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16. Abstract

This report explains a method of determining if insulation on a stationary asphalt storage tank is cost-beneficial. In addition, the present practice of preparing stored asphalt for use in maintenance activities in Texas is reviewed. A description of energy and heat transfer in stored asphalt is included.

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Energy Savings Through Asphalt Tank Insulation

by
Kenneth D. Hankins

Research Report 187-3

Research Study 1-10-77-187

Conducted by
Transportation Planning Division
Research Section
State Department of Highways
and Public Transportation

In Cooperation With the

U.S. Department of Transportation
Federal Highway Administration

February, 1979

The contents of this report reflect the views of the author, who is responsible for the facts and accuracy of the data reported herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Acknowledgements

The research reported herein was conducted under the supervision of Mr. John F. Nixon, Engineer of Research, and the general supervision of Mr. Phillip L. Wilson, State Planning Engineer, Transportation.

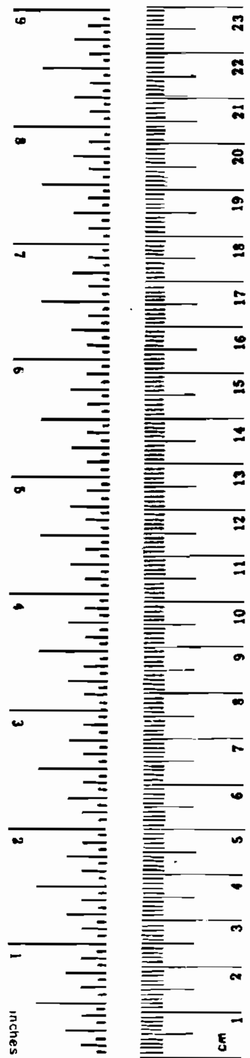
This report is actually an extension and further study of a paper prepared by Dr. Gerald Jones and Mr. Jim Broughton of the Mechanical Engineering Department of the University of Texas at Austin. Dr. Jones and Mr. Broughton worked through Dr. Clyde Lee with The Center For Highway Research (CFHR). The U.T. paper is found in Appendix A. The information found in this report does not necessarily reflect the views or policies of the CFHR or the Mechanical Engineering Department. However, the author acknowledges the excellent work and assistance of this group.

Acknowledgement is given to Mr. Brad Hubbard and Mr. James Wyatt for the technical support received during this study. Both men prepared portions of this report and performed many of the technical calculations found herein.

METRIC CONVERSION FACTORS

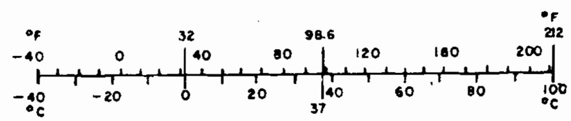
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Implementation

It is suggested that District maintenance personnel study the asphalt storage in the District and develop methods to conserve the energy used in preparing asphalt for use in maintenance operations. In many of the northern Districts (as well as heavy use in southern Districts) storage tank insulation may prove economically beneficial. Information in this report will aid in determining if insulation is economical.

Summary

This report is an expansion of a paper prepared by the Mechanical Engineering Department of the University of Texas. The information contained in this report will allow the user to decide if insulation of an asphalt storage tank is cost-beneficial. The user may also select the optimum thickness. The information needed by the user by which to make a decision to insulate is two-fold: (1) the present unit ($/MMBtu) cost of fuel used to heat a storage tank and (2) the asphalt preparation cost (includes fuel costs and personnel time).

I. Background

About two years prior to this report, information was received from the Oklahoma Department of Transportation concerning a solar-heated asphalt storage tank. Since the Texas Department of Highways and Public Transportation was in the process of reviewing all operations with the idea of reducing costs and energy consumption, effort was immediately given to the study of solar-heated storage tanks. It became apparent that the major energy-saving component of such a system was insulation, particularly the insulation placed around the tank. One of the first to mention the benefits of insulation and urge further study was the Planning and Research Engineer of the FHWA Austin Division Office.

Asphalt is generally delivered "hot". It was believed that insulation would conserve this heat to the extent that even the expenditure for insulation could be justified. If a tank were to be heated by external means, insulation could be quickly justified. These ideas, encouragement and information lead to contact with The Center for Highway Research (CFHR) at the University of Texas at Austin. The CFHR contacted the Mechanical Engineering Department and obtained the aid of Dr. Gerald Jones and Mr. Jim Broughton. Mr. Broughton, supervised by Dr. Jones, developed the paper found in Appendix A. The paper provides a method whereby field personnel can decide if the insulation of an asphalt storage tank is warranted.

II. Object

The major object of this report is to provide maintenance personnel with a method of determining if insulation of asphalt storage tanks is warranted. The second objective is to present the UT-ME document entitled "Insulation of Asphalt Storage Tanks". Additionally, this report provides calculations which compliment the UT-ME document and explains various heating practices used by the Department.

III. Definitions and Heat Information

There is an increasing probability that in the near future highway engineering and maintenance personnel will be forced to think and act in terms of energy and heat transfer. In the past, if asphalt, aggregate or water needed to be heated, little attention was given to heating methods. Today highway personnel are beginning to note the amount of energy used in heating a given quantity of material. Discussions center around the total energy consumption needed to construct a given length of highway.

Therefore, it is helpful to review the terms and facts presented in the UT-ME paper along with additional items of information.

1. Btu - British termal unit - the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit (at or near 39.2^{o}F). In the international system 1 Btu = 1.055 Joules.

2. Approximately 1 Million Btu, (MMBtu) will be produced by

   a. burning 1000 cubic feet of natural gas
   b. burning 6.6 gallons of diesel or kerosene
   c. using 293 Kwh of electricity
   d. burning 11 gallons of LPG

3. The approximate costs of the various energy sources listed in "2" above are: (Note these costs vary greatly with time and place and are intended as examples.)

   a. 1000 cubic feet of natural gas will cost about $2.00
   b. 6.6 gallons of diesel (@$0.50/gal) = $3.30
   c. 293 Kwh of electricity (@$0.05/Kwh) = $14.65
   d. 11 gallons of LPG (@$0.45/gal) = $4.95

Efficiencies of the heating units must be considered but one MMBtu delivered by electricity will generally cost more than gas or diesel (3 times the cost of LPG, 4 times the diesel cost and 7 times the gas cost). Heating with diesel fuel or LPG generally costs more than using natural gas (about 1.6 or 2.5 times in the example given).

It would be possible to use this type of information to develop rather accurate energy consumption figures for various highway maintenance or construction jobs or practices. For example, a diesel truck which gets about 10 mpg will expend about 15,000 Btu/mi

$$\frac{1 \times 10^6 \text{ Btu}}{6.6 \text{ gal}} \times \frac{1 \text{ Gal}}{10 \text{ mi}} = 15,151 \frac{\text{Btu}}{\text{mi}}$$

Other uses may be in the household or maintenance facility. An example may be a 4500-watt electric hot water heater which uses 4400 Kwh per year (estimated quantity - domestic family). This usage consumes about 15 MMBtu per year.

$$\frac{4400 \text{ Kwh/Yr.}}{293 \text{ Kwh/MMBtu}} = 15.017 \frac{\text{MMBtu}}{\text{Yr.}}$$

IV. Present Methods of Treating Stored Asphalt

In order to obtain data for design purposes and to establish background information of asphalt usage by maintenance forces, each of the 25 districts was contacted. The contact was generally by the phone and a prepared set of questions was asked of each person called. The person most often contacted in the districts was the District Maintenance Engineer; however, on occasions the discussion was held with superintendents, supervisors and foremen. Initially, the prepared questions were not well-designed and the interrogators were unfamiliar with the problem. Therefore, the answers and data will be more reliable with increased numbers of contacts.

Data obtained from each district may be found in Appendix C and a summary is presented in Table I. It was found that the stationary tanks vary in size from about 10,000 to 18,000 gallons. However, the tanks are commonly 12,000-gallon. There are a few large (around 6,000-gallon) portable tanks in use; however, there is generally one stationary tank per section. Many sections have more than one tank. Some of the tanks are very old. Most of the tanks are single-compartment, but a few are divided into two parts to hold different materials.

A few tanks have been insulated previously. Two districts have buried tanks which in effect use the earth as insulation.

The heating procedure is generally a forced air method using Kerosene or Diesel. Natural gas is used to heat several tanks, and electric heating elements are used in two districts (with the buried tanks). An Electro-Tape is used to heat the valves in District 8 (Abilene). District 21 (Pharr), District 15 (San Antonio), and District 13 (Yoakum) use or have used wind breaks around the legs of the tank stand and cradle. In connection with the wind break, District 21 and a few locations in District 15 use a portable heater called a Salamander. The Salamander is fired only during cold periods inside the wind break to provide the heat necessary to prevent the emulsion from breaking. It should be noted that the Districts mentioned are in the southern area of the state.

One of the major reasons for the telephone contacts and questions was to determine the amount of funds being expended per tank for fuel. Of course many of the districts did not have accurate records of these costs. The reasons for the lack of cost records are many, varied and valid. Some of the districts do maintain cost records, and others offered educated guesses. These are as follows:

District 2 (Fort Worth) - Tanks are heated from 30 to 60 days during the year in those areas of heavy use. Five tanks are insulated. The cost of fuel and labor for heating a tank will vary from $500 to $5000 per year. The district spends approximately $20,600 per year on all tanks for this purpose.

District 4 (Amarillo) - About $100 per month per tank is expended during the winter months.

TABLE I

PRESENT TREATMENT METHODS OF STORED ASPHALT

District Number	No. Tanks Heated	No. Tanks Unheated	No. Tanks Insulated	Heating Methods	Type of Asphalt
1 Paris	Unknown	12		Kerosene Forced Air	RC-2
2 Ft. Worth	8	26	5(3"Fib.Gl.)	Kerosene Forced Air	Emul, RC-250, RC-5
3 Wichita Falls	5	14		Nat. Gas	Emul, RC-250
4 Amarillo	2	36	2(1" Foam)	Nat. Gas	Emul, RC-250
5 Lubbock	19	19		Nat. Gas	Emul, RC-2, MC-30, MC-300
6 Odessa	6	20		Nat. Gas,Have Used Elec.	Emul, MC-800
7 San Angelo	3	17		Nat. Gas	Emul, MC-800
8 Abilene	0	24			Emul, RC-5
9 Waco	0	25	1		Emul.
10 Tyler	0	11			RC-2
11 Lufkin	2	8	2(Buried)	Electric	Emul, RC-2
12 Houston	0	12			RC-2
13 Yoakum	12	9	Windbreaks	Kerosene Forced Air	Cat. & Ani. Emul, RC-250
14 Austin	Questioned only one section.			Nat. Gas	MC-800
16 Corpus Christi	0	18			Emul, RC-2
17 Bryan	2	10	4(Buried)	Electric	AC-5
18 Dallas	0	12	(1 Portable)		Emul, RC-2
19 Atlanta	0	14			RC-2, MC-30
20 Beaumont	Have 1 tank per section				Emul, RC-2
21 Pharr	22	0	Windbreaks & Salamanders	Kerosene	Emul, Reclamite
22 Del Rio	10	0	(2 Portable)	Butane	RC-2
23 Brownwood	1	Unknown	?(3"Fib.Gl.)	Nat. Gas & Butane	Emul.
25 Childress	0	16			RC-2

Note: Data was obtained in February-March, 1978.

V. Practicability and Costs

If a storage tank is to be maintained at a relatively high temperature, insulation will certainly be economical. Even if tanks are only heated prior to use, and this use or heating occurs at frequent intervals, insulation is economical. The prior chapters of this report have been dedicated toward allowing the user to determine if insulation is economical even if the stationary tank is non-heated and the heating is done in smaller (portable) tanks. This chapter will be concerned with the practicability of the previous information and some of the costs involved in preparing asphalt for use in maintenance activities.

Consideration must be given to practical study. How can storage tank insulation help if the tank is not heated? The discussions before and following are based on the assumption that the asphalt will be delivered hot. Emulsions are apparently delivered at temperatures as high as 160°F. If that heat can be saved or prolonged for a relatively long time the asphalt will not need to be heated again before use. In other words, a Btu saved is a Btu earned. Figure 4 of the UT-ME paper shows that if the asphalt was delivered at 140°F, the temperature would only be about 57°F after one month with no other heat added, and the air temperature at a constant 40°F. This information is for one inch of polyurethane foam. If two to three inches of foam were used, even higher temperatures would remain after one month. Emulsion will probably be relatively viscous and slow flowing around 50 to 60°F, but even with an unheated storage tank, the asphalt could be more easily removed for heating in smaller tanks as compared to that of a non-insulated tank. Therefore, even if a tank of emulsion asphalt (say 12,000 gallons) was not used in a one-month period, benefit from insulation can be noted. Some of these benefits of an insulated storage tank in the above conditions are:

(1.) Emulsion can be used for about 5 or 6 days after delivery with little or no reheating. Exceptions to this will vary depending on the use of the asphalt material.
(2.) For the next 7 or 8 days the emulsion should flow freely from the storage tank into a smaller portable tank; however, some heating may be necessary.
(3.) From about 14 to 30 days after delivery, the emulsion will be thick and will require longer fill times from the larger to smaller tanks, and considerable heating may be necessary.
(4.) Quite likely the temperature of emulsion in an unheated tank would not be reduced to 32°F within the winter period even in the northern districts. Danger of cracking in freezing conditions would be less.
(5.) Insulation in summer air temperatures prolongs the effects noted in (1) through (3) above.

Costs of preparing asphalt for use include fuel costs, the initial cost of heating equipment, the cost of maintaining heating equipment and the labor cost of initiating and monitoring heating equipment during operation. Probably the initial cost of heating equipment and the cost of keeping the equipment in repair should not be considered because this cost will be minor. Typically, one man will be assigned to heat the asphalt. Appendix B indicates the man generally comes one hour before the other members of the crew and either (1) heats the asphalt in the large storage tank or (2) drains the asphalt in a small distributor and heats the asphalt in the distributor.

District 5 - (Lubbock) Approximately $14,500 per year is used for heating about 19 tanks (or about $764 per year per tank).

District 11- (Lufkin) There are two electric heating elements per tank and power to each element costs about $100 per month. Therefore some $200 per month per tank is used during the winter months.

District 14- (Austin) The maintenance section in Lockhart indicates some $14 to $26 per month per tank is expended during the winter.

The effort to conserve and reduce costs is evident in maintenance operations throughout the state. For example, after a few telephone contacts it became evident that most maintenance sections in the districts have small (generally 600-gallon) distributors. A common practice in maintenance sections is to drain needed unheated asphalt from a stationary storage tank into a distributor. The asphalt is then heated in small distributor for use during the day or portion of a day, thus saving the cost of heating the large storage tank. This method is in widespread use by all districts (even in summertime use by those districts which heat the large storage tanks).

The time required to drain the asphalt from an unheated storage tank into the small distributor can be lengthy in the winter time. District 17 personnel estimate the time to be one hour per 100 gallons to fill a distributor from a storage tank by gravity flow in cold weather. (An Electro-Tape heated valve may reduce the drain time.)

The districts estimate from 1 to 4 hours to heat the asphalt in the distributor using from 5 to 15 gallons of diesel. Many sections ask one man to arrive early (generally one hour early) to prepare the asphalt for use. Some districts consider the cost of a man arriving early an added cost and other districts believe the cost should not be charged to asphalt heating because the man generally leaves an hour early. There are from 4 to 9 men in a repair crew, and if any delay due to heating the asphalt is expereienced, these men could be idle. Most maintenance personnel contacted seemed incensed that there was not a better method of preparing the asphalt for use so that the manpower available could be better used.

Another example of conservation was shown by several districts which tend to consolidate asphalt use in the wintertime. Wintertime operations are generally crack sealing and pot-hole failure repair. In rural areas, these operations require smaller quantities of asphalt as compared to the strip or full-width seals and patches during warmer weather. Because of the smaller quantities, only a few stationary storage tanks are maintained during the winter and several sections draw from one tank. The insulation of these tanks should show benefit in the case of medium to heavy use.

Asphalt is generally delivered hot from the refinery. Therefore, during periods of heavy asphalt use, maintenance operations tend to time deliveries to use the asphalt while hot.

There are several people in an asphalt crew. If there are delays in heating asphalt, generally the crew will or can be involved in preparing the area to be treated. However, even small delays in asphalt preparation can cause relatively large labor costs. As noted in Figures 10 and 11 of the UT-ME paper and information shown following, insulation can be justified if average weekly asphalt preparation costs are around $12 (or more). One hour of a man's time can almost amount to this figure.

VI. Determination of Insulation Needs

If Table A in Appendix B (page 53) were expanded to include similar information for several thicknesses of fiberglass insulation, and the costs were developed for an annual basis, it would be possible to construct the plot shown in Figure 1. Figure 2 is a sister plot for polyurethane foam insulation. Note the plot data is like that used in Figures 10 and 11 of the UT-ME paper, but data has been plotted in a different manner. It would be found that for a given unit fuel cost (say \$2/MMBtu) there will be an optimum thickness which will provide the lowest "Annual Preparation Cost". Using Figure 1 with a Unit Fuel Cost of \$2/MMBtu, the optimum thickness is 2 inches and the "Annual Preparation Cost" is about \$700. Note the increased "Annual Preparation Cost" to the left of the optimum (or the lower thickness of insulation) is mainly due to fuel costs to maintain the tank at 140°F with 65°F air temperature. However, the increased "Annual Preparation Cost" to the right (or greater insulation thicknesses) is caused by the increased insulation fabrication costs. This would mean that to the left of optimum the small amount of insulation has a low cost, but the energy loss causes a large amount of fuel to be used. To the right of optimum the reverse is true. The large thickness of insulation allows little energy loss and will lower fuel costs, but the cost of insulation increases the annual cost above the optimum. Also, note greater thicknesses are justified if the unit fuel costs are higher. Based on the above information, the thicknesses shown in Table II are optimum for the associated unit fuel costs.

The following method is suggested for use by the Department in determining if insulation is warranted. This method would be to compare the present asphalt preparation costs with the expected costs after insulation. The after-insulation costs should include the cost of insulating the tank and the fuel costs during the "payoff" period. The present asphalt preparation costs should include the fuel cost and the labor cost. Figures 3 through 10 have been prepared to assist thereader in developing insulation warrants and "payoff" periods. Figures 3 through 6 treat fiberglass insulation, and Figures 7 through 10 are for polyurethane foam insulation. Two families of linear curves are shown on each plot. One family of curves shows after-insulation costs which include the initial cost of the insulation at time zero and the (after-insulation) fuel costs as time is accrued. The second family of curves is present yearly asphalt preparation costs and was plotted simply to aid the reader. If the reader's present preparation costs are not exactly \$500, \$1000, etc., it may be necessary to extrapolate between curves. Since little is known about insulation life, it is suggested that a 10-year life be used as a time basis.

The following example will assist in explaining the use of the above information. Assume a maintenance section stores emulsion in a large storage tank which is not heated. A 600-gallon distributor is filled about two times a day for a four-week period during the summer (40 times) and about twice each week during an eight-week period during the fall and again in the spring (32 times). Also assume some 10 gallons of diesel are used at each heating. Then the distributor is heated 40 + 32 or 72 times per year and 720 gallons of diesel are used per year. Assuming diesel costs \$0.757 per gallon, then some \$545 would be used for fuel in one year. If one MMBtu is produced for each 6.6 gallons of diesel burned, some 109 MMBtu are produced by burning 720 gallons. The unit fuel cost would be about \$5/MMBtu (\$545/109 MMBtu). Also assume one man hour is expended at each heating at a cost of \$6.32 per man hour. Then \$455 (72 x \$6.32) would be used in labor costs. The asphalt preparation cost will be the present fuel and labor costs or \$1000 per year (\$545 + \$455).

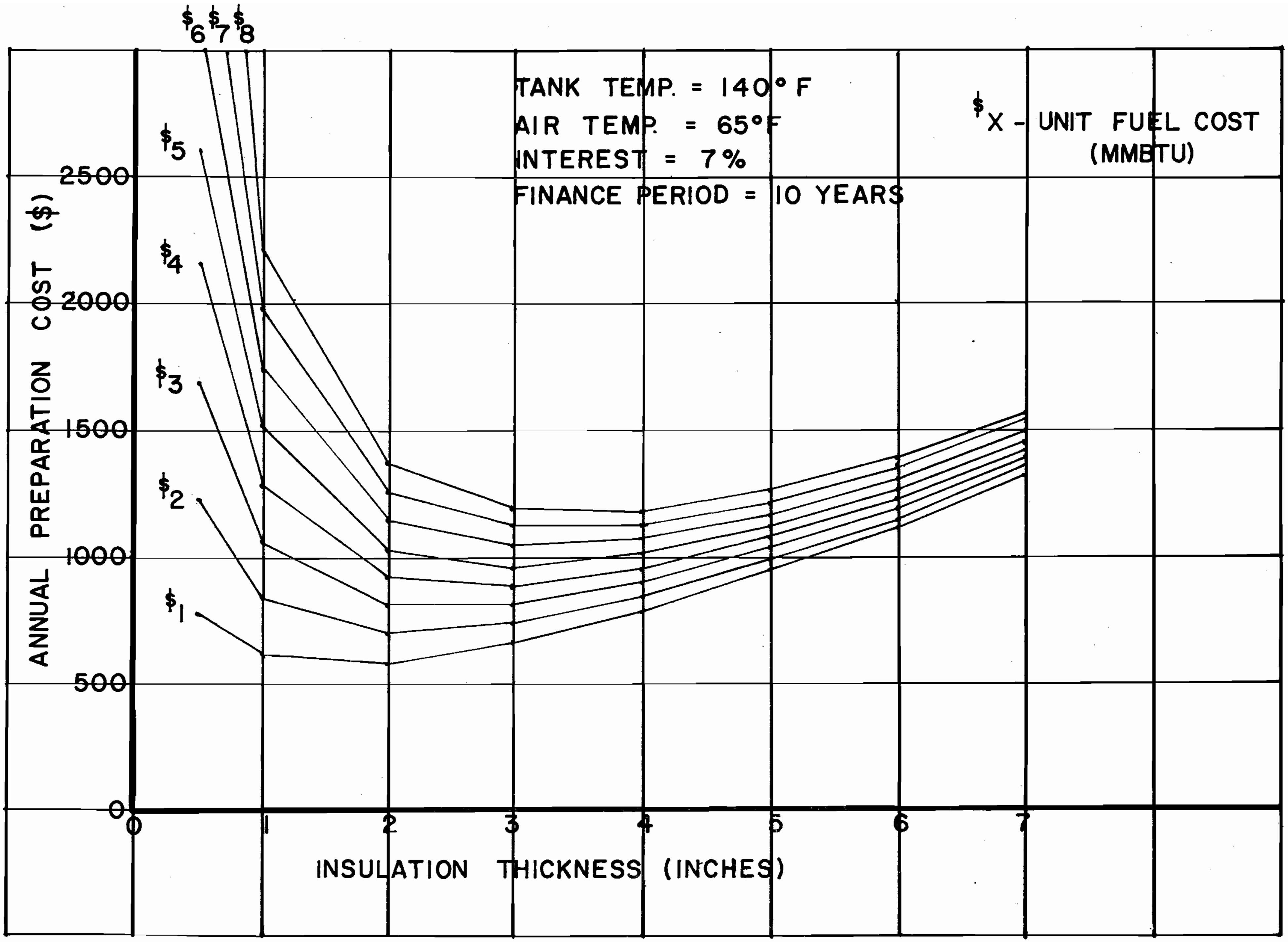

FIGURE 1 OPTIMUM INSULATION THICKNESS FOR FIBERGLASS

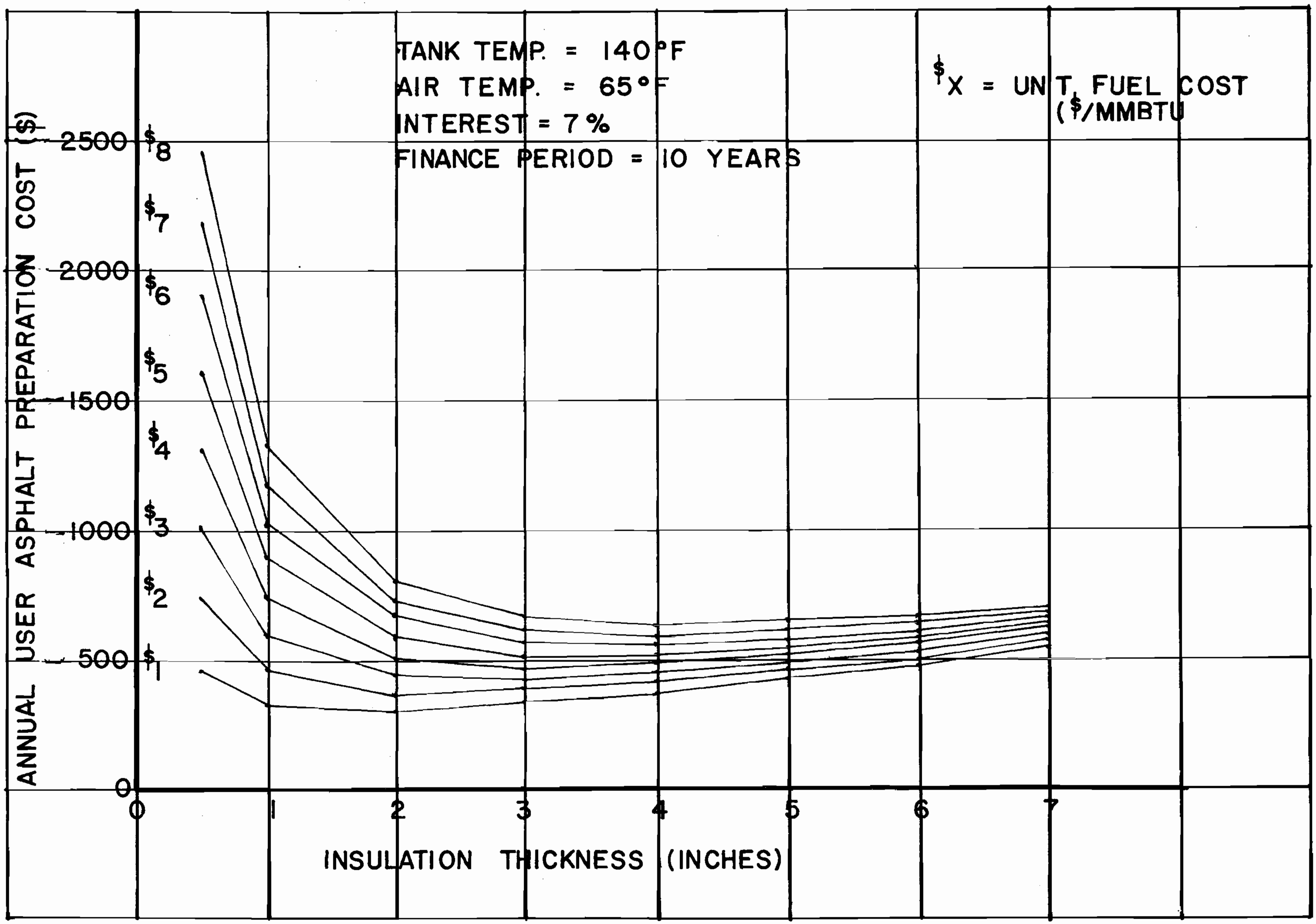

FIGURE 2 OPTIMUM INSULATION THICKNESS FOR FOAM

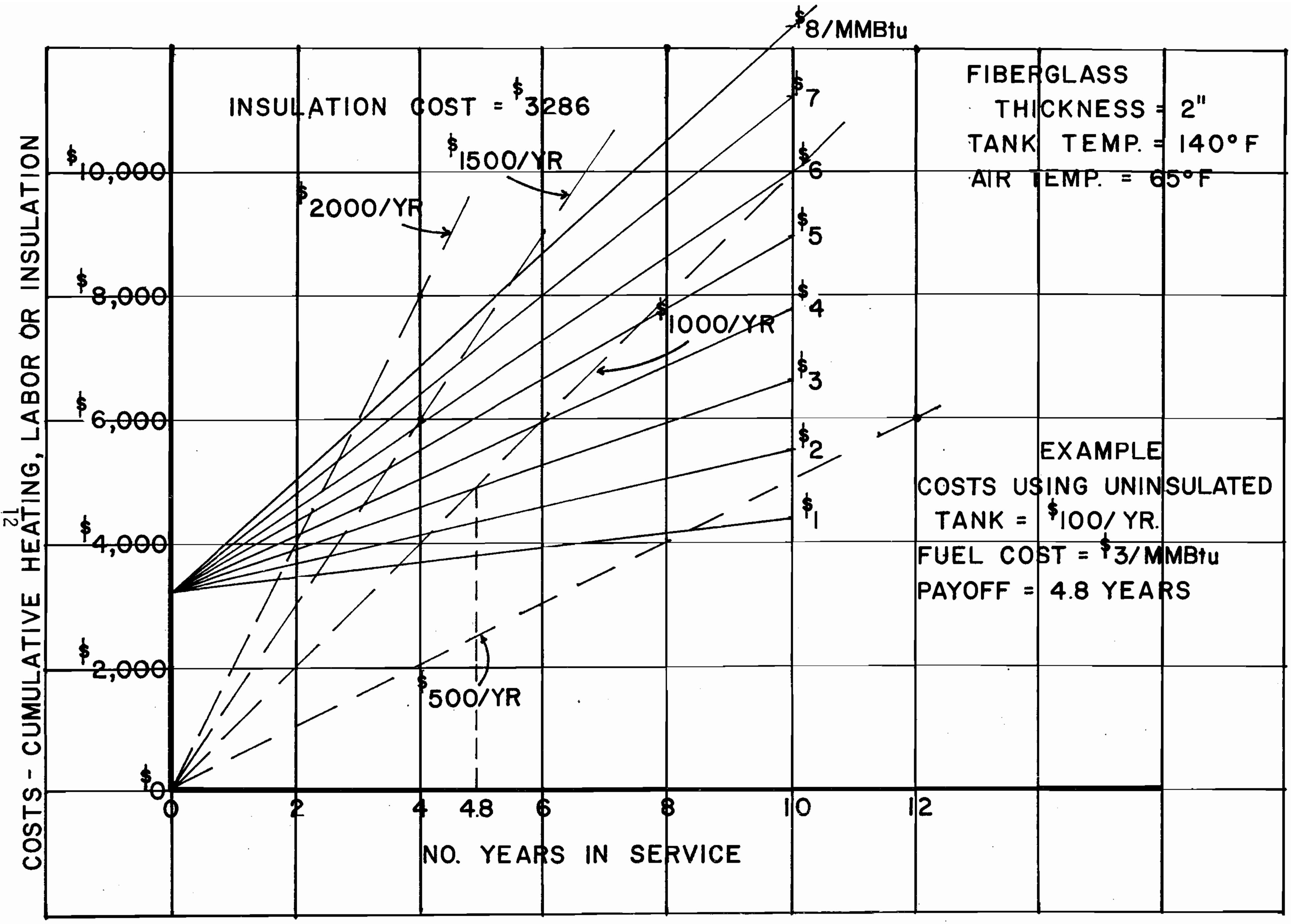

FIGURE 3 ASPHALT TANK USE COSTS WITH AND WITHOUT INSULATION

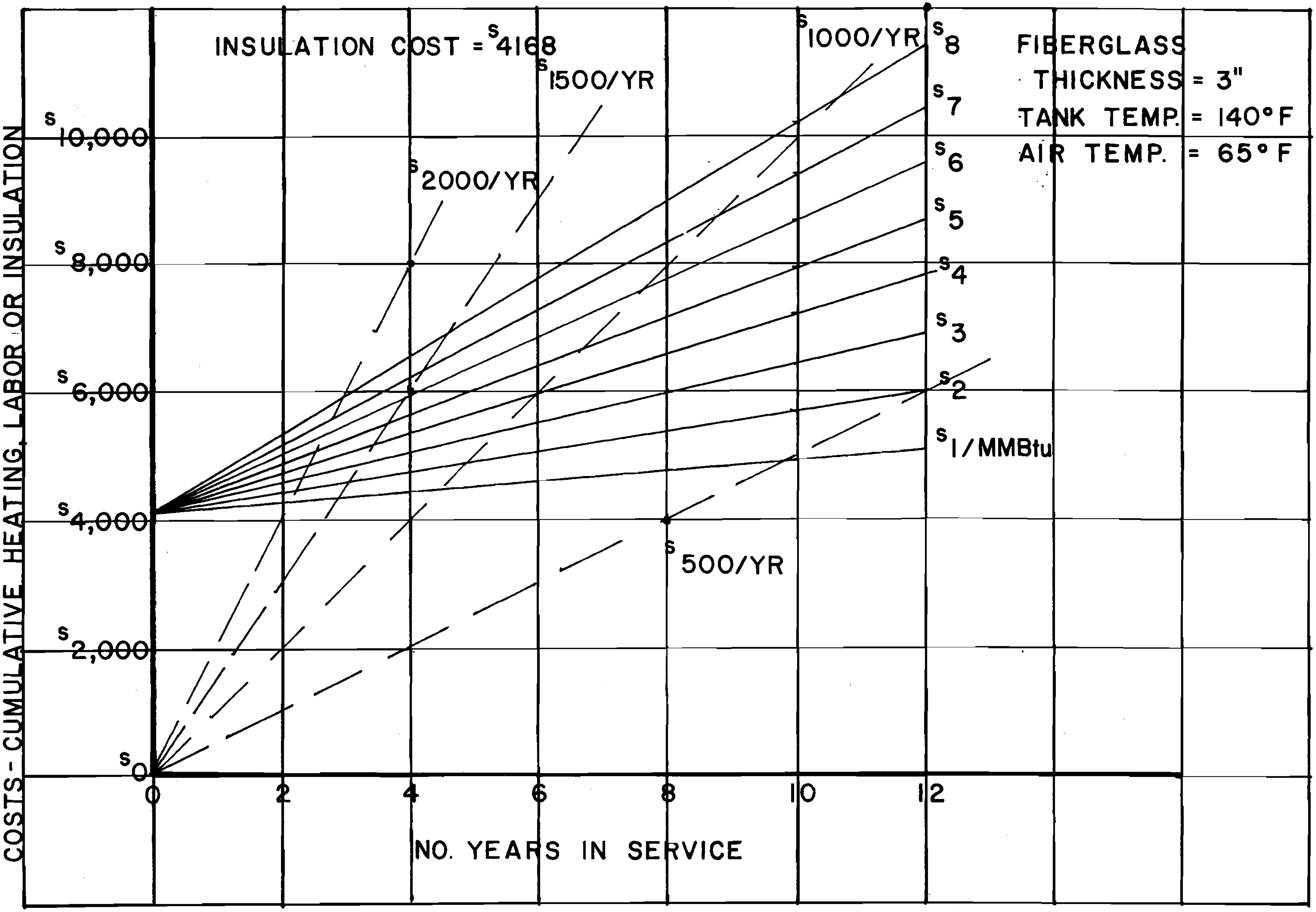

FIGURE 4 ASPHALT TANK USE COSTS WITH AND WITHOUT INSULATION

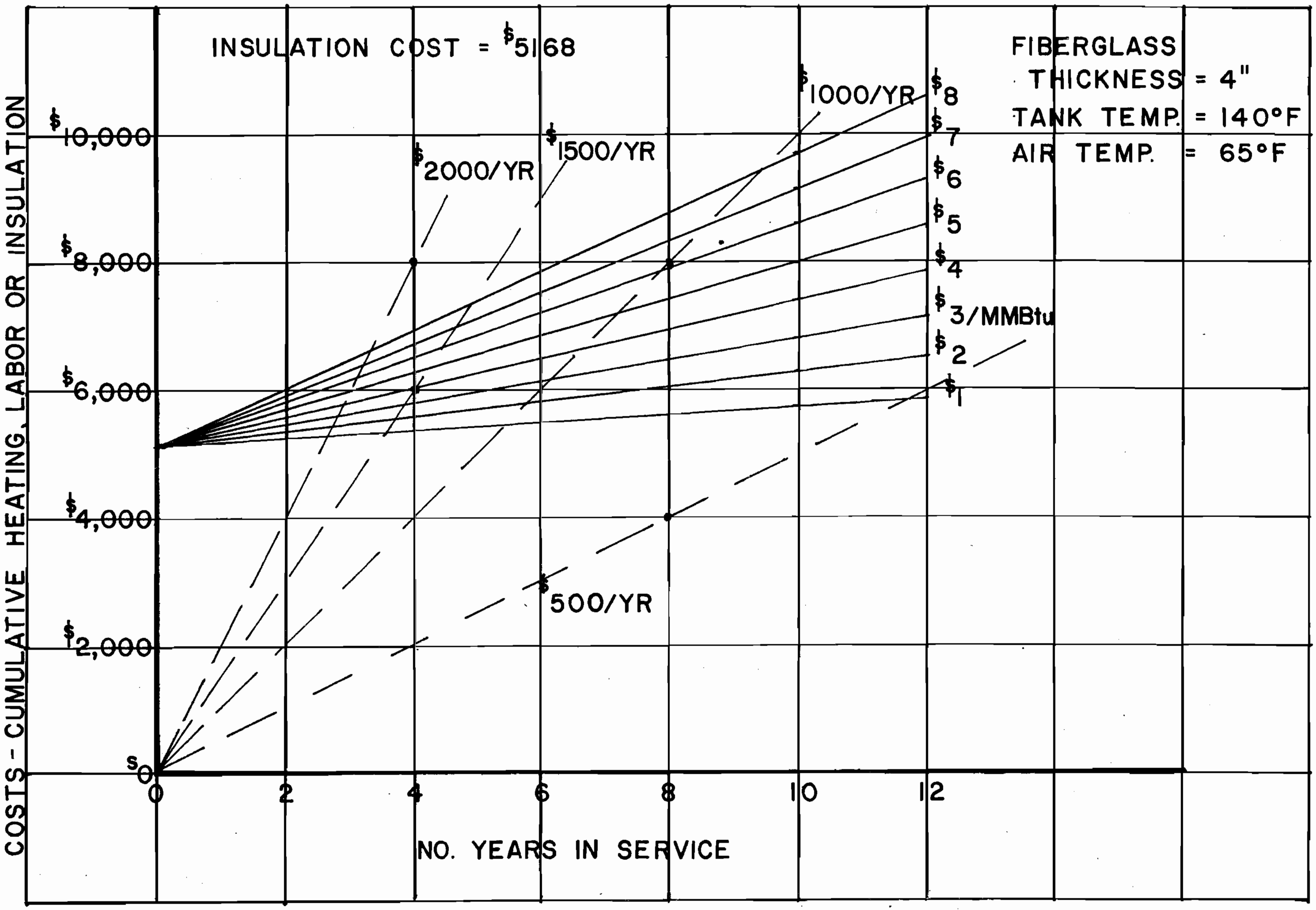

FIGURE 5 ASPHALT TANK USE COSTS WITH AND WITHOUT INSULATION

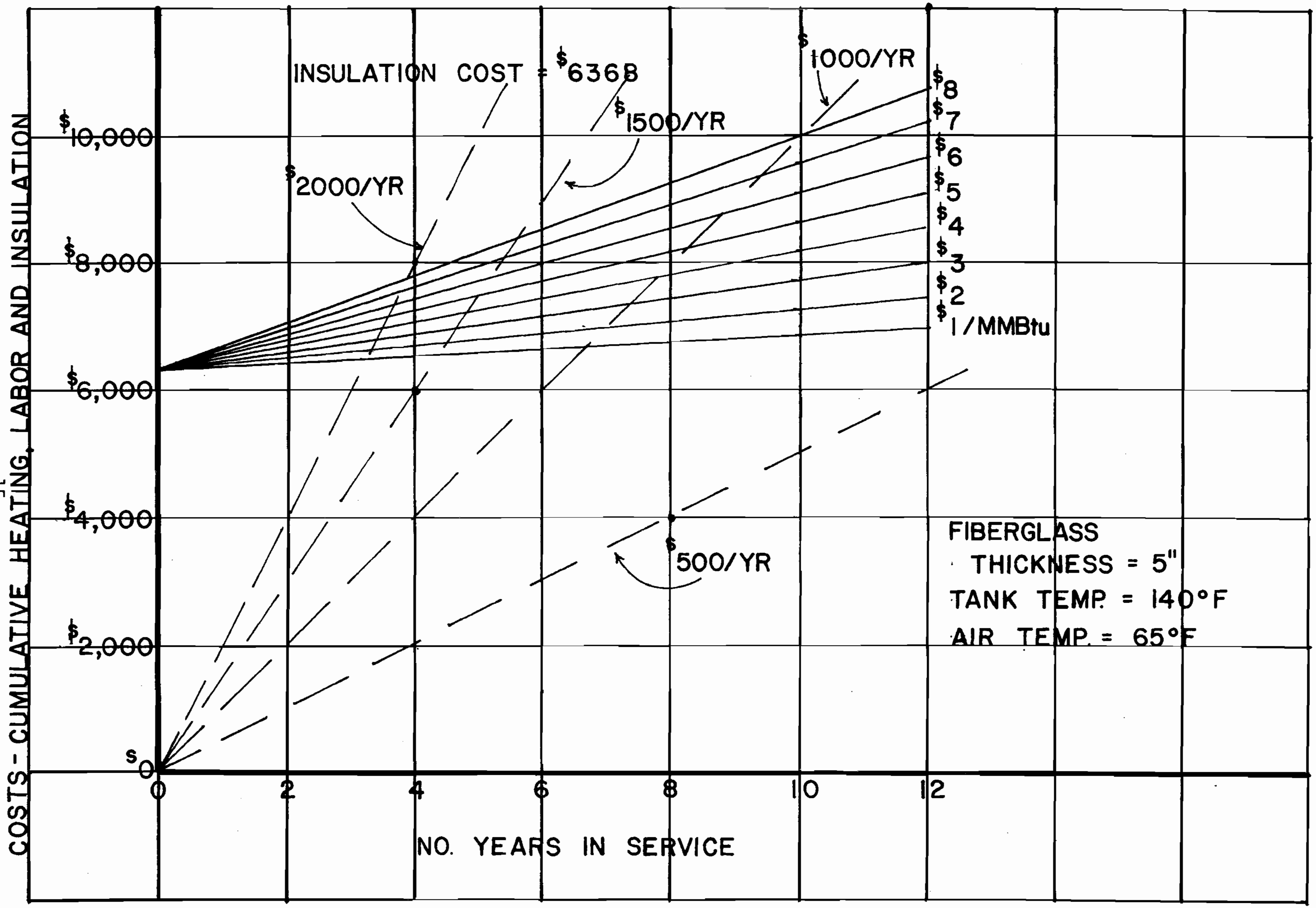

FIGURE 6 ASPHALT TANK USE COSTS WITH AND WITHOUT INSULATION

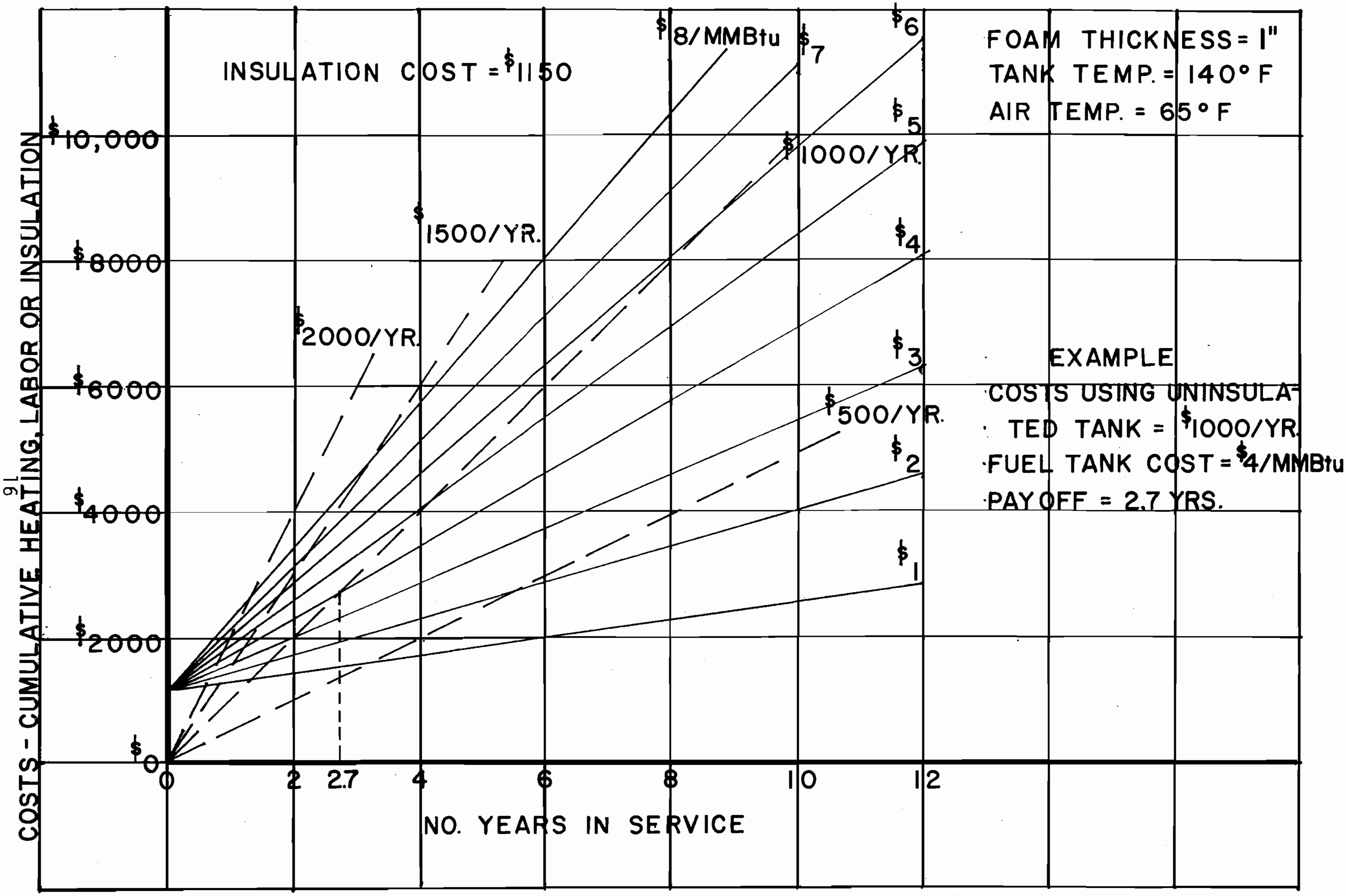

FIGURE 7 ASPHALT TANK USE COSTS WITH AND WITHOUT INSULATION

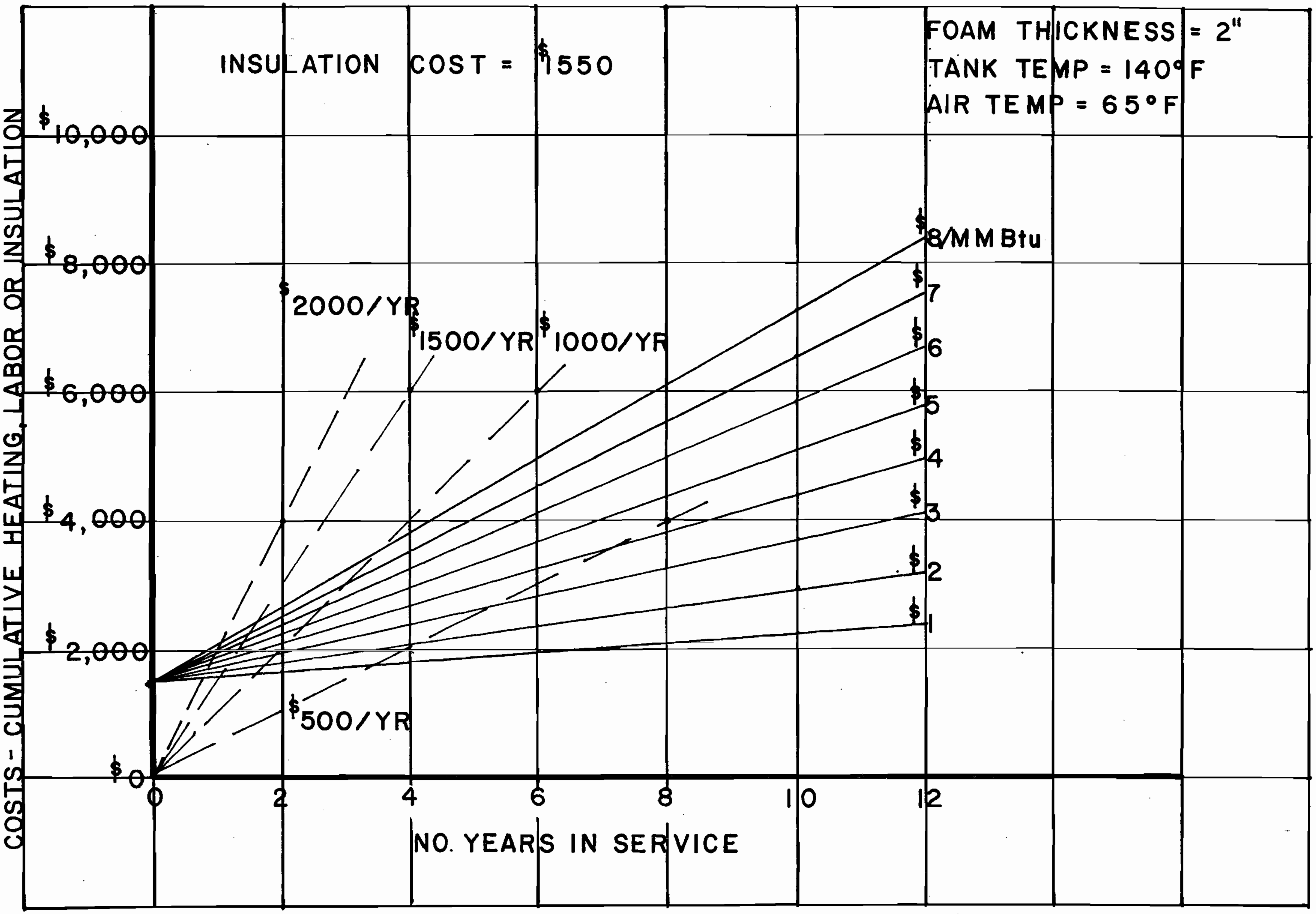

FIGURE 8 ASPHALT TANK USE COSTS WITH AND WITHOUT INSULATION

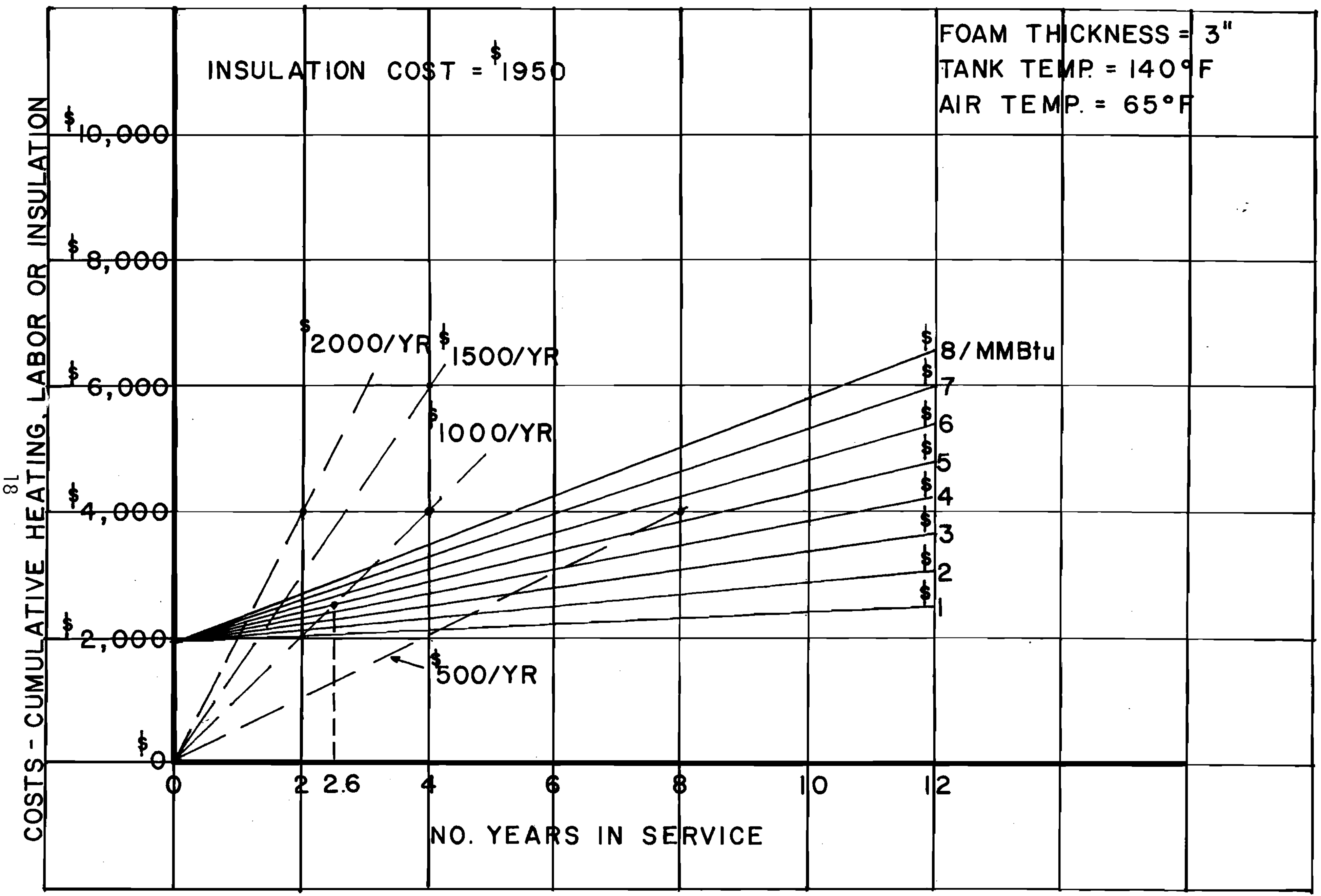

FIGURE 9 ASPHALT TANK USE COSTS WITH AND WITHOUT INSULATION

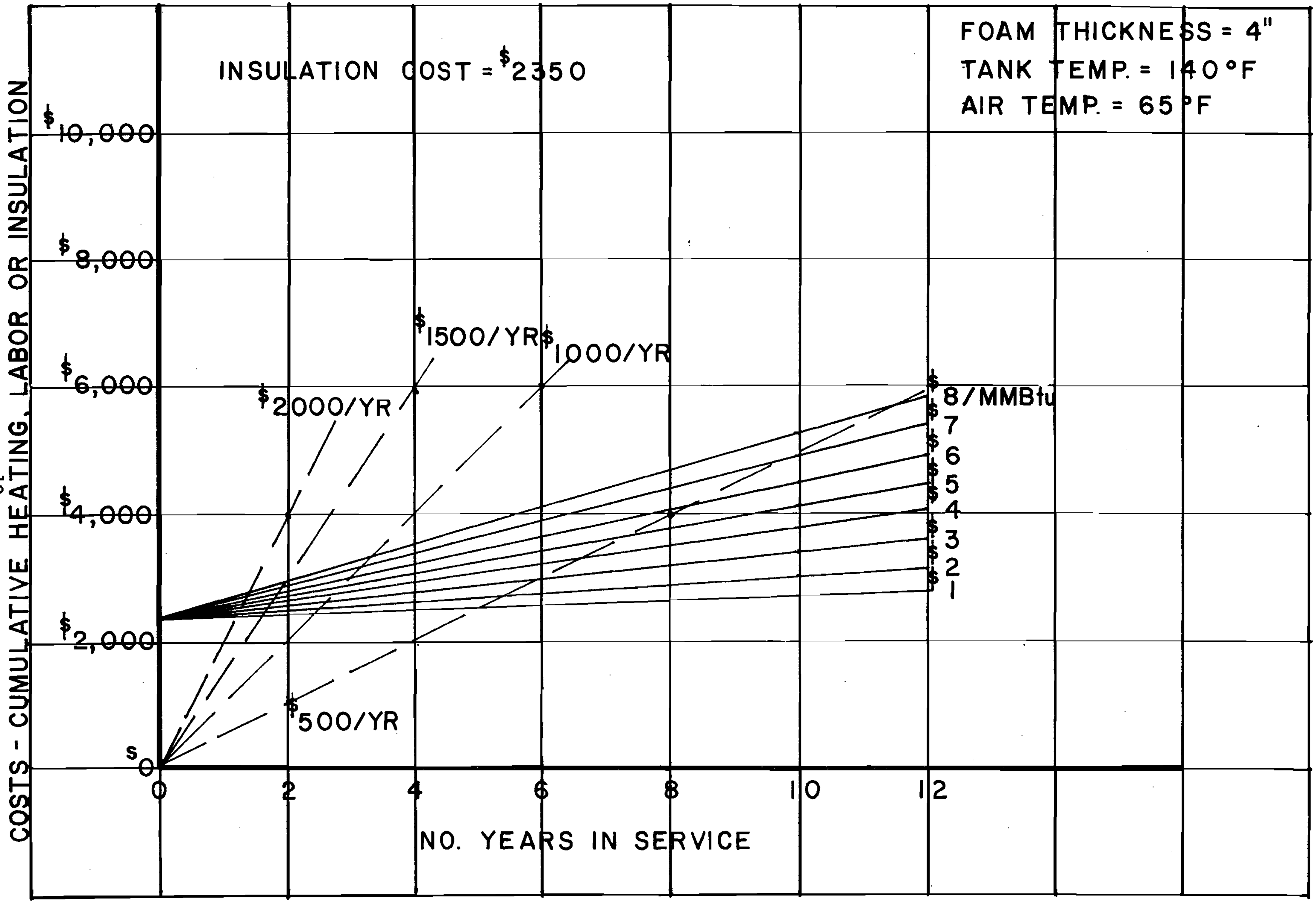

FIGURE 10 ASPHALT TANK USE COSTS WITH AND WITHOUT INSULATION

Foam insulation would probably be used with emulsion and Table II indicates 3 inches is optimum for a unit fuel cost of \$5/MMBtu. Using Figure 9 (3" of foam) find where the Asphalt Preparation cost of \$1000/Yr. crosses the unit fuel cost line of \$5/MMBtu. At this intersection point, read the No. Year in Service of 2.6 vertically under the point. This would indicate the savings after insulation would pay for the insulation in 2.6 years even though the tank was being maintained at 140°F for the 2.6-year period. A savings of over \$1000 would accumulate at a time 4 years after insulation. The savings may be noted by following the \$1000/Yr normal cost up to the 4 year point and read a cost of \$4000. Next trace the "insulation with \$5/MMBtu" line out to the 4-year period and read a cost of about \$3000. The difference in these costs is the savings after 4 years.

Since little is known about insulation life, it is suggested that a 10-year life be used as a time basis. Therefore, if the "payoff" period is 10 years or less, insulation is warranted.

TABLE II
OPTIMUM INSULATION THICKNESS

Polyurethane Foam

Optimum Thickness for	Unit Fuel Cost
2"	$1 & $2 / MMBtu
3"	$3, $4, & $5 / MMBtu
4"	$6, $7, & $8 / MMBtu

Fiberglass

Optimum Thickness for	Unit Fuel Cost
2"	$1, $2, & $3 / MMBtu
3"	$4, $5, $6, & $7 / MMBtu
4"	$8 / MMBtu

VII. Insulation and Application

A part of the UT-ME paper was dedicated to comparing contract costs of insulation with costs of installation using state forces. Because of loss of volatile materials (potential energy) in cut-back materials and the large amount of heat necessary to thin AC's, maintenance basically uses emulsified asphalts. The extensive use of emulsions will mean many storage tanks can use polyurethane foam for insulation. If several emulsion tanks are to be insulated in the state it may be wise to purchase a foam spray rig, train a crew and provide the service to Districts desiring polyurethane insulation. The cost of the foam spray rig is shown to be $4600 (page 45). A primer spray rig, a sand blast rig and an air compressor which are shown to cost about $10,000 are presently available. Therefore, the cost of polyurethane foam as applied by state forces should be low. This type of insulation could also be used in other applications. Also, contract costs for polyurethane foam will vary. An unofficial telephone bid by a local contractor for the Austin area was $1800 for 2 inches on a tank 10 feet in diameter and 20 feet in length; however, the bid may not have included the butylrubber weather coat.

Apparently, fiberglass insulation can be installed easily. The fiberglass must be weatherproofed because if the fiberglass is saturated with (rain) water, the insulation value is decreased to an extremely large extent. It would appear that the weather coat for the fiberglass is generally an aluminum sheeting. During this study, Texas Emulsions Company (Corpus Christi, Texas) graciously provided a tour of their facilities which included vertical-insulated storage tanks and discussed insulation fabrication methods. One fabrication method was described as follows:

1. Obtain the fiberglass bats, corrugated aluminum, bands, metal screws and other materials as necessary.
2. The usual maintenance tank has a horizontal axis, but several lengths of rope (about 1/4 inch diameter) are cut to the approximate dimension of the circumference of the tank (about one or two feet short of this length). To one end of the tank attach a wire hook and to the other attach a light spring. (Strips of a tire tube cut in sprial manner and tied together have also been used successfully.)
3. Loop the ropes around the tank and attach the hooks to the springs in such a manner that the ropes will be snug to the tank. In other words, the springs cause the ropes to be tight around the tank but the rope may be pulled away from the tank to insert the bats between the tank and rope.
4. Using a three man crew, place the fiberglass bats around the tank at one end. The length of the bat should be equal with the length of the tank.
5. The bats should be held in place by the ropes. Sufficient ropes should be used to allow complete encasement of the tank with the bats. Then 3/4" steel banding is placed around the bats and the ropes removed. If more than one layer of bats are to be used to obtain the necessary thickness, the bats should be so placed that the joints are staggered. Several small spikes (wires) may be butt-welded to the tank ends at various locations. Fiberglass is impaled on the spikes and held in place in this manner. Small metal clips can be inserted over the spikes to hold the fiberglass to the tank ends. The spike length should be about 1/2 inch less than the fiberglass thickness.

6. With the ropes in place, insert the aluminum in the same manner. Lap the aluminum at least 3 inches, one corrugation, drill holes and attach the two sheets with metal screws along the length of the sheets as they are placed.

7. Place the 3/4-inch strapping around the diameter of the tank on top of aluminum, tighten the straps (bands) slightly and attach the band ends. Be careful not to tighten the straps excessively because this will reduce the thickness of the insulation.
8. Mastic can be applied along the seams of the aluminum if desired.
9. One method of attaching the cylindrical aluminum weatherproofing to the end aluminum, often used by contractors, is the "Pittsburg Fold". The ends are run through a machine which results in a Z-Shaped fold. The cylindrical and end aluminum folds are placed together and closed by tapping with a hammer around the edge. Another method could be to exte nd the cylindrical ends of the aluminum past the ends of the tank and insulation to form a tab to attach the end pieces with metal screws. The ends could be insulated by attaching the preformed fiberglass bats to either the tank ends or to the aluminum with an adhesive. The aluminum could be precut to the exact dimension as the tank end plus circumferential insulation thicknesses. The pre-cut aluminum ends would need an additional diameter length which would be cut and bent to form tabs which would be attached to the extended cylindrical aluminum weatherproofing previously mentioned. Mastic should be used at the seams.

It is not the intent of this report to discourage other types of insulation or other types of weatherproofing for insulation. Thermal conductivity or "R" values of other insulation materials may be directly compared to the polyurethane foam and the fiberglass used in this report. Other weatherproofing should be studied to insure the material prevents the entrance of water or the rapid decay of the insulation material.

VIII. Discussion and Recommendations

This report shows the benefit of using insulation in reducing energy use and therefore costs. The report is in explanation of a document prepared by the Mechanical Engineering Department at the University of Texas. The UT-ME document shows that very small average weekly costs in the preparation of asphalt for use warrant the expenditure of insulation. A slightly modified procedure has been developed for use by the Department in obtaining optimum thicknes and justifying insulation.

From previous information obtained from Districts, it is believed that many stationary asphalt storage tanks owned by the Department will warrant insulation. In some cases, a work plan can be prepared for winter operation which may consolidate use so that more than one maintenance section can obtain asphalt from a tank thereby reducing the need for the number of insulated tanks.

The cost of insulation can be reduced by using state forces in installation. In the case of polyurethane foam, the foam spray rig would need to be purchased and a crew trained. The foam appears to cost less than fiberglass regardless of whether the fabrication is by contract or state forces. However, fiberglass can be easily installed by state forces especially during winter or slack work periods.

Therefore, the following recommendations are made:

1. Working through the Maintenance Operations Division, Districts should study the asphalt storage source for each maintenance section.
2. Where tanks warrant insulation, insulation should be provided in an effort to reduce costs and conserve additional energy.
3. The Maintenance Operations Division, working with the Equipment and Procurement Division, should study the application of polyurethane foam by state forces to determine if a foam spray rig, other equipment and a trained application crew are needed.

APPENDIX A

UT - ME Paper

"Insulation of Asphalt Storage Tanks"

Insulation of Asphalt Storage Tanks

Submitted to: Texas State Highway Department

From: Center for Highway Research
The University of Texas

Tables of Figures

Insulation of Asphalt Storage Tanks

As requested by the Texas Highway Department, the Center for Highway Research at the University of Texas has conducted a study of the economic feasibility of insulating asphalt storage tanks. Since concise data is not always available to perform the analysis, the study has been conducted on the basis of several assumptions concerning the current manner in which asphalt is heated. This report will discuss the assumptions made for analysis, cost savings, graphical presentations, types of insulation available, and installation of the insulation.

Due to the lack of standard procedure concerning field practice, this study has been conducted based on several assumptions. The considerations to be taken into account for economic analysis were based upon average current costs of fuel and the practice of using portable units to do most of the asphalt heating. In locations where the portable units are seldom used and most heating is done in the large tanks, the computer output will provide the most accurate solution to the problem. However, if most of the heating is done in the portable units, figures 8, 9, 10, and 11 should be used.

The analysis of insulation economics was done with the aid of a computer program available through the Department of Mechanical Engineering at U. T. The program was adjusted to fit the unique problem of Texas State Highway Department tanks and results were based on the Lubbock (District 5) information which provided an accurate account of fuel consumption. The program input has been adjusted to give results as closely as possible to the probable heat loss based upon hand calculations and the Lubbock data. One should note that the economic insulation thickness in the computer output is determined by comparing the effects of insulated versus uninsulated tanks, which renders the results useless in all cases where the large storage tanks are not in use. There is no way to account for the use of portable heating units in the computer analysis.

The analysis of the effects of insulation upon heat loss and economics has been presented graphically in order to more easily visualize our problem. The graphs are of three types:

1) comparison of temperature change of tank contents with time and at various ambient temperatures
2) insulation thickness as a function of volume of asphalt used
3) insulation thickness as a function of cost of fuel presently used in heating the asphalt

One can easily see the benefits of insulation in reducing heat loss from the tanks by referring to figures 1 - 7. The contents of the tank will remain at higher temperatures for a significantly longer period of time, resulting in cost savings from reduced heating loads. A comparison of heat loss rates for insulated and uninsulated tanks is shown in figure 1. Over a three day period, the uninsulated tank will lose about 63% of its heat while the polyurethane insulated tank will lose only about 17% of its heat. For example, if the initial temperatures were $160^{O}F$ for each tank and the ambient air temperature were $40^{O}F$, then after three days the heat losses would be 5.0×10^6 and 1.4×10^6 BTU for the uninsulated and insulated tanks respectively. This translates to a savings of more than $15 over this period.

Another advantage of adding insulation is that heating would be

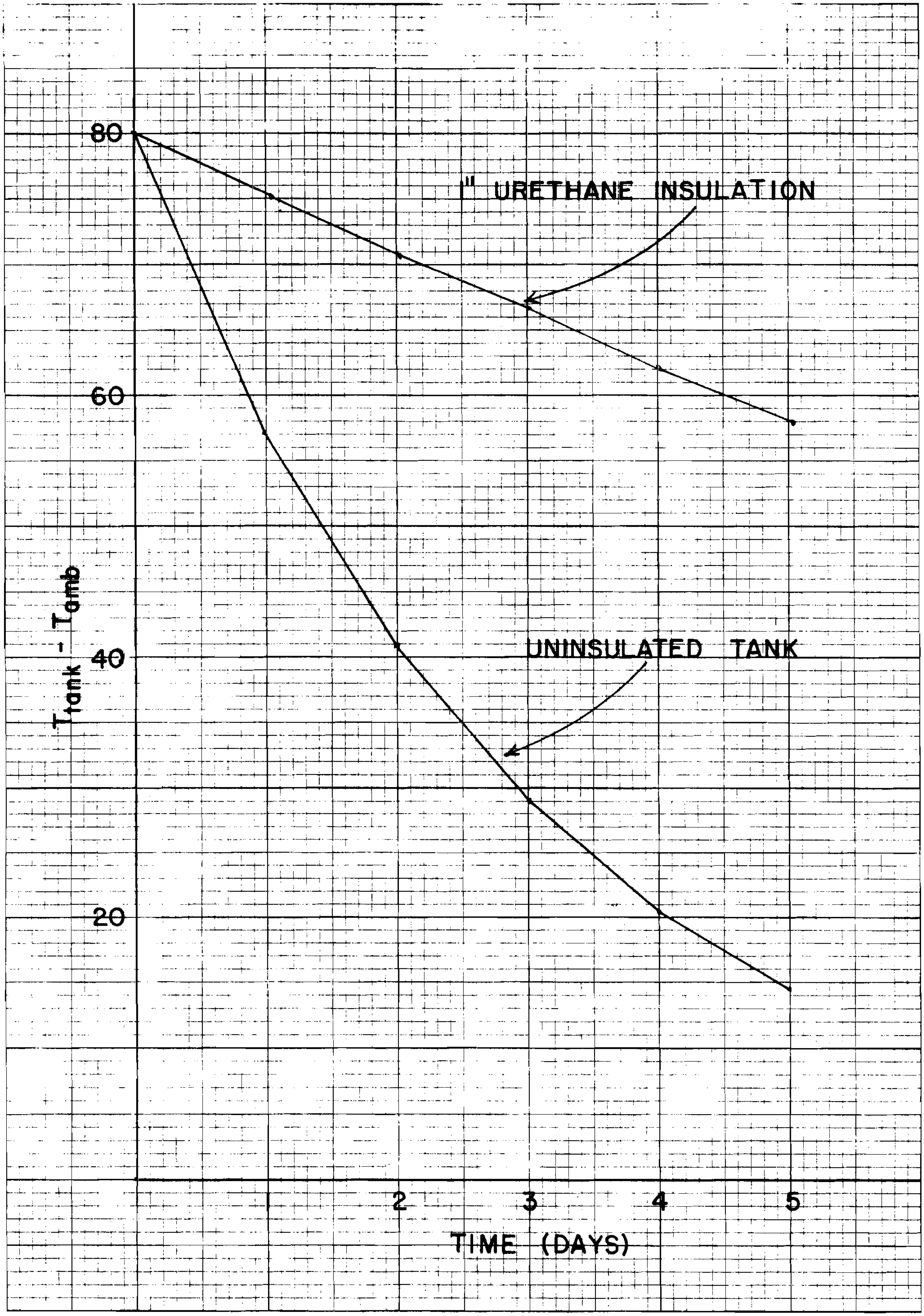

FIGURE I TEMPERATURE CHANGE WITH TIME

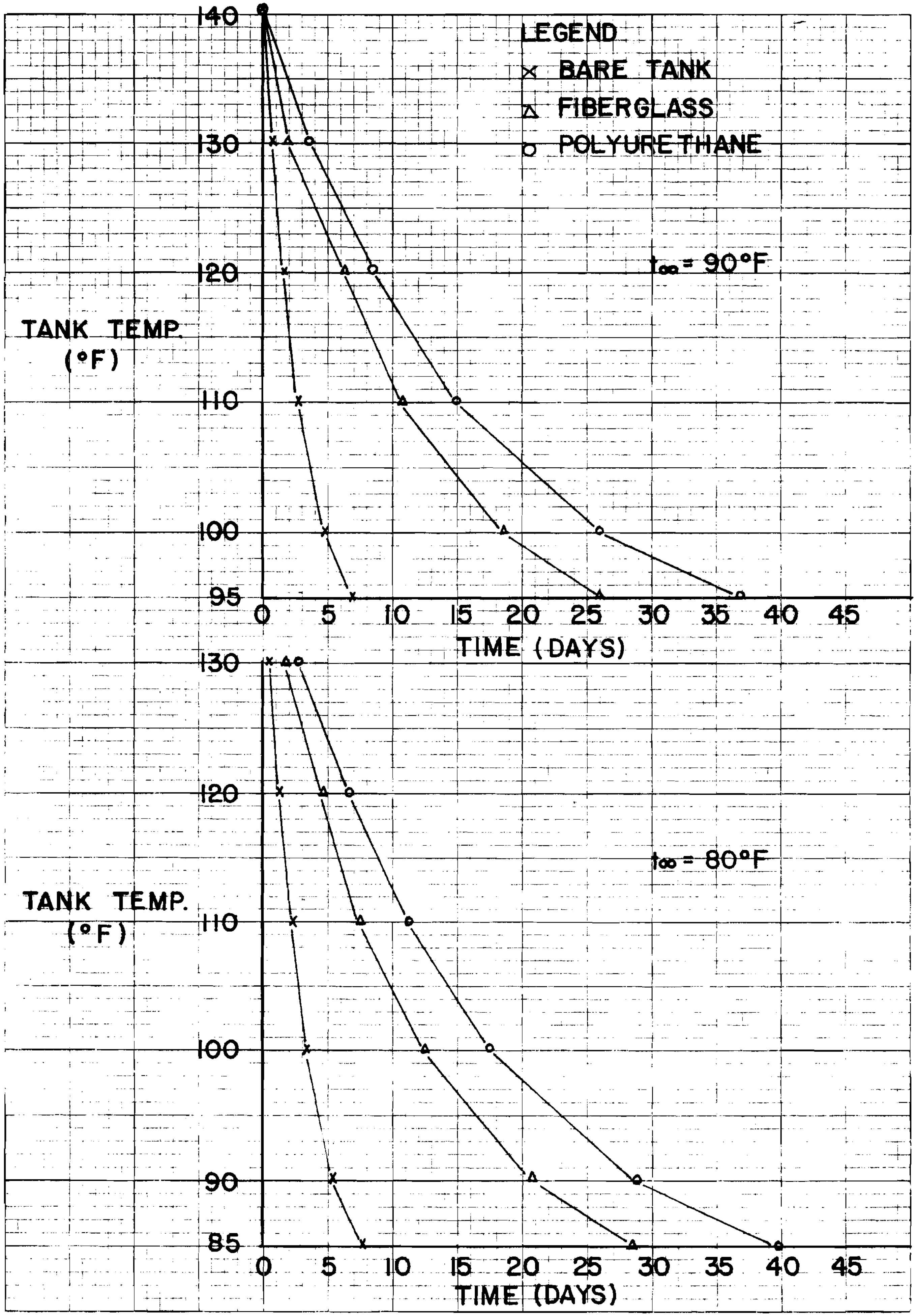

FIGURE 2 TEMPERATURE CHANGE WITH TIME

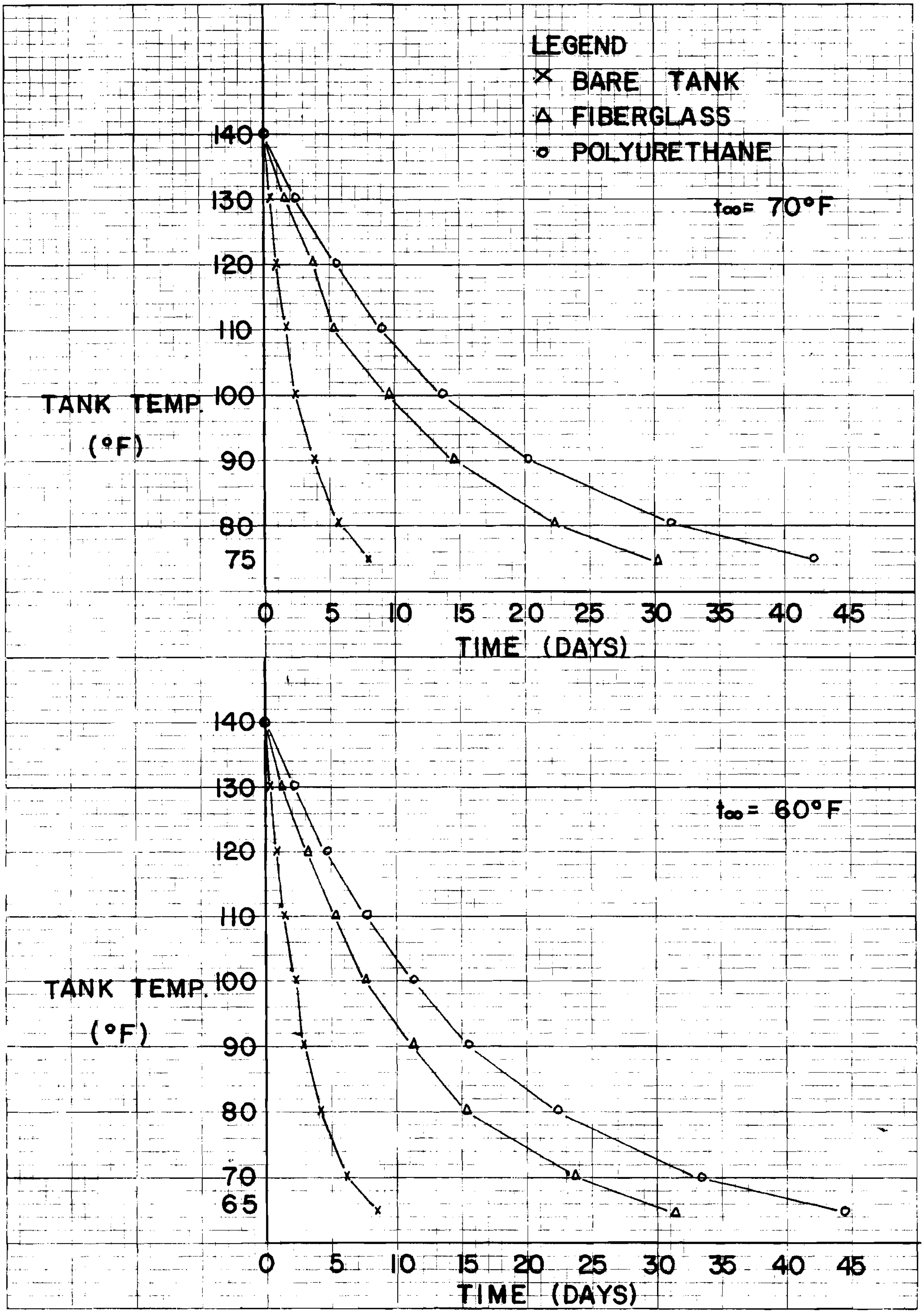

FIGURE 3 TEMPERATURE CHANGE WITH TIME

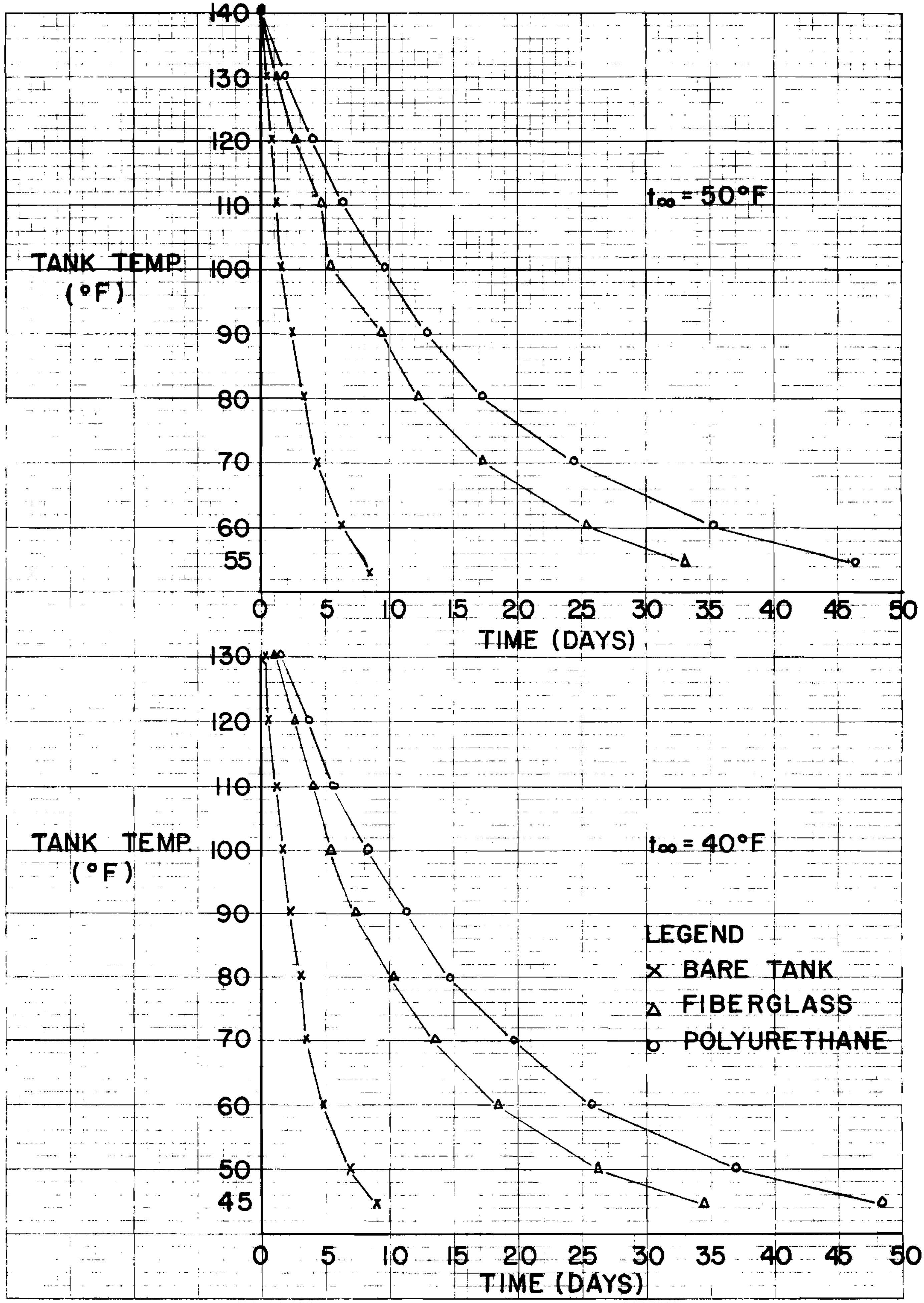

FIGURE 4 TEMPERATURE CHANGE WITH TIME

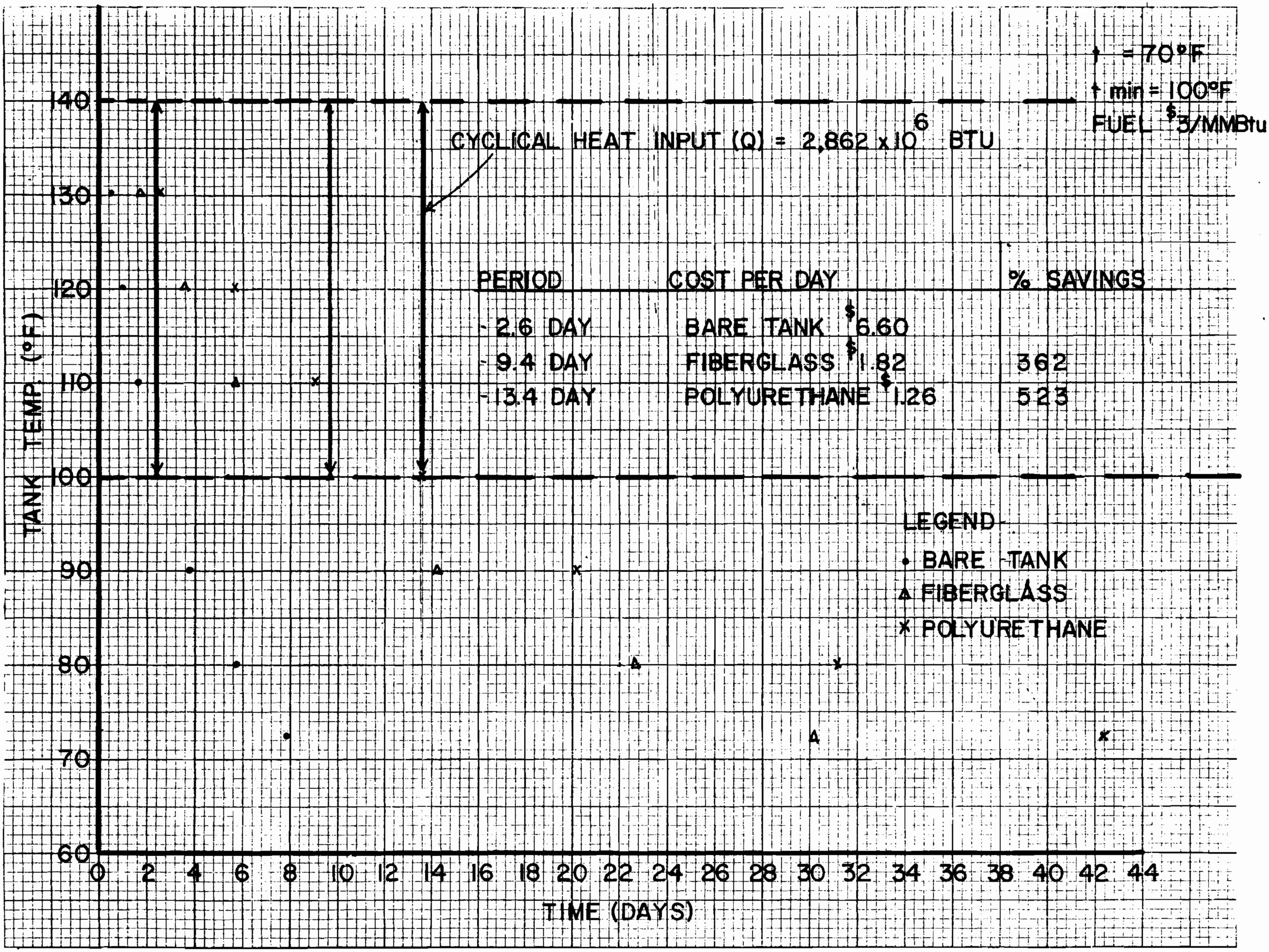

FIGURE 5 COMPARISON OF COST SAVINGS FOR CYCLIC HEATING

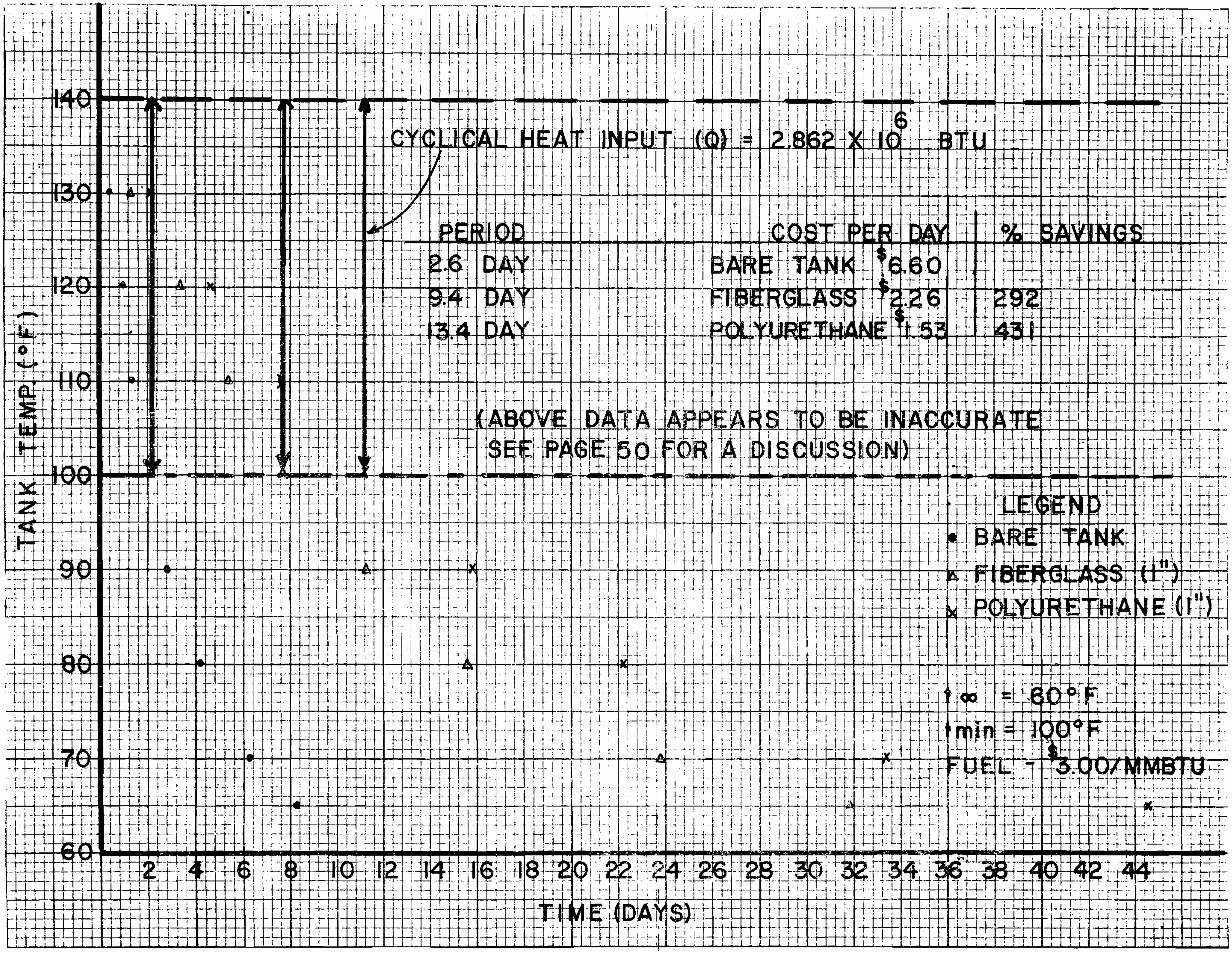

FIGURE 6 CYCLIC HEATING

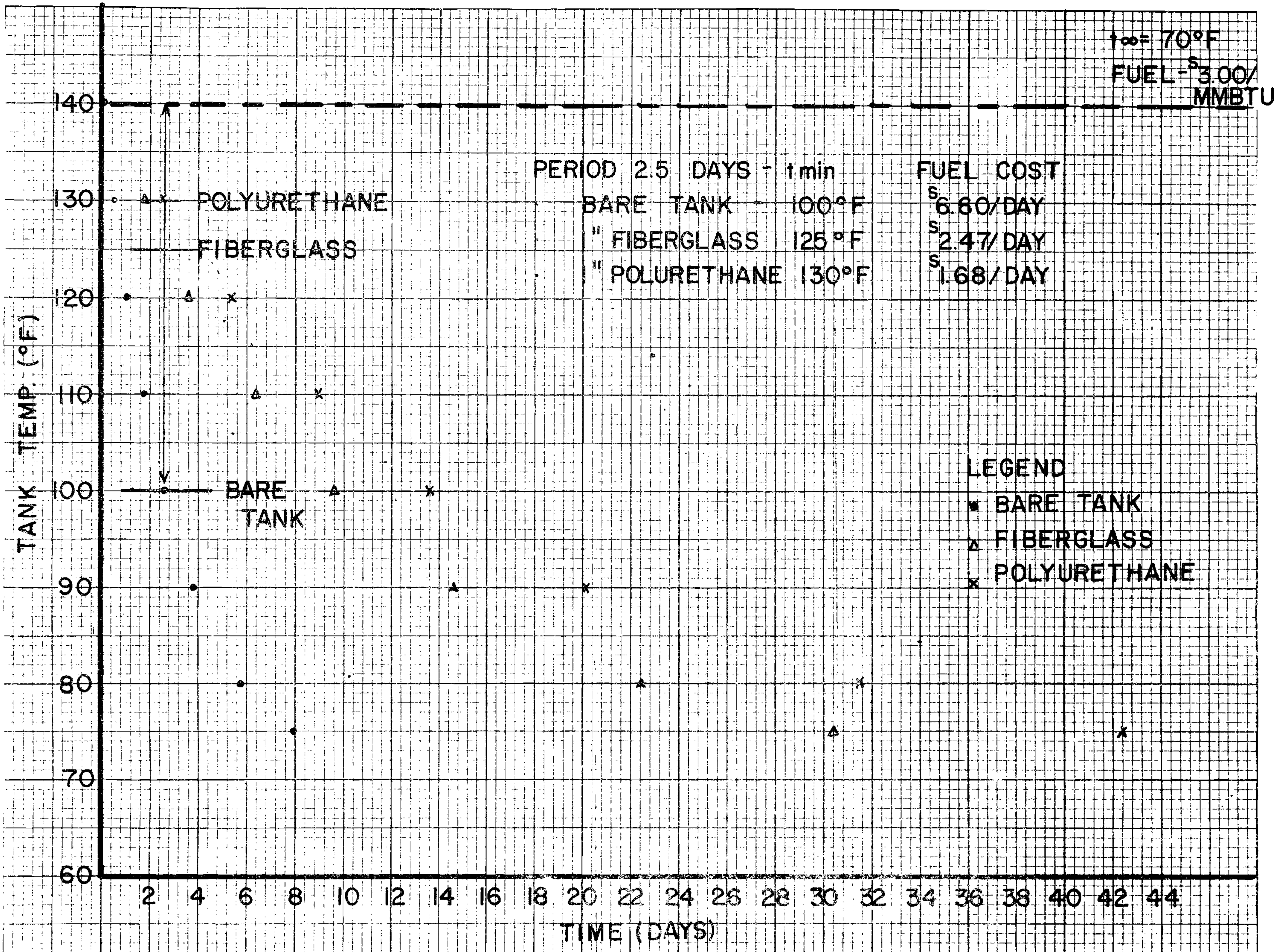

FIGURE 7 CYCLIC HEATING

repuired less frequently. Assume the tanks are kept between 110°F and 140°F by periodic heating. The average temperature in Lubbock for January is 39°F. The period for heating the uninsulated tank would be about one day while the insulated tank would be heated every six days. The difference in fuel costs for these two months combined is $97. That is, an insulated tank would save $97 in fuel costs during January and July.

Figures 8 and 9 may be used to determine whether a storage tank should be insulated based upon the volume of asphalt used on a weekly average and heated in portable units. The horizontal axis will give the least amount of asphalt used in an average week for a given district. In other words, if a district uses less than the amount indicated on the graph, insulating would be uneconomical. This minimum useage standard is based upon the cost of maintaining the large storage tank at 140°F.

Figures 10 and 11 may be used to determine the economic insulation thickness as a function of the total cost of fuel presently used to heat the asphalt whether in the large storage tanks or in portable units (based on 20 year payback). These two figures will be the most accurate in determining a solution, provided present fuel costs are known.

The two types of insulation used for this type application, polyurethane foam and rigid fiber glass, have several characteristics worthy of consideration. Polyurethane foam will be discussed first.

The most serious drawback in using polyurethane foam is the fact that the foam will lose its bond with the steel tank surface at 200°F. Since the asphalt in storage if often heated to 160°F - 170°F, the chance of allowing the tank to overheat in the range of 190°F - 200°F is significant. This choice of insulation, then, would dictate the installation of several temperature indicators at various positions in and on the

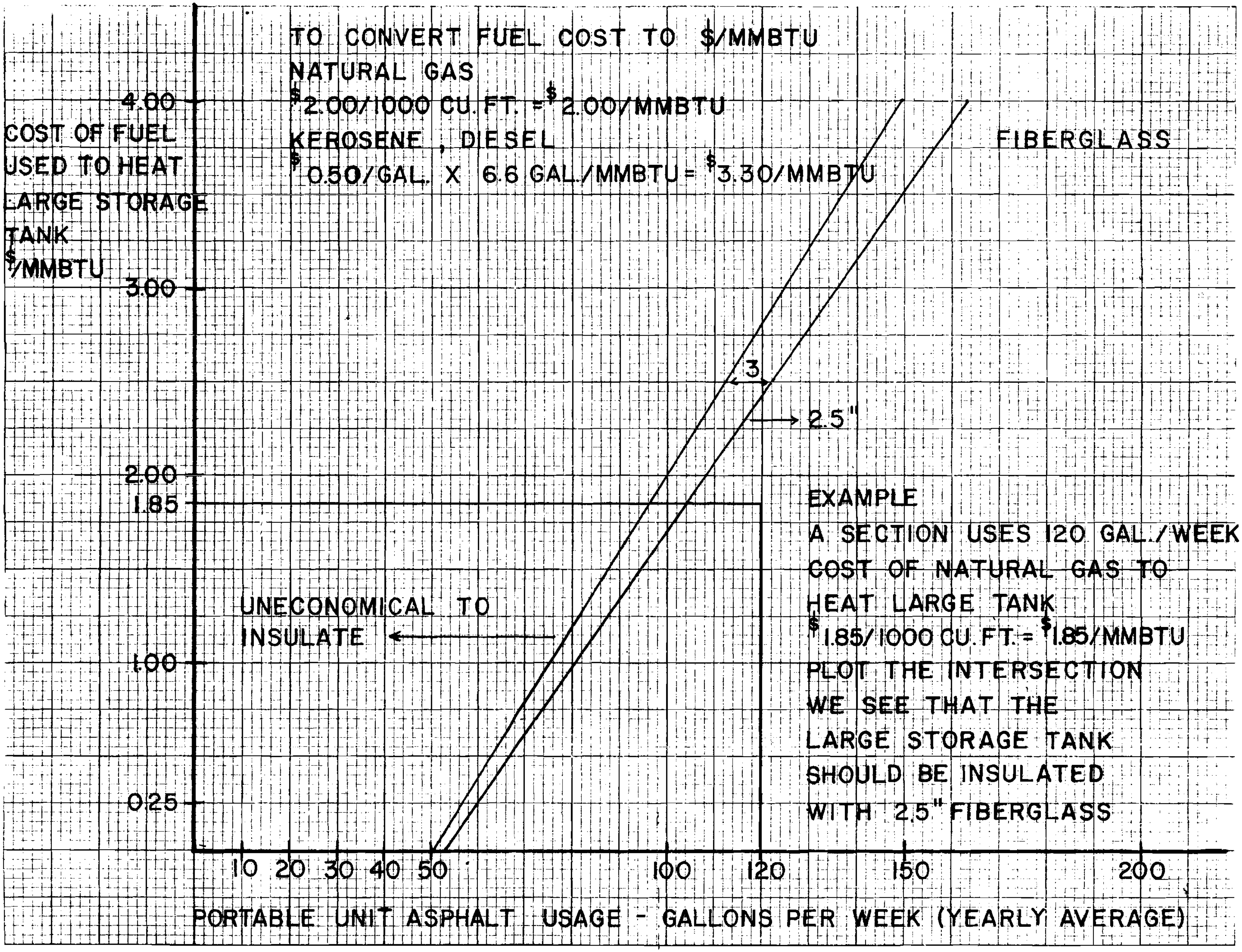

FIGURE 8 MINIMUM ASPHALT USAGE TABLE FOR FIBERGLASS

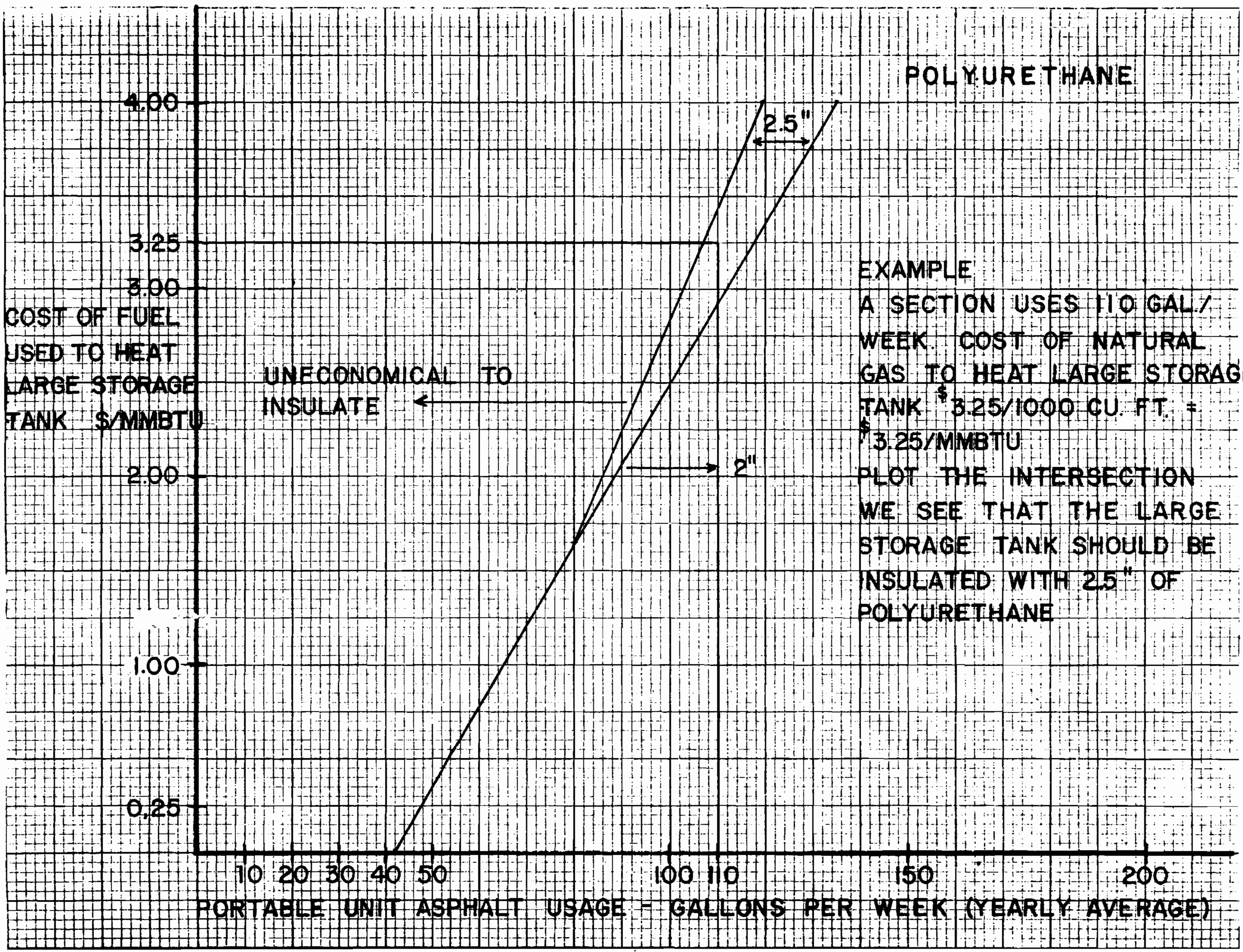

FIGURE 9 MINIMUM ASPHALT USAGE TABLE FOR POLYURETHANE

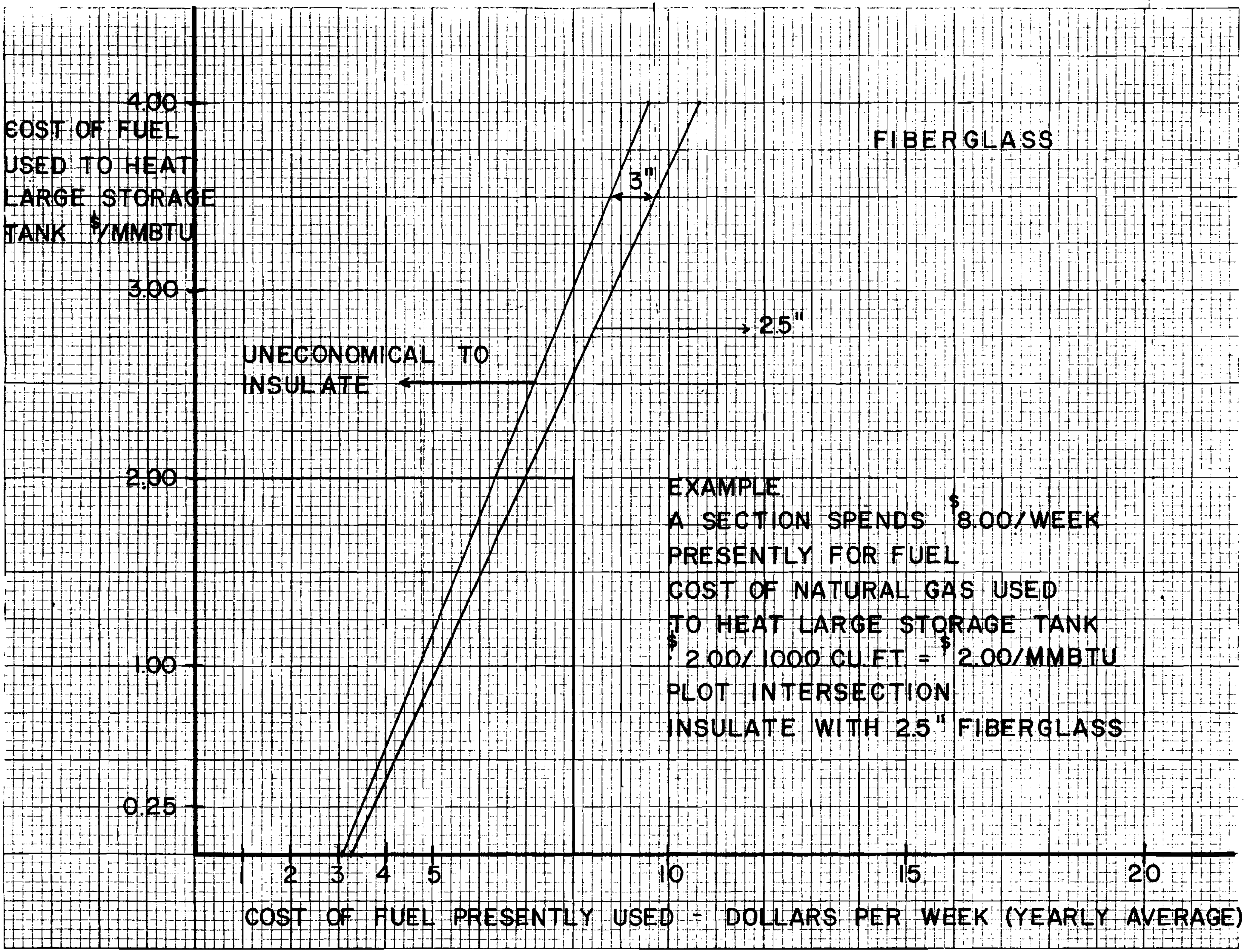

FIGURE 10 SELECTION OF INSULATION THICKNESS FOR FIBERGLASS

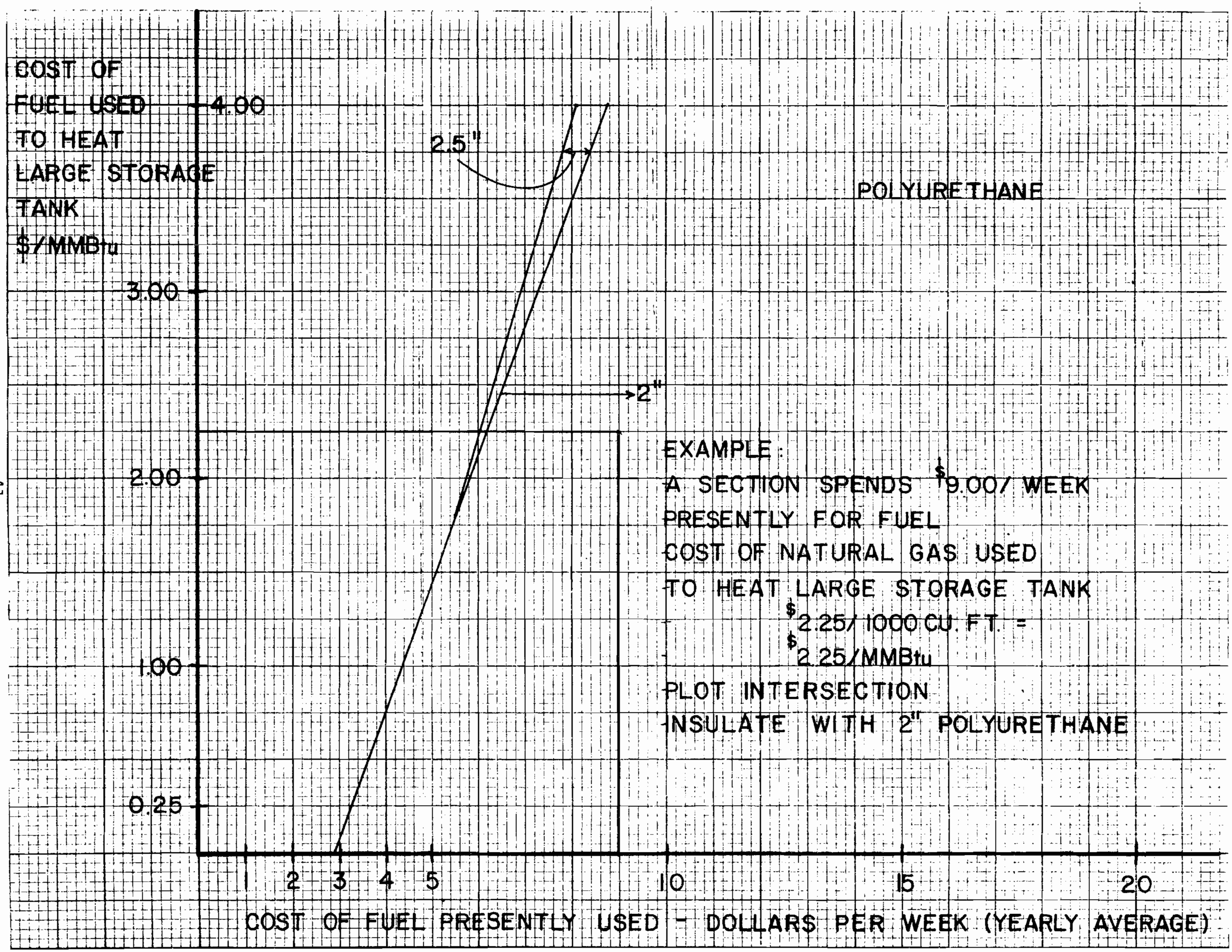

FIGURE II SELECTION OF INSULATION THICKNESS FOR POLYURETHANE the tank or a thermostatically controlled burner. Other drawbacks include:

1) A trained crew is necessary to operate the application spray rig, requiring considerable skill.

2) The durability is somewhat questionable since the age of most tanks previously insulated with foam is about 8 years. A 15 - 20 year lifetime should be expected.

3) The insulation will need to be repaired since the foam will be damaged. The cost will be about $50 per year.

4) An aluminum saddle will need to be used near the entry port in order to prevent spillage onto the insulation.

Positive points for the application of polyurethane foam are the fact that the initial cost is lower and it is a better insulator.

The rigid fiber glass with an aluminum shell has several advantages over polyurethane foam. The problem of high temperatures is alleviated since fiber glass can withstand terperatures up to 435^{O}F. The lifetime of the insulation will be indefinite provided a yearly check is made for water leaks. The installation procedure requires less skill although a trained crew would still need to be provided. However, since fiber glass incurs greater initial cost and is not as good an insulator, the payback period will be longer.

The installation of either type of insulation will require special care since poor application will considerable shorten the life of the insulation. The polyurethane foam requires the greatest skill and care in installation since a poor application will guarantee early failure of the insulation. The application of polyurethane foam requires extensive tank surface preparation. The tank must first be sandblasted to a clean finish and then spray painted with a prime coat, allowing suitable drying time before application of the foam. The foam is then sprayed in place to the desired thickness and coated with a butyl rubber weathercoat of 20 mil thickness. The cost of contracting the application of the foam is about $2.90 per square foot for 1" and adding $0.15 per square foot for each additional 1/2" of insulation. The cost of using state employees to apply the insulation will be about $1.25per square foot, adding $0.28per square foot for each additional 1/2" above 1".

The installation of the rigid board fiber glass will require less skill though it will be more expensive. The insulation is applied to the tank and covered with an 0.016" aluminum shell. In order to secure the shell, the aluminum is banded or pop riveted in place. All joints should be caulked to prevent the entry of water. The cost of contracting the job will be about $2.95 per square foot, adding $0.06 per square foot for each 1/2" above 1" thickness. The cost for employing state forces will be about $2.10 per square foot also adding $0.06 above 1". The fiber glass should prove to be the most economical selection of material over a period of 20 - 30 years.

Table of Costs

Fiber Glass

Contract Price

1"	$2315
1 1/2"	$2365
2"	$2410
2 1/2"	$2460
3"	$2500

Cost With the Use of State Employees

1" fiber glass @ $0.30/ft^2$	$236
1 1/2" @ $0.40/ft^2$	$314
2" @ $0.50/ft^2$	$393
2 1/2" @ $0.60/ft^2$	$471
3" @ $0.70/ft^2$	$550
300 ft^2^ aluminum 2.6 @ $85.00	$225
Bands, rivets and mastic	$150

Labor

1 foreman 32 hours @ $9.00	$288
3 laborers 96 hours @ $7.00	$672

Total Cost

1"	$1571
1 1/2"	$1649
2"	$1728
2 1/2"	$1806
3"	$1885

Table of Costs

Polyurethane

Contract Price	
1"	$2275
1 1/2"	$2400
2"	$2510
2 1/2"	$2525
Cost With the Use of State Employees	
10000 lbs. foam	$7050
1" covers 10000 ft.^{2}; cost per tank	$ 554
1 1/2" 6675 ft.^{2}; cost per tank	$ 829
2" 5000 ft.^{2}; cost per tank	$1107
2 1/2" 4000 ft.^{2}; cost per tank	$1384
Butyl rubber wearthercoat; 785 ft.^{2} @ \$0.18/ft.^{2}	$142
Prime coat; 785 ft.^{2} @ \$0.03/ft.^{2}	$ 25
Sand	$ 25
Labor	
1 foreman 8 hours @ $9.00	$ 72
2 laborers 16 hours @ $7.00	$112
Equipment	
Foam spray rig	$4600
Primer spray rig	$2000
Sand blast rig	$1500
Compressor	$7850
Cost per tank (approximate)	$ 50

Polyurethane continued

Total Cost

1"	$ 980
1 1/2"	$1255
2"	$1533
2 1/2"	$1810

Summary of Method for Calculations

The conclusions reached in the study to arrive at the economic insulation thickness were based on heat transfer calculations for a typical storage tank maintained at 140 °F and estimates of costs incurred for insulating the tanks with state employees.

The heat transfers (BTU/hr) for a typical tank 10' in diameter and 20' long with an average ambient temperature of 65°F are as follows:

	1"	1 1/2"	2"	2 1/2"	3"
Fiber Glass	12500	8800	6800	5500	4630
Polyurethane	8400	5830	4460	3600	

The economic calculations were based upon a minimum payback period of 20 years with money valued at 7% annually. The results are calculated from the minimum capital rate of return on the investment over a period of 20 years when compared to the present cost of fuel used in any given section. In other words, how much money must be saved per year because of insulation in order to justify the investment?

Example:

2 1/2 " fiber glass costs $1806/tank

$Q = 5500$ BTU/hr

boiler efficiency = 50%

cost of fuel presently used $10.00/week

cost of fuel used to heat large storage tank - natural gas - $2.25/MMBTU

The heat added per year:

$$Q_{yr} = \frac{5500 \times 24 \times 365}{0.50} = 9.636 \times 10^7 \text{ BTU}$$

Cost of fuel: LARGE TANK MAINTAINED AT 140°F

$$\frac{9.636 \times 10^7 \times 2.25}{1 \times 10^6} = \$216.81/\text{year}$$

Cost of insulating (20 year period)

$$C_{20} = (1.07)^{20} \times 1806 = \$6988.65$$

Rate of capital return per year in order to justify investment:

$$CRR = \frac{\$6988.65}{\frac{(1.07)^{20} - 1}{.07}} = \$170.47/\text{year}$$

The amount of money spent on fuel after insulating plus the rate of capital return must equal or exceed the amount presently spent on fuel.

$$C_{yr} = \$170.47 + \$216.81 = \$387.28/\text{year}$$

$$C_{week} = \frac{\$387.28}{52} = \$7.45/\text{week}$$

Since $7.45/week is less than $10.00/week, the insulation of the tank is justified.

Figures 10 and 11 were constructed with these types of calculations. No values are represented for insulation less than 2 1/2" for fiber glass and 2" for polyurethane because the cost of additional insulation is negligible compared to the fuel savings. One might guess that 6" of either insulation would be better than the recommended amount. However, the addition of any more insulation becomes less and less beneficial. The values given are judged to be the maximum useful thickness and should not be exceeded.

Figures 8 and 9 are provided strictly as a guideline in the event that a good cost estimate for present fuel usage is unavailable. The figures are based on the assumption that heating in portable units costs roughly $0.065/gallon of asphalt. Estimates of kerosene or butane useage and man hours involved in the heating process were included to arrive at the cost. Either of the two figures should be used <u>only</u> if no fuel cost estimates are available. The assumption of $0.065/gallon should be varified beforehand.

All of the presented calculations are based upon current fuel prices and the assumption that heating is done within the tank flues.

Conversion of Fuel Costs to $/MMBTU

Natural Gas

$1.00/cu. ft. = $1.00/MMBTU

Kerosene,diesel, butane, or propane

$1.00/gal × 6.6 gal/MMBTU = $6.60/MMBTU

Appendix B

Comments on UT-ME
Document

Appendix B
UT-ME Document - Comments

The UT-ME paper is self-explanatory; however, there are several items which will be expanded. Figures 1 through 7 of the UT-ME paper were developed to provide background information to the reader. As would be expected, for a given tank with a certain amount of insulation, the tank contents will lose temperature more rapidly at cooler outside air (ambient) temperatures, or winter loss will be greater than summer loss. Figures 2 through 4 also show temperature loss of the bare tank compared with one inch of fiberglass and one inch of polyurethane foam insulation. It may be noted that polyurethane foam is a more effective insulator as compared to fiberglass. The calculations were based on a 12,000-gallon tank which is 20 feet in length, and 10 feet in diameter.

Figures 5 through 6 show the temperature loss for the same (full) tank along with the cost of heating. The cost is based on heat being applied when the asphalt temperature falls to 100°F and shuts off when the temperature is raised to 140°F. Costs of heating a bare tank are compared with two types of insulation. Note that some 2,862,000 Btu are needed to increase the tank temperature from 100°F to 140°F at a 70°F air temperature. The Btu required to increase the temperature of 12,000 gallons of asphalt 40°F will vary due to loss from the tank while heating; however, it is estimated that 2.5 to 3.0 MMBtu will be needed. There appears to be a mistake in cyclic periods in Figure 6. It is believed the data on the plot should read:

Period		Cost per Day	% Savings
2.2 Days	Bare Tank	$7.81	
7.6 Days	Fiberglass	$2.26	346
11.2 Days	Polyurethane	$1.51	510

Figure 7 is similar to Figures 5 and 6 except the daily cost is based on a 2.5-day recycle period. In this case the cost of the heat needed to raise the temperature of a specific condition back to 140°F has been used. For example, the bare tank would need to be reheated from 100°F up to 140°F. However, the polyurethane would only need heat energy to increase the temperature from 130°F to 140°F for the same period.

Figures 10 and 11 of the UT-ME paper are the focal point of the response to the Department's request for aid. It may be noted that Figure 10 is for fiberglass insulation whereas Figure 11 concerns polyurethane foam. If a Departmental employee wanted to determine if fiberglass insulation on a storage tank is a given area would be economical, the procedure given on the plot of Figure 10 could be used. Only two items of information are needed, that is, (1) the average weekly cost of the fuel used and (2) the present cost of fuel (or energy) per MMBtu. It should be noted that the plot is based on calculations which maintain tank temperatures at 140°F when the air temperature is 65°F. A 65°F air temperature will be close to the statewide yearly average temperature.

As explained on page 37 of the document, Figures 8 and 9 are based on Figures 10 and 11. The vertical axis of both sets of plots are identical. The horizontal axis of Figure 8 was obtained by dividing the costs found on the horizontal axis of Figure 10 by $0.065/Gallon. The horizontal axis of Figures 9 and 11 are similarly associated. In effect the UT personnel converted average weekly fuel cost to number of gallons of asphalt used weekly if the cost of heating one gallon of asphalt is $0.065. Figures 8 and 9 were developed to use in case heating costs were unknown, particularly if a large storage tank is not heated and heating occurs in a small portable distributor or pot. In other words all the investigator needs to know is the amount of asphalt used weekly (whether heated in a large tank of a small distributor) and the unit cost of heating fuel in the subject area.

Figures 10 and 11 were based on calculations given on pages 51 and 52 of the UT-ME document. An expansion of these calculations follows:

> Note on page 47 the heat transfers for various thicknesses are given. For example, with the tank temperature at 140°F and air temperature at 65°F about 5500 Btu/hr will be lost through the tank with 2-1/2 inches of Fiberglass. This loss may be approximated as:
>
> $$Q = \frac{uA}{d} (T_T - T_A)$$
>
> $$Q = \frac{0.22(785)}{2.5} \ (140-65) = \text{about } 5500$$
>
> Where Q = energy loss (Btu/hr)
> u = thermal conductivity of fiberglass (Btu/inch, °F, ft^2, hr) (0.22 for fiberglass and 0.14 for polyurethane)
> A = surface area of the tank (785 ft^2)
> d = insulation thickness (inches)
> T_T = Tank Temperature (°F)
> T_A = Air temperature (°F)

This heat loss must be replaced. The tanks to be heated are generally fabricated with two 6" pipe flues running the length of the tank. A forced air burner directs the flame into the flue. Natural gas or diesel is generally used as fuel. The heat transfer occurs from the burned fuel through the flue into the asphalt. UT-ME estimates the efficiency of this type of heater to be 50 percent. This would mean that to obtain one unit of energy (Btu) in the asphalt, twice this energy must be used. Therefore 11,000 (that is 2 x 5500) Btu will be used each hour. The document shows some 96.36 MMBtu will be used each year. If the fuel costs $2.25 per MMBtu, the annual cost will be $216.81 as shown on page 47 of the document.

UT-ME personnel contacted insulation contractors in the spring of 1978 and obtained the information found on pages 44 through 46. Page 44 of the paper indicates that the cost of covering a 12,000-gallon storage tank (785 ft^2) with 2-1/2 inches of fiberglass will be about $1806. If $1806 were invested at 7 percent over a 20-year period the total worth would be $6,988.65 as shown on page . The benefits of insulation must exceed this amount. Therefore; the rate of capital return per year is $170.47 also shown on page 47 of the document.

There are basically two costs involved which must be considered. The cost of the insulation ($170.47 per year) and the cost of the fuel needed to maintain the asphalt at 140°F with 65°F air temperature ($216.81/year). If these costs are summed and divided by 52, the weekly cost is obtained ($7.45/week).

If the above procedure was repeated for various unit fuel costs, Table II would result. Note the insulation cost is constant regardless of fluctuations in fuel costs. Data similar to that found in Table II was used to prepare the 2-1/2-inch plot shown in Figure 10 of the UT-ME paper. The 2-1/2-inch linear curve shown on Figure 10 is based on the cost of maintaining the asphalt tank at a level where the material could be loaded and used without other heating. Therefore, the economics of heating asphalts in other equipment such as a small distributor can be compared. Using the example on Figure 10, assume the asphalt in a tank is maintained at 140°F with 65°F air temperature and fuel costs $2.00/MMBtu. Then 2-1/2 inches of fiberglass insulation is in place, the cost to the Department will be about $7.00/week. In comparison, if the present weekly cost of heating in a small distributor is $8.00 (4 Gal/Day @ 2 Days/Week @ $0.50/Gal = $4.00 plus 1/2 man hour delay per week @$8.00/hr. = $8.00/week), it would pay to insulate with 2-1/2 inches of fiberglass. It would appear as if $1.00 per week could be saved. On the other hand, if the asphalt used is not heated, and small quantities are used daily, the average weekly cost may be less than $4.00. In this case, insulation will be uneconomical.

Little is known about the life of polyurethane foam when used as storage tank insulation. Some of the oldest insulation of this type on heated exposed tanks which could be found was about 8 years of age. UT-ME personnel indicate, on page 37 of the document, that the foam will lose bond with a steel tank at 200°F. But during conversations with an insulation contractor, the contractor indicated successful use in temperatures up to 300°F. Based on the information collected, it is suggested that foam not be used on storage tanks where cutbacks or oil asphalts are to be heated and maintained. Fiberglass could be used in this case. However, it does appear that either foam or fiberglass could be used with tanks containing emulsion. Other types of insulation are available which can be used on storage tanks. If other types are considered, it is suggested that study be given to the effects of tank heat, gasoline or asphalt spillage, and weatherproofing needed.

Various types of protective coatings have been used for both foam and fiberglass. Protective coatings are essential to good insulation and must be used. It is suggested that the protective coating for the fiberglass be a jacket fabricated from aluminum sheets at least 0.016-inch in thickness. Further it is suggested that the protective coating for foam be composed of one of the following materials which are generally applied by spraying or by brush:

1. Urethane
2. Neoprene-hypalon
3. Silicone
4. Hypalon mastic
5. Chlorinated Rubber
6. Acrylic

TABLE A
ECONOMICS ASSOCIATED WITH 2.5 INCHES
OF FIBERGLASS INSULATION

Cost of Fuel per MMBtu ($)	Rate of Capital Return-Tank ($)	Annual Fuel Cost ($)	Total Annual Cost ($)	Weekly Cost ($)
0	170.47	0	170.47	3.28
0.25	170.47	24.09	194.56	3.74
1.00	170.47	96.36	266.83	5.13
2.00	170.47	192.72	363.19	6.98
3.00	170.47	289.08	459.55	8.84
4.00	170.47	385.44	555.91	10.69

APPENDIX C

TREATING STORED ASPHALT

DISTRICT COMMENTS

HEATING OF ASPHALT STORAGE TANKS

District 1 **Location** Paris

No. of Heated Tanks 1 Mobile 1 Stationary **No. Unheated Tanks** ______

Method of Heating "Super Heater" - Kerosene

Type of Asphalt Heated RC-2

Cost of Fuel $.412/gal. **No. of Insulated Tanks** ______

Size of Tank 12,000 gal.

Frequency of Use **Summer** every 5 to 10 days

Winter every 10 to 15 days

Maintained Temperature ~ 100 degrees F.

Remarks: This is just one maintenance section. Probably ten in the District. One tank is stationary and the other mobile. Tank is heated on the average of 1 to 2 times per month for 1 to 2½ hours before use.

HEATING OF ASPHALT STORAGE TANKS

District 2   Location Fort Worth

No. of Heated Tanks 8   No. Unheated Tanks 26

Method of Heating kerosene

Type of Asphalt Heated RC-250, RC-5, Emulsion

Cost of Fuel $ .45/gal.   No. of Insulated Tanks 5

Size of Tank 12,000

Frequency of Use   Summer ______

Winter ______

Maintained Temperature ______

Remarks: Insulated tanks have 3" fiberglass plus tin shells.
One portable tank for AC asphalts. Tanks heated 30-60 days per year.
Total cost for fuel and labor for heating all tanks approximately $20,600.

HEATING OF ASPHALT STORAGE TANKS

District 3

Location Wichita Falls

No. of Heated Tanks 5

No. Unheated Tanks 14

Method of Heating Natural Gas - Forced Air Burners in Flues

Type of Asphalt Heated RC-250 Emulsion

Cost of Fuel $2.70 - 3.12/1000 cu.ft.

No. of Insulated Tanks

Size of Tank heated - 14,000 gal.
unheated - 11,750 gal.

Frequency of Use

Summer daily

Winter daily

Maintained Temperature 2 tanks @ 140 degrees F.
3 tanks @ 90-100 degrees F

Remarks:

HEATING OF ASPHALT STORAGE TANKS

District 4 Location Amarillo

No. of Heated Tanks 2 No. Unheated Tanks 36

Method of Heating Natural Gas - Burners in Flues

Type of Asphalt Heated RC-250 Emulsion

Cost of Fuel $ Winter 100/mo./tank No. of Insulated Tanks 2-1" polyurethane foam

Size of Tank 10,000 gal

Frequency of Use Summer

Winter

Maintained Temperature When in use 165-170 degrees F.

Remarks: When using the 600 gal. distributors, the asphalt is heated about 1 hour before use.

HEATING OF ASPHALT STORAGE TANKS

District 5 Location Lubbock

No. of Heated Tanks 19 No. Unheated Tanks 19

Method of Heating Natural Gas - Heater in Flues

Type of Asphalt Heated AC-5, RC-2, MC-30, MC-800, EA-11M

Cost of Fuel $ 1.85/MCF No. of Insulated Tanks

Size of Tank 12,000 gal.

Frequency of Use Summer

Winter

Maintained Temperature 175 - 260 degrees F.

Remarks: Average cost of $769.00/year/tank to heat. Tanks heated only small amount in morning before use, then heating is continued in small distributors.

HEATING OF ASPHALT STORAGE TANKS

District 6 | Location Odessa

No. of Heated Tanks 6 | No. Unheated Tanks 20

Method of Heating 4-gas, 1-elect. (not used past several years)

Type of Asphalt Heated MC-800, EA-10S

Cost of Fuel $2.00/MCF | No. of Insulated Tanks

4"valves replaced by 6" valves

Size of Tank 10 to 12,000 gal.

8 - two compartment

18 - one compartment

Frequency of Use Summer

Winter

Maintained Temperature 70 - 80 degrees F.

Remarks: Heated storage tanks maintained at 70-80 degrees F. After asphalt loaded into 600 gal. distributor, then heated to 125-130 degrees F. for emulsions and 150-175 degrees F. for MC-800. Small distributors heated with butane or kerosene at $.45/gal. Heaters used an estimated 60 days per year.

HEATING OF ASPHALT STORAGE TANKS

District 7 — Location San Angelo

No. of Heated Tanks 3 — No. Unheated Tanks 17

Method of Heating Butane or Natural Gas Burners

Type of Asphalt Heated MC-800

Cost of Fuel $.50/gal.- Butane $2.00/MCF-gas — No. of Insulated Tanks

Size of Tank 10,000 gal.

Frequency of Use — Summer daily - 2 weeks/mo.

Winter daily

Maintained Temperature 100 degrees F.

Remarks: All tanks painted black. Heat maintained at 100 degrees F. After loaded into 600 gal. distributor, then heated approximatly 4 hours using 10 to 15 gal. of kerosene or diesel at a cost of $.45 to $.50 per gal.

The District uses an average of 600 gal. of asphalt per week. They are in the process of adding heating flues to remainder of tanks.

HEATING OF ASPHALT STORAGE TANKS

District 8 | Location Abilene

No. of Heated Tanks 0 | No. Unheated Tanks 24

Method of Heating Heated in Distributors

Type of Asphalt Heated Emulsion, RC & AC

Cost of Fuel $ ______ No. of Insulated Tanks ______

Size of Tank 10,000 gal.

Frequency of Use Summer ______

Winter ______

Maintained Temperature ______

Remarks: Tank valves heated with electro-tape. Deliveries are timed to use preheated asphalt and subsequent heating is made in 600 gal. distributor or pots.

HEATING OF ASPHALT STORAGE TANKS

District 9 | Location Waco

No. of Heated Tanks 0 | No. Unheated Tanks 25

Method of Heating Heated in Distributors

Type of Asphalt Heated Emulsions

Cost of Fuel $ | No. of Insulated Tanks 1

Size of Tank 12,000 gal.

Frequency of Use Summer seal and patch

Winter not much

Maintained Temperature

Remarks: Small distributor or pot is loaded and heating is then performed.

HEATING OF ASPHALT STORAGE TANKS

District 10 — Location Tyler

No. of Heated Tanks ____ — No. Unheated Tanks 11

Method of Heating Diesel - Super Heater occasionally (1 to 2 times/year)

Type of Asphalt Heated RC-2

Cost of Fuel $ .52/gal. — No. of Insulated Tanks ____

Size of Tank 10 to 12,000 gal.

Frequency of Use — Summer 2 to 3 per week

Winter ____

Maintained Temperature occasionally to 175 degrees F.

Remarks: Small Distributor or pot is loaded, then heating is performed with butane fired heater using approximately 5 gal. butane at $.45/gal.

HEATING OF ASPHALT STORAGE TANKS

District 11 Location Lufkin

No. of Heated Tanks 2 No. Unheated Tanks 8

Method of Heating electric element

Type of Asphalt Heated emulsion

Cost of Fuel $200/mo/tank No. of Insulated Tanks 2-under ground

Size of Tank 12 to 18,000 gal.

Frequency of Use Summer ______

Winter ______

Maintained Temperature ______

Remarks: ______

HEATING OF ASPHALT STORAGE TANKS

District 12 Location Houston

No. of Heated Tanks 0 No. Unheated Tanks 12

Method of Heating ______

Type of Asphalt Heated RC-2

Cost of Fuel $______ No. of Insulated Tanks ______

Size of Tank 10 to 12, 000 gal.

Frequency of Use Summer ______

Winter ______

Maintained Temperature ______

Remarks: Small distributor is loaded, then heated with butane.

HEATING OF ASPHALT STORAGE TANKS

District 13 Location Yoakum

No. of Heated Tanks 12 No. Unheated Tanks 9

Method of Heating Kerosene Burners in 6" Flues

Type of Asphalt Heated CRS-2, RC-250, EA-105

Cost of Fuel $ No. of Insulated Tanks

Size of Tank 13-11,750 gal 3-10,600 gal. 1-11,000 gal.
1-12,000 gal 2-13,000 gal. 1-14,000 gal.

Frequency of Use Summer

Winter

Maintained Temperature

Remarks: Tanks heated only during winter months (Nov.-March) when asphalt is to be used or to prevent emulsified asphalt from separating. Tanks are painted black and some have windbreakers around bottom. An estimated 1,500 gallons of fuel per year is used to heat tanks. When asphalt is heated in small 600 gal. distributors it takes 1 man hour and 15 gallons of kerosene at $.42/gallon.

NOTE: One tank of emulsion was lost in this District due to freezing. The emulsion "Broke" leaving a high viscosity asphalt separated from the water. They believe the Flues are too high in the tank and not heating the lower portion.

HEATING OF ASPHALT STORAGE TANKS

District 14 Location Austin

No. of Heated Tanks Lockhart 1 No. Unheated Tanks ________

Method of Heating Natural Gas Burner

Type of Asphalt Heated MC-800

Cost of Fuel $14.50 to 26.00/mo. No. of Insulated Tanks ________

Size of Tank 11,000 gal.

Frequency of Use Summer ________

Winter ________

Maintained Temperature ________

Remarks: This is only one maintenance section of 12 in the District.

HEATING OF ASPHALT STORAGE TANKS

District 16 | Location Corpus Christi

No. of Heated Tanks 0 | No. Unheated Tanks 18

Method of Heating ____________________

Type of Asphalt Heated ____________________

Cost of Fuel $ ____________ | No. of Insulated Tanks 0

Size of Tank 9-100,000 gal.
9-12,000 gal.

Frequency of Use Summer ____________________

Winter ____________________

Maintained Temperature ____________________

Remarks: ____________________

HEATING OF ASPHALT STORAGE TANKS

District 17 Location Bryan

No. of Heated Tanks 2 No. Unheated Tanks 10

Method of Heating Elect. Heaters

Type of Asphalt Heated OA

Cost of Fuel Approx. $12,000/Mo $1,207.00/45,438KW/H No. of Insulated Tanks 4 underground

Size of Tank 4 - 12,000 gal 1-10,000 gal 3 - 8,000 gal. 1 - 10,400 gal 1- 8,500 gal 1 - 7,800 gal. 1 - 7,500 gal

Frequency of Use Summer

Winter

Maintained Temperature 275-280 degrees F.

Remarks: Gravity flow requires approximately 1 hour per 100 gal. to fill distributor from storage tank in winter months.

HEATING OF ASPHALT STORAGE TANKS

District 18 Location Dallas

No. of Heated Tanks 0 No. Unheated Tanks 4-port. 12-perm

Method of Heating ____

Type of Asphalt Heated EMUL. RC-2. Cutbacks

Cost of Fuel $ ____ No. of Insulated Tanks 1-portable

Size of Tank 10,000 gal.

Frequency of Use Summer ____

Winter ____

Maintained Temperature ____

Remarks: Heating accomplished in small distributors only.

HEATING OF ASPHALT STORAGE TANKS

District 19 Location Atlanta

No. of Heated Tanks 0 No. Unheated Tanks 2 port, 4 stat.

Method of Heating kerosene in circulating heater for 2 skid mounted portable tanks

Type of Asphalt Heated MC-30, RS-2

Cost of Fuel $ _____ No. of Insulated Tanks _____

Size of Tank 5,500 to 12,000 gal.

Frequency of Use Summer _____

Winter _____

Maintained Temperature _____

Remarks:

HEATING OF ASPHALT STORAGE TANKS

District 20 Location Beaumont

No. of Heated Tanks 0 No. Unheated Tanks 10

Method of Heating ______

Type of Asphalt Heated ______

Cost of Fuel $______ No. of Insulated Tanks 0

Size of Tank 11,000

Frequency of Use Summer ______

Winter ______

Maintained Temperature ______

Remarks: Heating done in distributors only. RC-2 and EA11-M used.

HEATING OF ASPHALT STORAGE TANKS

District 21 | Location Pharr

No. of Heated Tanks 22 | No. Unheated Tanks ____

Method of Heating Kerosene or Diesel in Salamander Heaters

Type of Asphalt Heated Emulsions - Rapid and Medium set

Cost of Fuel $____ No. of Insulated Tanks ____

Size of Tank 12,000 gal.

Frequency of Use Summer ____

Winter ____

Maintained Temperature 100-140 degrees F

Remarks: Ranks painted black with enclosed stands. Heaters used approximately 6 times in 13 years.

HEATING OF ASPHALT STORAGE TANKS

District 22 Location Del Rio

No. of Heated Tanks 10 No. Unheated Tanks ______

Method of Heating Butane Heaters

Type of Asphalt Heated RC-2

Cost of Fuel $______ No. of Insulated Tanks 2- portable

Size of Tank 12,000 gal.

Frequency of Use Summer ______

Winter ______

Maintained Temperature just enough to load

Remarks: Tanks heated just as needed and just enought to load distributor. Additional heating in distributor.

HEATING OF ASPHALT STORAGE TANKS

District 23 | Location Brownwood

No. of Heated Tanks 1 | No. Unheated Tanks ?

Method of Heating Butane & Natural Gas - Forced Air Burners in Flues

Type of Asphalt Heated summer - CRS-2
winter - EA-11M

Cost of Fuel $ | No. of Insulated Tanks 1-3" Fiberglass

Size of Tank 11,000 gal.

Frequency of Use Summer

Winter

Maintained Temperature just enough to flow

Remarks: Tank insulated with 3" fiberglass bats banded on and asphalt mastic painted on by brush. Still in good condition after 5-6 years.

HEATING OF ASPHALT STORAGE TANKS

District 25 | Location Childress

No. of Heated Tanks ______ | No. Unheated Tanks 16

Method of Heating ______

Type of Asphalt Heated ______

Cost of Fuel $______ | No. of Insulated Tanks ______

Size of Tank 11,000 gal.

Frequency of Use — Summer ______

Winter ______

Maintained Temperature ______

Remarks: Insulation and heating system desired to enable use of asphalt other than RC-2.