two systems.

Fig. 1—The Energy Management problem.

Proper close humidity control is very important in supermarket applications. High humidity levels increase the latent load on refrigeration plus cause inefficient display case operation when frost forms on evaporator coils. If uncontrolled, high humidity could cause unpleasant store conditions such as peeling paint and plaster, warped ceiling tiles, and paper labels becoming unglued from merchandise. High humidity conditions in a store also require maximum use of anticondensate heaters to prevent moisture from condensing on display surfaces.

Store humidity conditions influence the following:

1. Number of display case defrost cycles.
2. Energy consumption of anticondensate heater.
3. Latent load on refrigeration compressors.
4. Run time of dehumidification equipment.

Unlike other closely controlled commercial applications, the supermarket varies in temperature throughout the store. The coldest area is around the low temperature cases. Cold air spillage causes the ambient temperature surrounding cases to drop as much as 10 F [5.6 C] lower than rest of supermarket.

Fig. 2 resembles an infrared snapshot of a supermarket area showing horizontal temperature stratification.

This lateral stratification of temperature has a major effect on energy management control. Stratification affects the location of thermostats and dehumidistats as well as placement of cases, air distribution patterns and the savings provided by an energy management control system.

A supermarket is also unique in the high amount of energy consumed per square foot. An electrical bill for a typical 20,000 square foot [1858 square metre] supermarket is $40,000 to $60,000 per year. In larger stores and tight energy rate areas, energy usage may exceed $100,000. Fifty percent of the energy consumption is required to run the refrigeration system. This high energy expense makes the supermarket a particularly good target for energy management control.

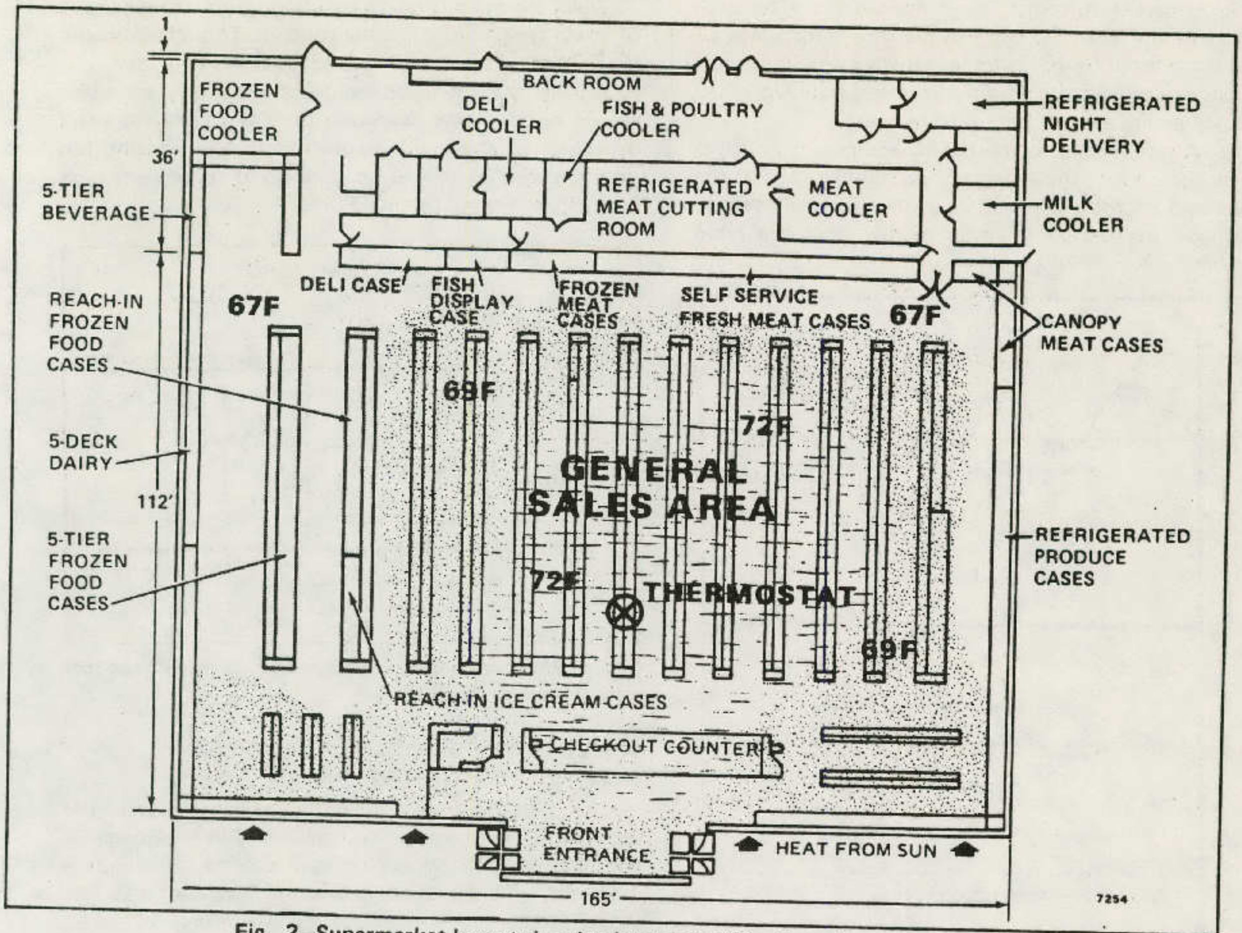


Fig. 2—Supermarket layout showing lateral stratification of temperature.

ENERGY SAVING OPPORTUNITIES

1. REDUCING ENERGY WITH HEAT RECLAIM

An energy saving method then can reverse the tendency of the refrigeration and environmental HVAC systems to fight each other. The refrigeration system removes heat away from the display cases, then releases the heat through the condenser coil. But, if the heat given off by the condenser is recycled to control the space temperature, then the load on the auxiliary heating equipment is decreased. Heat reclaim takes advantage of free energy that was previously being wasted. Depending on geographical location and corresponding weather requirements, it can satisfy a large percentage of the store's total heating load.

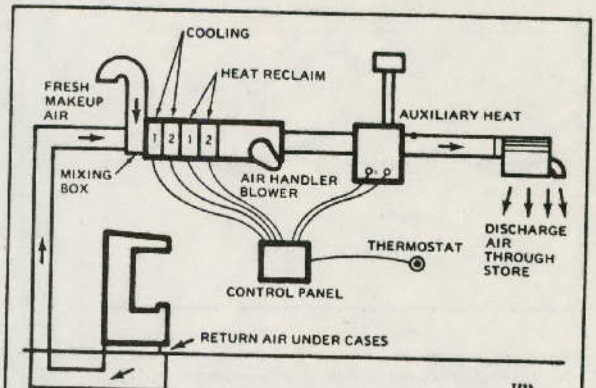


Fig. 3—Typical heat reclaim system.

2. REDUCING ENERGY BY WIDENING DEADBAND

Saving energy is accomplished by simply operating the heating and cooling equipment less often. This is done by widening the deadband between heating and cooling operations.

For comfort control, the deadband is minimal (1 to 2 F [1 C]) in most commercial HVAC applications. However, to save energy, comfort can be compromized with a 3 F to 5 F [1.5 to 3 C] deadband where no heating or cooling occurs. This causes the space temperature to fluctuate without activating HVAC equipment.

Supermarket customers dress appropriately for each season of the year. So, we can sacrifice some space air comfort without losing customer satisfaction. Since most people accept cold aisles from refrigeration spillage, they also will accept a wider temperature swing.

As shown in Fig. 4, the HVAC equipment cycles at the upper end of the deadband in summer, and at the lower end of the deadband in winter. So the effective deadband per season is more narrow than the rated deadband.

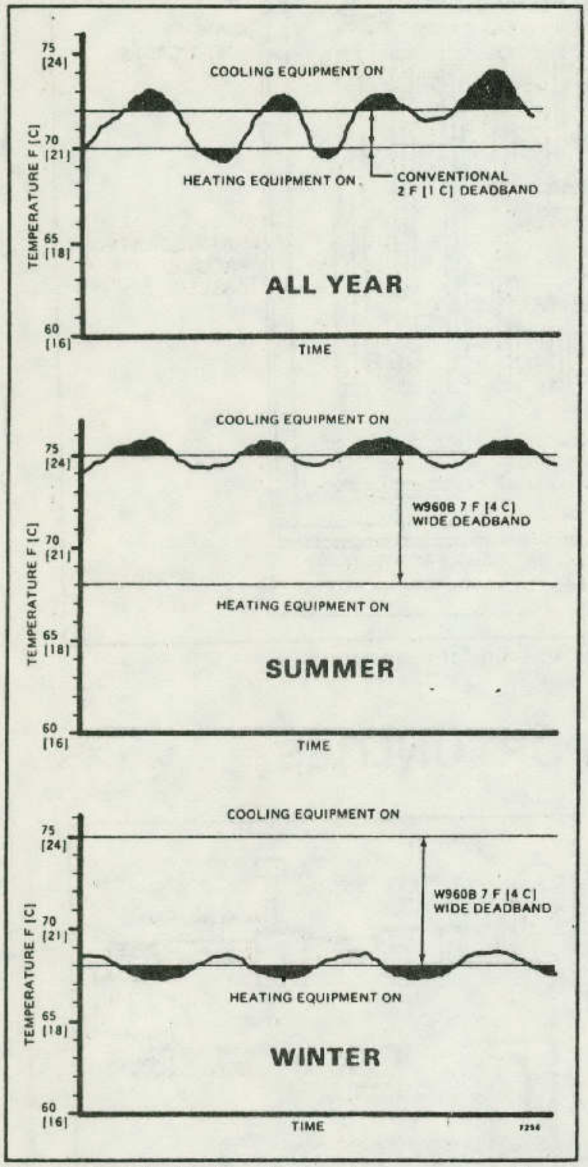


Fig. 4—A wider deadband allows for temperature fluctuations and reduces equipment operating time. Shaded areas indicate equipment operating time.

3. REDUCING ENERGY BY NIGHT SETBACK

Heating energy may also be saved by lowering the space temperature at night, when the supermarket is unoccupied. (However, this may be prohibitive if the store is open 24 hours a day.)

When the store is relatively unoccupied, strict control of space temperature is not a concern. This allows lowering the space temperature to reduce the energy load.

During the night operation, the cooling set point should be the same as during the day to prevent extra operation of the cooling equipment. Additionally, humidity overrides should be considered to prevent high humidity during unoccupied times.

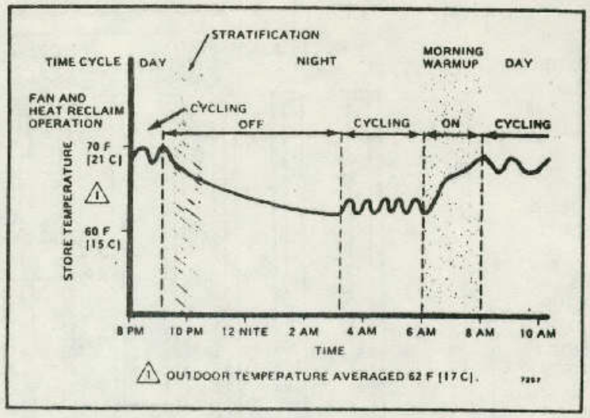


Fig. 5—Lowering store temperature at night reduces energy load.

4. REDUCING ENERGY REQUIRED FOR REFRIGERATION

Lowering the space temperature at night reduces the load on the refrigeration equipment. With less temperature difference between the case and the surrounding space air, the compressors operate less and uses less energy to maintain the same case temperature.

5. REDUCING ENERGY BY CYCLING THE BLOWER

This saving may be increased by cycling off the blower when possible at night. When the space air is not circulated, it stratifies, or forms layers as the warmer air rises.

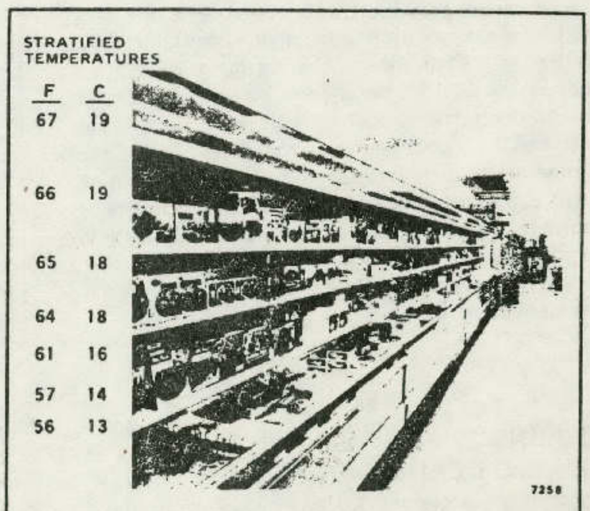


Fig. 6—Typical vertical stratified temperatures around an open multideck case.

The rising warm air is replaced by cold air spillage around the display cases. This cold air then forms an insulating blanket around the cases. The blanket reduces cold air spillage and lowers the ambient temperature and relative humidity so that the compressors operate even more efficiently during the night period. The energy saved by the blower is equal to the blower rating times the number of hours off each night.

At night, lowering ambient temperature and relative humidity around the cases can provide further energy savings. In this night period, the actual moisture content of the air is lowered. With less moisture, less condensation forms on coils of the refrigeration display cases. With less frost, the refrigeration equipment operates at even higher efficiency. If the cases are controlled by a CR70 Demand Defrost Control, the cases are defrosted less often, which saves energy. Anticondensate heater operation may also be substantially reduced if the heaters are controlled by a device such as the Honeywell H409 Anticondensate Heater Control.

W960B SUPERMARKET ENVIRONMENTAL SYSTEM WITH NIGHT SETBACK

To achieve unoccupied energy savings described in the last section, Honeywell developed the W960B Energy Optimization panel. It optimally controls 4 stages of heating, 2 stages of cooling, and 2 stages of dehumidification. A widened deadband and night setback reduce the energy required for environmental heating and cooling, as well as refrigeration display case operation.

Although the W960B controls space conditions, it is designed to reduce the load on the refrigeration equipment. At night, it reduces the temperature difference between the cases and space air and temporarily locks out the blowers. This reduces frost buildup on coils, and stratifies the surrounding air. For optimum equipment control, the W960B has a remote set point and electronic sequencing for equipment staging.

THE SYSTEM

W960B Supermarket Environmental System with Night Setback and auxiliary controls are shown in Fig. 7.

TEMPERATURE SENSORS

The system senses space temperature and dewpoint. A day thermostat keeps the space temperature in the general sales area at the normal day setting while the store is occupied.

During the night, the space temperature is lowered 10 F to 15 F [5.5 to 8 C] to increase the operating efficiency of the refrigeration cases. If the space temperature becomes too low, the store would become uncom-

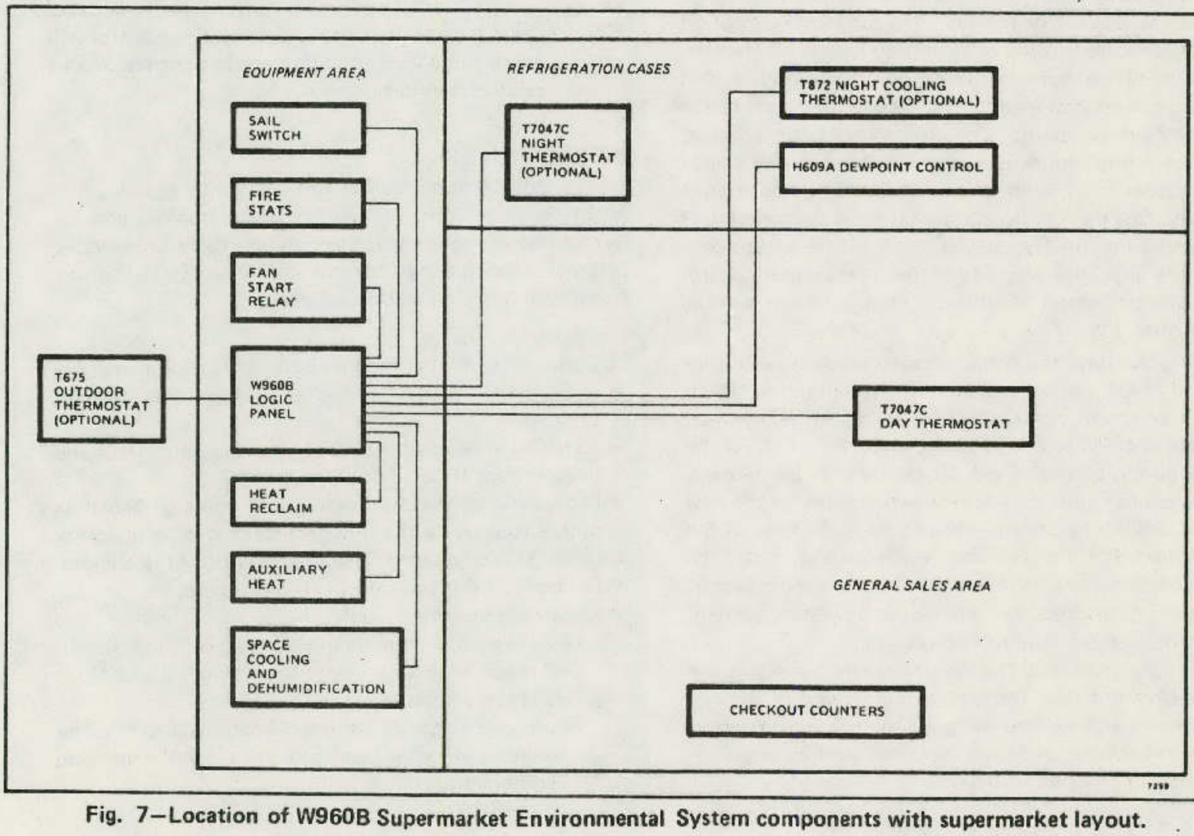


Fig. 7—Location of W960B Supermarket Environmental System components with supermarket layout.

fortable for stock people and the system may not have the capacity to pull up to the day temperature. Also, the milk and fresh meats in medium temperature cases may freeze. To prevent freezing, an optional night heating thermostat is located in the medium temperature case area.

The day and night temperature sensors are located in the sales area while the set point adjustments are in the W960B panel to prevent tampering.

Lowering the night temperature during the heating season reduces operating time and energy consumption of the refrigeration equipment. During the cooling season, the HVAC cooling equipment should not pull down the space temperature because the HVAC operating costs would exceed the savings from reduced operation of the refrigeration equipment. However, an optional night cooling thermostat may be located in the refrigeration case area to maintain the day set point for cooling only. Otherwise, the HVAC cooling equipment could be locked out entirely during the night cycle.

An outdoor thermostat is optional. In the morning, when the space temperature is rising to the daytime level, the outdoor thermostat determines if auxiliary heat is needed. If the outdoor temperature is above 20 F [minus 8 C], then heat from the sun, store lights, and heat reclaim are usually enough to heat the space air to the daytime level. The outdoor thermostat allows auxiliary equipment for warm-up only during the coldest winter days.

DEHUMIDIFICATION (DEWPOINT CONTROL)

Dehumidification is most important to maintain product quality and to minimize frost buildup on refrigeration display cases. For this purpose, the H609 Dewpoint Control is located in the refrigeration case area. Usually, dehumidification controls sense relative humidity, but the dewpoint control maintains store moisture level below a preselected dewpoint. The dewpoint is the point at which moisture condenses out of the air—the factor which causes frost buildup is condensation, not relative humidity. So, the key to condensation is the amount of moisture in the air. By sensing the actual moisture content of the air, the dewpoint control offers closer control of moisture forming conditions than a device sensing relative humidity.

During the day, the recommended space temperature is 72 F [24 C] and 40 percent relative humidity, which equals a dewpoint control setting of 45. At night, when the space temperature is reduced to 60 F [11 C], if the relative humidity rises from 40 percent to 60 percent, and the relative humidity sensor would turn on the first stage of cooling to dehumidify the store. In spite of the relative humidity increase, the dewpoint level is still the same. The dewpoint level remains constant regardless of the temperature drop. So, the H609 Dewpoint Control will not turn on the cooling equipment.

Therefore, the H609 Dewpoint Control maintains the store dewpoint below the preselected dewpoint setting. This shows how the H609 energizes the dehumidification equipment less often and saves more energy than a control responding to relative humidity.

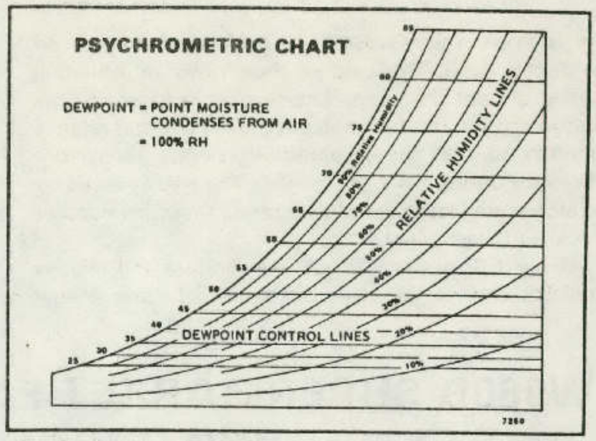


Fig. 8—Dewpoint compared to relative humidity on a psychrometric chart.

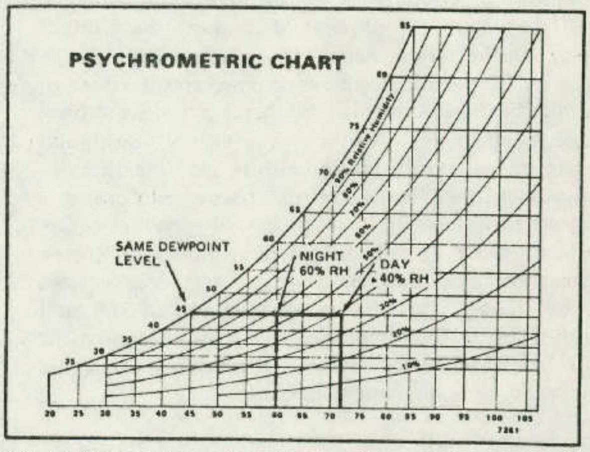


Fig. 9—On a temperature drop, a dewpoint control will energize dehumidification equipment less than a relative humidity sensor.

W960B PANEL

The W960B Supermarket Environmental System with Night Setback controls heating, space cooling and dehumidification equipment through four daily time cycles. Internal time settings control the Day, Stratification, Night, and Morning Warm-up Cycles.

The panel includes:

- 2 adjustable temperature set point potentiometers (day and night) within a locked cabinet to prevent tampering.
- Extra wide deadband between heat reclaim (H2) and booster heat (H3).
- Separately adjustable heating and cooling throttling ranges to provide the most efficient staging of equipment. Throttling range also selects width of deadband.
- Cycles HVAC blower during Night period.
- Electronic sequencer controls—
  - —2 stages of heat reclaim (heat stages 1 and 2).
  - —2 stages of auxiliary heat (heat stages 3 and 4).
  - —2 stages of cooling.
  - —up to 2 stages of dehumidification. (NOTE: The dehumidification controls turn on the cooling equipment.)

TIME CYCLE OPERATION

FUNCTION	DAY	STRATIFICATION	NIGHT	MORNING WARM-UP
Heat Reclaim	Cycles	Off	Cycles	On
Booster Heat	Cycles	Off	Cycles	Off
Cool	Cycles	Off	Off	Cycles
Dehumidification	Cycles	Off	Cycles	Cycles
Fan	On	Off	Cycles	On

Time (Example) 8 AM 9:30 PM 10:30 PM 6 AM 8 AM

- Skip-a-day feature allows panel to operate in constant Night operation on day(s) when store is not open.
- Indicator lights to show status of heating, cooling, and first dehumidification stage, plus power on. Lights also indicate night setback, fan, and auxiliary heat lockout.
- Disconnect switch manually de-energizes all system functions (except clock timers).
- A manual Night Setback Switch bypasses the Stratification, Night Setback and Morning Warm-up Cycles when switch is in OFF position. The panel controls the system at Day cycle operation until this switch is returned to ON position.
- A manual Auxiliary Heat Lockout Override Switch allows auxiliary heat stages 3 and 4 during the Morning Warm-up cycle when the switch is in the ON position. The switch energizes just long enough to establish a holding circuit, which energizes auxiliary heat stages. Then, the switch spring-returns to OFF position so that auxiliary heat lockout is maintained in the next Morning Warm-up cycle.

W960B TIME CYCLE OPERATION

The Supermarket Environmental System divides the 24 hour day into four time cycles. The day cycle occurs when the supermarket is at full employee and customer occupation. The Stratification, Night and Morning Warm-up cycles occur at times of lesser store occupancy. Typical operating times are shown with each cycle.

DAY CYCLE (8 AM TO 9:30 PM)

Day operation continues while the supermarket is occupied. Space heating and cooling equipment is controlled by the W960B internal day set point potentiometer and the sensor located in the sales area. The blower runs constantly, and the dewpoint control turns on space cooling on a call for dehumidification. The day cycle maintains comfortable space conditions for the customers and employees.

STRATIFICATION CYCLE (9:30 PM TO 10:30 PM)

In preparation for the night setback period, the stratification cycle shuts off all heating, cooling, dehumidification and air handling equipment. Without circulation, the air forms layers, or stratifies. The warm air rises, and the open display cases have air spillage that creates a microclimate around the cases which is cooler and drier than the store average temperature and humidity. The microclimate eliminates the need for air conditioning at night because this cool air acts as insulation to maintain cool temperatures within the case with less operation of the refrigeration equipment. As seen in Fig. 10, the microclimate remains only while the blower is not running.

Stratification also reduces the need for dehumidification. During this time, the relative humidity and dewpoint level drops as shown in the chart. Initially, moisture condenses out of the air onto the refrigeration case surfaces and coils at the same rate as during the day cycle. But, without air circulation, the moisture level is not replaced; so, the stratification period lowers the dewpoint of the space air around the cases, which reduces the need for dehumidification during the night cycle.

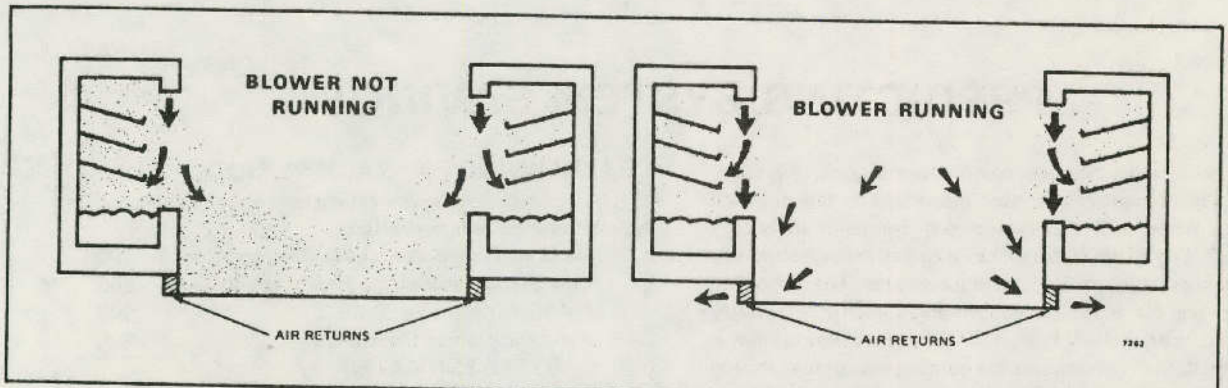


Fig. 10—Without blower operation, a cool air microclimate is formed around refrigeration cases.

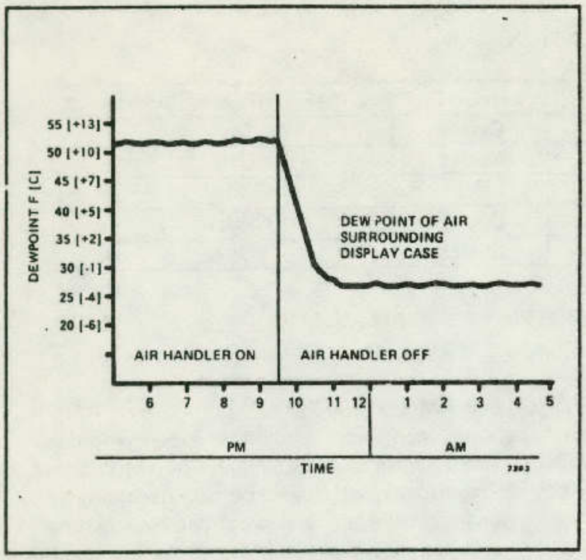


Fig. 11—Dewpoint is lowered when air handler is turned off during stratification period.

NIGHT CYCLE (10:30 PM TO 6 AM)

During the night cycle, the main objective is to save energy. The W960B panel maximizes space control requirements to provide energy savings through reduced operation of the refrigeration and HVAC equipment.

All heating equipment is controlled by the sensor and the night set point potentiometer. The night set point lowers the space temperature 10 to 15 F [5.5 to 6.5 C] below the day set point. Therefore, the heating equipment does not run as often. If the store does not have a heat reclaim system, the W970B will save additional heating energy during this time. This reduces the temperature difference between the space temperature and the refrigerated display case temperature, which reduces the load on the refrigeration system.

Space cooling equipment remains locked out unless the space temperature rises above the optional night cooling thermostat set point or H609 dewpoint control set point. During the cooling season, this thermostat maintains the night space temperature at 72 F [22 C].

Since untreated air does not require circulation during a period when the supermarket is unoccupied, the blower operates only when a call for heating, cooling, and dehumidification equipment. By keeping blower operation to a minimum, the system maintains the microclimate around the refrigeration cases.

The dewpoint sensor controls dehumidification equipment at the same set point as during the day cycle.

MORNING WARM-UP (6 AM TO 8 AM)

During the heating season, this cycle provides time for the space conditions to return to the day level before the supermarket opens. During this time, solar heat, heat generated by the store lights, and heat reclaim should sufficiently raise the space temperature up to the day set point 72 F [22 C]. To save energy, the W960B panel locks out auxiliary heat during this time. However, to provide for emergencies, auxiliary heat is energized under the following conditions:

a. Auxiliary Heat 3 was energized at the beginning of the Morning Warm-up cycle. If auxiliary heat was needed to maintain the Night cycle space temperature of 60 F [16 C], then it should remain energized to raise the space to the day set point of 72 F [22 C].
b. The Auxiliary Heat Lockout Override Switch in the W960B panel is turned to ON.
c. The outdoor air temperature falls below the set point of the optional T675 Outdoor Air Thermostat. If the outdoor air is below the recommended set point of 20 F [minus 18 C], auxiliary heat is used if required to help raise the space temperature.

During the cooling season, space temperature is controlled by the Day Set Point Potentiometer.

To provide fast store warm-up, all condenser heat should be available for heat reclaim.

Also, to provide adequate heat reclaim, case defrost cycles should not be scheduled during morning warm-up period.

A supermarket changes in its needs for space control during a 24 hour day. During the three time cycles when the store is unoccupied, the W960B varies the space conditions to provide the greatest operating efficiency.

PREDICTING SYSTEM SAVINGS

When considering a new environmental control system, supermarket owners are most interested in the payback period. When will the system pay for itself in energy savings? The W960B panel has a direct measurable way of proving system payback within one year. The following savings are for a typical supermarket with a previously installed heat reclaim system. If a heat reclaim system is not installed, the savings on the heating equipment during night setback should be included.

DETERMINING PAYBACK PERIOD

The following example estimates annual savings on a typical supermarket operation.

Medium Temperature Case Refrigeration	$ 700
Low Temperature Case Refrigeration	500
HVAC Air Handler	600
Air Conditioning Compressor	325
TOTAL ESTIMATED ANNUAL SAVINGS	$2,125

If space cooling comes from a packaged air conditioning unit, that savings may also be added to the total.

The estimated installed cost of a W960B panel with sensors is approximately $1000.

Approximate Equipment Cost	$ 700
Installation	300
TOTAL INSTALLED COST	$1,000

The payback period is cost divided by savings.

$$\text{Payback Period} = \frac{\text{Cost}}{\text{Savings}} = \frac{\$1,000}{\$2,125} = .47 \text{ years payback}$$

A W960B panel installed in a typical supermarket will pay for itself in 6 months.

ACTUAL SAVINGS ON BLOWER

Each supermarket differs in the type of equipment, floor layout, outdoor climate, store operating hours and many other factors. The cost for installing a W960B system is easily obtained, but a concrete method of estimating annual savings is needed.

Direct savings may be measured by installing an elapsed time meter on the HVAC Air Handler, or blower. The elapsed time meter measures the blower off time, which is the energy saved from the present operation where the blower is running constantly. Here is savings calculation for a typical supermarket with the following specifications.

Electric Bill (per month)	$3,300
Kilowatt Hours per Month	144,000 kWh
3-phase Blower	
Line Voltage	208V ac
Amps Full Load	34.7
Power Factor	.8

1. From the elapsed time meter, determine the hours saved since installing the W960B and calculate a yearly hour savings.

EXAMPLE: The meter shows 497 hours after a typical month. If the blower ran constantly before installing the W960B, it would run for 720 hours. Deduct 497 from 720 to get monthly hour savings. Multiply by 12 for yearly savings.

720 hours Blower Runs Constantly
− 497 hours Blower Operation with W960B
223 Monthly Hours Saved
Yearly Hours Saved = 223 x 12
= 2676 hours

2. Figure the electrical power (kW) used by the blower.
kW = volts x amps x power factor x $\sqrt{3}$ phase
= 208 x 34.7 x .8 x 1.7
= 10 kW

3. To determine the utility charge per kilowatt-hour (kWh), use the lowest charge in your utility rate structure (charge for highest catagory of energy consumed in your application). Remember that the energy saved by the W970B will come off this charge for the highest amount of consumed energy. If the application is using 200,000 kWh per month, the utility rate is $0.023 per kWh.

EXAMPLE RATE STRUCTURE
First 20,000 kWh — $0.041 per kWh
Next 80,000 kWh — $0.032 per kWh
Next 900,000 kWh — $0.023 per kWh

4. Determine the dollar savings for blower operation.
$ Savings from Blower = Blower kW x hours saved x utility charge per kWh
$ Saving = 10 kW x 2676 hours x $0.023 per kWh
= $615

5. Compare the actual blower savings to the estimated value.

ACTUAL REFRIGERATION SAVINGS

The refrigeration savings cannot be recorded by elapsed time meters. An elapsed timer only records the on time of each compressor. It does not differentiate between the compressor running at full load and a compressor running under light load conditions. During night setback, the load is reduced on the compressors which decreases the power consumption. However, this does not significantly change the on-off time of the compressors, as recorded by the elapsed time meter.

Refrigeration savings depend on the reduced compressor loading during the stratification and night setback periods. This reduced energy is due to the insulating microclimate and the lowered ambient temperature at this time. The savings are calculated by the formula on this page.

ΔT AFFECTS SAVINGS

Before reviewing refrigeration savings, temperature difference (ΔT) should be explained.

From the supermarket study, the estimated savings for medium temperature cases is $700; for low temperature cases, the savings is $500. The medium temperature cases have a greater dollar savings. This extra savings results from less temperature difference (ΔT) between the space temperature and medium temperature case surfaces than between the space and low temperature case surfaces.

For example, assume the space temperature at the cases is 70 F [21 C], the average surface temperature of the medium temperature cases is 35 F [2 C] and the average low temperature case is 0 F [minus 18 C]. Remember, the space temperature around the refrigeration cases will be a few degrees lower than in the general sales area.

The ΔT = Space Temperature—Surface Temperature

Medium Temperature Case
ΔT = 70 F - 35 F = 35 F [ΔT = 21 C - 2 C = 19 C]

Low Temperature Case
ΔT = 70 F - 0 F = 70 F [ΔT = 21 C - minus 18 C = 39 C]

When the store temperature drops from 70 F [21 C] to the night temperature set point of 60 F [11 C], the temperature difference is reduced by 2/7 for the medium temperature cases, but only 1/7 for the low temperature cases. The night space temperature is 60 F [16 C].

$$\text{Reduced } \Delta T = \frac{\text{Day space temp. - night space temp.}}{\text{Day } \Delta T}$$

$$\text{Medium Temperature Case Reduced } \Delta T = \frac{70\text{ F} - 60\text{ F}}{35\text{ F}} = \frac{2}{7}$$

$$\left[\frac{21\text{ C} - 16\text{ C}}{19\text{ C}} = \frac{5}{19}\right]$$

$$\text{Low Temperature Case Reduced } \Delta T = \frac{70\text{ F} - 60\text{ F}}{70\text{ F}} = \frac{1}{7}$$

$$\left[\frac{21\text{ C} - 16\text{ C}}{39\text{ C}} = \frac{5}{39}\right]$$

Since the medium temperature cases have twice the ΔT reduction, the savings on compressor operation will also be greater.

REFRIGERATION SAVINGS FORMULA

This formula shows the dollar savings from reduced operation of the refrigeration equipment during the stratification and night cycles.

$$\underset{(\$)}{\text{Savings}} = \underset{\text{kW Draw}}{\text{Compressor}} \times \underset{\Delta T}{\text{Reduced}} \times \text{Reduced Compressor Operation hours/year} \times \text{Cost/kW}$$

Here is a savings calculation for a typical supermarket with the following specifications:

kW Draw =
- Medium Temperature Case—35 kW
- Low Temperature Case—50 kW

ΔT =
- Medium Temperature Case—2/7
- Low Temperature Case—1/7

Hours of Reduced Operation =
(Stratification Cycle Hours + Night Cycle Hours) x Days in Year

Reduced Operation = (1 hour + 7.5 hours) x 365 days = 3102.5 Hours Saved per Year

Cost per kW = $0.023

Medium Temperature Case
Savings = 35 kW x 2/7 ΔT x 3102.5 hours x $0.023 = $714.17

Low Temperature Case
Savings = 50 kW x 1/7 ΔT x 3102.5 hours x $0.023 = $510.21

ACTUAL SAVINGS ON A/C COMPRESSOR

The method for determining savings on the air conditioning compressor is similar to the refrigeration system formula.

$$\text{Savings} = \text{kW Draw} \times \text{Strat. Night (Hours)} \times \text{Cooling Season (Days)} \times \$/\text{kW}$$

If the optional night cooling thermostat is used, the thermostat will leave the air conditioning system de-energized approximately 70 percent of the stratification and night period. Add a .70 factor to the formula.

$$\text{Savings} = \text{kW Draw} \times \text{Strat. Night (Hours)} \times \text{Cooling Season (Days)} \times .70^{a} \times \$/\text{kW}$$

[a] Use .70 factor if optional night cooling thermostat is used.

Here is an example savings calculation:
- kW draw = 20 kW
- Stratification Night Hours = 8.5
- Days in Cooling Season = 120
- Cost Per kW = $0.023
- Savings = 20 kW x 8.5 hours x 120 days x .70 factor x $0.023
- Savings = $328.44

This savings figure assumes that the air conditioning system was running constantly during the 8.5 hour night period before the W960B was installed. For this reason, only use the cooling season days where the air conditioning unit operates during most of the night period.

In addition to the savings mentioned, many supermarkets will save energy from reduced operation of the heating equipment, particularly if a heat reclaim system was not previously installed. Also, if the store has an H409 controlling anticondensate heaters, the W960B Supermarket Environmental System with Night Setback will cause reduced operation of the heaters. If the store has a CR70 Demand Defrost System, the reduced ambient temperature will allow the defrost heaters to run less often.

Using the actual savings for the blower, refrigeration cases, air conditioning compressor and any other equipment, calculate the payback period as shown on page 8.

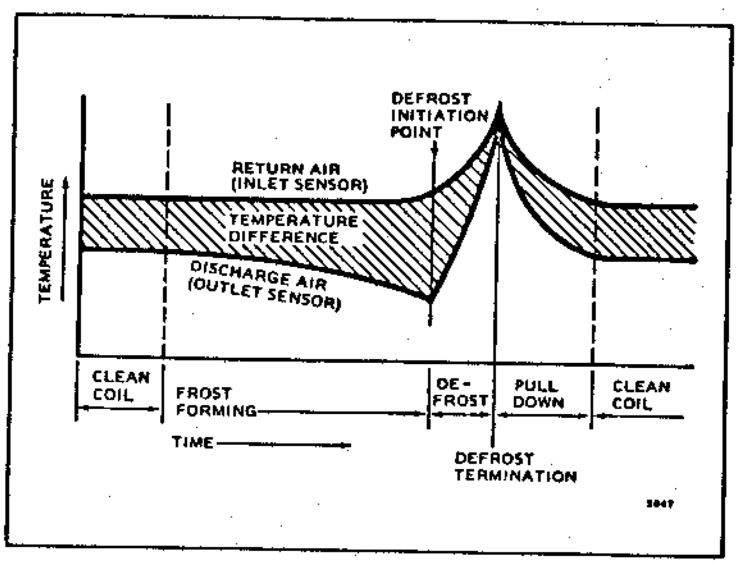


Fig. 2—Complete defrost cycle.

ardco

Ardco, Inc. 12400 S. Laramie Ave. Chicago, Illinois 60658 312 388 4300

7 Scan-X can be installed on any 2 to 5 door upright freezer equipped with Ardco Swingline doors.

Scan-X has a total capacity of 16 amps at 115 vac. Scan-X may also be customized for use on most types of refrigeration equipment requiring anti-condensate heaters. For more details, contact your upright manufacturer or an Ardco representative.

8 Scan-X can be field installed on any existing Ardco equipped upright freezer.

Ardco Scan-X has been designed to be retrofitted on uprights already in use in stores. The entire unit is prewired making installation simple and economical.

9 Scan-X has the shortest payback period of any anti-condensate heater control.

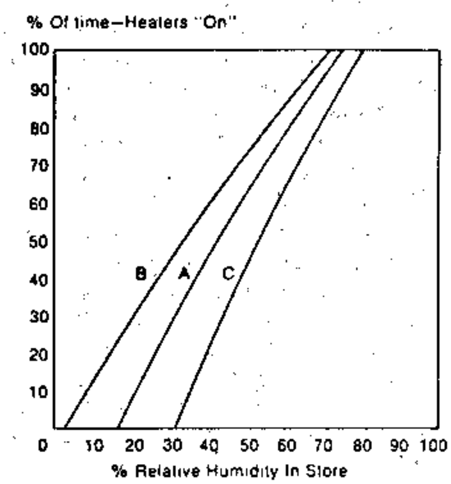
Ardco's Scan-X is an inexpensive option. The savings in energy and operating costs with Scan-X are dramatically significant. At 75°F—55% rh, Scan-X will save 30% of the power used to operate anti-condensate heaters; at 75°—35% rh, the savings are 60%. A more complete review of the savings possible with Scan-X can be found in the charts included in this brochure.

10 Scan-X is another industry "first" exclusively engineered by Ardco.

Since its founding in 1958, Ardco has been dedicated to the design, engineering and manufacturing excellence of glass display doors. Its reputation for excellence has made Ardco Swingline doors the standard of the industry.

Ardco Scan-X
Anti-Condensate Heater "On Time"*
Frozen Food Temperatures

Curve A 75°F Room; −5° F Return air
B 75°F Room; −14°F Return air
C 66°F Room; −5° F Return air



*Typical performance curves. Actual performance on specific cases may vary due to differences in case design.

Ardco, Inc. reserves the right to discontinue or change at any time, specifications, designs or materials without notice and without incurring any obligation.

Average Savings per door per year with Ardco Scan-X

Frozen Food Case Temperatures*
Room Temp—75°F
0° Return Air

In-Store Relative Humidity—Yearly Average in Percent	1¢	2¢	3¢	4¢	5¢	6¢	7¢	8¢	9¢
60	$11.00	$22.00	$ 33.00	$ 44.00	$ 55.00	$ 66.00	$ 77.00	$ 88.00	$ 99.00
55	13.00	27.00	40.00	53.00	67.00	80.00	93.00	107.00	120.00
50	15.00	30.00	45.00	60.00	75.00	90.00	105.00	120.00	135.00
45	19.00	38.00	57.00	76.00	95.00	114.00	133.00	152.00	171.00
40	22.00	44.00	66.00	88.00	110.00	132.00	154.00	176.00	198.00
35	31.00	62.00	93.00	124.00	155.00	186.00	217.00	248.00	279.00
30	32.00	63.00	95.00	126.00	158.00	190.00	221.00	253.00	285.00
25	35.00	69.00	104.00	138.00	173.00	208.00	242.00	277.00	312.00
20	38.00	76.00	115.00	153.00	191.00	230.00	268.00	306.00	345.00
15	42.00	84.00	127.00	169.00	211.00	254.00	296.00	338.00	381.00

Price of Electricity—per KWH

*75°F Room—lights on 12 hours, off 12 hours per day—100 door openings and 1 stocking per day. Actual savings may vary due to differences in case design.

ENERGY CONSERVATION FOR SUPERMARKET SERVICEMEN

ART PEREZ, P.E., FAYEZ ABRAHAM, P.E.
Tyler Refrigeration Corp.

Maintenance plays a main role in supermarket power consumption. Take two typical stores in the same climate, location and with approximately the same shopping area and equipment. One store may be much more efficient in energy use than the other. Why? The efficient store has received proper attention from a person qualified to get the most efficient operation from the equipment.

A service engineer, knowledgeable about cause and effect regarding energy use, can take the other less efficient store and drop the power consumption as much as 20%. How? By fine tuning the equipment, following regular maintenance procedures, utilizing ordinary maintenance procedures, applying available off-the-shelf controls and employing some up-to-date techniques for energy conservation.

Take a look at what consumes energy in a typical supermarket, Fig. 1.

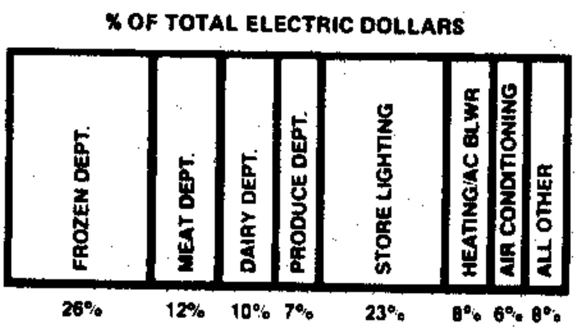


Fig 1. Typical usage breakdown for midwest supermarkets with multi-deck freezers and multi-deck meat cases. 55% of total usage is in refrigeration.

1. The refrigeration systems consume:

a. Frozen department	—	26%
b. Meat department	—	12%
c. Dairy department	—	10%
d. Produce department	—	7%
Total		55%

2. Store lights consume about 23%.

3. Store environment consumes:
   a. heating — 8%
   b. air conditioning — 6%

4. All others (meat grinders, saws, compactors, etc.) consume 8%.

It becomes evident that the major portion of power is consumed by the refrigeration systems. Each situation must be analyzed by qualified technical people to achieve the proper balance between equipment and the store's environment to minimize energy consumption.

Air Distribution Systems

Within the supermarket's environment, the air distribution system is involved with the greatest potential for saving energy. This system must distribute conditioned air uniformly throughout the store so that the zone which is most important to the shoppers will be conditioned to human comfort levels. For most people 68° F, 30% R.H., is the lower limit and 76° F, 55% R.H., is the upper level. Since air velocity should not exceed 50 FPM, chill effect is negligible.

Low return ducts in-floor or at floor level are a must for the efficient supermarket. Depending on many variables, lowering the return air registers in many markets would, by itself, reduce heating bills by as much as 20% and, in addition, make air conditioning more effective, Fig. 2.

covered and put back into the store, the cost of replacing the evaporator-extracted heat with newly created heat is eliminated.

There is an added bonus in recycling the condenser heat. Because of heat of compression, the heat discharged at the condenser, the heat of rejection, is normally higher than the heat extracted at the evaporator, i.e., the refrigeration load.

For the medium-temperature systems, the heat of rejection is 35% higher than the refrigeration load; and for the low-temperature systems, the heat of rejection is 65% higher.

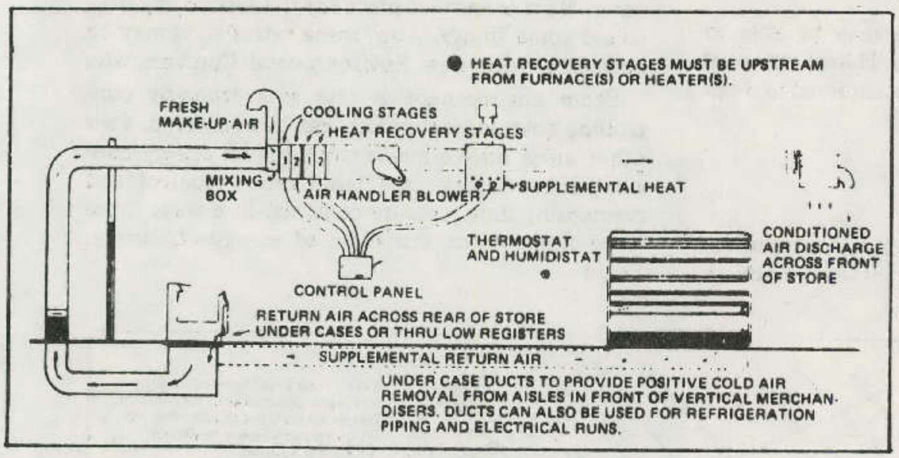


Fig. 2.

A more positive means of inducing beneficial air movement is to provide return air ducts beneath the cases. The effect of high or center return air grilles is to short circuit air over the merchandising area. For example, it is common to find return air temperatures over 90° F. with high returns. This is not only unnecessarily expensive, but it fails to properly heat and cool where the people and the thermostats are — four to five feet above the ground.

Maintenance people may be able to make air distribution adjustments to aid the above. On the other hand, it may take significant retrofitting which a qualified service engineer may want to recommend.

Heat Recovery

With well-engineered heat recovery systems, condenser heat can be discharged back into a store to eliminate a large portion of winter's heating cost. In some areas, particularly the southern states, no make-up heat is necessary in an average year. In the summertime, the condenser heat can be discharged to the outside.

Refrigeration systems within the store environment extract heat from evaporators and discharge heat at the condenser. This heat extracted by the display fixtures comes from the store in the first place and has to be replaced. If this heat is re-

For a 20,000 sq. ft. store, average savings with an efficient heat recovery method are outlined below, assuming gas heat at $3.0/million BTU's:

Minneapolis, MN	$10,720
Chicago, IL	8,570
Seattle, WA	6,000
Atlanta, GA	3,857
Dallas, TX	3,086
Los Angeles, CA	2,743
Miami, FL	300

Consider the different methods of heat recovery. With the direct air cooled method, the air from the air-cooled condenser is discharged to the atmosphere in the summertime, but during the winter is used to supplement the store heating. This method works well, but has the disadvantage of moving great quantities of unfiltered air into the store and often requires blower fans with high initial and operating costs.

The close circuit water method can only be used with closed circuit water-cooled condensers. Simply explained, the hot water is circulated to a coil in the air handler to discharge the heat back to the store.

The disadvantage of this method is that pumping the water can be expensive; furthermore, the closed circuit water can be running at 100° F. or cooler. A 100° F. heat source is not particularly good for the store, since it is relatively cool. Condenser pressure would run relatively high, too, in order to obtain 100° F. cooling water temperature.

The dual condenser method is an arrangement whereby remote primary air condensers may be used for summertime cooling. In the heating season, a refrigerant gas valve circuits the gas to a secondary condenser coil located in the store's air handling system. This method recovers the heat for the least possible cost and can be applied to the primary condensing system.

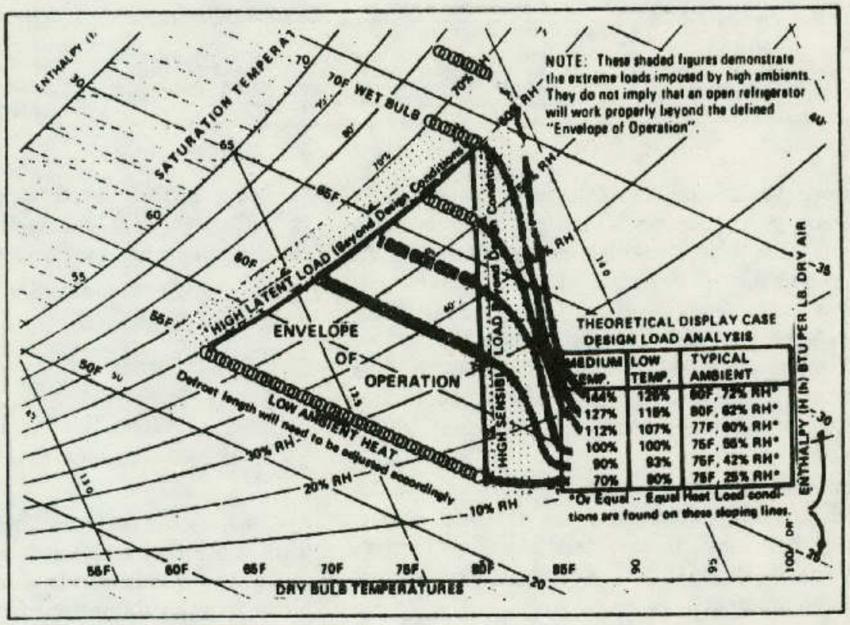
Once again, a service engineer may be able to take some steps to improve things. If heat recovery is not employed, it might be considered a high priority retrofit recommendation.

Effect of Ambient Conditions

Control of the store's environment is the cornerstone for energy conservation. Severe ambient conditions impose higher loads on refrigeration systems, just as mild ambient conditions will conserve energy. If store humidity is high, the cases will undertake the job of removing excess moisture from the air. This moisture, removed as extra frost formation on the case evaporator coils, requires extra defrost time and heat to melt it down the drain. It's important to emphasize that air conditioning dehumidifies efficiently; cases do not.

As a result of a theoretical and practical study of inter-effects between the store's environment and the store's refrigeration equipment, an envelope of operation was developed by Tyler using a portion of the psychrometric chart, Fig. 3.

Fig. 3. The Triangular area labeled "ENVELOPE OF OPERATION" on this abbreviated psychrometric chart delineates the ambient conditions in which refrigerated display cases are designed to operate. The labeled border areas outside of the boundaries tell in what way design limitations have been exceeded. Note that the High Latent Load boundary is the 60% r.h. line, and that the High Sensible Load boundary is the 80F (dry bulb) line. The Low Ambient Heat line is a less critical condition which may require longer defrost times on timed off-cycle defrost. This is because ambient heat alone is generally the source of defrost heat for dairy, deli and meat cases. Although defrosts may have to be lengthened, less frequent defrosting will be required.



The chart shows an approximate change in heat load on an open refrigerator to changes in store ambient:

EXAMPLE: If store ambient dropped from 75° F., 50% R.H., to 70° F., 40% R.H., the refrigeration loads will drop 22% for the medium-temperature cases and 14% for the low-temperature cases. Here is another place for the service engineer to aid some things. Also, some retrofitting may be necessary with new Environmental Controls, etc.

Store environment is one area whereby controlling environment energy can be conserved. Two other areas have a major emphasis on energy consumption: display case temperature control and condensing unit pressure controls. In a way, those three items form a triangle of energy efficiency, Fig. 4.

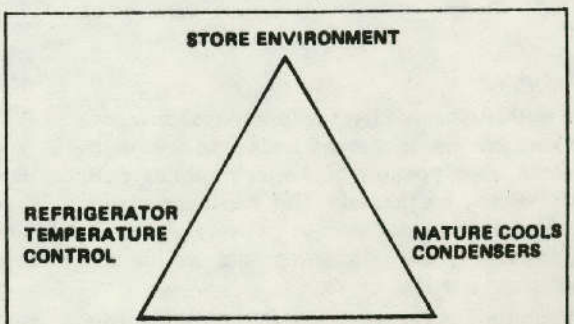


Fig. 4. TRIANGLE FOR ENERGY EFFICIENCY

RSE

FINE TUNING AND MAINTENANCE PROCEDURES

Fine tuning and regular maintenance procedures of cases, coolers and condensing units contribute to the conservation of energy in the supermarket. The following is an outline of the primary elements which affect a store's energy consumption.

CONTROL SETTING FOR REFRIGERATORS

Optimum control settings for display cases and coolers are those which produce satisfactory temperatures and lowest operating costs. Setting controls lower than necessary should be avoided. It does not make economic sense to run a frozen food case at ice cream temperatures, or a dairy case at near freezing.

LIGHTING

Internal light fixtures not only consume energy but also generate heat inside the case, increasing the refrigeration load.

Double savings can be achieved by turning off parts of or even all internal fixture lighting. This reduces the power required for lights and reduces the refrigeration loads. This, of course, depends on the operator.

High light levels over top display cases will make it necessary to operate fixtures colder. Maintaining a maximum of 100 foot candles over these cases should be adequate. Higher level lights over top display cases will increase both power consumption for lights and the refrigeration loads.

ANTICONDENSATE HEATERS

Anticondensate heater wires are used on display cases to prevent sweating where cold surfaces meet the warm ambient temperature in the store.

Anticondensate heater wires not only consume electric energy to operate, but they also increase the refrigeration load.

Glass door freezers consume high amounts of energy for the electrically heated glass and door frames. The heat input to the glass door freezer is normally designed so the glass door remains free of condensation under relatively high humidity conditions.

With lower humidity conditions in the store, the heat input to the glass and door frames can be dropped substantially. Dropping the heat will save electric energy and reduce the refrigeration load. Therefore, the use of anticondensate heater controls is recommended, especially for the glass food freezers.

NIGHT COVERS

Almost all manufacturers of commercial refrigerators recommend the use of night covers for low-temperature fixtures. Refrigeration load of cases will drop with night covers; also, product temperatures will improve. Night covers are mostly aluminum and, when used, should be kept below load lines.

It's a good idea to consult the case manufacturer before using any night covers.

DRAFTS

Regardless of the cause, be it an open door or an improperly directed heating louver, any appreciable air movement over open cases will prove troublesome and costly.

High-velocity air movement over open cases will interrupt the refrigerated air curtain and increase the mixture of store air with it. As a result, higher refrigeration loads will be imposed on the case, and defrost frequency will possibly increase.

Air movement can be easily checked with smoke. Once the source of a draft is determined, a way can be found to eliminate it.

CLEANING

Display cases should be thoroughly cleaned on a regular schedule.

Follow manufacturer's procedures for cleaning. Cleaning display cases periodically will prevent future failure and will save money and energy.

Occasionally during cleaning you may find plugged drains, unplugged fans, dirt accumulated on fan blades or heat transfer surfaces, etc. Be sure to keep them all clean and functional.

FINE TUNING AND MAINTENANCE PROCEDURES OF CONDENSING UNITS

CONTROL SETTING

In the winter months, maintain the lowest head pressure at which the system can operate without short-cycling or impairing expansion valve capacity. This will increase compressor efficiency and capacity and conserve energy.

For every 10° F. drop in condensing temperature, a corresponding drop (up to 10%) in electric energy will occur, see Fig. 5, 6.

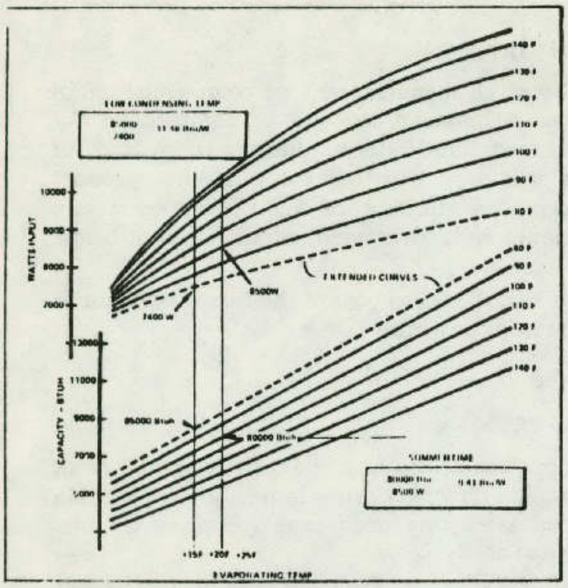


Fig. 5. SUMMERTIME Btu/W figure is derived from the standard conditions of 100F Condensing and +20F Suction for this 10 HP compressor. A substantially more efficient Btu/W figure is obtained from the LOW CONDENSING TEMP conditions of 80F Condensing and +15F Suction. (The lower suction temp allows for the unavoidable pulldown of the system when it has surplus capacity for this application.)

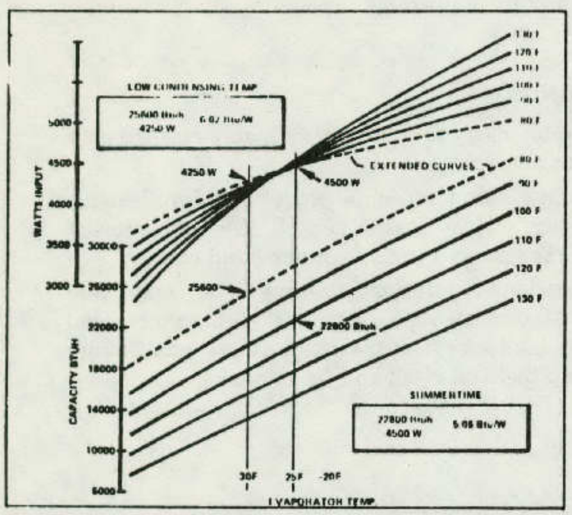


Fig. 6. SUMMERTIME Btu/W figure is derived from the standard conditions of 100F Condensing and −25F Suction for this 5 HP compressor. A substantially more efficient Btu/W figure is obtained from the LOW CONDENSING TEMP conditions of 80F Condensing and −30F Suction. (The lower suction temp allows for the unavoidable pulldown of the system when it has surplus capacity for this application.)

Imposing summer conditions of 100° F. or higher is no longer recommended through the mild seasons. Head pressure can be dropped to 100° F. or even 90° F. condensing temperature. Below that limit consult with the case manufacturer.

After reducing head pressure, carefully observe the effect on heat recovery, hot gas defrost and liquid feeding to the cases. Re-adjust the controls if necessary to reach optimum efficiency.

DEFROSTING

Defrosting costs represent only a small percentage of the total operating cost. For a 20,000 sq. ft. store, the average defrost monthly cost is about $100 at 3¢ KWH.

Only a small portion of defrost heat is consumed to melt the frost on the coil surfaces. The major portion is consumed to heat up the ducts, coil surfaces, etc. It is estimated that 50-70% of the defrost heat will remain in the cabinet after defrost. As soon as the system switches back to refrigeration, this heat has to be extracted from the cabinet.

Reducing the number of defrosts can be profitable in three ways:

1. Saves the energy required for defrost.
2. Saves the energy required to extract the remaining heat introduced to the fixture to get rid of the frost.
3. Maintains the refrigerated food quality better by avoiding defrost warm-up.

AVAILABLE DEFROST METHODS

1. Time Clock

Defrost frequency is normally scheduled for the worst humidity conditions. Defrost frequency will remain the same during the year.

When humidity level in the store drops, so does the need for defrost. However, time clocks are not flexible systems, and the refrigeration systems will still have the same number of defrosts throughout the year.

Temperature termination is recommended to maintain product quality and conserve energy.

2. Demand Defrost

Initiates a defrost when frost build-up on evaporator coils reaches a specific limit.

Demand defrost uses sensors to measure the inlet and outlet temperature of the air to the evaporator coil. With a clear coil, the air temperature differential across the evaporator is relatively small, say 10° F. When frost builds up at the evaporator coil, this differential will gradually increase. When the air temperature differential across the evaporator coil reaches a specific value, say 20° F., the control will initiate a defrost.

Defrost staggering of different systems cannot be assured using only this control. And there is a possibility that several defrosts will be initiated at the same time and/or during high-demand periods.

3. Proportional Defrosts

This control senses the store's relative humidity and controls the frequency of defrosts for all refrigerators in the store environment.

In humidity conditions as high as 60% R.H., it schedules 100% of recommended defrosts. In milder conditions, it proportionally reduces defrost frequency. At 30% R.H., defrost frequency will drop to one-half, and at 20% R.H. defrost frequency will drop to one-third, Fig. 7.

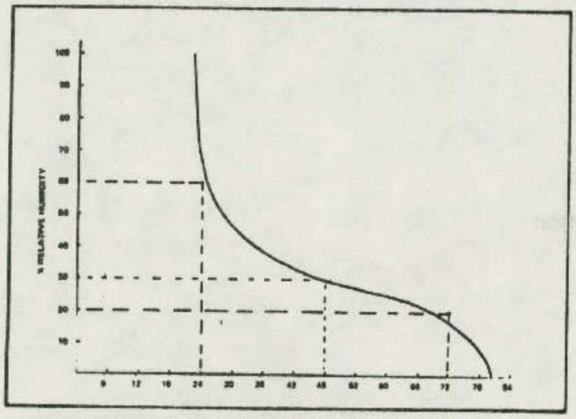


Fig 7. CAM SHAFT TIME IN HRS PER REVOLUTION

Defrost staggering can be maintained by this method. However, a defrost could still be initiated at high-demand periods.

Defrost control systems are recommended for energy conservation, even though savings are relatively small. Consult the case manufacturer for recommendation before applying any defrost control.

POWER FACTOR CAPACITOR

The motors and other inductive equipment in a supermarket require two kinds of electrical power. One type is working or power-producing current, measured in Kilowatt (KW). This is what actually powers the equipment and performs useful work. Secondly, inductive equipment needs magnetizing current to produce the flux necessary for the operation of the inductive devices. The unit of measurement of magnetizing power is the Kilovar (KVAR). Most AC power systems require both Kilowatts and Kilovars. Capacitors installed near the loads are the most economical and efficient way of supplying these Kilovars.

The use of capacitors will lead to:

1. Reduced power costs.
2. Gain in system capacity.
3. Improved voltage.
4. Reduced power loss.

CAUTION:

Power factor should not exceed 95% per compressor manufacturer recommendations.

SUCTION LINE PRESSURE DROP

Minimizing of all the pressure drop from the suction line is vital to the efficiency of refrigeration. The use of EPR or TPR valves creates pressure drop in the suction line.

Also, with EPR valves, display case temperatures vary with seasons, since EPR valves keep the suction pressure constant regardless of the refrigeration load or ambient changes. This represents another disadvantage of using EPR valves.

Inefficient methods of case temperature controlling should be changed to conserve energy. But be sure to consult case manufacturer for recommendations, because complications can occur as a result of improper adjustments.

Elimination of the pressure drop from the suction line can save up to 10% of power consumed.

CONCLUSION

It's obvious that the combination of a well-planned supermarket energy system and a comprehensive maintenance program can substantially reduce a store's energy consumption. The key is to analyze all of the factors involved — not just one or two. Simply employing a heat recovery system or changing the nighttime setting of the store will not result in impressive energy savings. All of the elements affecting a store's power consumption must be taken into consideration, beginning with the air distribution and heat recovery systems and the control of the overall store environment. Three elements have a major effect on supermarket power consumption — store environment, the method of controlling display case temperatures and head pressures of condensing units. Optimizing the energy use in these three areas will result in considerable savings in energy consumed. In a way, these three elements will form a triangle of energy efficiency. Retailers all around the country are proving again and again that, by taking advantage of this "triangle of energy saving" and employing a regular maintenance program, they can operate more efficiently and, therefore, more profitably.

1976 SMI* STUDY

"AVERAGE SUPERMARKET USED 25.5 KWH OF ELECTRICITY PER DAY FOR EACH 100 SQ. FT. SELLING AREA".

This equals 93 KWH per sq. ft. per year.

A SERVICE MAN CAN AID A SUPERMARKET OPERATOR REDUCE HIS USAGE BELOW THE SMI* AVERAGE.

TEACH HIM TO APPLY THESE TIPS.

PLANNED MAINTENANCE –

- Clean condensers – Check with flashlight
- Check all fans on cases and compressors for proper operation
- Clean case bottoms – grilles and coils
- Check and replace filters in store air systems
- Tighten all openings into store
- Put all lighting on a schedule preferably mechanical
- Check heating/cooling controls

WORK OUT A RETROFIT PLAN WITH A TRUSTED SPECIALIST

ROUTINE CLEANING AND INSPECTION

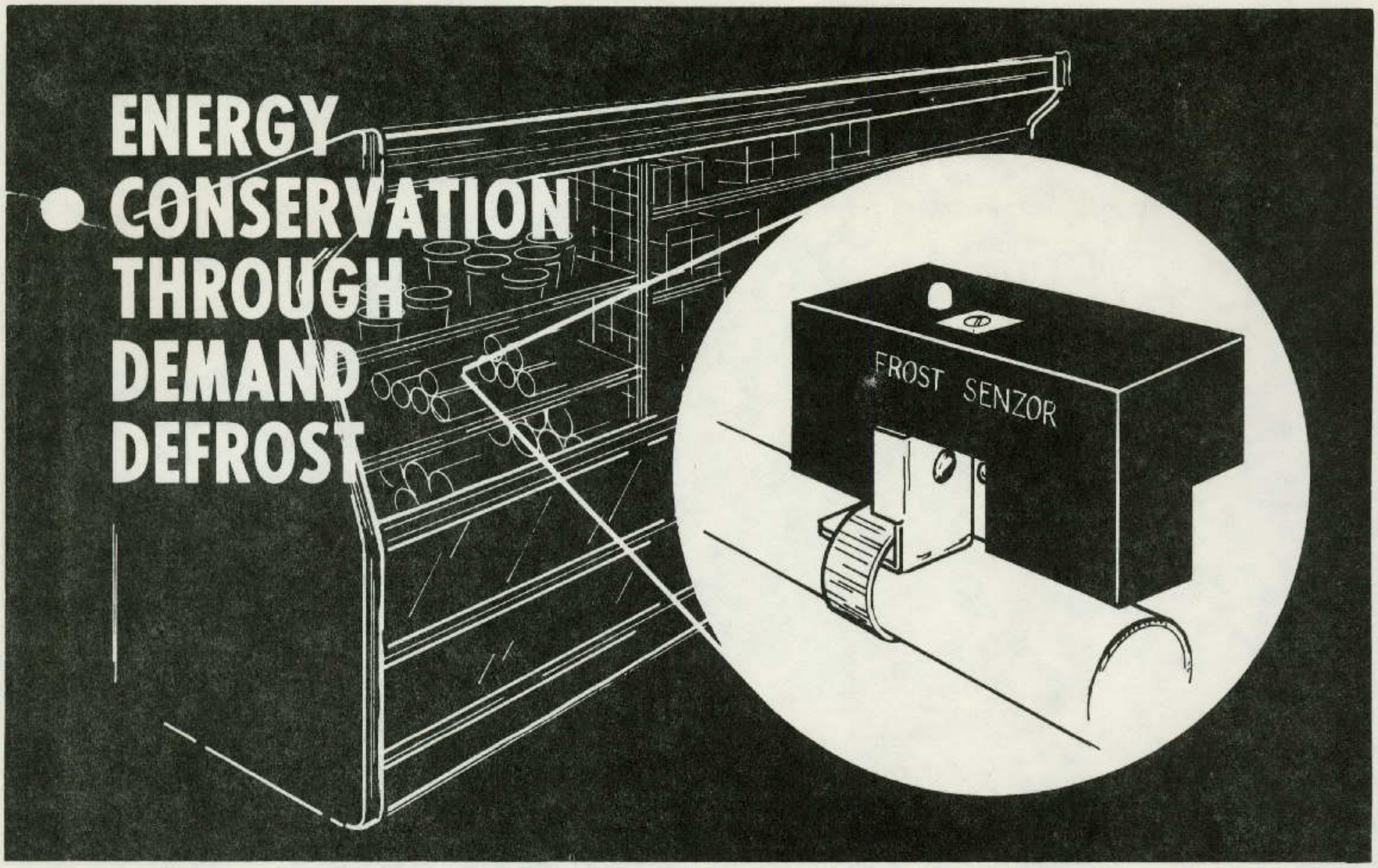
	Weekly	Every 2 Weeks	Monthly	Every 2 Months	Quarterly	Annually
Fresh Meat	X					
Smoked Meat			X			
Milk		X				
Cheese						X
Frozen Food & Ice Cream						X
Produce					X	
Deli	X					
Coolers			X			
Freezer Coils						X
Prep Room Coils				X		
HVAC					X	

* Supermarket Institute is now Food Market Institute

Refrigeration Service Engineers Society

BETTER SERVICE THROUGH KNOWLEDGE

FOUNDED 1933



ALTECH FROST SENZOR

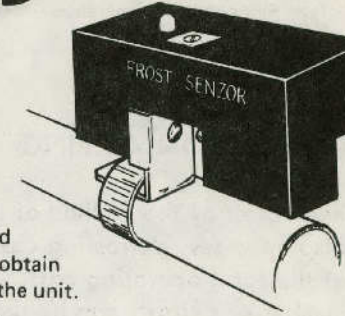
- Eliminates 50%-70% of Scheduled Defrosts
- Improves Product Appearance and Quality
- Reduces the Systems' Energy Consumption
- Prolongs Product Shelf Life
- Schedules Defrosts During Non-Peak Periods
- Decreases Product Shocking
- Electronically Measures Frost Thickness
- Ideally Suited for Retrofitting Existing Fixtures
- Dependable — Totally Solid State
- Easy to Install
- Uses Existing Time Clock
- Investment Payback Typically 10-15 Months

The Altech Frost Senzor is an energy saving device that reduces power consumption in low-temperature refrigeration systems by eliminating unneeded defrost cycles. Since less defrosts are required product appearance, quality and shelf life are enhanced.

The solid state unit fastens to the refrigeration cooling coil and electronically measures the frost thickness that forms on it. Typically, a single Altech Frost Senzor is required for each condensing unit system. After detecting the fixtures optimum frost build-up level, the Altech Frost Senzor initiates a defrost cycle. Unlike previous "demand defrost" devices, the Altech Frost Senzor reacts directly to the cause for defrosting (frost build-up), and not to some effect such as fixture air velocity, humidity or temperature differences.

The Altech Frost Senzor features a LED lamp that indicates the unit's operational mode and a field adjustable set-screw that permits unit triggering to a desired frost thickness. The device functions in gas, electric and air defrost systems and can be installed on multi-deck, single-deck, reach-in and walk-in freezer equipment. The Altech Frost Senzor is ideally suited for retrofitting existing fixtures. A complementary device — the Altech **Signal Transmission Kit** — facilitates the installation process by eliminating the tedious task of pulling control wire.

SYSTEM INSTALLATION AND WIRING DIAGRAMS



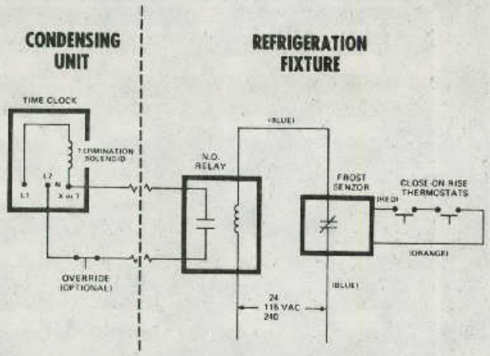
MOUNTING

The Altech Frost Senzor simulates a cooling coil fin. It can be mounted either on the return bend or on the air outlet side of the cooling coil. The refrigeration fixture type and model number will determine the unit's optimum installation location. In either case, to obtain frost build-up on the Altech Frost Senzor plate (fin), air flow must freely move through the unit.

When mounted on the return bend of the cooling coil, the Altech Frost Senzor should be fastened as close as possible to the expansion valve feed. Make certain that all air restrictive grilles or plates provide adequate air flow through the Altech Frost Senzor by either removing or adding holes in them.

When fastened on the air outlet side of the cooling coil, the Altech Frost Senzor should be mounted at the rear circuits of the coil since they generally provide the first passes fed by the distributor. The unit should be located half-way between fans to minimize the effects of fan failure. To provide adequate air movement through the unit, the entire length of a 2" wide path of fins must be removed in front of it. This path insures like frost build-up on the aluminum plate of the Altech Frost Senzor (where frost thickness is measured) as that on the front of the coil, even if the face of the coil blocks.

TERMINATE CONFIGURATION

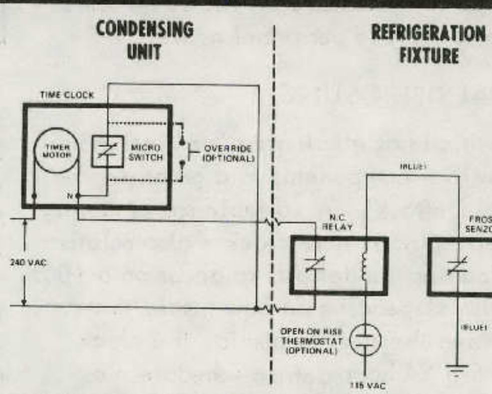


The Altech Frost Senzor is a normally closed switch. When the frost on the cooling coil accumulates to a point where a defrost is required, the Altech Frost Senzor opens, thereby opening the relay contact. The timer is no longer terminated and will initiate a defrost at the next schedule defrost pin. Defrost termination takes place when the "close-on-rise" thermostats close thereby resetting (closing) the Altech Frost Senzor switch.

MICRO-SWITCH CONFIGURATION

The Altech Frost Senzor is a normally closed switch. When the frost on the cooling coil accumulates to a point where a defrost is required, the Altech Frost Senzor opens. This action closes the relay contact, thereby closing the 240 volt electrical circuit as it starts the timer motor defrost cycle.

Note that the timer motor has been stopped by the micro-switch just prior to initiating a defrost. It mechanically opens as the defrost pin comes up. When a defrost is initiated, the micro-switch contact closes and the clock remains running until the next defrost pin opens the contact again.



ALTECH CONTROLS CORPORATION

9720 TOWN PARK – SUITE 101
HOUSTON, TEXAS 77036
713/777-8877

TYLER
Tyler Refrigeration Corporation
Niles, Michigan 49120

PROPORTIONAL DEFROST CONTROLLER

DEFROST CONTROLLING

Regardless of the method of defrosting refrigerated display cases, defrosting cost is only a small part of the total operating cost. However, reducing the number of defrosts can be profitable in three ways:

1. It can save much of the energy required to defrost cases.
2. It can maintain refrigerated food quality better by avoiding more frequent defrost warmup.
3. It can save the energy otherwise required to re-refrigerated product warmed slightly during defrost.

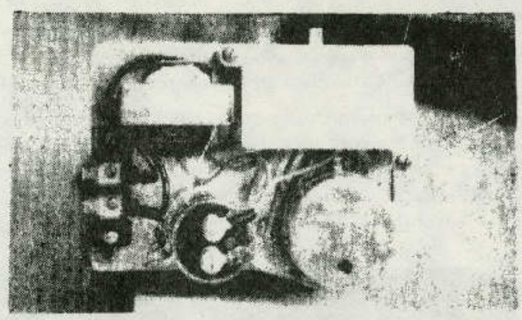
TYPICAL DEFROST CONTROLS

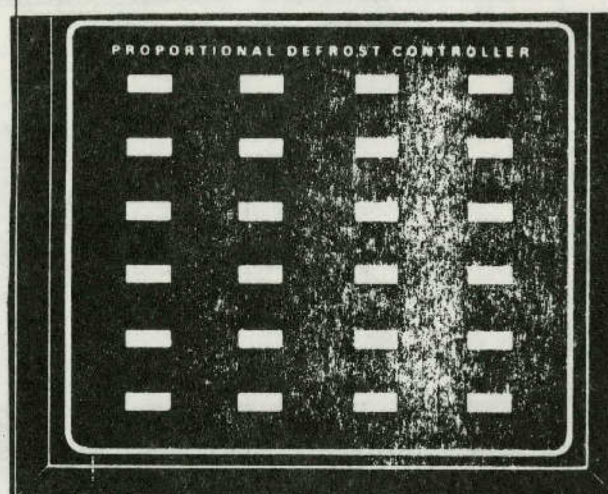
Defrosting is usually accomplished with the use of time clocks, set for the worst (summertime) conditions. These are inflexible systems and they impose more frequent defrosts than necessary when drier conditions prevail in the store. During the heating season, stores are typically drier.

Demand defrost controls use devices to sense the condition of the refrigerator coil, defrosting it only when that case needs it. Flexibility has been gained, but demand defrost has been typically confined to low temp multi-shelf cases or multi-shelf meat cases. The controls have proved to be somewhat confusing to service personnel as well.

PROPORTIONAL DEFROSTING

A new system which has eliminated "service-shock" by utilizing familiar components to a great degree is "Proportional Defrost". A variable speed motor, operating a multi-circuit time clock - also relatively familiar - causes the defrosts to occur on a 100% to 33% schedule, depending on how humid the store air is. When the store is humid, the clock will operate a full 24 hour defrost schedule - as the case manufacturer recommends. As humidity drops, the motor slows - stretching out the 24 hour schedule to as long as 72 hours.





Since the slightly modified conventional clocks in the system handle the defrost cycles normally, defrost times are standard and can be terminated by temperature or pressure or time as is normally done.

If for some reason, standard defrosting would be desirable, the clocks can be employed conventionally. by flipping a swtich and resetting the clock.

PD 200 SERIES PROPORTIONAL DEFROST INSTALLATION INSTRUCTIONS

The PD 200 Series Proportional Defrost System is relatively uncomplicated to install for either new installations or retrofit. If you have any questions, contact your Tyler man.

Install the variable speed PD and the required numbet of modified *Tyler model timers in a panel. There will then be one modified *8000 series for each RM programmable plug-in cam module. Wire the RM drive assembly with 120 volt input, and connect the sensor with standard bell wire as shown in the accompanying wiring diagram.

Connect each PD module with its corresponding Tyler model clock. Three wires are to be used for this 24 volt wiring. The diagram suggests using Brown, Yellow and Black.

After the wiring is complete, program the PD modules. The PD drive assembly controls the length of time between defrosts, while the *8000 series controls the length of the defrost cycle. Therefore each module of the PD drive is programmed with the required number of defrosts per day for the cases being controlled by that module. This would be taken from the manufacturer's recommendations. This corresponds to the worst conditions of 60% rh and will automatically result in fewer defrosts when the humidity is less than 60%.

SENSOR LOCATION

It is recommended that the humidity sensor be located about 5 feet (1.5 Meters) above the floor on a post or support near the LOW TEMPERATURE cases where actual store humidity can be sensed. Care should be taken at this point in mounting so that no outside air currents or direct drafts will affect operation of the humidity sensor.

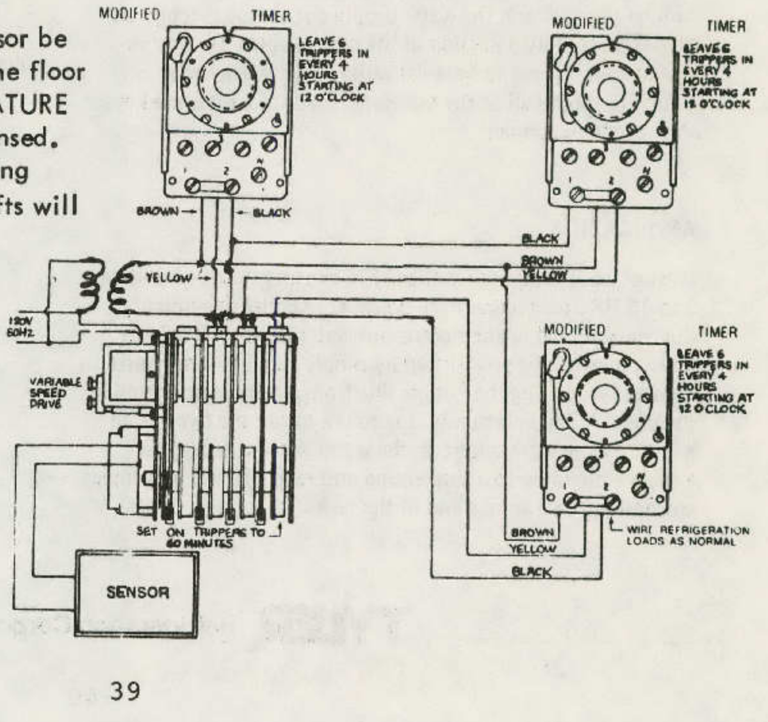
SENSOR CAUTION! - The sensor supplied is for AC current ONLY! Do not check it with an ohmmeter! The sensor should be handled by its edges ONLY since salt from your fingers may ruin it. There should be no reason to handle it except for replacement.

The time fail-safe termination setting on the PD module must be set for 60 minutes, but remember, this is not the length of defrost controlled by the corresponding Tyler model time clock. Set the length of defrost time fail-safe termination on the corresponding *Tyler model control to the required time for the cases being controlled. Each Tyler model series must be of the modified version and have an outer tripper positioned every four hours beginning at midnight.

Since the PD modules are running at variable speed, depending on relative humidity, the program no longer relates to time of day. Staggering defrosts is still accomplished since the cams are mounted on a common shaft. Also, the Tyler model timers are modified so that they do not run until defrost is initiated by the appropriate PD cam module. Once initiated, it will run for 4 hours, then stop and wait for the next defrost initiation signal from the PD.

WIRING CONNECTIONS

Brown ----- Transformer
Black ------ Common
Yellow----- N.O. Switch



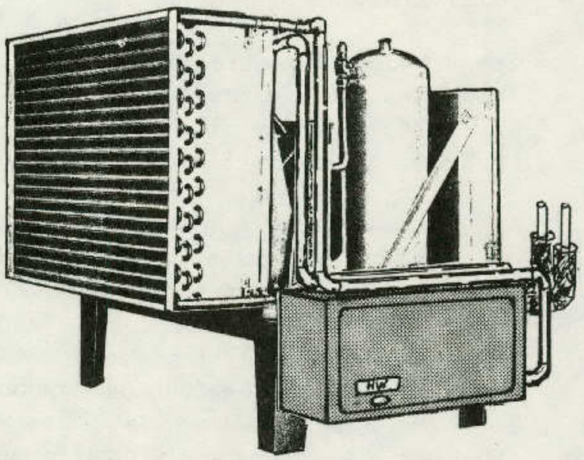
TYLER Technical Memo

PLANNING - INSTALLATION - SERVICE

TM 76-1, December, 1976

TYLER Watt Watcher

TYLER HW SYSTEM



TECH MEMOS – BACK AGAIN!

There's a lot that needs to be presented about services, products, concepts and hardware. Tech Memos are designed to try to combine all of Tyler product offerings with ideas for profitable merchandising.

TYLER HW SYSTEM – APPLIED HEAT RECOVERY

Trade magazines have run articles regarding the application of hot water heating packages on condensing units. This is a practical method of using the superheated gas from a condensing unit to heat water for the entire hot water needs of a supermarket. Tyler's version is called the Tyler HW System and is a heat exchanger with the compressor discharge gas circulating through the shell and the water supply circulating through the interior coil. Only a portion of the heat rejected by the condensing unit is used to heat the water. This is generally enough to supply all of the hot water needs of a supermarket when properly applied.

APPLICATION

Most of what's required is already in existing stores. A suitable 3 to 10 HP (low temperature preferred) condensing unit and the conventional gas or electric hot water heater. The Tyler HW System can be retro-fitted by simply running some water lines and extending the hot gas line from a compressor through the unit. A 220 volt supply is required to run the circulation pump. For new installations, the water heating package is available mounted to a condensing unit rack. The unit occupies an additional 8" on one end of the rack.

POTENTIAL SAVINGS

The chart below gives some of the data necessary to determine the worth of installing a hot water heating package in a store.

STORE SIZE IN SQUARE FEET	Hot Water Heating Requ'ment Therms/Yr	MAXIMUM ANNUAL SAVINGS POSSIBLE	
		Elect. @ 4¢/kwh	Gas @ $3/Mcfh *
10,000	650	$ 760	$254
15,000	760	889	297
20,000	880	1029	344
25,000	1000	1170	390
30,000	1110	1299	433
35,000	1230	1440	480
40,000	1340	1568	522

1 Therm = 100,000 Btu. *70% gas efficiency

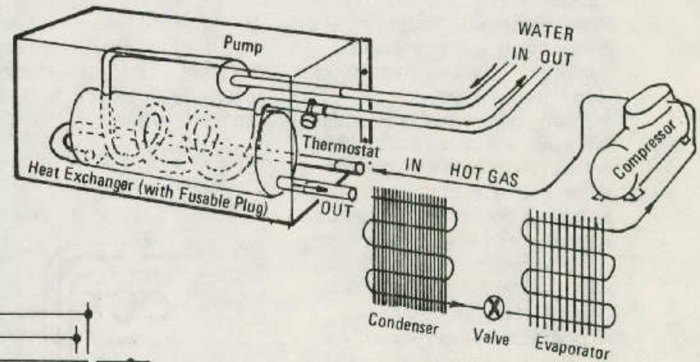
TYLER Refrigeration Corporation | Niles, Michigan 49120

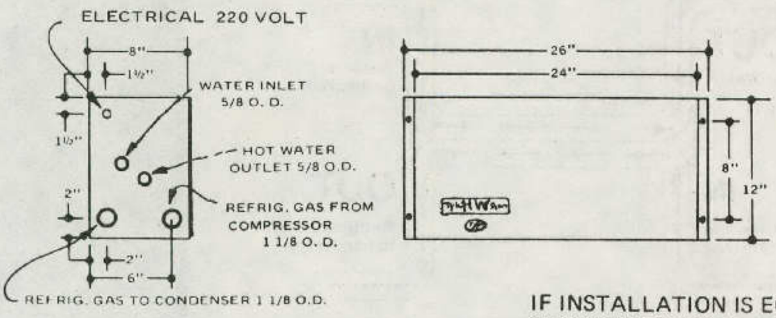
INSTALLATION POINTERS

Here are some pointers which apply to retrofit or new installations:

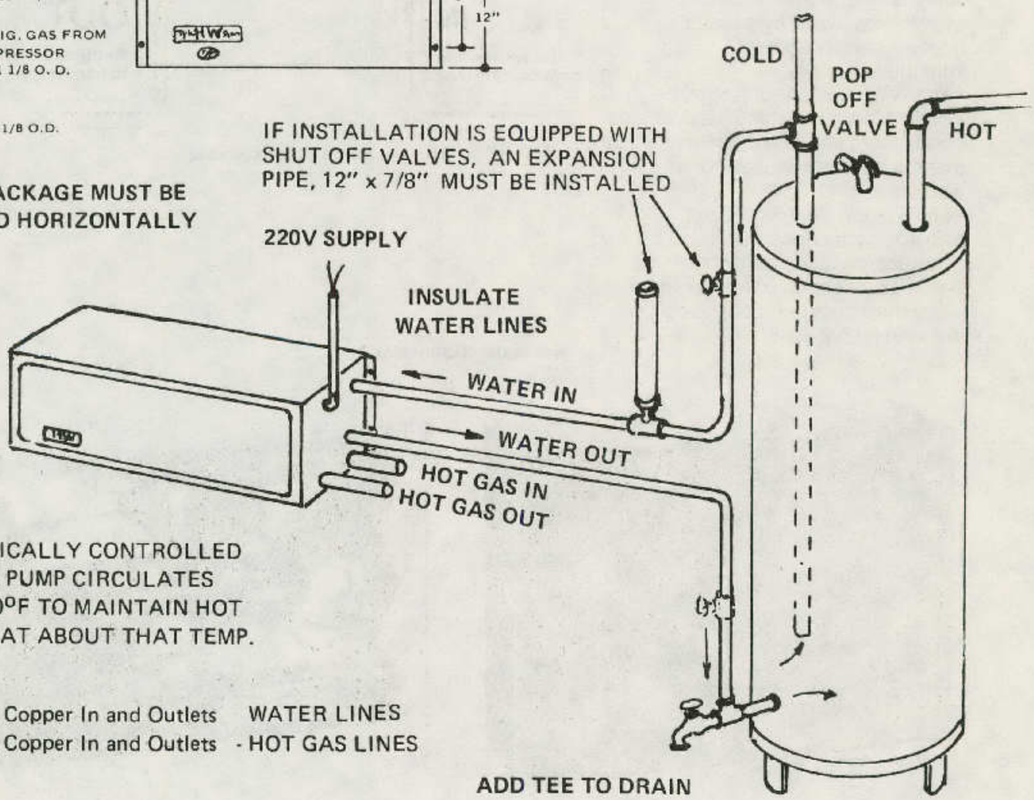
1. The unit must be mounted horizontally as illustrated to assure oil return to the refrigeration system.
2. Keep the unit as close to the condensing unit as possible to avoid running the larger 1-1/8" hot gas piping any great distance.
3. If shut off valves are to be installed which can isolate the water line through the HW System, a 12" section of 7/8" O.D. pipe should be installed in a tee to allow for expansion.
4. Use a large hot water heater to provide adequate storage – 100 gallons or more.
5. If the existing hot water heater is small, consider using an insulated tempering tank (used electric hot water heater) to supply the regular heater.
6. After installation, test the system by turning off the gas or electric hot water heat to see how well the system will handle the store needs. If it doesn't because of lack of temperature or because usage peaks outrun the supply, –
   - With electric – disconnect lower heater thermostat, set top thermostat to act as a back up.
   - With gas – set the thermostat at a lower setting to provide a back up supply.

Tyler Tech Staff





HW PACKAGE MUST BE MOUNTED HORIZONTALLY



THERMOSTATICALLY CONTROLLED CIRCULATION PUMP CIRCULATES WATER AT 140°F TO MAINTAIN HOT WATER TANK AT ABOUT THAT TEMP.

5/8" O.D. Copper In and Outlets WATER LINES
1 1/8" O.D. Copper In and Outlets - HOT GAS LINES

GAS OR ELECTRIC HOT WATER HEATER.

Friedrich®
CENTRAL COOLING AND HEATING

Hot Water Generator™

for use with Friedrich RCA/RCB Condensing units
or Friedrich RYA/ECC Split Heat Pump

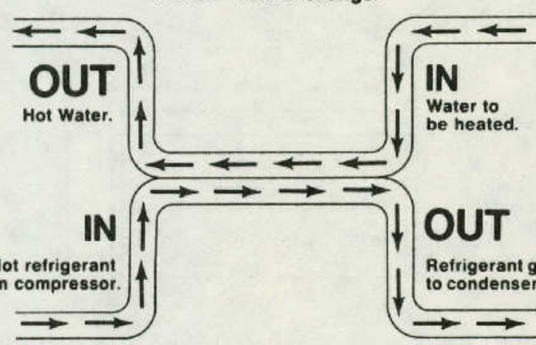
Description

• Hot Water Generator™ captures waste energy from compressor and uses it to heat hot water for the home.
• Can substantially reduce hot water heating costs, providing up to 100% of daily domestic hot water heating requirements, depending on use of air conditioning condensing unit. Hot Water Generator™ operates when condensing unit is on cooling cycle, or it operates year round with Friedrich Heat Pumps.
• When compressor is operating, hot water is available normally without additional energy from either gas or electric water heater.
• Uses exclusive TwinEx™ heat exchanger to transfer heat from refrigerant to hot water.
• By-pass is automatically controlled by hot water temperature. When water temperature falls below preset level, water is diverted through heat exchanger to be heated. If water temperature is above preset level, water by-passes heat exchanger and is immediately available.
• Hot Water Generator™ must be installed indoors within 25 feet of condensing unit, and not more than 25 feet from household hot water tank.
• HWG Hot Water Generator™ also is ideal for restaurants and other commercial establishments that keep air conditioning running year round and have continuing demand for hot water.

Features

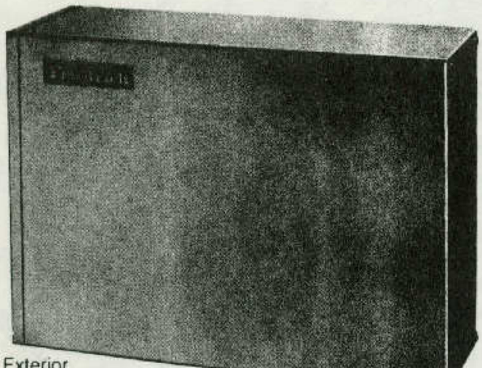
1. Exclusive, double-wall tube-type TwinEx™ heat exchanger is enclosed in insulated cabinet. System is designed to prevent refrigerant or lubricant contamination of water.
2. Adjustable water temperature thermostat allows higher overall water temperatures for heavy usage.
3. Automatic two-speed pump has magnetically driven impeller; no shaft is needed, reducing potential problem area. There are no seals to leak.
4. Sealed ball bearings on pump motor eliminate need for oiling.
5. Factory assembled package is designed to be matched with correct Friedrich condensing units or heat pump.
6. Low refrigerant side pressure drop results in increased capacity compared to high pressure drop on some competitive models.

TwinEx™ Heat Exchanger

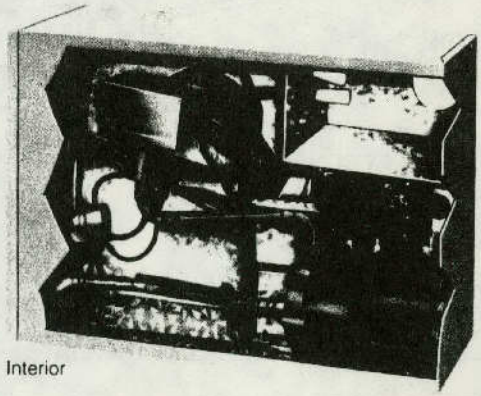


TwinEx—patent pending

Hot Water Generator™



Exterior



Interior

Another Energy Economizer Product from Friedrich

DHW Series

Friedrich Hot Water Generator™

DHW Series

for use with Friedrich RCA /RCB Condensing units or Friedrich RYA /ECC Split Heat Pumps

Remote Air Cooled Heat Pumps

Heat Pump Model #	Cooling Mode: Unit (1) Capacity (BTUH)	HWG Capacity (BTUH)	Recovery (3) (GPH)	Utilization Efficiency (4): Separate (EER)	Combined (EER)	Combined Energy Reduction (%)	Heating Mode: Unit (1) Capacity (BTUH)	HWG Capacity (BTUH)	Recovery (3) (GPH)	Utilization Efficiency (4): Separate (COP)	Combined (COP)	Combined Energy Reduction (%)
RYA 018	17500	2200	3.8	7.0	9.2	23	16700	2100	3.6	2.4	2.8	16
024	23000	3100	5.3	6.5	8.4	23	22900	2900	5.0	2.4	2.9	16
030	29500	4600	7.8	6.6	8.9	26	27700	3500	6.0	2.2	2.5	13
036	35000	5500	9.4	6.2	8.3	25	31700	3900	6.7	2.1	2.4	12
042	40000	6200	10.6	6.3	8.4	25	37000	4400	7.5	2.2	2.4	11
048	48000	6800	11.6	6.7	9.0	25	42200	4800	8.2	2.3	2.6	13

Remote Air Cooled Condensing Unit

Condensing Unit Model #	Unit (2) Capacity (BTUH)	HWG Capacity (BTUH)	Recovery (3) (GPH)	Utilization Efficiency (4): Separate (EER)	Combined (EER)	Combined energy Reduction (%)
RCA 018	17500	3500	6.0	5.6	7.8	28
024	24000	4600	7.9	6.0	8.4	28
030	30000	5700	9.8	6.2	8.7	29
036	34000	6400	11.0	6.0	8.3	29
042	41000	7200	12.3	6.5	9.1	28
048	47000	7600	13.0	6.9	9.6	28

Condensing (2) Unit Model #	Unit Capacity (BTUH)	HWG Capacity (BTUH)	Recovery (3) (GPH)	Utilization Efficiency (4): Separate (EER)	Combined (EER)	Combined Energy Reduction (%)
RCB 024	23000	3900	6.7	7.0	10	30
030	28000	5200	8.9	6.5	9.2	30
036	36000	6400	11.0	6.6	9.4	29
042	41000	6900	11.8	6.7	9.4	28
048	48000	7300	12.8	7.2	10.1	28
060	55000	7500	12.9	7.7	8.8	24

(1) Rating in accordance with ARI Standard 240-76 with inside condition of 70°F DB and outside of 47°F DB, 43°F WB, and in cooling with inside condition of 80°F DB, 67°F WB and outside condition of 95°F DB.
(2) Rating in accordance with ARI Standard 210-75 with inside condition of 80°F DB, 67°F WB and outside condition of 95°F DB.
(3) Rate of recovery, gallons per hour, when heating water from 70°F to 140°F.
(4) Utilities Efficiency is a ratio of the sum of the air cooling (or air heating) and hot water heating output capacities to the power input.
—Combined Utilities Efficiency is the ratio of such output to power input for a Friedrich heat pump equipped with a Hot Water Generator.
—Separate Utilities Efficiency is the ratio of such output to power input for a Friedrich heat pump, and for an equal amount of hot water heating performed solely in the owner's electric hot water heater.
When the efficiency is stated in EER, it is the sum of the air cooling and hot water heating capacities expressed in BTUH, divided by the power input in watts.
When the efficiency is stated in COP, it is the sum of the air heating and hot water heating capacities expressed in watts, divided by the power input in watts.

Installation

As an accessory package, Friedrich Hot Water Generator™ is easy to install for use with Friedrich air cooled units, 17,500 to 48,000 Btu/hr. Interconnects with storage type gas or electric hot water heaters, and produces up to 100% of hot water requirements.

Designed for 208/230 volt systems, 2 amps/30 watts. Suitable for connection with refrigerant R-22. Maximum capacity of 2-speed pump is 3 gallons per minute.

Hot Water Generator™ must be mounted indoors and must be located as close as possible to the outdoor unit, not exceeding 25 feet.

Recommended refrigerant line sizes:

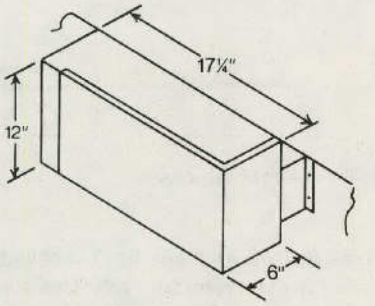
Condensing Unit Size (Btu/hr)	Copper OD"
18,000 to 24,000	3/8
30,000 to 48,000	1/2

Piping sizes between Friedrich Hot Water Generator™ and hot water heater should be in accordance with the following (distances should not exceed 25' because of pump capacity):

Distance between hot water heater and Friedrich Hot Water Generator™	Minimum recommended water line size (nom)
0- 5 feet	1/4" (3/8" OD)
5-25 feet	3/8" (1/2" OD)

Recommended: Refrigerant lines and water piping should have minimum of 1/4" thick closed cell piping insulation, such as Armaflex or Rubatex. Insulate hot water outlet line to prevent losses to ambient.

Brackets provided with unit for wall mounting



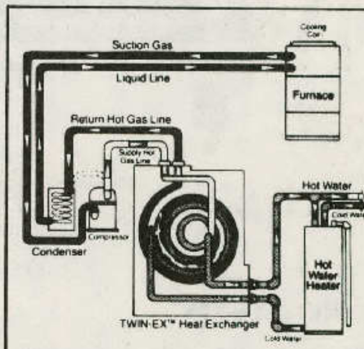


Diagram shows how the Hot Water Generator™ fits into a new or existing system.

Continuing research results in steady improvements. Therefore, these specifications are subject to change without notice.

Friedrich

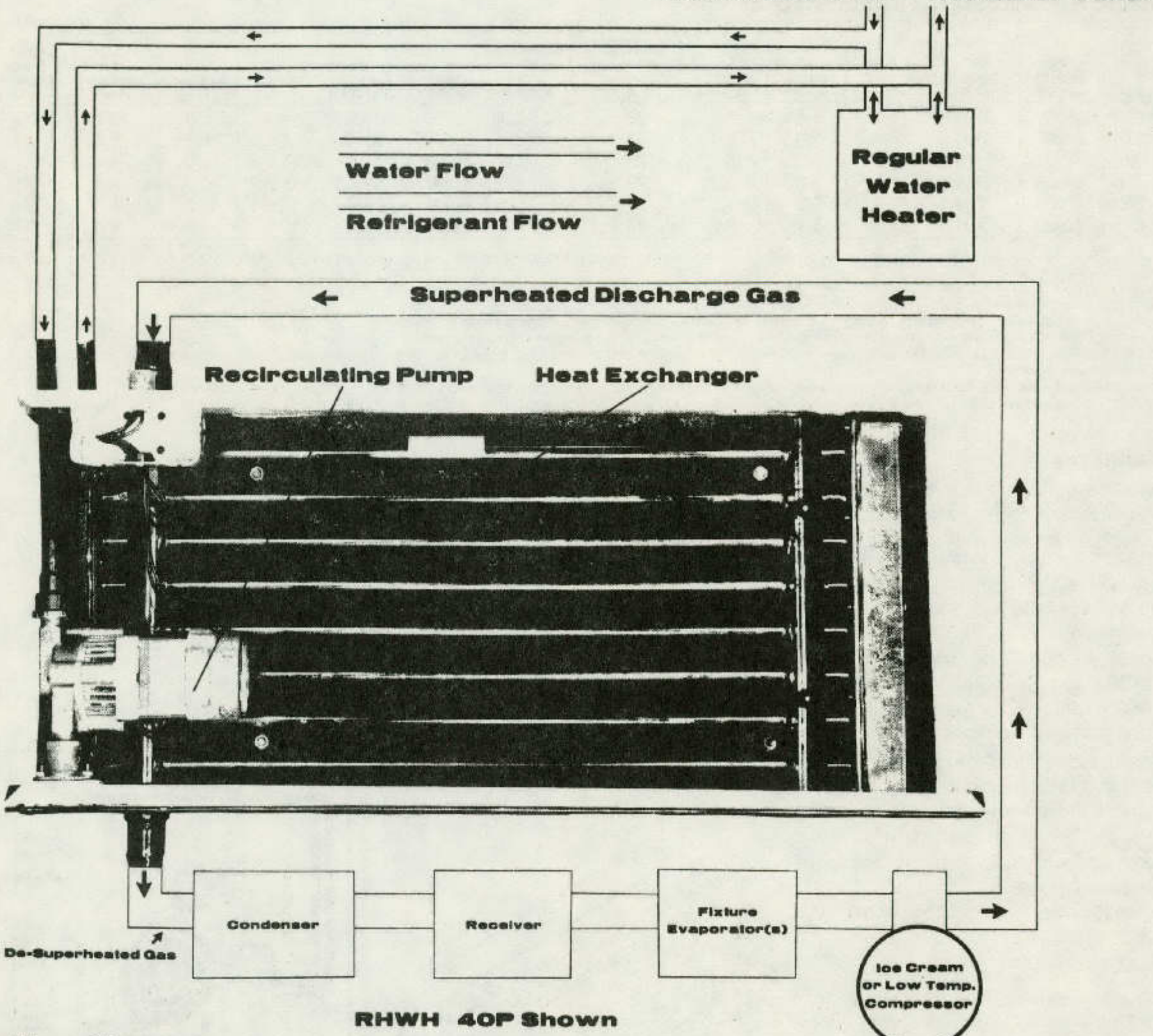
A Division of Wylain, Inc.

Friedrich Air Conditioning & Refrigeration Co.
4200 North Pan Am Expressway, San Antonio, Texas 78295
Telephone (512) 225-2000

RECLAIMED HEAT WATER HEATER

Engineered Supermarket Products enables you to convert your regular water heater to a supplemental appliance with an annual saving of several hundred dollars. The Reclaimed Heat Water Heater utilizes the hot gas discharge from a low temperature refrigeration condensing unit for heating water for your store. Capacity, depending on the refrigeration condensing unit and heater chosen, is approximately 35,000 to 150,000 BTUH.

The Regular water heater's temperature control should be set so that it will only turn on when the store's demand for hot water exceeds the Reclaimer's capacity. In many applications the Reclaimed Heat Water Heater will supply all of the water heating energy required and the electric or gas elements can be turned off.



RHWH 40P Shown

Application

The RHWH units are designed for wall mounting and are best located in the machine room and water lines run to the regular heater from there. If the store already has a recirculating pump then the "X" suffix model, which does not have an internal pump, should be specified. The standard model, which is 208-230 volt, is wired to operate with the compressor.

ENGINEERED SUPERMARKET PRODUCTS, INC.

DESIGNED FOR ENERGY CONSERVATION

2190 COFFEE ROAD • LITHONIA, GEORGIA 30058

(404) 482-7012

Specifications

	MODEL	DIMENSIONS IN/ MM A		B		C		CONNECTIONS IN/ MM REFRIG-OD		WATER- OD		WEIGHT LBS/ KG		ELECT. WATTS	MBTUH	RECOMMENDED WATER TANK SIZE
STANDARD - W/ PUMP	RHWH-35P	19	482	14	356	9	229	3/4	19	5/8	16	33	73	30	30-60	40-50 gal.
STANDARD - W/O PUMP	RHWH-35X	19	482	14	356	9	229	3/4	19	5/8	16	24	53	0	30-60	40-50 gal.
CLEANABLE - W/ PUMP	RHWH-40P	13	330	30	760	6	152	1 1/8	29	5/8	16	34	75	30	30-70	40-80 gal.
CLEANABLE - W/O PUMP	RHWH-40X	13	330	30	760	6	152	1 1/8	29	5/8	16	25	55	0	30-70	40-80 gal.
CLEANABLE - W/ PUMP	RHWH-150P	13	330	30	760	10	254	1 3/8	35	7/8	22	80	176	110	60-250	60-150 gal.
CLEANABLE - W/O PUMP	RHWH-150X	13	330	30	760	10	254	1 3/8	35	7/8	22	65	143	0	60-250	60-150 gal.

Selection and Application

Available in 115 volt or 208-230 models. 208-230 volt is standard. 50 Hz available when specified.

As a general guideline, the model RHWH35 is suitable for application to a 3, 5 or 7 1/2 hp. ice cream or low temp. unit and a 40-50 gallon water tank.

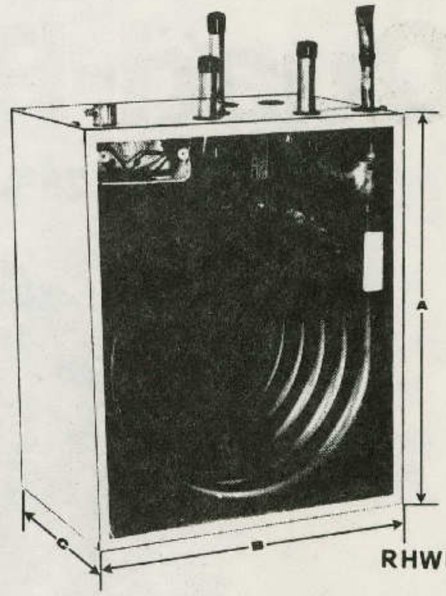
The RHWH40 is suitable for 3, 5, 7 1/2 or 10 hp units and a 40, 50, 60 or 80 gallon tank.

The RHWH 150 is suitable for up to 25 hp and can be fitted with either the large pump [standard and shown on pump curves below] or the smaller pump as used on the 35 & 40.

A pressure control must be utilized to maintain a minimum discharge pressure in the refrigeration system corresponding to a condensing temperature of 70 degrees F [21 degrees C].

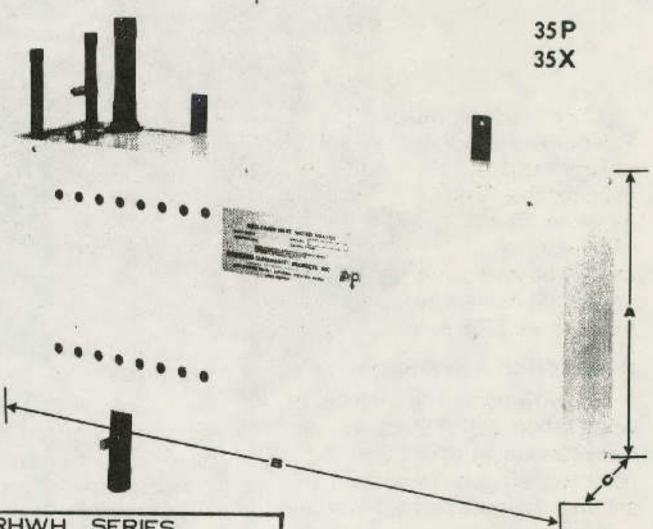
The 'X' Model should be located in the return line from the faucets -- not in the main water supply.

If the water supply is extremely hard, then the cleanable models, 40 or 150, should be used.



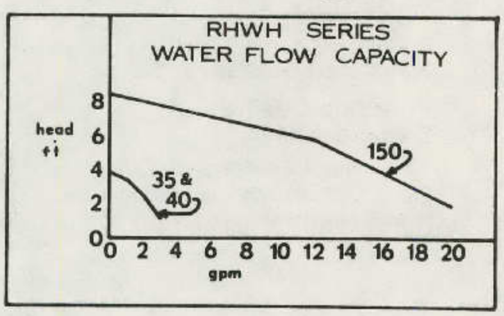
RHWH

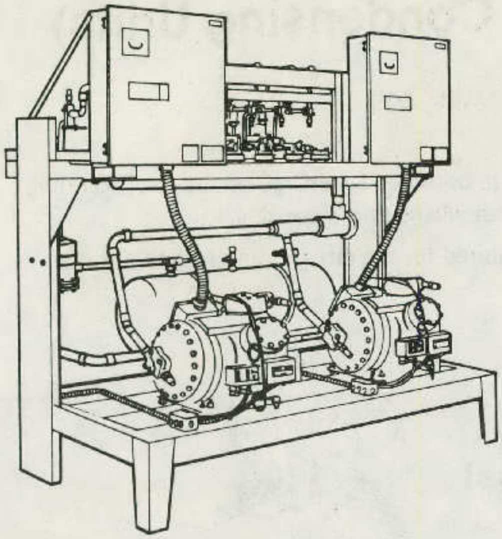
35P
35X

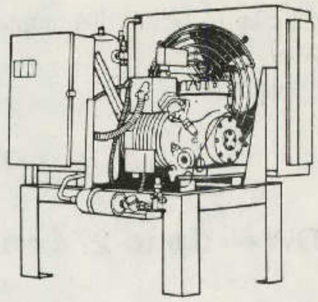


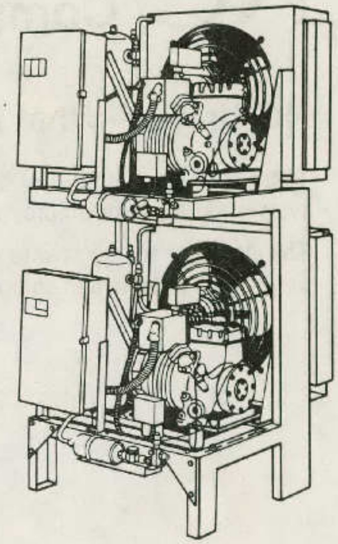
RHWH

40P
40X
150P
150X



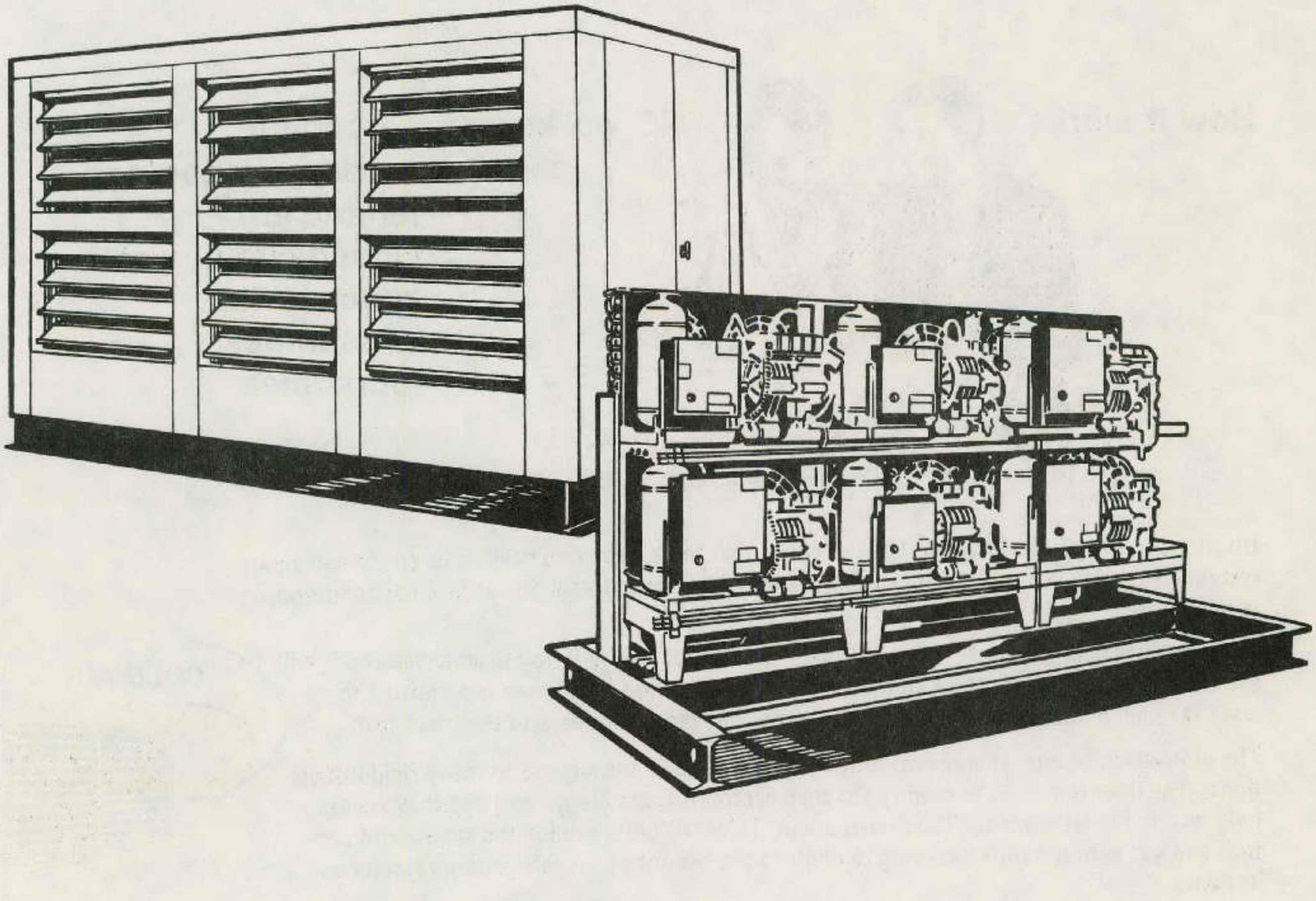






TYLER NC Compressor Units (and Condensing Units)

Refrigeration Corporation



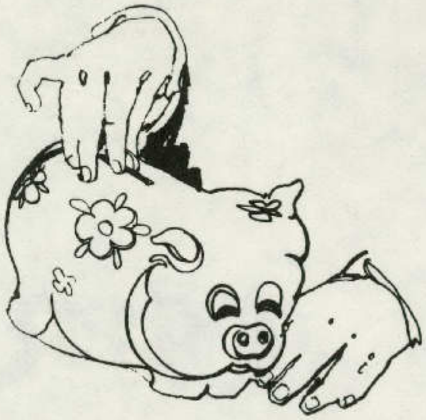
NC Compressor Units (and Condensing Units)

NC Units---What are they?

These are Tyler compressor or condensing units designed and equipped to optimize the energy use by a refrigerating system. These units employ natures cooling (NC) to reduce electrical cost whenever it's possible.

The electrical energy savings potential is up to 27% of that normally required for the refrigeration equipment (depending on climate and equipment mix).

WOW---Up to 27% savings!



But in my stores I use outdoor condensers - do NC units work there?

"The NC system is a design that will work on all styles of units including, air-cooled units, outdoor air-cooled units, remote air-cooled unit, water cooled and even water tower applications".

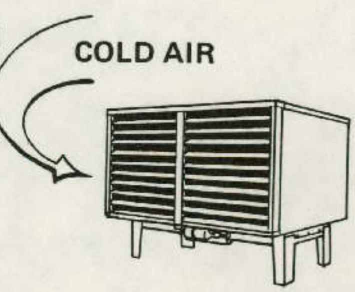
How it works

NC works on:
- **air cooled**
- **outdoor air cooled**
- **remote air**
- **closed circuit water**
- **water tower**
- **twosomes**
- **foursomes**

Up till now, electrical energy has been so cheap that there's been no need to be concerned about system efficiency. So ..... refrigerating systems were made to operate at summer conditions year around.

Several things have changed. The most important is that energy is no longer cheap and it will get more expensive. With the Tyler NC system, refrigeration equipment is permitted to operate at much milder conditions, including pressures, temperatures, and electrical costs.

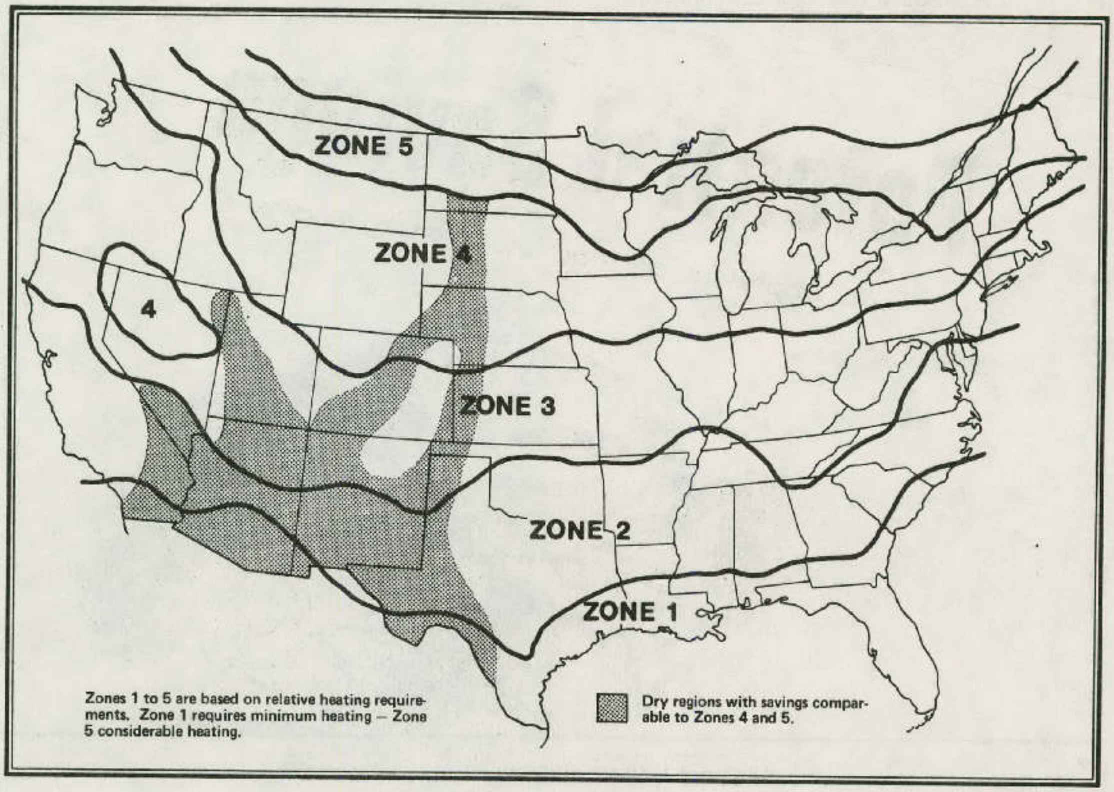
The motivation of high energy cost sent Tyler engineers to the lab and to many field installations. The intention .... to modify the then accepted Technology. In 1974 they started field testing the NC system. The results are in; Tyler NC units employ the simplest of controls and yet permit nature's cooling to work to the benefit of the refrigerating system and its owner.



What are the savings?

Electrical savings for compressor operation can exceed those available for commonly used heat recovery systems.

In the United States there are many more hours during which the outdoor temperature is below 70^{o}F, in fact, more below than above. When a refrigerating system is able to use these mild conditions, savings result. The map below is a general picture of the potential savings available by climatic zone provided of course, that the Tyler NC units and systems are employed.



What does it cost?

POTENTIAL SAVINGS AT $ .03/KWh	Zone 1 Miami	Zone 2 Dallas	Zone 3 St. Louis	Zone 4 Chicago	Zone 5 Minnea-polis
10,000 Sq. Ft. Store	3291	3084	2862	2343	1650
20,000 Sq. Ft. Store	5262	4965	4630	3801	2817

The cost is little more than a conventional system. All you have to do is:

1. Buy NC units.
2. Buy a NC control system for the display cases.

There are several control systems available to gain full benefit from the NC system.

Now you need information to help make a good business decision. Tyler will provide you with:

1. Specific cost information for the equipment.
2. Tabular projection of savings (for general study).
3. Computer projection of your store, in your city, for your specific electrical rates (for detailed study).

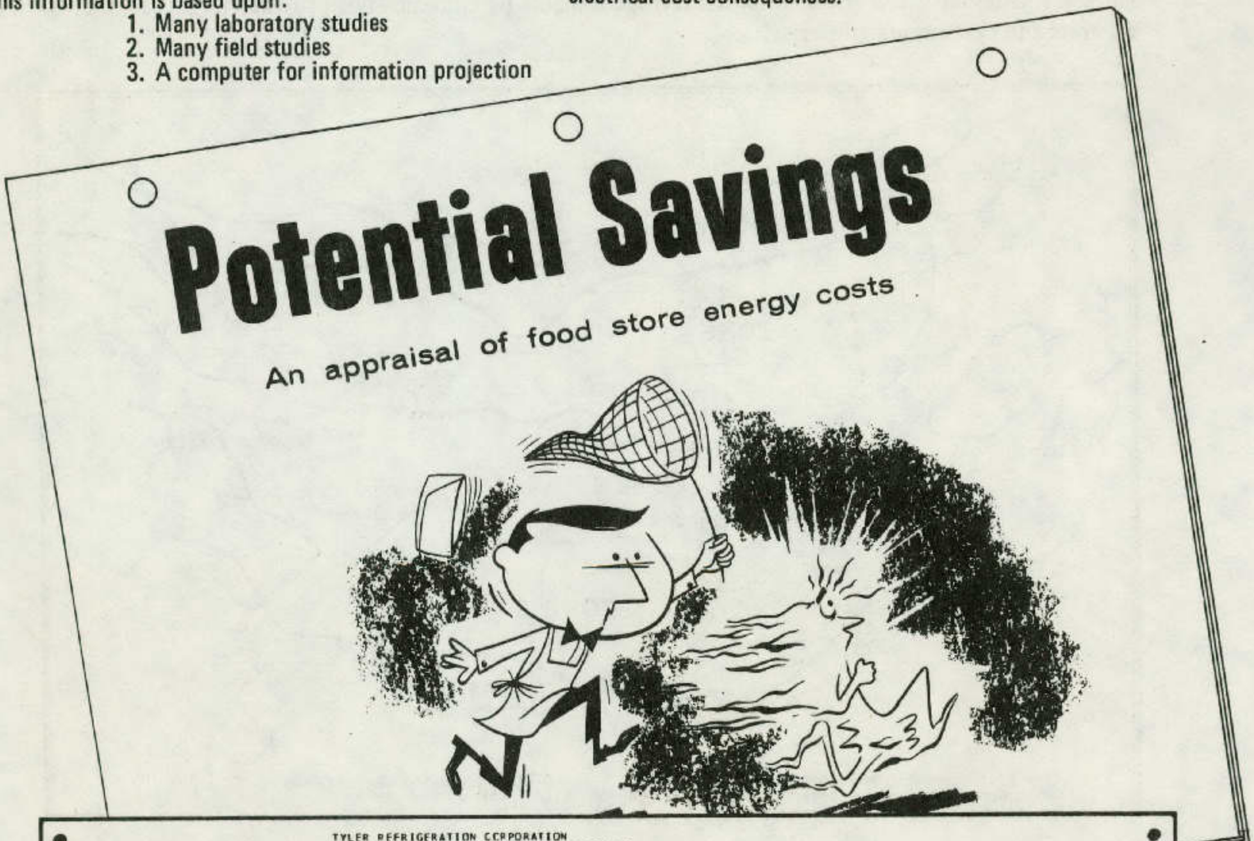
Two kinds of information from TYLER aid in a business decision

● A MANUAL OF TABLES (for general study)

This information is based upon:

1. Many laboratory studies
2. Many field studies
3. A computer for information projection

It permits study of the many variables which occur in a store and their electrical cost consequences.



TYLER REFRIGERATION CORPORATION
WATT-WATCHER VS. CONSTANT HEAD PRESSURE
POWER CONSUMPTION FOR COMPRESSORS ONLY

TYPICAL ILLUSTRATION
FOR A MEDIUM SIZE
SUPERMARKET IN
CHICAGO ILL SINGLE UNITS

MODEL NUMBER	DESCRIPTION	SUCTION TEMP.	WATT-WATCHER POWER CONS., KWH	WATT-WATCHER FLOATING C.T. DOWN TO, DEG.F	CONSTANT HEAD PRESSURE POWER CONS., KWH	CONSTANT HEAD PRESSURE CONST. C.T. AT, DEG.F	PERCENT OF SAVING
51096020H	9RC1 0750 TFC 208/240/3	35	38,483.05	60	58,341.40	115	34.0
51234610M	9RS3 0760 TFC 208/220/3	20	43,305.64	60	67,408.20	115	35.8
50579640M	MRB1 0500 TFC 208/220/3	20	24,165.60	60	36,938.00	115	34.6
51456510M	4RH1 1500 TMK 220/440/3	20	66,224.90	60	94,410.90	115	29.9
51216990M	4RA3 1000 TDK 220/440/3	20	45,827.25	60	72,627.70	115	36.9
51234610M	9RS3 0760 TFC 208/220/3	20	43,305.64	60	67,408.20	115	35.8
51216990M	4RA3 1000 TDK 220/440/3	20	45,827.25	60	72,627.70	115	36.9
51096020H	9RC1 0750 TFC 208/240/3	10	31,195.41	60	43,559.10	115	28.4
51234610L	9RS3 0760 TFC 208/220/3	25-	41,345.08	60	59,918.40	110	31.0
51234610L	9RS3 0760 TFC 208/220/3	25-	41,345.08	60	59,918.40	110	31.0
51234610L	9RS3 0760 TFC 208/220/3	25-	41,345.08	60	59,918.40	110	31.0
51234610L	9RS3 0760 TFC 208/220/3	25-	41,345.08	60	59,918.40	110	31.0
51234610L	9RS3 0760 TFC 208/220/3	35-	33,977.94	60	47,698.20	110	28.8
51259520L	GRB1 0760 TFC 208/220/3	25-	36,251.28	60	50,359.05	110	28.0
51259520L	GRB1 0760 TFC 208/220/3	25-	36,251.28	60	50,359.05	110	28.0
51259520L	GRB1 0760 TFC 208/220/3	25-	36,251.28	60	50,359.05	110	28.0
* * * * T O T A L * * * *			646,446.84		951,770.35		32.1
POWER CONSUMPTION COST @$.040/KWH			$25,857.87		$38,070.81		

NET ANNUAL SAVING OF $12,212.94

THE INFORMATION CONTAINED HEREIN, TO THE BEST OF OUR KNOWLEDGE, WAS CORRECT AT THE TIME OF THIS PUBLICATION. THE COMPETITIVE DATA, IF ANY, WAS COMPILED FROM THE LATEST PUBLISHED SPECIFICATION SHEETS, APPLICATION ENGINEERING DATA BOOKS, AND/OR INSTRUCTION BOOKLETS, WHICH WERE IN TYLERS POSSESSION AT THE TIME OF THIS PUBLICATION. FURTHERMORE, THIS INFORMATION IS INTENDED FOR USE BY PERSONS HAVING TECHNICAL SKILL, AT THEIR OWN DISCRETION AND RISK. SINCE CONDITIONS OF USE ARE OUTSIDE OF TYLER CONTROL, WE CAN ASSUME NO LIABILITY FOR RESULTS OBTAINED OR DAMAGES INCURRED THROUGH THE APPLICATIONS OF THE DATA PRESENTED.

● A COMPUTER STUDY of the specifics of your store

This is a study of your store projected by computer. It is specifically geared to the NC system and its $ benefits to you.

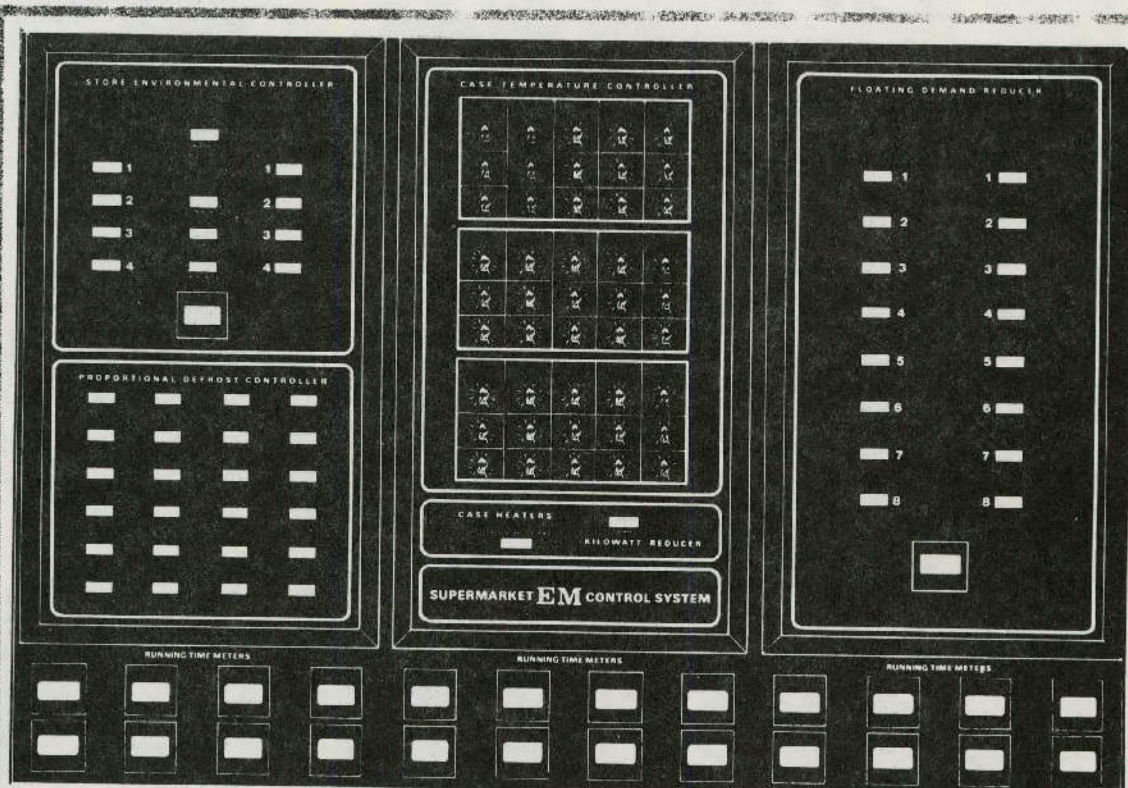
For either of these programs ask your TYLER man.

TYLER Refrigeration Corporation | **Niles, Michigan 49120**

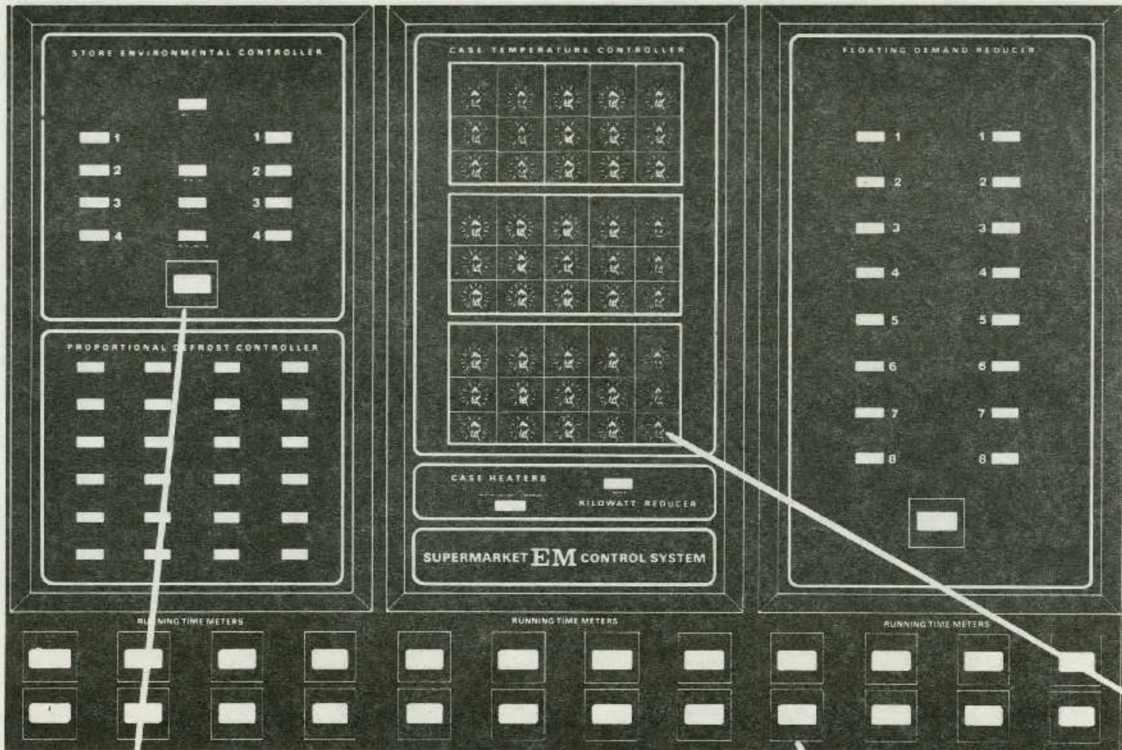
TYLER
Refrigeration Corporation

SUPERMARKET EM CONTROL SYSTEM

A SYSTEM FOR ENERGY MANAGEMENT IN SUPERMARKETS



TYLER Refrigeration Corporation * Niles, Michigan 49120



TYLER

STORE ENVIRONMENTAL CONTROL

information system

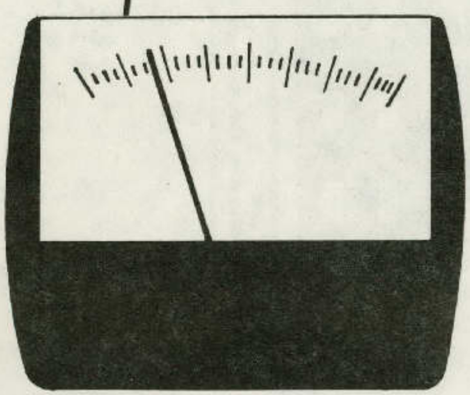
General: The information below is all that is necessary for a qualified person to fine tune the mechanical equipment in the store for the lowest possible heating, air-conditioning and refrigeration cost.

Temperature Controller:

1. Provides instantaneous temperature read out of refrigerators in store.
2. Alerts store personnel to abnormal condition - an alarm is given by a horn and blinking light.
3. Capability of sending messages by telephone lines.
4. Optional temperature logging.
5. Optional store dew point measurement.

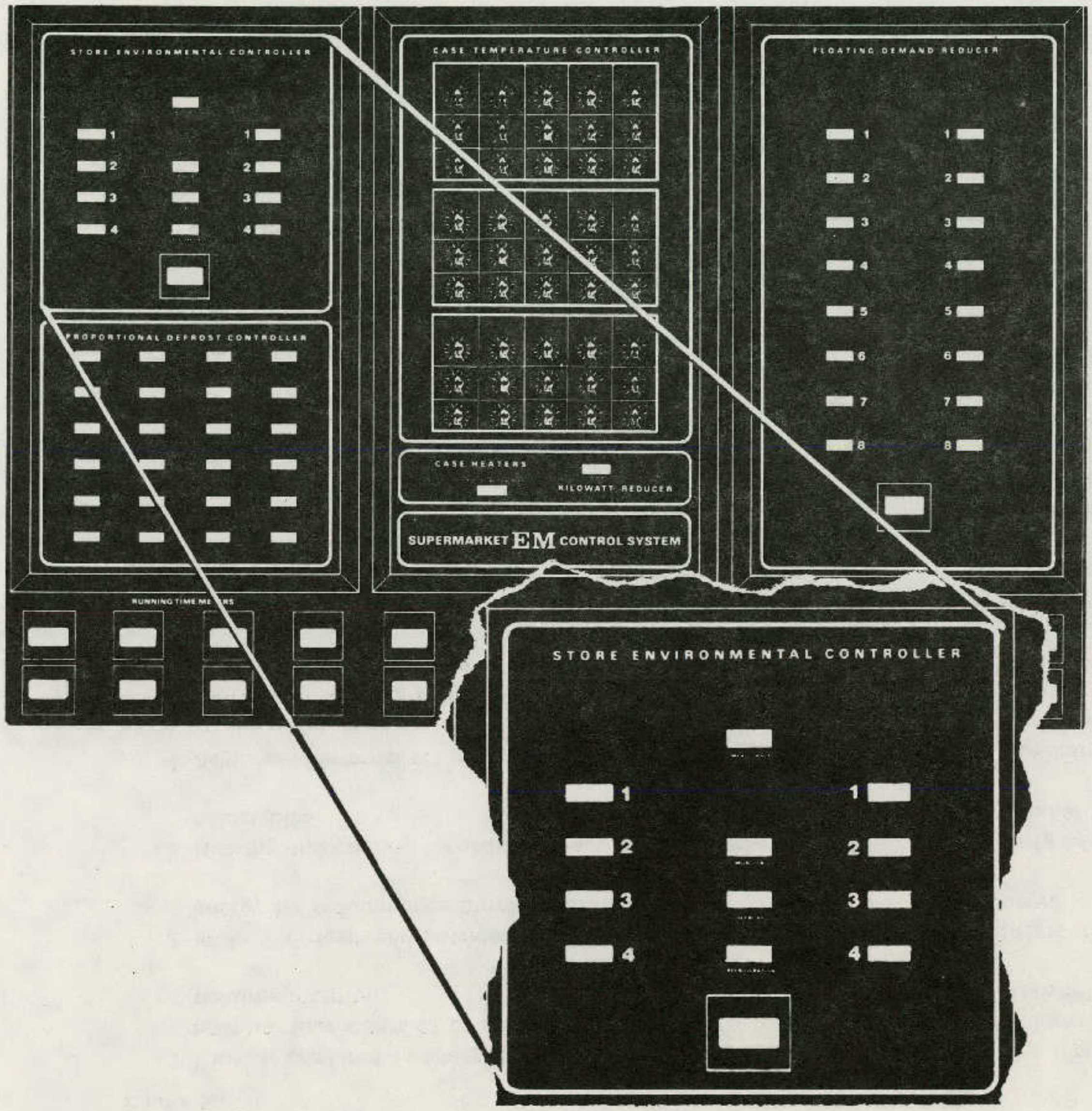
Store: Relative Humidity Indicator

Optional store relative humidity indicator for Management evaluation.



Run Hour Meters:

1. Provide Management information about the run time of every compressor in the refrigeration system.
2. Provide information about the run time of the heating & air condition equipment.
3. Provide the total time since EM Panel installation, or since job start up.



Potential Savings at $ .03/KWh	Minneapolis	Chicago	St. Louis	Los Angeles	Dallas
10,000 Sq. Ft. Store	935	600	420	295	215
20,000 Sq. Ft. Store	1925	1235	870	610	440

TYLER

STORE ENVIRONMENTAL CONTROL
with night set-back

This system is the most important part of any energy management system as the store environment has most to do with the cost of operating its mechanical equipment.

The "Store Environmental Control" is a solid state sequencing control system designed specifically for the unique heating, cooling, and humidity control requirements found in food markets. It provides stage controlling for up to 4 stages of heating and 4 stages of cooling, plus the ability to sense high store humidity and in turn operate stages of air conditioning and reheat for humidity reduction.

Temperature and humidity sensors are located in the sales area with adjustable set points located in the control panel so that only authorized personnel have access to adjustments. Band width adjustment for both heating and cooling are included for adjustment to specific needs. A dead zone or "no energy requirement zone" is part of the operation between heating and cooling bands.

The control system includes a flush clock for draining of migrated refrigerant to the heat recovery coil during times when hat recovery is inoperative.

An optional addition to this system is Night-set-back. This adds the means to automatically change the "night time settings" of the store for substantial energy savings. At night or during periods of store inactivity temperatures in the store are allowed to reduce (when it is able) the air-handler blower motor is also stopped for further savings and Auxiliary heat is locked out.

Safeguards are built in to provide the store and its equipment with the needed environment while capturing all the possible energy savings.

TYLER Refrigeration Corporation
Niles, Michigan 49120

Features:

1. Panel is prewired to energize up to four stages of heating, four stages of cooling and one stage of dehumidification.

2. Wide 6°F deadband between heating and cooling saves energy by reducing equipment operating time.

3. Heating and cooling throttling ranges are separately adjustable.

4. Adjustable internal set point.

5. Power indicator light plus lights on each heating, cooling and dehumidification.

6. Fused protection.

7. Include On-Off-Automatic switch on each stage of heating, cooling and dehumidification.

8. Adjustable clock timer provides refrigerant flushing.

Added features of Night Set Back:

1. Adjustable day and night temperature set points.

2. 7-day clock energize and de-energize the night set-back cycle. Any combination of store closing and morning warmup time can be programmed into the clock.

3. The night set back cycle turns off the air handler blower anand switches the thermostat to reduce set point temperature from 5° to 12°F.

4. Starts the air handler blower for warmup period before store opening. Recommended two hour recovery period.

5. Only heat reclaim stages will be allowed to cycle the air handler blower and to maintain the store at set point temperature.

6. Auxiliary heat is locked out over night and during morning warmup period.

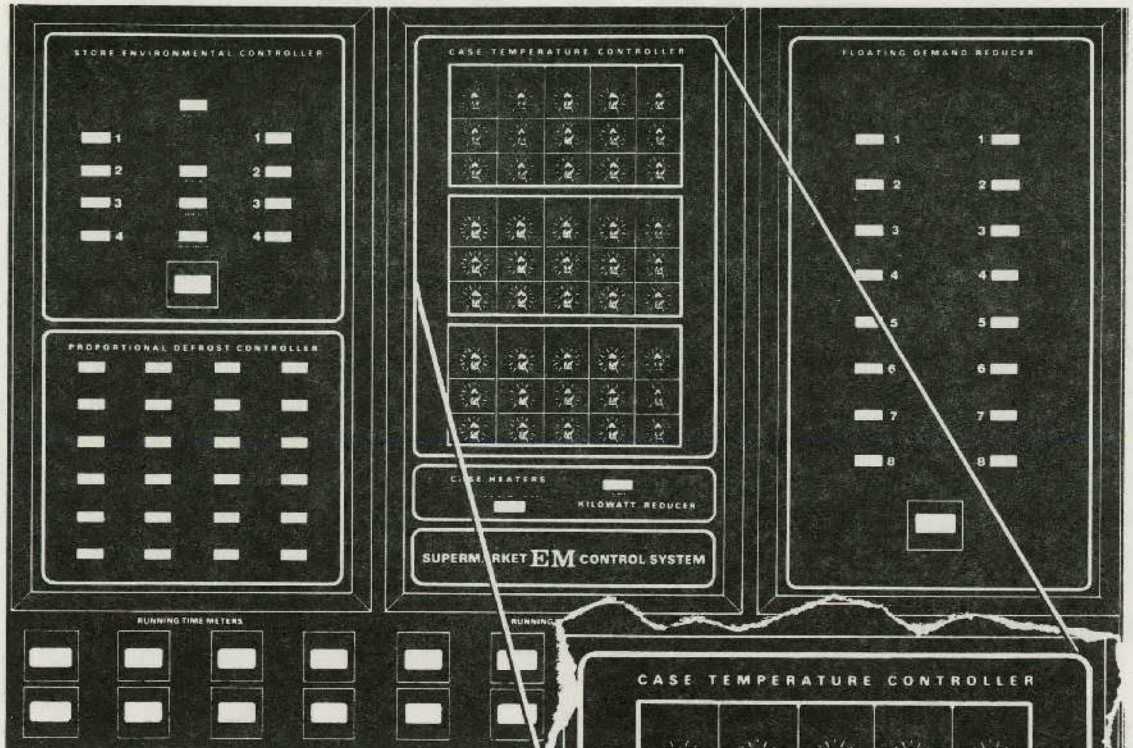
7. Manual override switch for auxiliary heat lock out.

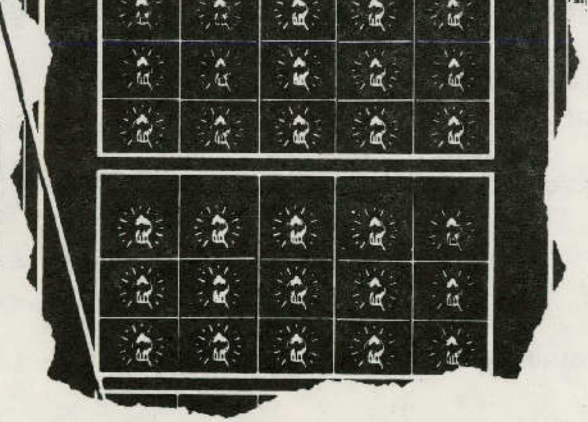
8. Humidity override will cycle the blower and dehumidification equipment during night cycle.

9. Air condition equipment is locked out during store closing until warmup period.

10. Closes off the make-up air damper during night set back.

11. 10 hour power failure protection for the 7 day clock.





Adjusts temperature to quality desired

Reads temperature at each location

TYLER

CASE TEMPERATURE CONTROLLER

Conventionally, display case temperatures are controlled by indirectly operating pressure controls. Adjustments to these controls are made by a mechanic at installation. If you're satisfied with the temperatures, they're left alone. *The optimum settings for any lineup of cases may never be made.* Optimum settings are those which produce satisfactory temperature *and* lowest operating cost.

It doesn't make economic sense to run a frozen food case at ice cream temperatures, or a dairy case at near freezing. These are expensive degrees of coldness, and the electric bill will reflect them.

For optimum settings, it's best to know the temperature of the refrigerators. It is particularly an advantage to have those temperatures constantly and conveniently available. Ideally, it's best to have a way to change the temperature of the refrigerators when an energy expert has determined that a change is in order.

The Tyler Case Temperature Controller can provide for these needs with a *digital readout* of case temperatures from a panel and a *dialable* temperature *adjustment.* This would be directly controlled by a solid state *temperature* sensitive device, doing away with the seasonal variations in case temperature which pressure controls allow. This keeps the cases at a more economical operating range throughout the year. It also puts temperature control in the realm of management for the first time.

A fringe benefit is that the Tyler Case Temperature Controller has a Performance Monitor to alert store personnel to abnormal temperatures. An alarm is given by a horn and blinking light. The capability to send messages by telephone lines is another valuable feature.

See Tyler Potential Savings book for estimating bill reduction.

TYLER Refrigeration Corporation
Niles, Michigan 49120

1. All store refrigeration systems can be controlled from this easily accessible central control.

2. Controls case temperatures accurately even when the seasons change.

3. Every module can control up to 9 cases or 9 line-ups.

4. Three set points per module, every set point can control three line-ups (or 3 cases). Each set point must share the same temperature.

5. Every line-up or case will have its own sensing probe and relay which energize or de-energize a solenoid valve (recommended at the case location) or compressor contractor.

6. Display module gives instantaneous digitla read out of refrigerator temperatures.

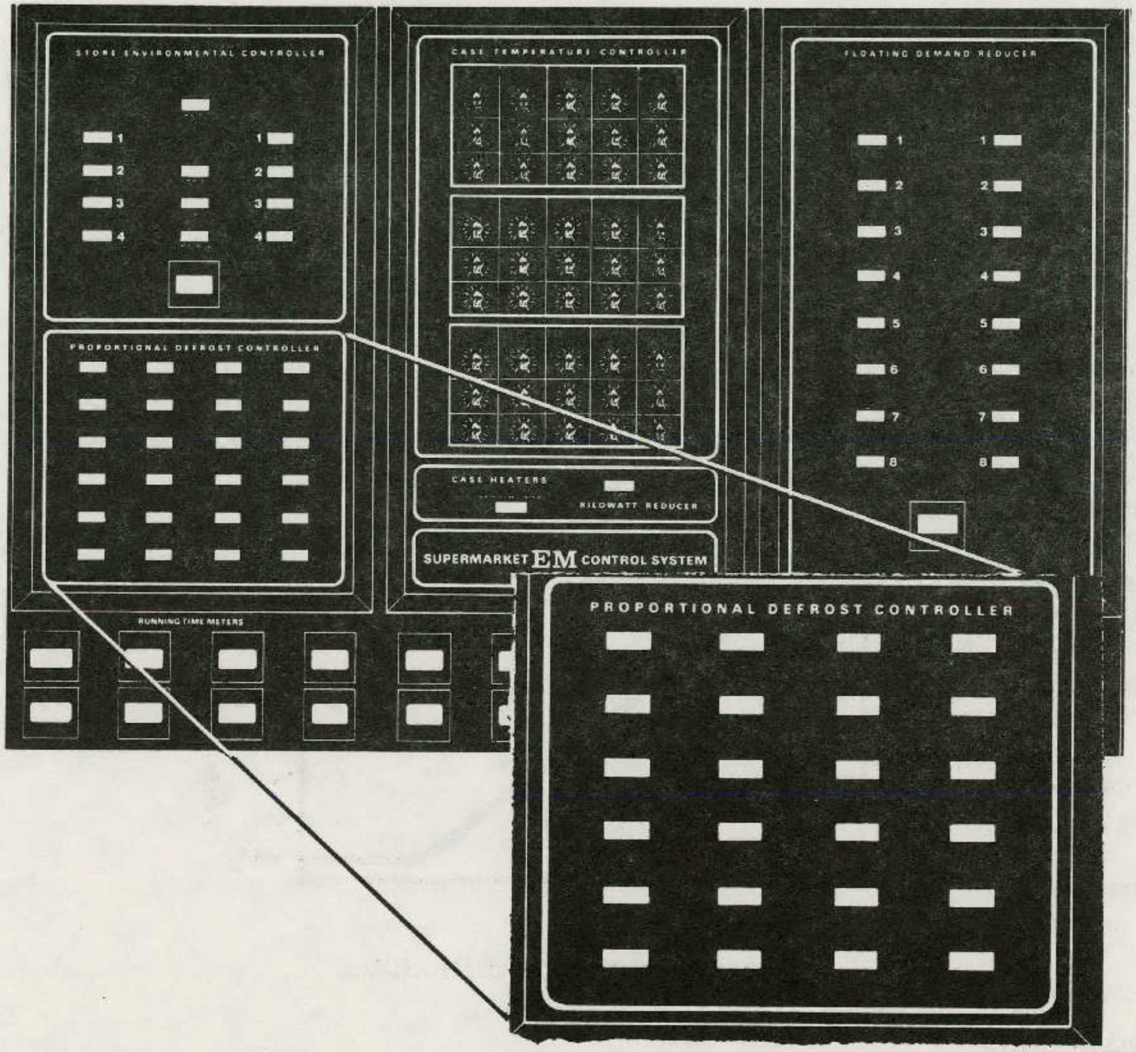
7. Fused protection.

8. Can handle up to 72 cases.

9. Performance Monitor can be added to alert store personnel to abnormal temperatures. An alarm is given by a horn and blinking light. The capability to send messages by telephone line is another valuable feature.

10. Temperature logging by means of simple plug connection to the cabinet; all temperatures can be recorded at selected intervals of 1, 2, 5, 10, 15, or 20 minute intervals. Recording is done on a magnetic tape cassette.

11. Print-outs from the tape can be used for periodic maintenance checks.



Potential Savings at $. 03/KWH	Minneapolis Denver	Salt Lake City Chicago	Sacramento St. Louis Boston	Los Angeles Dallas Atlanta Seattle	Miami
10,000 sq. ft. Store	309	258	228	168	126
20,000 sq. ft. Store	429	357	318	234	174

TYLER

PROPORTIONAL DEFROST CONTROLLING

Reducing the number of defrosts can be profitable in three ways:

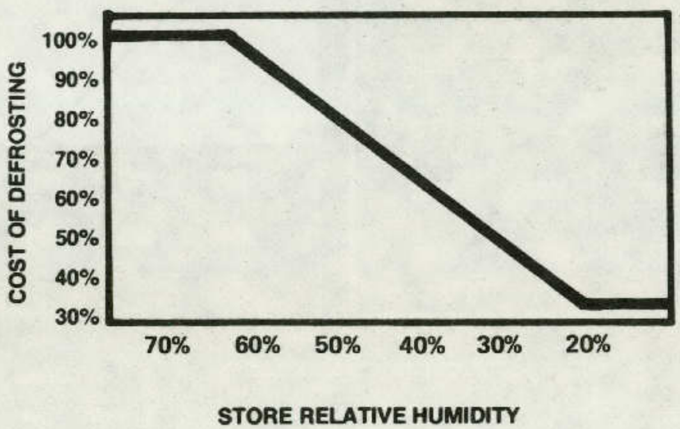
1. It can save much of the energy required to defrost.
2. It can maintain refrigerated food quality better by avoiding defrost warmup.
3. It can save energy required to re-refrigerate product warmed during defrost.

AVAILABLE DEFROST METHODS

* Defrosting is usually accomplished with the use of time clocks, set for the worst (summertime) conditions. These are not flexible systems.
* Demand defrost controls use devices to sense the condition of a refrigerator, defrosting it only when that case needs it. Flexibility has been gained but this application has been generally limited and complex.
* Proportional defrost senses the store's relative humidity and controls the frequency of defrosts for all refrigerators in the store environment. In the worst conditions, it schedules 100% of recommended defrosts. In milder conditions, it proportionally reduces defrosts to as few as one-third. Under steadily controlled environments, it can save up to two-thirds of "normal" defrost costs.
* Since the Tyler Proportional Defrost Controller can control all of the refrigerators within the store's environment, the savings can be significantly greater than with the other systems.

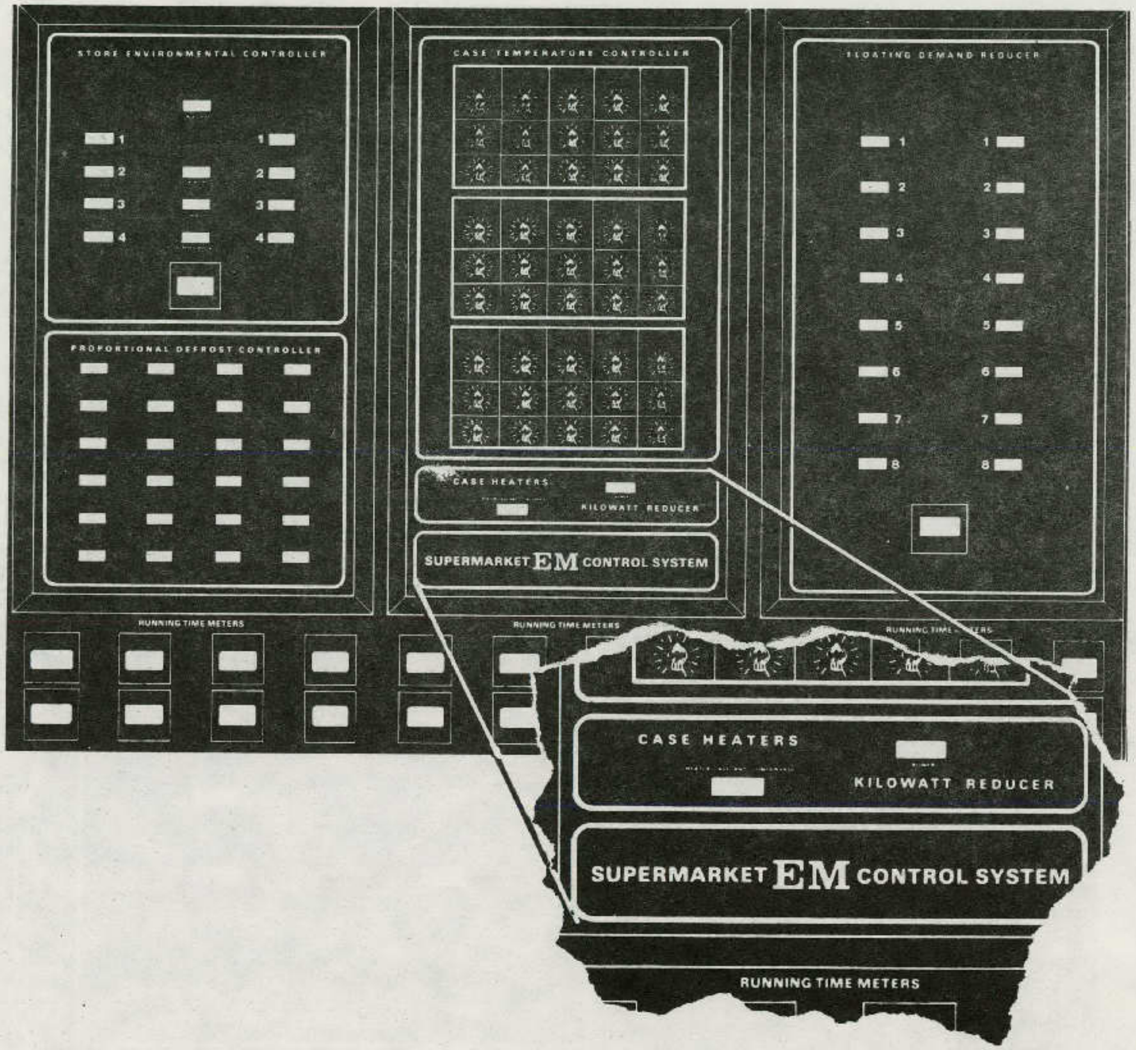
TYLER Refrigeration Corporation
Niles, Michigan 49120

PROPORTION DEFROST SYSTEM



PROPORTIONAL DEFROST CONTROLLING FEATURES

1. One master unit can handle up to 24 circuits.
2. Indicator lights show if systems in defrost or refrigeration modes.
3. Defrost frequency for each unit can independently be restored to conventional settings by a manual switch.
4. Defrost can be terminated by temperature, pressure, or time for the best quality performance of the refrigerator.
5. Fail safe time termination setting is provided for product protection.
6. Low voltage wiring, 24V from the clock to the Master module and to the store mounted sensor.
7. Defrost staggering is accomplished by a master module which maintains that separation.



TYLER

KWH REDUCER
also ES-1

KWH REDUCTION FOR CASE ANTI-SWEAT HEATERS

Anti-sweat heat is used on display cases to prevent sweating where cold surfaces meet the warm ambient temperature of the store. Proper design can eliminate most anti-sweat heat from open cases.

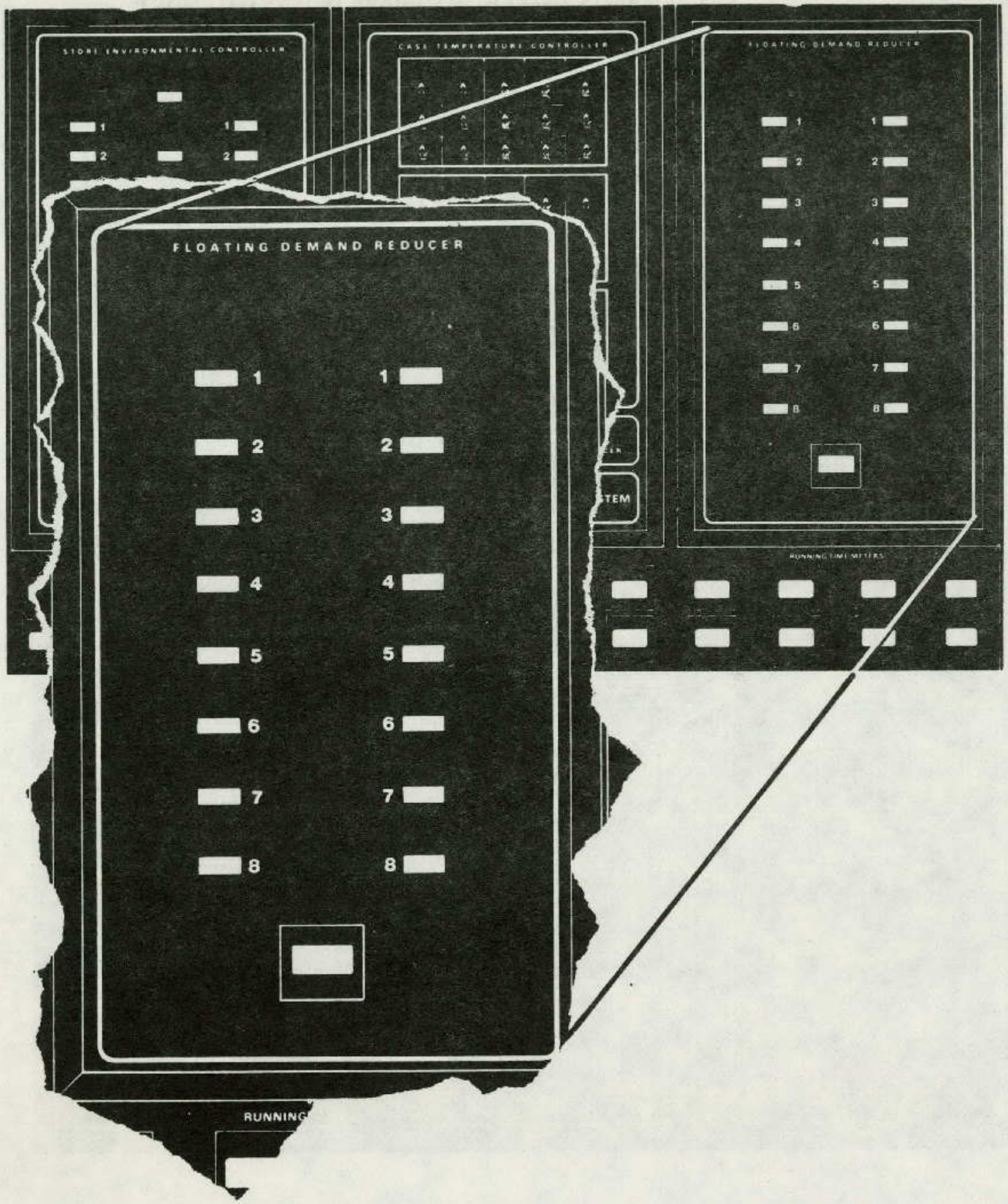
However, on glass door merchandisers, considerable anti-sweat heat is required for the electrically heated glass and door frames. They are separately circulated by Tyler for convenience in applying KWh reducer.

With a KWh Reducer in operation, very little and perhaps no heat at all will be required on the door circuit. This will depend upon the store humidity and the effectiveness of the store environmental control system.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
TYLER KWh REDUCER	$ 173.31	$ 237.48	$ 291.66	$ 350.84	$ 386.77

ESTIMATED ANNUAL SAVINGS WITH TYLER KWh REDUCER
(Based on $0.03 per KWh for 60' AFG case by map zone location)

TYLER Refrigeration Corporation
Niles, Michigan 49120



TYLER

FLOATING DEMAND REDUCER

ENERGY COSTS CAN HURT

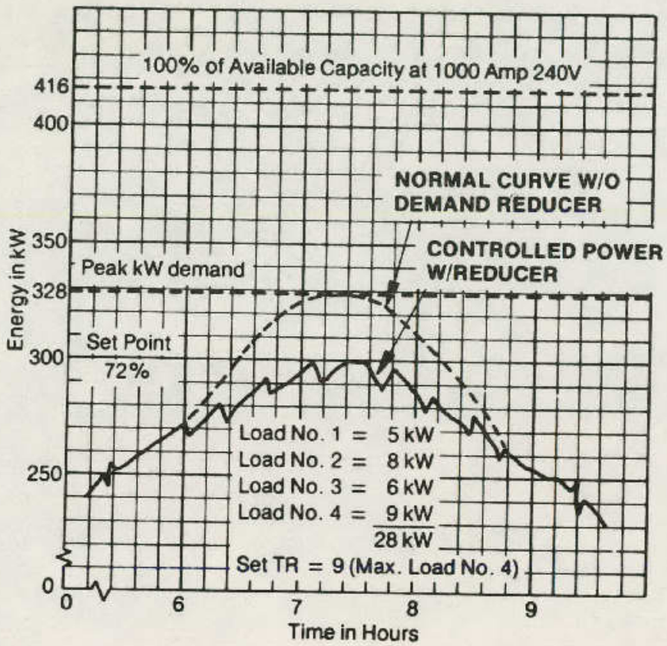
Energy costs hurt: We recognize your problem. Many stores spend $40,000 to $60,000 or more in energy bills, and the cost is rising every year. And of course, you can't cut energy consumption at random either, or you pay the price in spoiled merchandise and lost business. Yet, since every $1,000 spent in electric bills can be equivalent to about $100,000 in sales, there's a tremendous challenge to find a safe way to save energy.

Most electric utilities make charges based on highest demand for each month. This is defined as the highest (peak) 15 minutes (sometimes 30 minutes) energy use for the period. A demand reducer monitors the demand continually and "chops" the peaks by dropping certain pre-selected, non-critical electrical loads for a few minutes as required. Selection of these loads takes into account the owner's preference and the store's needs, such as store lighting, electric furnaces, water heaters, produce prep room, condensing units, etc. Savings are realized every month.

Tyler offers now optional service. At no cost to the customer, Tyler will examine the rate structure of your local power company to check the potential savings by reducing demand levels. Next, Tyler offers means for recording the load profile at your store for a few weeks on rental basis. Tyler will then analyze the results. If the results show potential for satisfactory pay back, a proposal will be made for a Demand Reducer to fit your needs.

TYLER | Refrigeration Corporation
Niles, Michigan 49120

EFFECT OF DEMAND REDUCER



General Features:

1. Continuously monitors power rate consumption.
2. Automatically sheds programmed loads, so that demand will not exceed set point.
3. Lights for indicating the number of loads that have been shedded.
4. Meter read out indicating actual KW being consumed at that instant in percent total load KW.
5. Designed to control up to 16 loads.
6. Optional recorder to make graphic record of demand profile.
7. Fail safe feature - should power be interrupted to panel, all loads are cycled ON to maintain safe product temperature in display cases.

7

BUILDING STRUCTURE

Insulation

Table of Contents

BUILDING ENVELOPE

David McCandless, Jr., A.I.A.
Planergy, Inc.

The total use of energy required in a commercial building for providing the proper environmental conditions of temperature, humidity, light and fresh air, involves not only the mechanical systems and services within the facility, but also the entire BUILDING ENVELOPE which must CONTAIN that man made environment and EXCLUDE the often adverse outside conditions.

Total energy management in a commercial building, therefore, must take into account all the possible ways that conductive and convective heat losses and gains, outdoors-to-indoors and indoors-to-outdoors, can occur through the BUILDING ENVELOPE, through the seasons of the year. It must also consider solar heat gains, helpful in winter and unwanted in summer. And, because of the oftentimes functional complexities of a commercial building, energy management should extend also to the separation of the environmental zones inside that building envelope.

A total energy management program must begin with a thorough energy audit of the commercial building and all its systems, not the least of which is the building envelope. That audit begins with a very thorough examination of all the physical conditions of the building which are subject to heat transfer. The items of that examination relate to those listed in the final section of this chapter under Dollar Savings Opportunities.

All the items found to exist in the basic audit, whether or not in need of repair or installation, should be scheduled for re-examination on an appropriate periodic basis so that cost-effective and energy-effective maintenance is achieved. This scheduling may be computerized as part of the overall building Energy Management Program. The conditions and effects of the building envelope would, in that way, become part of the monthly energy consumption analysis.

There are many small ways to conserve energy in the building envelope, as well as larger, more expensive improvements which can be made, and it is important to put these opportunities into some overall perspective. From the broad point of view there are five major areas of concern. They are, in order of importance for existing building considerations:

1. Reduction of infiltration and exfiltration
2. Reduction of solar heat gain through windows
3. Reduction of heat loss through windows
4. Reduction of heat gain and loss through walls, roofs, etc.
5. Reduction of internal heat transfer

A general analysis of each of these five subjects is presented in the discussion which follows. Some specific conditions are cited, but a more complete list of possible steps in energy conservation, especially for the many small efforts which add up to meaningful savings, are listed in the final section of this chapter under Dollar Savings Opportunities.

Infiltration and Exfiltration

The need for a large portion of the energy used for heating and cooling a typical commercial building results from the heat gains and losses through the building envelope. In the "typical" commercial building the major portion of that occurs as infiltration and exfiltration--air leakage through all kinds of cracks and crevices in the building envelope.

Outside air can leak through cracks around operative window sashesand doors, between the door or window frames and the wall materials they are set in, and through joints in the basic wall construction, especially in panelized wall systems.

There are many types of building exterior treatment and the chances for leakage in and out of the building envelope vary accordingly. Consider, for example, the increasing amount of crack-footage in the following list of facade-types:

a. Individual windows set in brick walls
b. Bands of windows set in brick walls
c. Precast panel systems, windows in some panels
d. Curtain wall treatment on 2 sides only
e. Curtain wall treatment on all 4 sides

At the same time consider the quality of the installation and the caulking materials used. These can vary from good to poor, and caulkings can change in quality with age. Happily, most of the curtain wall systems have very good details for holding the glass and for preventing leakage.

Infiltration and exfiltration vary with wind velocities and wind pressure, both positive and negative, on different sides of the building. Air pressures inside the building envelope can also be positive and/or negative, and these can combine with the exterior conditions to induce leakage wherever the potential exists.

There is also a stack effect in tall buildings, especially in such vertical spaces as stairways, elevators, and mechanical service shafts. Since warm air tends to rise, when outside air is cold there is a strong potential for infiltration at the bottom floors and exfiltration at the top.

Caulking between fixed systems and weather-stripping of movable window sashes and doors are the major means of reducing infiltration and exfiltration in the building envelope. There are probably as many types of caulking and weather-stripping materials as there are types of cracks to be filled. In general, the non-hardening, surface-skinning types of caulkings are best. Caulkings must have permanent adherence and should be chosen according to surfaces involved, and these surfaces must be clean and dry. For wide cracks a filler, or backer-rod can be used before the caulking. Weather-stripping includes compressible, closed cell foam, compressible "tubular" systems, and interlocking metal strip systems. Since there are so many different conditions which can exist for caulkings and weather-stripping it is wise to get expert advice on the subject.

Storm windows are often used to increase the thermal resistance through glass. Double glazing is also used for this purpose, but the storm window units have an advantage, generally, in increased control over leakage of air around the window frames. Depending on window framing and installation details, storm windows in secondary frames are usually more energy conserving than double glazing in a single frame, and they are often easier to accommodate in existing conditions.

Some examples of infiltration rates might illustrate the seriousness of this leakage which we cannot see and only rarely feel except in the utility bills.

infiltration

rate of infiltration thru window frames

fig. 18

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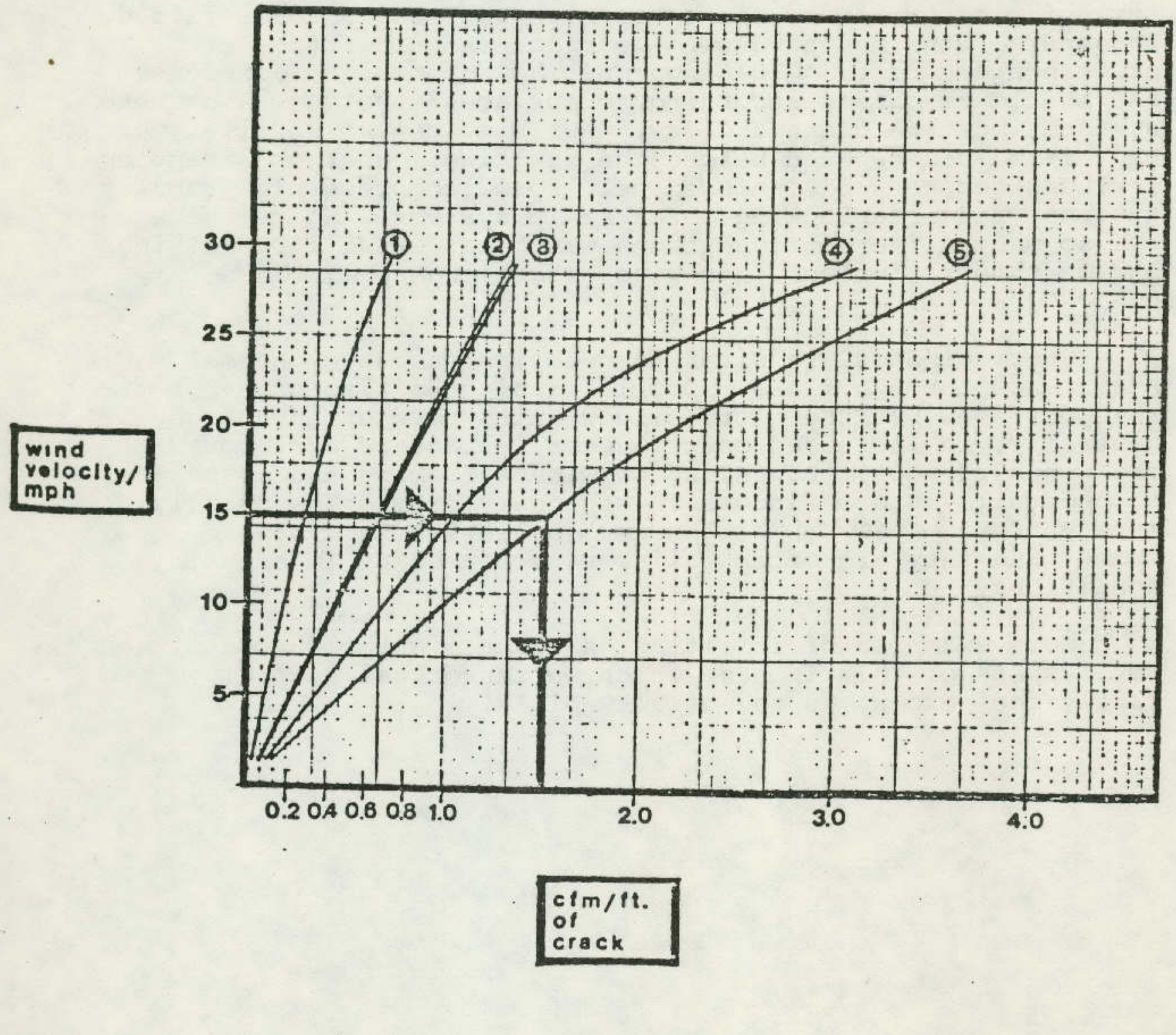
key to window infiltration chart			
(leakage between sash & frame)			
type	material	weatherstripped?	fit
① all hinged	wood	yes	avg.
	metal	yes	avg.
② all hinged	wood	no	avg.
	metal	no	avg.
dbl hung	steel	no	avg.
③ all	wood	yes	loose
dbl-hung	steel	yes	avg.
④ casement	steel	no	avg.
⑤ all hinged	wood	no	loose



1. <u>Window Leakage</u>

Data from the a Building Audit:
Indoor Temperature 70
Winter Degree Days, Dallas, 2400
Winter Design Temperature, Dallas 19
Wind Speed 15 mph
Wind Direction N.W.
Window Dimensions, Sash: 3' x 2'
Window Type: Fixed glass with movable sash vent at bottom; steel frame without weather-stripping
Note: 30 windows per floor
Window perimeter - 10' per window
Total such crack length = 300' feet
From Figure 18, type 2: infiltration rate thru frame = 0.65 CFM/ft.
Total Infiltration due to cracks: 0.65 x 300 ft. = 195 CFM
Total Infiltration in one 24 hour period:
195 x 60 minutes x 24 hours = 280,800 cu. ft.

To put this in perspective, note: that there are about 202,000 cu. ft. of volume in a GOODYEAR BLIMP. Therefore, about 1.4 BLIMPS of AIR leak through the operable sash of the windows on the one floor of the building every day.

2. <u>Door Leakage</u>

Assume a typical 3' x 7' metal exit door. Assume also, for sake of simplicity, a ½ inch crack around all four sides.

Total crack = 3' + 7' + 3' + 7' = 20' long
Each foot of crack = 1 square inch air space
20 x 1 sq. inch = 20 sq. inch air space
Total crack is equivalent to a 4" x 5" hole in the door.

Further:
Assuming: infiltration rate = 1.5 CFM/ft.
Total infiltration = 20 x 1.5 = 30 CFM
1 day infiltration = 30 x 60 x 24 = 43,200 Cu.Ft.
For 5 such doors: 5 x 43,200 = 216,000 cu.ft.
216,000 ÷ over 1 BLIMP per DAY 202,000

3. <u>Electric Outlets</u>

Research on infiltration in residential construction, conducted by the Texas Power and Light Company has shown that 20% of the leakage occurs through the wall outlets. This is a little more than the 19% for all the windows and doors combined in the "typical" houses measured. This 20% infiltration is from air that gets into the building framing system through various exterior cracks and "breathing" space, and travels along the paths of electrical runs and piping.

The building envelope of some buildings, especially one and two story structures, and some curtain wall systems, are undoubtedly similar in external and internal wall leakage.

Besides the opportunity to reduce air leakage through external caulkings of the wall structure system there is a type of gasket that can be placed behind the electrical outlet covers and switch plates. These gaskets, called Outlet Energy Savers, are a 3/16 inch open cell foam material, die cut to fit standard duplex receptacles and switches. When installed behind the face plates, these gaskets reduce air leakage significantly.

Solar Heat Gain

Heat gains from solar radiation through windows in Texas buildings can have a major impact on energy use, depending on such factors as orientation, exposure and shading, winter and summer, types of glass and glass treatment. Since Texas is in the southern part of this country where winters are not so severe, the need of cooling due to heat gain through windows is much more significant than for heating due to heat losses in the winter. This can be seen by a comparison of Figures 32 and 48 (from ECM-2), which show yearly heat losses and gains per sq. ft. of glass, for Houston and eleven other U.S. cities. The yearly heat gains indicated include both solar and conduction loads.

There is so much more heat gain from solar radiation than from conduction through the glass that radiative gains must be solved before considering the conductive heat transfer through the glass. When double glazing is then considered for reducing summer heat gains there will also be a real benefit in controlling heat losses in the winter season.

The effects of orientation are different for winter and summer. In winter the sun rises a little south of east, is low in the south sky at noon, and it sets correspondingly south of west. This sun movement allows a little east and west wall solar heat gain in the morning and afternoon, respectively,

YEARLY HEAT LOSS/SQUARE FOOT OF SINGLE GLAZING AND DOUBLE GLAZING

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	DEGREE DAYS	HEAT LOSS THROUGH WINDOW BTU/FT.^{2} YEAR					
				NORTH		EAST & WEST		SOUTH	
				SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE
MINNEAPOLIS	45°N	325	8,382	187,362	94,419	161,707	84,936	140,428	74,865
CONCORD, N.H.	43°N	300	7,000	158,770	83,861	136,073	73,303	122,144	67,586
DENVER	40°N	425	6,283	136,452	70,449	117,487	62,437	109,365	59,481
CHICAGO	42°N	350	6,155	147,252	75,196	126,838	65,810	110,035	58,632
ST. LOUIS	39°N	375	4,900	109,915	56,054	94,205	49,355	84,399	45,398
NEW YORK	41°N	350	4,871	109,672	54,986	93,700	48,611	82,769	44,580
SAN FRANCISCO	38°N	410	3,015	49,600	25,649	43,866	23,704	41,691	23,239
ATLANTA	34°N	390	2,983	63,509	31,992	55,155	28,801	51,837	28,092
LOS ANGELES	34°N	470	2,061	21,059	11,532	19,487	10,954	19,485	10,989
PHOENIX	33°N	520	1,765	25,951	14,381	22,381	12,885	22,488	12,810
HOUSTON	30°N	430	1,600	33,599	17,939	30,744	17,053	30,200	16,861
MIAMI	26°N	451	141	1,404	742	1,345	742	1,345	742

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fig. 32

YEARLY HEAT GAIN/SQUARE FOOT OF SINGLE GLAZING AND DOUBLE GLAZING

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	D.B. DEGREE HOURS ABOVE 78°F	HEAT GAIN THROUGH WINDOW BTU/FT.^{2} YEAR					
				NORTH		EAST & WEST		SOUTH	
				SINGLE	DOUBLE	SINGLE	DOUBLE	SINGLE	DOUBLE
MINNEAPOLIS	45°N	325	2,500	36,579	33,089	98,158	88,200	82,597	70,729
CONCORD, N.H.	43°N	300	1,750	33,481	30,080	91,684	82,263	88,609	76,517
DENVER	40°N	425	4,055	44,764	39,762	122,038	108,918	100,594	85,571
CHICAGO	42°N	350	3,100	35,595	31,303	93,692	83,199	87,017	74,497
ST. LOUIS	39°N	375	6,400	55,242	45,648	130,018	112,368	103,606	85,221
NEW YORK	41°N	350	3,000	40,883	35,645	109,750	97,253	118,454	102,435
SAN FRANCISCO	38°N	410	3,000	29,373	28,375	88,699	81,514	73,087	64,169
ATLANTA	34°N	390	9,400	59,559	50,580	147,654	129,391	106,163	87,991
LOS ANGELES	34°N	470	2,000	47,912	43,264	126,055	112,869	112,234	97,284
PHOENIX	33°N	520	24,448	137,771	97,565	242,586	191,040	211,603	131,558
HOUSTON	30°N	430	11,500	88,334	72,474	213,739	184,459	188,718	156,842
MIAMI	26°N	451	10,771	98,496	79,392	237,763	203,356	215,382	179,376

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fig. 48

and a lot of mid-day sun on the south walls and into south facing windows. In the summer, the sun rises a little north of east and it sets a little north of west, and at noon it is high overhead, barely shining on southerly walls and windows. Summer solar radiation, therefore, is more severe on eastern and western exposures and not so serious on southern exposures. North facing walls and windows get no sunshine in the winter and only early morning and later afternoon angular exposure to the sun in the summer.

Exterior architectural shading for windows must relate to these sun angles. On the east and west elevations such devices must be vertical, the full height of the windows, sometimes adjustable for the actual orientation and time of day. For south facing windows roof overhangs and horizontal, projecting "eyebrows", over each band of windows can be designed for complete summer shading yet allow winter solar gains. Such shading devices, when used, are usually part of the original design and construction. They are only occasionally installed on existing structures.

External shading devices are the most effective method of controlling solar heat gain because they prevent the sun from shining directly on the glass. There are some external louvered sun screens available which can be fixed to the window openings, and which provide meaningful shading, as shown in Figure 22 (from ECM-1) which indicates the shading coefficients for types of glass and shading devices. Sometimes these sun screens can be removed to allow winter solar heat gain.

Internal shading devices include drapes, venetian blinds, vertical louver blinds, roller blinds, and variations of these basic types. While less effective than other methods of solar heat gain, internal shades are relatively inexpensive and they are much more easily adjustable to the times of most solar gain and to the needs for light and view.

Tinted or reflective glass, and reflective polyester films applied to the inside of the glass may also be used to reduce solar heat gain. The tinted or reflective glass can be used to replace existing glass or to create double glazing (storm windows). The films are self-adhesive but require special care in application. With storm windows the film should be on the inner face of the outside layer of glass (do not put it on the inner glass or the reflected heat will be trapped).

An example of solar heat gain reduction involves the application of reflective solar film to 10,000 sq. ft. of east, south, and west windows in a 10 story office building in Miami, Florida. The annual energy savings calculated was 15% with a pay-back of just over 2 years.

fig. 22

SHADING COEFFICIENTS

GLASS	
1/8" Clear Double Strength	1.00
1/4" Clear Plate	0.93 - 0.95
1/4" Heat Absorbing Plate	0.65 - 0.70
1/4" Reflective Plate	0.23 - 0.56
1/4" Laminated Reflective	0.28 - 0.42
1" Clear Insulating Plate	0.80 - 0.83
1" Heat Absorbing Insulating Plate	0.43 - 0.45
1" Reflective Insulating Plate	0.13 - 0.31

SHADING DEVICE	WITH 1/4" CLEAR PLATE GLASS	WITH 1" CLEAR INSULATING GLASS
Venetian Blinds - Light Colored, Fully Closed	0.55	0.51
Roller Shade - Light Colored, Translucent, Fully Drawn	0.39	0.37
Drapes - Semi-Open Weave, Average Fabric Transmittance and Reflectance, Fully Closed	0.55	0.48
Reflective Polyester Film	0.24	0.20
Louvered Sun Screens - 23 Louvers/In.	0.15 - 0.35	0.10 - 0.29
- 17 Louvers/In.	0.18 - 0.51	0.12 - 0.45

In winter solar heat gain is beneficial and its usefulness must be balanced against solar gains in the summer, according to orientation, types of glass, reflective films, latitude, solar control devices and percentage of sunshine. Note that about 10% less sunlight penetrates double glazing than single glazing. However, double glazing reduces the heat load due to conduction, and the benefits from this more than offset the loss of solar radiation.

Heat Loss Through Windows

On the national scale it has been estimated that 20% of our energy goes to space conditioning in residential and commercial buildings. Of this, 25% results from heat losses and gains due to the relatively high thermal conductivity of windows -- an energy use equivalent to an average of 1.7 million barrels of oil a day.

Although, as was pointed out earlier, there is in Texas more of an energy concern for heat gain in summer than there is for heat loss through glass in winter, the heat loss is still significant. And there are some things which can be done to help save energy in this regard in Texas buildings.

The rate of conductive heat flow through various parts of the building envelope (glass, walls, roof, floors, etc.) is expressed as a "U"-value. This rating is in units of BTU's/hour/square foot of surface/degree F. of temperature difference inside to outside. The lower the U-value the higher the insulating value of the construction rated. Typical wall and roof construction vary from U=.4 down to U=.04 depending on the basic structural materials and the type and thickness of the insulation used. Single panes of glass in still air (less than 15 mph) have a U-value of 1.13. Double glazing reduces the U-value to about .55.

These values show that we should have a greater concern for heat flow through glass than through the "solid" parts of the building envelope, the exterior walls, the roof, and floors over unheated space. It is helpful to put this difference into some sort of perspective. We can do this by comparing their U-values and what would be equivalent areas for the same transmission of BTU's per hour.

Let us assume the following reasonable U-values for two windows and a wall:

a.	Window with single glass:	1.1 U-value
b.	Window with double glass:	.55 U-value
c. wall	inside = gypsumboard insulation = R-17 exterior = sheathing plus wood panel, painted	.055 U-value

We can see that the rate of heat flow through the solid wall is one-tenth that of the double glazed window which in turn is one half that of the single glass. Since this transmission rating is on a square foot basis we can also see that the same amount of heat would be transmitted through:

a. a single glass window: 2.5' x 4' = 10 sq.ft.
b. a double glazed window: 5' x 4' = 20 sq.ft.
c. the solid wall: 10' x 20' = 200 sq.ft.

Let us put these area comparisons into a little further perspective by relating them to the five types of exterior treatment discussed above in the section on infiltration. If individual windows set in a brick wall add up to only one tenth of the total wall area, and if the windows are double glazed, the heat transfer through wall and windows is equivalent. If those windows are in continuous bands they would probably equal about a third of the wall area, so there would obviously be more conductive heat gain and loss through the glass than through the solid wall. Precast panels with windows set into one of every five panels might still have glass areas equivalent to that of the basic brick design. In considering the curtain wall construction, if we assume that the spandrel panels are on opaque glass treatment, or some material of equivalent heat transmission, then the back up construction should include adequate insulation to achieve an appropriately low U-value for the full wall construction. In an all-glass building built before the national energy crisis began, it is very likely that the insulation behind the spandrel panels is inadequate by today's energy conservation standards.

As discussed above, using double glazing will reduce the conduction heat loss of single glazing by one half, but this will occasionally be modified somewhat by solar radiation and wind, and therefore by orientation. Wind destroys the exterior "air film" on the glass and this causes the U-value of the window to increase. Shutters, screens, trees, and other shielding devices will reduce this wind effect somewhat.

It is often easier to add storm windows to existing windows than it is to change to double glazing in the original frame. The choice will vary with the physical conditions, the present needs and replacement plans, etc., for each building. The use of storm windows may provide greater reduction in heat transfer through the windows because of the greater air space, and storm windows should give more control over air infiltration because of the second frame set tightly in the window opening.

The use of the various types of drapes, blinds, appropriate linings, etc. to cover the windows when not needed for light or view will also help reduce heat flow through windows. An added advantage provided by the drapes is that they will improve the Mean Radiant Temperature in a room or office.

The occupant will not feel so easily the "cold window" in the winter or the "heat from the window" in the summer. Eliminating this human response to radiant heat flow toward or from the glass will preclude the occupants' need for more heat or more cooling for human comfort.

When rooms or zones of the building are unused or closed off, the thermal transmission through the windows, in both winter and summer, can be meaningfully reduced by closing off the windows with various types of thermal barriers. Depending on the time the space is to be closed off, and on how the space heating and cooling is to be maintained, the thermal barriers can range from simple drapes and blinds to storm windows and even opaque, insulated panels.

Heat Flow Through Walls, Roof, Floors

In energy conservation we are concerned with the rate of conductive heat flow through various types of building construction. This is the "U"-value of each complete construction, inside-to-outside, including air films, as discussed above. By contrast, we are also concerned with thermal resistance of materials such as insulation, masonry, wood, plaster, etc. to heat flow through them. The thermal resistance of a material is its "R" value. The R-value of all materials in a wall construction can be added, and the resulting total R-value is the reciprocal of the U-value of the whole construction.

This relationship of the U-value to the total R-value, and then to the R-values of the parts of a construction, is meaningful in discussing the improvements that might be achieved by the addition of certain insulation materials. They are commercially rated by their R-values, even though we usually use the U-value as a rating of the total construction.

It is best to remember simply:

a. the higher the R-value, the better the "insulation"

and

b. the lower the U-value, the better the "insulation" of the whole construction.

For most constructions of walls, and also for roofs, the basic structural materials by themselves are inadequate as thermal barriers and various amounts and types of insulation are included in their design. Part of the physical examination of the building envelope in the basic energy audit of and existing building should be an analysis of the plans, details, and specifications of its construction to determine the resistance to heat flow of its many parts. This should be done for the various details of wall and roof construction, and for any floors over unconditioned spaces.

For most of Texas the heat gain of summer will be more of an energy concern than the heat loss in winter, but there are enough variables to consider that this should be determined for each situation. These variables include latitude, solar radiation, "degree hours" above 80°F, winter "degree days", building and wall orientation, surface heat absorption coefficients, seasonal wind patterns and velocities, as well as the theoretical U-value of each construction. A comparison of data, including yearly heat gains and heat losses, for walls and for roofs, in the city Houston, as shown in Figures 36, 40, 52 and 56, shows variations with these factors.

The mass of a wall does not give it a better, lower, U-value, per se. Mass simply provides a form of thermal inertia: it slows up the heat transfer and delays the impact of outdoor temperature changes on the inside conditioned space. The time delay allows the wall to act dynamically as a thermal storage system, smoothing out peaks in heat flow and reducing yearly heat loss somewhat. High mass walls of 80 to 90 lbs/sq. ft. have approximately 2% less yearly heat loss (or gain) than low mass walls of 10 to 20 lbs/sq.ft., assuming the same U-value and absorption coefficient for both walls.

When it is determined that the U-value of a wall should be lowered as an energy conservation measure, one naturally looks for methods to increase the insulation of the wall. It is seldom possible to do this without going to some extreme measures, such as removing the interior wall surfaces (gypsum board or plaster, usually) and then adding appropriately high R-value insulation before resurfacing the walls.

It is also possible to add insulation with a new facing over existing surfaces, as is shown in the following detail. When added to the exterior the treatment will have to be weathersealed and vapor-proofed, and it will give an entirely new look to the building unless a similar facing existed before. Such exterior treatment is feasible for low-rise structures, and difficult for tall buildings, and it causes little disruption inside.

YEARLY HEAT LOSS/SQUARE FOOT THROUGH WALLS

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	DEGREE DAYS	HEAT LOSS THROUGH WALLS BTU/FT.^{2} YEAR											
				NORTH				EAST & WEST				SOUTH			
				U=0.39		U=0.1		U=0.39		U=0.1		U=0.39		U=0.1	
				a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8
MINNEAPOLIS	45°N	325	8,382	74,423	70,651	20,452	19,335	70,560	62,229	19,378	16,787	66,066	51,298	18,109	13,530
CONCORD, N.H.	43°N	300	7,000	68,759	64,826	18,895	17,714	64,674	55,363	17,743	14,972	59,759	43,667	16,370	11,344
DENVER	40°N	425	6,283	57,337	53,943	15,755	14,824	53,726	44,937	14,763	12,198	48,780	34,095	13,405	8,720
CHICAGO	42°N	350	6,155	58,516	55,356	16,081	15,210	55,219	47,678	15,169	12,865	50,684	37,339	13,847	9,743
ST. LOUIS	39°N	375	4,900	45,046	42,149	12,379	11,565	41,981	35,192	11,533	9,476	38,038	26,344	10,425	6,660
NEW YORK	41°N	350	4,871	45,906	42,950	12,615	11,804	42,843	35,368	11,774	9,594	38,385	25,231	10,548	6,406
SAN FRANCISCO	38°N	410	3,015	23,258	21,120	6,392	5,803	20,916	15,631	5,748	4,118	16,948	9,812	4,645	1,743
ATLANTA	34°N	390	2,983	26,922	24,803	7,398	6,771	24,475	19,206	6,716	5,103	20,639	12,399	5,562	2,587
LOS ANGELES	34°N	470	2,061	9,900	8,549	2,720	2,349	8,392	5,758	2,306	1,316	6,139	3,040	1,520	155
PHOENIX	33°N	520	1,765	11,861	10,533	3,259	2,878	10,283	7,316	2,826	1,811	8,077	4,619	2,062	555
HOUSTON	30°N	430	1,600	14,592	12,956	4,011	3,557	12,888	9,379	3,542	2,351	10,878	6,760	2,909	1,142
MIAMI	26°N	451	141	210	106	7	0	92	0	0	0	6	0	0	0

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fig. 36

YEARLY HEAT LOSS/SQUARE FOOT THROUGH ROOF

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	DEGREE DAYS	HEAT LOSS THROUGH ROOF BTU/FT.^{2} YEAR			
				U=0.19		U=0.12	
				a=0.3	a=0.8	a=0.3	a=0.8
MINNEAPOLIS	45°N	325	8,382	35,250	30,967	21,330	18,642
CONCORD, N.H.	43°N	300	7,000	32,462	27,678	19,649	16,625
DENVER	40°N	425	6,283	26,794	22,483	16,226	13,496
CHICAGO	42°N	350	6,155	27,489	23,590	16,633	14,190
ST. LOUIS	39°N	375	4,900	20,975	17,438	12,692	10,457
NEW YORK	41°N	350	4,871	21,325	17,325	12,911	10,416
SAN FRANCISCO	38°N	410	3,015	10,551	8,091	6,381	4,784
ATLANTA	34°N	390	2,983	12,601	9,841	7,619	5,832
LOS ANGELES	34°N	470	2,061	4,632	3,696	2,790	2,142
PHOENIX	33°N	520	1,765	5,791	4,723	3,487	2,756
HOUSTON	30°N	430	1,600	6,045	4,796	3,616	2,778
MIAMI	26°N	451	141	259	130	139	55

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fig. 40

YEARLY HEAT GAIN/SQUARE FOOT THROUGH WALLS

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	D.B. DEGREE HOURS ABOVE 78°F	HEAT GAIN THROUGH WALLS BTU/FT.^{2} YEAR											
				NORTH				EAST & WEST				SOUTH			
				U=0.39		U=0.1		U=0.39		U=0.1		U=0.39		U=0.1	
				a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8	a=0.3	a=0.8
MINNEAPOLIS	45°N	325	2,500	364	2,442	19	390	1,346	7,665	164	1,747	1,601	7,439	164	1,574
CONCORD, N.H.	43°N	300	1,750	141	1,950	0	180	787	6,476	41	1,264	1,222	7,093	59	1,179
DENVER	40°N	425	4,055	321	2,476	0	291	1,361	8,450	66	1,597	1,513	8,138	78	1,301
CHICAGO	42°N	350	3,100	503	2,500	46	429	1,492	7,889	233	1,835	1,698	8,088	225	1,793
ST. LOUIS	39°N	375	6,400	2,246	5,966	419	1,386	4,165	14,116	950	3,571	3,994	12,476	779	3,074
NEW YORK	41°N	350	3,000	906	3,751	103	820	2,394	10,278	477	2,651	2,626	11,185	420	2,707
SAN FRANCISCO	38°N	410	3,000	0	0	0	0	0	3,268	0	262	43	3,459	0	297
ATLANTA	34°N	390	9,400	1,901	5,806	309	1,301	3,882	14,658	812	3,609	3,422	12,085	634	2,897
LOS ANGELES	34°N	470	2,000	0	774	0	10	180	6,575	0	889	527	7,182	0	980
PHOENIX	33°N	520	24,448	17,448	24,423	4,749	6,526	21,461	36,937	5,784	9,868	20,880	34,728	5,502	9,322
HOUSTON	30°N	430	11,500	5,002	10,687	1,178	2,643	7,895	22,431	1,981	5,521	6,985	20,893	1,605	4,713
MIAMI	26°N	451	10,771	7,507	15,717	1,912	4,052	12,358	31,745	3,164	8,416	11,778	29,906	2,814	8,057

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fig. 52

YEARLY HEAT GAIN/SQUARE FOOT THROUGH ROOF

CITY	LATITUDE	SOLAR RADIATION LANGLEY'S	D.B. DEGREE HOURS ABOVE 78°F	HEAT GAIN THROUGH ROOF BTU/FT.² YEAR			
				U=0.19		U=0.12	
				a=0.3	a=0.8	a=0.3	a=0.8
MINNEAPOLIS	45°N	325	2,500	2,008	8,139	1,119	4,728
CONCORD, N.H.	43°N	300	1,750	1,891	7,379	1,043	4,257
DENVER	40°N	425	4,055	2,458	9,859	1,348	5,680
CHICAGO	42°N	350	3,100	2,104	7,918	1,185	4,620
ST. LOUIS	39°N	375	6,400	4,059	12,075	2,326	7,131
NEW YORK	41°N	350	3,000	2,696	9,274	1,543	5,465
SAN FRANCISCO	38°N	410	3,000	566	5,914	265	3,354
ATLANTA	34°N	390	9,400	4,354	14,060	2,482	8,276
LOS ANGELES	34°N	470	2,000	1,733	10,025	921	5,759
PHOENIX	33°N	520	24,448	12,149	24,385	7,258	14,649
HOUSTON	30°N	430	11,500	7,255	20,931	4,176	12,369
MIAMI	26°N	451	10,771	9,009	24,594	5,315	14,716

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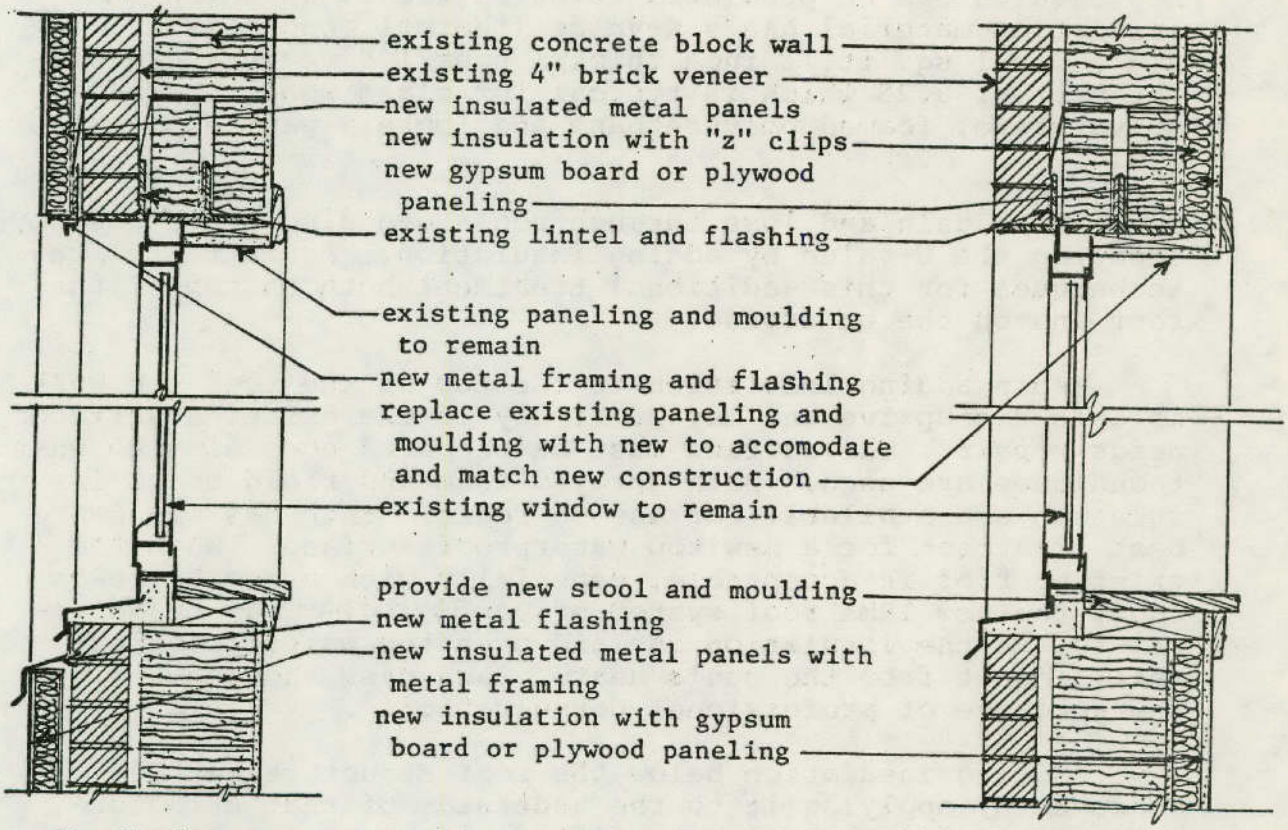
fig. 56



Insulation on exterior face

Insulation on interior face

When added to the interior, such treatment is easier in tall buildings but it is disruptive to normal operations. In either case there are likely to be architectural and mechanical complications not readily discernable, and there are usually building code conditions to consider, so it is advisable to get competent professional help in such an undertaking.

When adding insulation to a wall of known U-value the new U-value can be predicted using Figure 37 in which the insulation material has a K-value (thermal conductivity, in BTU's per 1 sq. ft./1 inch thick/1 hour/1^{o}F temperature difference) of 0.25 which is typical for glass wool, beaded polystyrene, foamed polyurethane and loosely packed mineral wool.

Heat gain and loss through roofs can also be reduced by lowering the U-value by adding insulation. Again there are techniques for this additional treatment both on top of the roof and on the underside.

When adding insulation to the top of the roof the work is less disruptive and may be timely if the existing surface needs repair. The surface must be prepared according to what techniques are used. Both sprayed foam and rigid board insulation are available for use on roofs. Each has its own best treatment for a new top waterproof surface. When the existing roof is acceptable, especially with a new built-up roof, the new IRMA roof system of Dow Styrofoam may be appropriate, as the insulation is laid <u>over</u> the water proofing, shielding it from the sun's heat. Each case should be given the guidance of professional consultation.

Adding insulation below the roof structure may be achieved by applying it to the underside of that structure by spray application or with fitted pieces of insulation board. The complications of working above and around existing utility lines, pipes, ducts and structural members may be the determining factors involved. The need for insulating the pipes, ducts, etc., should not be overlooked, nor should their location in the attic space allow some area of the roof underside to go untreated. If the insulation is laid over the existing ceiling it is important to consider the pipe and duct insulation and possibly the need for attic ventilation.

As a rule of thumb, the inches of duct insulation required is one fifteenth of the temperature difference between the conditioned air inside the duct and the unconditioned air in the attic space.

heating

effect of insulation on 'u' value

fig. 37

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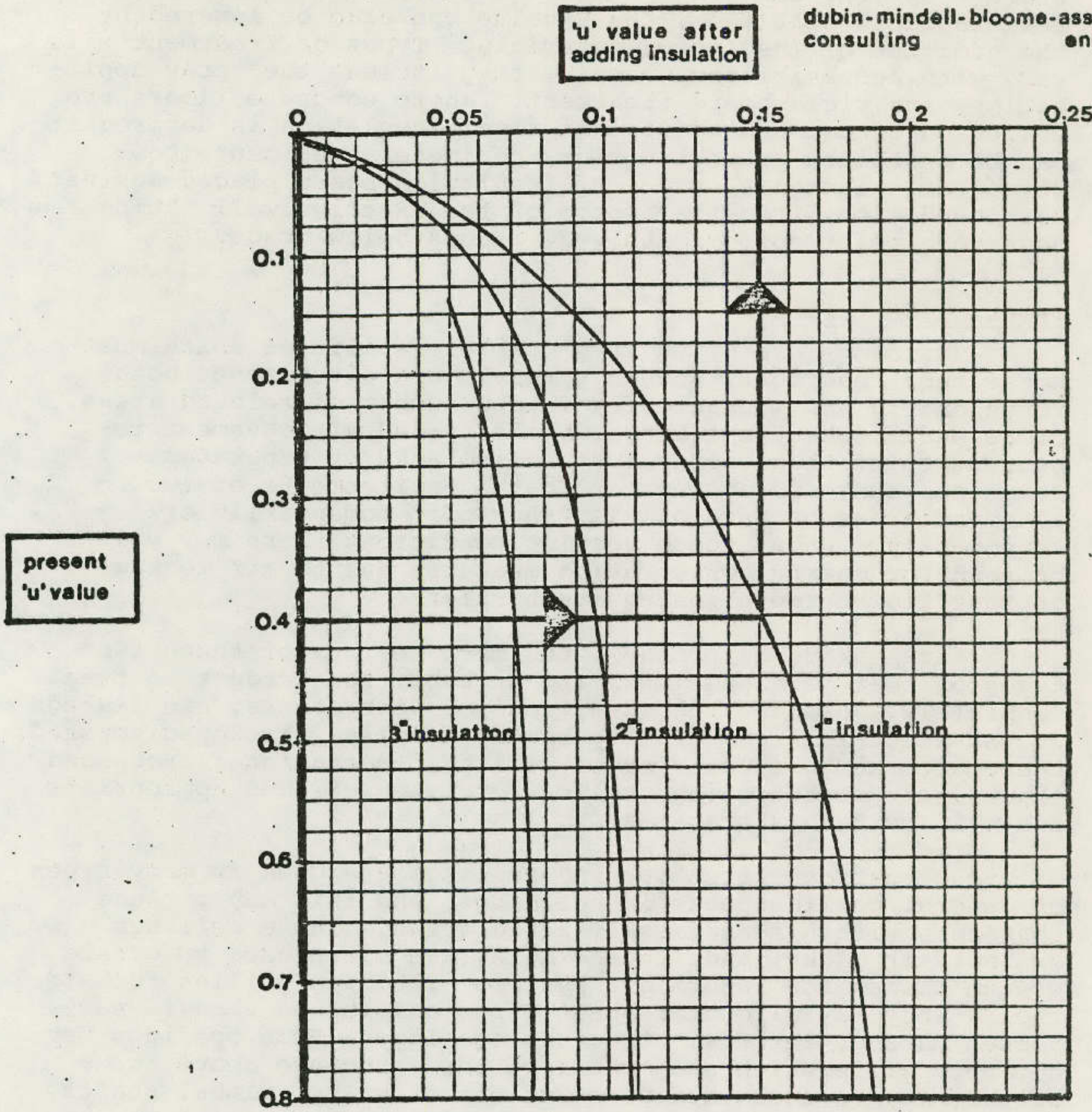


When floors over unconditioned spaces (crawl spaces, vented and unvented; pipe and mechanical spaces, rough storage spaces; outdoor spaces) are deemed to have inadequate resistance to heat flow, the U-value can also be lowered by the addition of insulation materials. Types of treatment will vary with accessibility. Again, they include the spray applications and rigid board treatment. Where concrete floors are poured on grade, and additional floor insulation is desired it can be installed as an exterior, perimeter treatment (Dow Styrofoam, Fiberglas, etc.) of insulation board placed against the foundation, from the bottom of the exterior wall facing down to a point approximately 24 inches below grade.

Internal Heat Flow

Buildings are often very complex facilities which must house many functions, and as a result are often zoned both functionally and mechanically into a number of related areas. Occasionally the temperature, humidity and air movement requirements of these zones must be isolated or separated. Sometimes there is a contrast in the environments of two adjacent areas because one is "shut-off" momentarily or temporarily. Under these varying conditions there may well be need for energy conservation measures due to air leakage or heat flow through inadequate barriers.

Air leakage is probably the more serious of these two types of heat gain and loss, and probably the hardest to treat completely. Besides the conditions of door cracks, and leakage around electrical and utility boxes in walls, already discussed, there are the various types of ceiling penetrations: recessed lights, air conditioning grilles, etc., which need appropriate seals in certain situations.

Accoustical tile "lay-in" ceilings are used in many types of general public spaces in buildings, and this may include corridors within mechanically zoned areas. These ceilings are not air tight, and, furthermore, are often used to create plenum spaces for return air systems with open grilles for air flow. They may allow more heat gains and losses than is suspected through internal structure openings. Such openings may be above walls which stop short of the structure above them; or they may be uncaulked penetrations of walls, slabs, shafts, chases, etc., for pipes, ducts, conduit, and special function services.

By its very nature, the construction of a commercial building must accommodate many mechanical systems and services, and plenums, shafts and pipe chases must be used. Many types of wall penetrations and openings which cannot be seen above ceilings do occur.

The mechanical systems engineer for the building may be the first to suspect energy losses through such hidden paths of internal leakage: they may even be causing imbalances in his systems. Such leakage should be investigated by him and by the maintenance personnel, both on a "suspicion" basis and in the basic energy audit of the building, and treatment should be performed according to what is found.

Conductive heat flow through walls, floors, ceilings, and such internal barriers, will be of concern only when one area is much hotter or much colder than the adjacent occupied space. Such conditions should be anticipated by the building staff, especially the mechanical systems engineer and those responsible for the energy management program for the facility. They should be able to plan accordingly, even to the installation of additional insulation treatment, as well as control of air leakage.

Conclusions

While many small efforts can be made for energy conservation in the existing building envelope, some of the more complicated measures are both expensive and disruptive. Such treatment should not be viewed with dismay. Not only can the expensive, disruptive opportunities for energy conservation be planned to be carried out in any remodelling which goes with expansion, but also the experience of energy audits and total energy management can make a major impact on the planning of future facilities.

The importance of controlling (1) INFILTRATION AND EXFILTRATION, and (2) SOLAR HEAT GAIN should not be lost in considering the other concerns of this chapter. These two first concerns are the only two Major Energy Conservation Opportunities which related to the BUILDING ENVELOPE out of the 20 ECO's discussed in the very complete and detailed study, <u>Guidelines for Saving Energy in Existing Buildings</u>. This manual is divided into two parts: <u>Building Owners and Operators Manual, ECM-1</u> and <u>Engineers, Architects and Operators Manual, ECM-2</u>. It was prepared by Dubin-Mindell-Bloome Associates for the Federal Energy Administration, 16 June 1975. Both volumes are available through the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161.

DOLLAR SAVINGS OPPORTUNITIES

In a commercial building there are numerous Dollar Savings Opportunities (DSO's) which relate to the Building Envelope and its interior partitioning. These opportunities to save energy and operating costs range from changes in simple human habits to those in elementary maintenance, to those in major maintenance and even to substantial changes with justifiable payback. The simplest DSO's can sometimes be the most important as they relate to the big concerns of infiltration and solar gains.

In each case the DSO's presented below are arranged in order of energy conservation effectiveness as well as by minimal and significant cost.

A. Minimal Expense:

1. Replace broken or cracked window panes.
2. Replace worn or broken weather-stripping around operable windows. If possible, install weather-stripping where none was installed previously.
3. Weatherstrip operable sash if crack is evident.
4. Caulk around window frames (exterior and interior) if cracks are evident.
5. Rehang misaligned windows.
6. Be certain that all operable windows have sealing gaskets and cam latches that are in proper working order.
7. Replace any worn or broken weather-stripping on doors, and install weather-stripping where none was installed previously.
8. Rehang misaligned doors.
9. Caulk around all door frames.
10. Inspect all automatic door closers to ensure that they are functioning properly. Consider adjustments to enable faster closing.
11. Inspect gasketing of garage and other overhead doors. Repair, replace or install as necessary.
12. Caulk, gasket or otherwise weatherstrip all exterior joints, such as those between wall and foundation or wall and roof, and between wall panels.
13. Caulk, gasket or otherwise weatherstrip all openings, such as those provided for entrance of electrical conduits, piping, through-the-wall cooling and other units, outside air louvers, etc.

14. Where practical, cover all window and through-the-wall cooling units when not in use. Specially designed covers can be obtained at relatively low cost.
15. Inspect condition of indoor shading devices such as drapes and blinds which can reduce heat gain as much as 50%. Keep indoor shading devices clean and in good repair.
16. During the heating season, close all interior shading devices before leaving to reduce night time heat losses.
17. Use opaque or translucent insulating materials to block off and thermally seal all unused windows.
18. Consider posting a small sign next to each operable window instructing occupants not to open window while the building is being heated or cooled.
19. Consider placing a small sign next to each door leading to the exterior or unconditioned spaces advising occupants to keep door closed at all times when not in use.
20. Consider installing signs on exterior walls near delivery doors providing instructions to delivery personnel on operation of doors.
21. Establish rules for all building personnel regarding opening and closing of doors, directing them to keep them closed whenever possible.
22. Consider installing automatic door closers on all doors leading to exterior or unconditioned spaces.
23. If the building has a garage but does not have a garage door consider installing one, preferably motorized to enable easier opening and closing.
24. Consider use of a card-, key- or radio frequency-operated garage door which stays closed at all times except when in use.
25. Where roof insulation is not practical, consider insulating the top floor ceiling. This can be done easily with blown insulation. In most cases, ceiling insulation also will require a vapor barrier placed on the warm side of the ceiling - if not integral with the insulation - to prevent structural damage caused by rot, corrosion or expansion of freezing water.

26. If remodelling or modernization is contemplated consider adding insulation to all exterior walls as well as those which separate conditioned and nonconditioned spaces.
27. Add or improve insulation under floors, over garages, or in other unconditioned areas.
28. Repaint or clean exterior finish to improve reflective characteristics.
29. Repaint or resurface roof to make it more reflective.
30. Install baffles to prevent wind from blowing directly into an outdoor air intake.
31. Inspect electrical outlets, switches, and other recessed utility services for air infiltration and exfiltration and caulk or gasket, air-tight, as required.
32. Inspect recessed ceiling fixtures for air leakage and caulk as required.
33. Inspect lay-in ceiling systems and construction above such ceilings for infiltration, especially between interior zones of differently conditioned air, and seal walls, etc. as required.
34. Inspect skylights for air leakage; caulk and weatherstrip accordingly. Also consider the benefits and losses associated with light and solar heat gain in winter and in summer.
35. Provide window shades, blinds, and double glazing or storm windows to reduce the human comfort demands associated with adverse Mean Radiant Temperatures of glass in both winter and summer extremes.
36. Where water or moisture leakage occurs check also for air leakage, heat flow and damage to insulation or caulking materials.

B. Significant Expense

1. Install tight fitting storm windows where practical.
2. Consider adding reflective and/or heat-absorbing film to glazing to reduce solar heat gains by as much as 80%. Be aware that such films will reduce substantially the benefits of natural lighting and solar heat gain in winter.

3. Consider adding reflective materials to the window side of draperies to reflect solar heat when draperies are drawn.

4. Install indoor shading devices where none now exist, even if exterior shading devices are used. They should be light colored and opaque.
5. Consider installation of outdoor shading devices such as sunshades which reflect solar heat before it has a chance to enter the building, and which dissipate heat outdoors rather than indoors. Adjustable sunshades enable entrace of warming rays during the heating season.
6. Consider reglazing with double or triple-glazing, or with heat absorbing and/or reflective glazing materials.
7. Consider installation of insulating glass windows with adjustable shading louvers between the glass.
8. Consider adding roof deck insulation, especially if your building is 20 years old or older. Assuming that the roof-ceiling sandwich is not used as a return air plenum, a thermal transmission value (U-value) of 0.05 (maximum in Texas) BTU/Hr./Sq.Ft.(°F.) is considered to be an attainable goal through roof-ceiling sandwich.

   Note: In Texas, if the roof-ceiling sandwich is a return plenum, a roof deck U-value of 0.03 is suggested. This should be verified by the mechanical engineer for each such situation.
9. Consider making delivery entrances smaller. The larger the opening the greater the air infiltration when doors are open.
10. Consider using an expandable enclosure for delivery ports. It reduces infiltration when in use because it can be adjusted to meet the back of a truck reducing substantially the amount of air which otherwise would infiltrate.
11. Consider installation of an air curtain or a kinetic air barrier, especially in delivery areas. The device prevents penetration of unconditioned air by forcing a layer of air of pre-determined thickness and velocity over the entire entrance opening. (An expert in the field should be consulted

before obtaining such a device, especially when high rise structures are involved. The degree of stack effect, among other things, determines its usability.)

12. Consider installation of a vestibule for the front entrance of a building, where practical. It should be fitted with self-closing weather-stripped doors. It is critical that sufficient distance between doors is provided.
13. Consider using revolving doors for main access. Studies have shown that such devices allow far less air to infiltrate with each entrance or exit. Use of revolving doors in both elements of a vestibule is most effective. If high peak traffic is involved, swinging doors can be used to supplement revolving doors.
14. In locations where strong winds occur for long durations, consider installing wind screens to protect external doors from direct blast of prevailing winds. Screens can be opaque, constructed cheaply from concrete block, or can be transparent, constructed of metal framing with armored glass. Careful positioning is necessary for infiltration control.
15. Study developments in the glass industry on a regular basis, and consider changes where improvements in glazing materials or techniques appear to be both energy conserving and cost effective.

COEFFICIENT OF HEAT TRANSMISSION ("U")

OVERALL COEFFICIENT OF HEAT TRANSMISSION OR THERMAL TRANSMITTANCE (AIR TO AIR); THE TIME RATE OF HEAT FLOW USUALLY EXPRESSED IN BTUH PER SQUARE FOOT PER FAHRENHEIT DEGREE TEMPERATURE DIFFERENCE BETWEEN AIR ON THE INSIDE AND AIR ON THE OUTSIDE OF A WALL, FLOOR, ROOF OR CEILING. THE TERM IS APPLIED TO THE USUAL COMBINATIONS OF MATERIALS, AND ALSO TO SINGLE MATERIALS, SUCH AS WINDOW GLASS, AND INCLUDES THE SURFACE CONDUCTANCE ON BOTH SIDES. THIS TERM IS FREQUENTLY CALLED THE "U" VALUE.

RESISTANCE FACTORS (R-FACTORS)

THE THERMAL RESISTANCE VALUE FOR ANY SPECIFIC THICKNESS OF INSULATION. R-FACTOR IS THE RECIPROCAL OF THE THERMAL TRANSMITTANCE (1/U) OR THE HEAT FLOW IN BTU PER HOUR THROUGH A SQUARE FOOT OF ANY GIVEN THICKNESS OF A HOMOGENOUS OR COMPOSITE MATERIAL. R-FACTORS ARE SIGNIFICANT BECAUSE THEY ARE THE ONLY FACTORS THAT CAN BE HANDLED ARITHMETICALLY, AND THEY ARE USED TO DETERMINE THE OVERALL RESISTANCE ("U" VALUE) OF VARIOUS COMPONENTS IN THE BUILDING ENVELOPE. THE RECIPROCAL OF THE SUM OF VARIOUS R-FACTORS EQUALS THE "U" VALUE.

$Q = U \cdot A \cdot \Delta T$

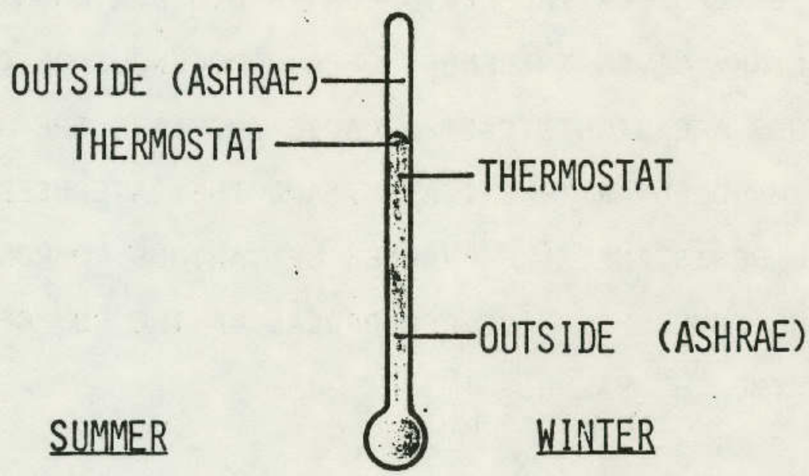
Q IS BTUH: HEAT FLOW PER HOUR

U = U-VALUE, FOR EACH TYPE OF WALL, GLASS, CEILING, ETC.

$$\text{U-VALUE} = \frac{1}{\text{R TOTAL}}$$

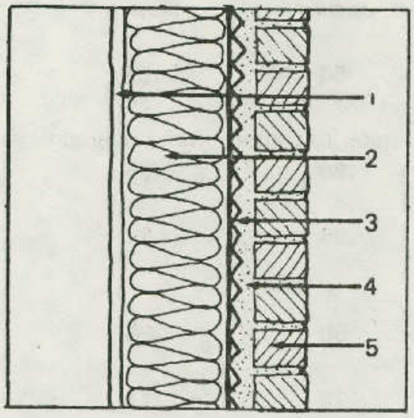
A = SQ. FT. AREA OF WALL, ETC.

ΔT = "DELTA-T" = DIFFERENCE IN THE DESIGN TEMPERATURES



TYPICAL WALL SECTIONS

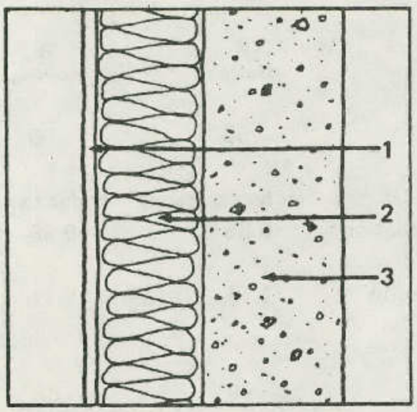
HEAT TRANSFER COEFFICIENT
WALL CONSTRUCTION ASSEMBLY



WEIGHT 48.2 lb./ft^2

List of Construction Components		R cooling	R heating
1.	5/8" Gypsum Board	.56	.56
2.	Insulation	(refer to graph)	(refer to graph)
	3½" Furring Space (without insulation)	.85	.95
3.	Paperback Metal Lath	—	—
4.	1" Grout	.20	.20
5.	3" Brick Veneer (130 lbs/ft^3)	.33	.33
	Inside Surface Air Film	.68	.68
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		**2.87**	**2.89**

HEAT TRANSFER COEFFICIENT
WALL CONSTRUCTION ASSEMBLY

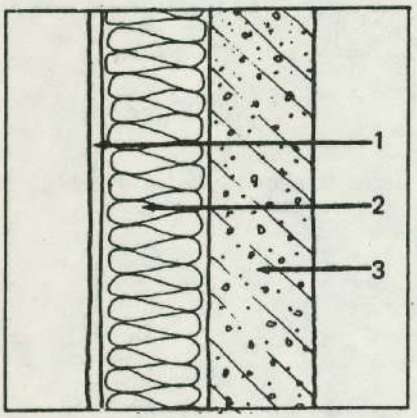


WEIGHT 95.5 lb./ft^2

List of Construction Components		R cooling	R heating
1.	5/8" Gypsum Board	.56	.56
2.	Insulation	(refer to graph)	(refer to graph)
	1½" Furring Space (without insulation)	.85	.95
3.	8" Concrete (140 lb/ft^3)—not dried	.64	.64
	Inside Surface Air Film	.68	.68
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		**2.98**	**3.00**

TYPICAL WALL SECTIONS

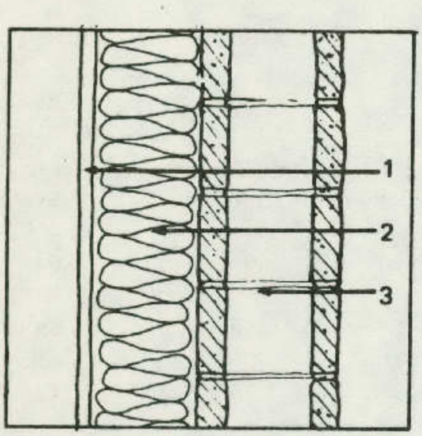
HEAT TRANSFER COEFFICIENT
WALL CONSTRUCTION ASSEMBLY



List of Construction Components		R cooling	R heating
1.	5/8" Gypsum Board	.56	.56
2.	Insulation 1½" Furring Space (without insulation)	(refer to graph) .85	(refer to graph) .95
3.	6" Precast Concrete (140 lb/ft^3) oven-dried aggregate	.66	.66
	Inside Surface Air Film	.68	.68
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		3.00	3.02

WEIGHT 72.2 lb./ft^2

HEAT TRANSFER COEFFICIENT
WALL CONSTRUCTION ASSEMBLY



List of Construction Components		R cooling	R heating
1.	5/8" Gypsum Board	.56	.56
2.	Insulation 1½" Furring Space (without insulation)	(refer to graph) 0.85	(refer to graph) 0.95
3.	8" Concrete Block (3 oval core sand and gravel aggregate open core)	1.11	1.11
	Inside Surface Air Film	.68	.68
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		3.45	3.47

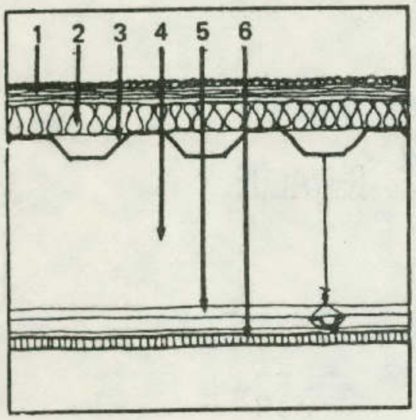
TYPICAL INSULATION MATERIALS

WALL INSULATION

	R-VALUE
BLANKET AND BATT	
Rock Wool, Fiberglass	
3-3½ inches	11
5¼-6½ inches	19
BOARD, INSULATING	
Extruded Polystyrene (Styrofoam)	
3/4 inch	4.05
1 inch	5.41
1½ inch	8.11
2 inch	10.81
Super-Sheath (with aluminum facing)	
1 inch	6.15
High-R Sheating (Owens-Corning)	6.00
Thermax Sheating (Celotex)	
3/4 inch	6.00
1 inch	8.00

TYPICAL ROOF SECTIONS

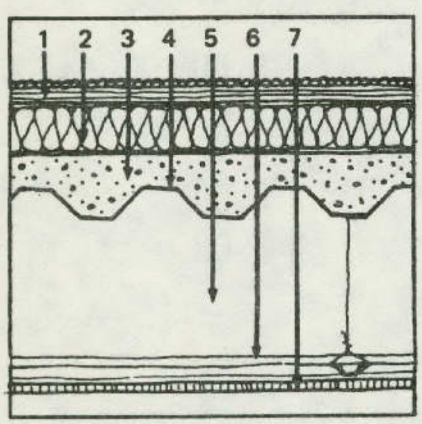
HEAT TRANSFER COEFFICIENT
ROOF CONSTRUCTION ASSEMBLY



WEIGHT 7.9 lb./ft^2

List of Construction Components		R cooling	R heating
1.	3/8" Built-up Roofing	.33	.33
2.	Rigid Insulation	(refer to graph)	(refer to graph)
3.	1½" Metal Decking	—	—
4.	Air Space	.80	.80
5.	Metal Furring Channels	—	—
6.	Suspended Acoustic Tile 1/2"	1.25	1.25
	Inside Surface Air Film	.92	.61
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		3.55	3.16

HEAT TRANSFER COEFFICIENT
ROOF CONSTRUCTION ASSEMBLY

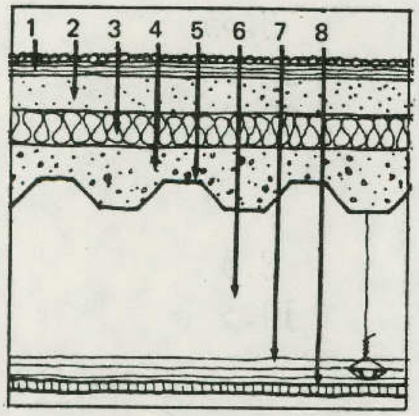


WEIGHT 26.7 lb./ft^2

List of Construction Components		R cooling	R heating
1.	3/8" Built-up Roofing	.33	.33
2.	Rigid Insulation	(refer to graph)	(refer to graph)
3.	2" Lightweight Concrete 80 lb/ft.^{3}	.80	.80
4.	1½" Metal Decking with Concrete Fill (avg. depth 3/4") 80 lb/ft^3	.30	.30
5.	Air Space	.80	.80
6.	Metal Furring Channels	--	--
7.	Suspended Acoustic Tile 3/4"	1.89	1.89
	Inside Surface Air Film	.92	.61
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		5.29	4.90

TYPICAL ROOF SECTIONS

HEAT TRANSFER COEFFICIENT
ROOF CONSTRUCTION ASSEMBLY



List of Construction Components		R cooling	R heating
1.	3/8" Built-up Roofing	.33	.33
2.	2" Insulating Concrete 30 lb./ft^3	2.22	2.22
3.	Rigid Insulation	(refer to graph)	(refer to graph)
4.	2" Lightweight Concrete 80 lb./ft^3	.80	.80
5.	1½" Metal Decking w/Concrete Fill (avg. depth ¾") 80 lb./ft^3	.30	.30
6.	Air Space	.80	.80
7.	Metal Furring Channels	--	--
8.	Suspended Acoustic Tile 3/4"	1.89	1.89
	Inside Surface Air Film	.92	.61
	Outside Surface Air Film	.25	.17
Total Resistance R_t (without insulation)		7.51	7.12

WEIGHT 31.7 lb./ft^2

TYPICAL INSULATION MATERIALS

ROOF INSULATION

	R-VALUE
CELOTEX TEMPCHEK	
1.2 "	8.33
2"	14.3
3"	22.2
CELOTEX THERMAX	
1.2"	8.3
2"	14.3
ZONOLITE CONCRETE	
2"	4.5
4"	7.5
2" WITH 2" INSULPERM*	12.5
2" WITH 4" INSULPERM	20.0
4" WITH 2" INSULPERM	15.0
4" WITH 4" INSULPERM	23.0
FESCO BOARD (JOHNS-MANVILLE)	
1½"	6.67
2"	10.00
3¼"	20.00

*INSULATING BOARD

MODEL CODE
FOR
ENERGY CONSERVATION

MAXIMUM ALLOWABLE U VALUE (U_O)

$$U_O = \frac{A_{OW}U_{OW} + A_{OR}U_{OR} + A_{OF}U_{OF}}{A_{OW} + A_{OR} + A_{OF}}$$

A_{OW} = OVERALL WALL AREA

A_{OR} = OVERALL ROOF AREA

A_{OF} = OVERALL FLOOR AREA

HEAT TRANSMISSION COEFFICIENTS
BTU/HR/SQ.FT./^{O}F
(U-VALUE)

	HIGH	LOW
WINDOWS		
SINGLE GLASS	1.10	.88
DOUBLE GLASS	.78	.46
ROOF	.59	.025
WALLS	.504	.058

MODEL CODE FOR ENERGY CONSERVATION

ALLOWABLE INFILTRATION RATES

WINDOWS	0.5 CFM PER FT OF OPERABLE SASH CRACK
DOORS*	11.0 CFM PER LINEAR FOOT OF CRACK

MODEL CODE FOR ENERGY CONSERVATION

AIR LEAKAGE

EXTERIOR JOINTS AROUND WINDOWS AND DOOR FRAMES; OPENINGS BETWEEN WALLS AND FOUNDATIONS, BETWEEN WALLS AND ROOF/CEILINGS AND BETWEEN WALL PANELS; OPENINGS AT PENETRATIONS OF UTILITY SERVICES THROUGH WALLS, FLOORS AND ROOFS; AND ALL OTHER SUCH OPENINGS IN THE BUILDING ENVELOPE SHALL BE CAULKED, GASKETED, WEATHERSTRIPPED OR OTHERWISE SEALED IN AN APPROVED MANNER.

*SWINGING, SLIDING, REVOLVING DOORS.

8

MISCELLANEOUS

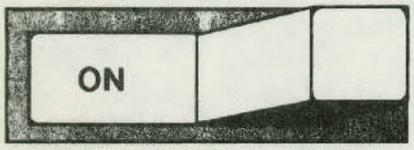
MISCELLANEOUS

TABLE OF CONTENTS

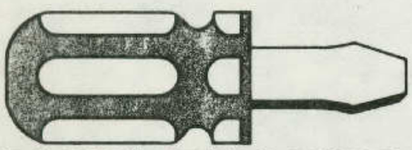

BAKED
HAM
LIVER-
WURST
ROAST BEEF
WIDE
BOLOGNA
59¢
CHOCOLATE
PUDDING
45¢

BAKERIES AND DELICATESSENS

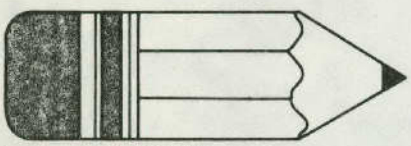
The amount of energy that a retail food store uses for baking and food preparation naturally depends on the size of those operations and product demand. However, the bakery and delicatessen sections of most stores contain the following types of energy-using equipment: ovens, proof boxes, deep fat fryers, steamers, and exhaust systems. This section of the guide outlines specific energy-efficient procedures for operating and maintaining each of these major types of equipment and concludes with planning suggestions for all energy-using equipment.



OPERATION



MAINTENANCE



PLANNING

OVENS AND PROOF BOXES

Widely used in bakeries and delicatessens, ovens and proof boxes are major energy users. For each hour of operation, a typical gas bake oven uses 75 cubic feet of gas; an electric bake oven, 20 kWh of electricity. Of these amounts, only 40 to 60 percent actually bakes the food; the remainder of the energy is released to the air, often burdening the HVAC system.

Operation

- If possible, when using electric ovens, bake during offpeak hours (usually from 8 p.m.-10 a.m.), when electric demand is the lowest and electricity can be generated most efficiently.
- Preheat only until the needed temperature is reached. While this varies with each type of equipment, preheat times average 5 to 15 minutes. If using more than one oven, stagger preheat times.
- Set thermostats at the lowest temperature that will still achieve desired results.
- Load oven(s) to capacity to use as much of the baking heat as possible.
- Load the entire oven at once and as quickly as possible to reduce heat losses. For every second the oven door is open, the interior temperature drops 10°F.
- Use a timer when baking to avoid opening the oven door.
- Use a second oven only when baking schedules overlap unavoidably.
- Turn off oven(s) and keep closed when not in use.

Maintenance

- Keep the lower edge of the door free of food particles to insure that the door closes evenly and seals tightly.
- Keep interior walls and heating elements clean to obtain maximum heat transfer.
- Every few months have a qualified service representative calibrate the oven thermostat with a thermocouple. If an oven is not heating normally, have it checked immediately.
- In any self-cleaning or continuously cleaning oven, check for dents in the surface that might inhibit performance.
- Once a year have a service representative thoroughly inspect the oven's burners, thermostat, door closings, and insulation.

DEEP FAT FRYERS

All commercial fryers, whether gas or electric, have two energy-saving features: accurate temperature controls, which allow cooking times to be estimated and scheduled precisely, and fast startup times to reduce energy losses from heat waste. However, fryers must be correctly operated and maintained for these features to be effective.

Operation

- Preheat fryer according to manufacturer's instructions (generally 7 to 15 minutes).
- Turn fryer off or reduce to idling temperatures during slack periods.
- Turn thermostat up only as high as required to reach frying temperatures (325° to 335°F).
- Do not load fryer beyond the manufacturer's stated capacity (usually one-half to two-thirds capacity).

Maintenance

- Filter sediment from cooking fat as necessary; builtup sediment reduces cooking efficiency.
- Clean heating elements at least once a week; clean daily for high-volume frying. Remove any burnt food or grease that could interfere with efficient operation.
- Clean grease and food particles from exhaust hoods, and clean their filters regularly.

STEAM COOKERS

Steam cooking is highly efficient for several reasons:

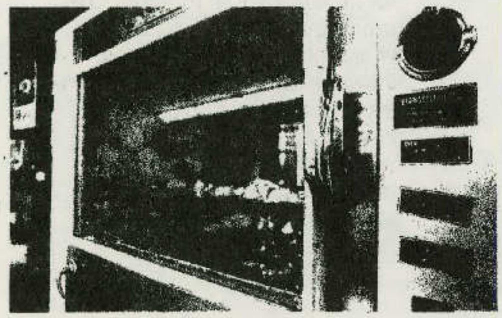
- Steam cooks at relatively low temperatures of 212° to 250°F.
- Steam transfers its heat to food rapidly and thus requires shorter cooking times.
- Steam equipment requires relatively little preheat time.

Operation

- Fill cooking vessels according to manufacturer's recommendations and to capacity if possible.
- Turn off equipment unless actually cooking, as preheat times are short.

Maintenance

- Repair all steam leaks, no matter how small; even a small leak will increase the load on an HVAC system and waste steam-generating energy.
- Keep equipment lid and door seals clean and free of debris to prevent leakage.



EXHAUST SYSTEMS

Exhaust systems, usually required by ordinance and recommended for customer comfort, carry grease-laden air out of the bakery and/or delicatessen parts of the store. Because the air within the store is expensively conditioned, it is important to design systems to minimize the amount of air exhausted while maintaining applicable fire code standards and preventing cooking odors and fumes from permeating the sales area. Makeup air systems are designed to perform these functions. A makeup air unit is auxiliary to the HVAC system and simpler in construction and pumps in fresh outdoor air to replace air expelled by the exhaust system. In this manner, the amount of expensively heated or cooled air drawn from other portions of the store and expelled through the exhaust is reduced.

How well the exhaust system is maintained also affects energy use significantly. Deposits of grease in exhaust systems and HVAC ducts can reduce efficiency dramatically and are also a fire hazard.

Operation

- Use the exhaust system only when cooking.
- Install control switches that shut off each exhaust independently.

Maintenance

- Clean or replace grease traps or filters regularly. Grease accumulated on collectors not only reduces the amount of air being exhausted but also constitutes a fire hazard.
- Check air distribution regularly to insure that air from the cooking area does not escape into the sales area by simply observing whether the ventilator hoods are collecting smoke. If they are not, have your maintenance representative alter the air flow pattern.
- Have the exhaust system ductwork cleaned regularly to remove grease deposits.
- Have exhaust fan drives checked regularly; replace frayed or otherwise damaged V-belts; check V-belt tension. Loose belts reduce fan performance and may upset air distribution.

ALL EQUIPMENT

Planning

Before investing in new cooking equipment, compare the energy efficiencies of different types by monitoring your own equipment. Ask your utility company to install meters on energy-using equipment, and then compare the amount of food baked with the amount of energy used by various pieces of equipment. Once you have determined the most energy-efficient types of equipment, apply the following guidelines when you purchase new equipment:

- Choose equipment that has a short preheating time.
- Purchase equipment that produces satisfactory results at relatively low baking temperatures. Consider using ovens that have circulating fans, for example.
- Select an exhaust system that exchanges an equal quantity of conditioned air for the air removed from the cooking area through a makeup air unit.
- Provide efficient exhaust hoods and ventilating systems for all ovens, fryers, and steamers.
- Install makeup air units near exhaust system in cooking areas.

TRACKING YOUR ENERGY USE

The easiest way to track energy use is to monitor your electric bill. Because electricity is the major source of energy for most grocery stores, the conservation measures described in this guide will have their greatest effect on electricity use. However, if you would like to monitor heating and cooking fuels as well, you can convert them to kWh equivalents by using the instructions and conversion figures provided here.

To facilitate comparison among different-sized stores, energy use is computed on the basis of either kWh per square foot of *sales area* or per square foot of *ground covered*. Choose the base that is consistent with the other costs you monitor. Caution: when comparing your store's energy use with that of another, be sure that the bases are the same!

Follow the steps below to determine your monthly energy use. An energy tracking worksheet is provided on the following page to help you with these calculations. The poster in the back of the book can be used to plot energy use and costs. Be sure to display it in a prominent location so that your employees can see the effects of your management program.

1. Assemble your electric bills or, if you wish, all your energy bills. The bills may be confusing at first, but with a little study you can find the information you need to calculate your energy use.
   ELECTRICITY: Locate the number of kilowatt hours (kWh) used during the billing period. Many bills will state the demand kilowatt also; ignore this for the present. If you have trouble locating kilowatt hours on the bill, call your electric company for help. If you are tracking electricity ONLY, go to Step 4.
   NATURAL GAS: Record the energy use, which is stated in cubic feet. Be careful: sometimes only the number of *thousands* of cubic feet is listed [for example, 36 (thousand cu. ft.)]. Make sure you write down the *entire* number.
   FUEL OIL: Record the number of gallons of fuel oil delivered as shown on the bill.
2. If you are tracking heating or cooking fuel as well, multiply each fuel use quantity by the number shown on the tracking worksheet to yield the equivalent kWh. This number indicates approximately how many kWh of electricity would be required to produce the same energy as the fuel actually used.
3. Total the numbers of equivalent kWh for each fuel for the month.
4. Divide the total kWh (or kWh equivalent) by the store sales area or total ground area to obtain kWh per square foot. This number is a reasonably accurate indication of your monthly energy use and can be compared with figures from other stores. It will vary with the seasons as more or less energy is required to operate the store. If store expansion changes the sales area or total ground area, use the new area for subsequent calculations.
5. Record significant changes in store operation in the "Notes" column of the worksheet. Examples include installation of new equipment, modified store hours, fuel shortages, and implementation of specific energy conservation measures.
6. Record monthly the dollar amount of your electric bill, or all energy bills, consistent with the tracking method you choose.
7. Plot kWh or total energy use and the equivalent cost on the tracking poster so that store employees can see how the conservation program is working. Arrange the dollar and kWh scales so that your typical monthly energy cost and kWh use fall near the middle of the scales. The solid lines on the sheet should be labeled as round numbers, with either $100, $500, or $1,000 per space. Connect the data points on the graph to show trends. Do not be surprised if monthly kWh or energy cost goes up even when energy use decreases. This shows that the conservation program is working and that your bills would have been even higher because of increased energy cost were you not practicing energy conservation.

Extracted from: <u>How Business in Los Angeles Cut Energy Use By 20 Percent.</u>

MARKETS

Two supermarket chains and one independent market were included in the survey. Chain A's stores averaged 270,300 sq. ft. in floor area; Chain B's averaged 240,000 sq. ft. The independent market had a floor area of about 125,000 sq. ft.

The markets reported that if their volume of business was off it was because of the gasoline shortage, not the electricity shortage, but the chains expressed some concern that the electricity shortage might put a damper on their expansion plans.

All of the markets conserved on lighting. They:

- Reduced lighting levels by 30 to 50 percent in selling areas and by 50 percent in storage areas.
- Turned off one or two exterior signs.
- Turned off some lights in their parking lots but not enough to jeopardize security.

An obvious target for conservation in markets is their extensive refrigeration equipment, but the steps they can take are limited. The independent market said it couldn't make any adjustments in its refrigeration equipment; Chain B raised its average freezer temperature from -5°F to 0°F.

Chain A, however, mounted a detailed conservation program. Within three days it had developed a plan and distributed it to its stores; within seven days the plan was in effect. It spelled out lighting and temperature adjustments and included such measures as installing lids on freezers. In addition, Chain A called in its refrigeration contractor to perform the following adjustments in each store:

- Set each defrost clock properly on each compressor.
- Set freezer cases for minimum possible defrost.
- Check head pressures in each unit.
- Check overoperation of evaporative condensers.
- Vacuum out all cooler coils.
- Adjust door strikes on all cooler doors.
- Change filters on furnace, air conditioning, and meat preparation coils.
- Set heating thermostat at 68°F.
- Set air-conditioning thermostat at 78°F.
- Make sure air conditioning and furnace are not on at the same time.

As a result of its efforts, Chain A reported that its stores averaged cutbacks of 18 to 22 percent. Chain B said it had reached the 20 percent quota. The independent market did no better than a 10-percent cutback.

Extracted from: <u>A Study of the Impact of Reduced Retail Store Operating Hours on Sales, Employment, Economic Concentration, and Energy Consumption.</u>

5.5.2 Supermarkets

A closed supermarket consumes a tremendous amount of energy. Compressors for food refrigeration run twenty-four hours a day and account for 50% - 60% of a market's electrical consumption. In addition, the ambient air must be carefully controlled at 75°F but the relative humidity cannot rise above 50%. As a result, the success of energy conservation techniques depends upon the percentage of total energy consumed by food refrigeration. The higher this percentage is, the lower are the percentage savings attributable to the use of energy saving techniques. Since newer stores have more refrigeration equipment than older stores, these newer stores must be considered separately.

Older stores report a 19% savings due to the use of energy saving techniques in total energy consumption for the period of January to June, 1974. This percentage is based on the 1972 year. Newer stores report a 16% saving in total energy consumption. (See Table 5.5-2). The energy saving techniques employed in both old and new stores were:

a) setting thermostats at 64° in winter and maintaining 50% relative humidity.

b) turning off baking ovens at night rather than leaving them on.

c) reducing light 33% - 50%.

d) turning off store lights at night.

It is important to note that a X% lighting reduction does not yield an X% reduction in total energy consumption. Because heating must be increased when lighting is reduced, the actual savings are approximately X/2%.

Many of the potential energy saving techniques require new construction or extensive refitting. Ideas which have been studied for future implementation are:

1) using waste heat from refrigerator compressors to heat the store for 3 months of a six month heating season.

2) using real time control devices for electrical machinery.

3) increasing insulation of building.

4) optimizing sites for effects of sun, wind, shade trees, wind screen trees, etc.

5) replacing existing refrigeration equipment with more efficient equipment.

Both the older and newer stores operate 14 hours per day. For the newer store,

$$S = 16\%$$

$$L = 7\%$$

based on the fact 16% of KWH are used for lighting therefore,

$$Es = \frac{16\% + 7\%}{14} = 1.6\%$$

For the older store,

$$S = 19\%$$

$$L = 8\%$$

Therefore,

$$Es = \frac{19\% + 8\%}{14} = 1.9\%$$

Average Es = 1.75%.

Es should be higher for older stores which have proportionally less refrigeration equipment than newer stores.

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RETAIL BUSINESS

OFFICE BUILDINGS

HOTEL/MOTEL/ RESTAURANTS

CHURCHES

FAST FOOD RESTAURANTS

LOCAL GOVERNMENTS

NEW RESIDENTIAL

SCHOOLS

HOSPITALS

SUPERMARKETS

SHOPPING CENTERS

RIDE SHARING

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