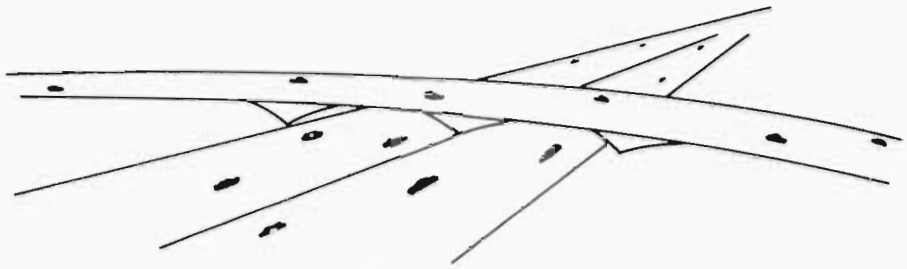

DEPARTMENTAL RESEARCH

Report Number 229-1

Solar Heating An Asphalt Storage Tank

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

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16. Abstract

This report describes a solar heating system for a 12,000 gallon asphalt storage tank. The solar system uses a water heater as a backup system. The asphalt to be heated is a rapid-cure cutback (RC-2). The design, plans, specifications and costs are included.

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SOLAR HEATING AN ASPHALT STORAGE TANK

in

Lubbock, Texas

by

Kenneth D. Hankins

Research Report 229-1

Research Study 1-10-78-229

Asphalt Tank With Solar Heating

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

June, 1978

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

The United States Government and the State Department of Highways and Public Transportation do not endorse products or manufacturers. Trade or manufacturer's names appear herein solely because they are considered essential to the object of this report.

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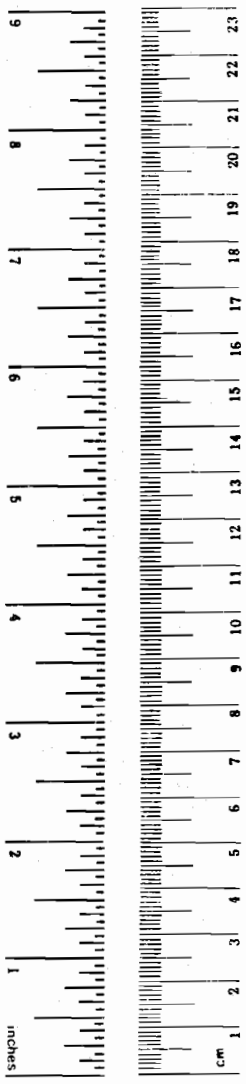
METRIC CONVERSION FACTORS

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

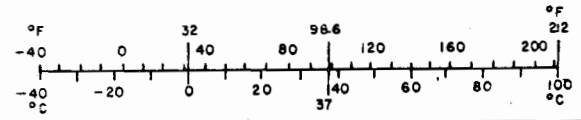


TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

IMPLEMENTATION

The implementation of this report is inherent in that a solar-heated asphalt tank is to be installed. Future implementation or other uses of this method of heating tanks will depend on the result of this study, particularly, initial costs and the pay-off time period.

Other items related to implementation are:

(1) Application of knowledge gained in this project to other fields such as heating or cooling departmental buildings, restareas, and information centers.

(2) Energy savings by using insulation on tanks without solar heating. In certain tank installations presently in use, energy savings would result with a rather quick pay-off if insulation were provided for the tank.

(3) Knowledge gained in this project will serve as a foundation for expanded uses of other types of solar heating such as concentrating, tracking collectors.

SOLAR HEATING AN ASPHALT STORAGE TANK

IN

LUBBOCK TEXAS

I. DESIGN INFORMATION

The asphalt storage tank to be heated is a 12,000 gallon tank which is 10 feet in diameter and 20 feet in length. The tank location will be in the Lubbock, Texas area. After discussions with Oklahoma and Arizona transportation personnel it was decided to heat the asphalt tank using Solar-assisted methods.(1)

The design of the solar system for the storage tank was performed by Mr. Stan Bond under the direction of Dr. Jerald Jones with the Mechanical Engineering Department at the University of Texas through a request to Dr. Clyde E. Lee with the CFHR.(2) The design utilizes the concept that the asphalt will be delivered at a high temperature and the heat loss or cooling of the tank due to the temperature differential between tank and ambient air temperature must be resupplied by solar energy. The optimum design would consider summer temperatures as well as winter temperatures. In other words, the design should consider air temperature conditions between summer and winter. Previous studies indicate a two-inch foam insulation on the tank optimizes cost and heat loss.(3)

The heat loss of the tank was calculated using the following equation:

$$Q_{Loss} = UA \quad (T_{Tank} - T_{amb})$$

Where

Q_{Loss} = Heat Loss in Btu/hr

U = Insulation Factor in Btu/hr ft^2 °F

A = Surface Area of the Tank

T_{Tank} = Temperature of the Tank (or contents) in °F

T_{amb} = Ambient Air Temperature

$$A = 2(\pi R^2) + \pi DL$$

$$= 2(\pi 5^2) + \pi(10)(20) = 785.4 \text{ ft}^2$$

$U = 0.07$ Btu/hr ft^2 °F for 2-inch foam insulation

T_{Tank} = assumed to be 180° F

T_{amb} = 39° F for Winter (Average temperature in Lubbock in January for 1976)

= 80° F for summer (Average temperature in Lubbock in July for 1976)

Then for Winter

Q_{Loss} = 55.9 Btu/hr °F (180° F - 39° F) X 24 hr/day

= 190,000 Btu/day

For Summer

Q_{Loss} = 55.9 Btu/hr °F (180° F - 80° F) X 24 hr/day

= 130,000 Btu/day

Solar energy has not been adequately measured throughout Texas or the United States at the present time. For example, only four stations have reported Solar energy in Texas for a period of seven years. Cloud cover and other factors suggest that historical records are needed. However, it becomes necessary to estimate this energy from published contour maps. These maps, or estimated tables, offer average monthly values. Solar energy information is offered based on flat or horizontal plate measurements and is often called "insolation." Insolation values are available in terms of Btu/ft^2 Day. To convert the daily values to hourly values it is necessary to employ a factor which estimates the fraction of the daily total isolation available during the hour in question. This fraction changes daily and the daily fractions change monthly as the sun declination varies. The angle at which the sun strikes the collector(s) is very important and should be as close to normal or perpendicular as possible. The sun declination angle changes throughout the year and ranges from a +23°27' to a -23° 27' with the autumn and spring seasons being near 0° (or in a plane with the equator). The latitude at which the panel is located also influences angle at which the sun strikes the collector face. Other angles are used in the calculations such as the angle between the sun and a horizontal plane as the angle changes from morning to evening. Therefore, it is necessary to tilt the collector panel. This tilt angle should be continually changed for optimum conditions but in this design it is held constant in relation to the winter season. The reasoning is that sufficient solar energy will be available to the tank in the summer even if the tilt angle is set for winter. The collectors should be positioned so that the tilt angle is north - south (top to bottom) so that the sun passes over the collectors in an east - west manner. Even in this position there will still be some solar energy reflected from the collector surface and lost.

The solar collectors have various and changing efficiencies and are affected by heat losses through the collector insulation, flow rate through the collector, etc. Therefore the collector efficiency is continually changing and it is probably not possible to find a collector at present with an average efficiency greater than about 60%.

The calculations showing the solar input are shown on Tables II and III for a selected collector. Table II is for January and Table III is for July. Note the calculations are for 1/2 day with the remaining 1/2 day assumed to be similar. The results are given in terms of Btu/ft^2 for a representative day. Therefore, the size or surface area of the collector would depend on sufficient solar energy being obtained and supplied to the tank to offset the heat loss from the tank. The calculations are as follows:

Heat loss in January = 190,000 Btu/Day (previous calculations)

Solar Energy available in January = 922 Btu/ft^2 Day

$$\frac{190{,}000 \text{ Btu/day}}{922 \text{ Btu/ft}^2 \text{ Day}} = 206 \text{ ft}^2$$

Heat loss in July = 130,000 Btu/Day (previous calculations)

Solar Energy available in July = 636 Btu/ft^2 Day

$$\frac{130{,}000 \text{ Btu/Day}}{636 \text{ Btu/ft}^2 \text{ Day}} = 204 \text{ ft}^2$$

The selected collector contains 36 ft^2 of effective area per panel. Six panels or 216 ft^2 were recommended.

Time: Solar time.

F_P: Fraction of daily total insolation for each hour of the day.

Q: Daily insolation $\bar{X}'' F_P$.

$\text{Cos}\theta_z$: Cosine of Azimuth angle.

$\text{Cos}\theta_T$: Cosine of angle between sun at solar noon and normal to collector.

$F_{\tau\alpha}$: Normalized transmission factor to compensate for losses in cover glass at angles other than normal.

Q_N: $Q \times \frac{\text{Cos } \theta_T}{\text{Cos } \theta_z} \times F$

$\frac{T}{Q_N}$: $(T_{\text{collector inlet}} - T_{\text{ambient}}) / Q_N$ $\quad \frac{°F \text{ hr ft}^2}{\text{Btu}}$

η : Collector efficiency = $.67 - .34 \frac{\Delta T}{Q_N}$

Qu : energy collected.

Note: Calculation procedure is from Dr. Gary Vliet's solar energy course at U. T.

TABLE I
DESCRIPTION OF TERMS

TABLE II

SOLAR ENERGY CALCULATIONS FOR JANUARY

January, Lubbock, δ = -20, T_{amb} = 39° F, Latitude 34°, Tilt 44°

Tank temperature = 180°, Collector inlet temperature = 200° F, Day length = 10 hr.

Average insolation = 1202 $\frac{Btu}{ft^2/day}$ (from State Energy Conservation Manual) KTA Collector $\left[.67 - .34 \left(\frac{\Delta T}{Q_N}\right)\right]$

Time	F_P	Q	Cos θ_z	Cos θ_T	$\frac{\text{Cos } \theta_T}{\text{Cos } \theta_Z}$	F_{2-}	Q_N	$\frac{\Delta T}{Q_N}$	2	Q_u
7:30	.020	24	.10	.41	4.1	.60	59	2.7	0	0
8:30	.065	78	.28	.62	2.2	.85	146	1.1	.25	36
9:30	.110	132	.41	.78	1.9	.95	238	0.67	.45	107
10:30	.145	174	.51	.90	1.8	.99	310	0.52	.48	149
11:30	.165	198	.56	.96	1.7	1.00	337	0.48	.50	169
		606								
								Half Day Collection:		461
								Full Day:		922

TABLE III

SOLAR ENERGY CALCULATIONS FOR JULY

July, Lubbock, $\delta = +20$, $T_{amb} = 80°$ F, Latitude = 34°, Tilt = 44°

Tank Temperature = 180° F, Collector inlet temperature = 200° F, Day length = 14 hr.

Average insolation = 2544 $\frac{Btu}{ft^2 day}$ (from State Energy Conservation Manual)

Time	F_P	Q	Cos θ_z	Cos θ_T	$\frac{\text{Cos } \theta_T}{\text{Cos } \theta_z}$	$F_{\tau\alpha}$	Q_N	$\frac{\Delta T}{Q_N}$	η	Q_u
5:30	.010	25								
6:30	.025	64								
7:30	.044	112	.51	.29	.57	.42	27	4.4	0	0
8:30	.079	201	.68	.50	.74	.70	89	1.4	0	0
9:30	.099	252	.82	.65	.79	.85	169	0.71	.42	71
10:33	.113	287	.92	.79	.81	.95	221	0.54	.48	106
11:30	.124	315	.97	.86	.87	.99	271	0.44	.52	141
		1055								

Half Day Collection: 318 $\frac{Btu}{ft^2}$

Full Day Collection: 636 $\frac{Btu}{ft^2}$

II. CALCULATIONS FOR A PRESSURE DROP OF HEATING AGENT

The collector system specified uses 0.03 gpm per square foot of collector. There are 42 square feet of collector area per panel (even though the effective area is 36 ft^2). Therefore,

$$42\ ft^2 \times 0.03\ gpm/ft^2 = 1.26\ gpm.$$

The collector system also has a pressure drop of 0.29 psi per panel at 1.26 GPM. Since the six panels are connected in parallel rather than in series, the six panels would be similar to one panel requiring 1.26 GPM and there would be a pressure drop of 0.29 psi.

The elevations shown on the plans indicate a head loss of about 10.0 feet or 4.32 psi.

The pressure loss in the tubing to, from, and through the storage tank is assumed to be equal to 1-1/2 times that of a collector panel or about 0.44 psi.

Therefore:

Total Pressure Drop = Collector Press. Drop + Head + Tubing Press. Drop

= 0.29 psi + 4.32 psi + 0.44 psi = 5.05 psi

Total Flow Rate = 1.26 GPM.

A circulation pump was selected to meet these requirements.

III. TANK TEMPERATURES WITH SOLAR HEAT

Even with the above calculations in hand it is difficult for highway personnel who are not experienced in solar energy and heat transformation to visualize the actual ebb and flow of temperature within the system. Therefore, the author attempted the calculations that follow. "Solar Energy Thermal Processes; by John A. Duffie and William A. Beckman was used as source information.(4)

In the system described, some heat loss will occur even though the entire system is insulated. The energy loss in the collectors has been considered in the calculations in the form of collector efficiency. Energy will also be lost through the tubing, pump, valves, and other hardware. However, the major energy loss will occur at the asphalt tank. The energy loss will be replaced through solar or auxiliary heat.

The following equation was used to calculate the tank temperatures at various times and conditions:

$$T_{New} = T_{Old} - \frac{t}{WC}\left[Q_{in} - uA\,(T_{Old} - T_{amb})\right.$$

Where:

T_{New} = New temperature in °F

T_{Old} = Old temperature in °F

t = Time differential considered in hours (or 1 hour)

W = Weight of material (or asphalt) considered in pounds or 83,300 lbs

C = Specific heat of material (or asphalt) considered in Btu/lb/°F or 0.75 Btu/lb/°F

Q_{in} = Energy input into the material in Btu/hr

U = Thermal transfer factor in $Btu/ft^2 hr°F$ or 0.08 Btu/ft^2 hr °F

A = Surface area of the tank in ft^2 or 785 ft^2

T_{amb} = Ambient air temperature in °F

Note the portion of the equation relating to conduction heat loss is $UA(T_{Old} - T_{amb})$. The energy input supplied by solar or auxiliary means is the Q_{in} which was obtained from the design in Tables II and III. The difference between the energy loss and energy gain could be termed the resultant energy. The t/WC converts the resultant energy to resultant temperature. If the resultant temperature is subtracted from the previous temperature (T_{Old}) a new temperature is determined (T_{New}). A continuation of these calculations at a t interval will reveal the ebb and flow of the temperature in the tank. Tables IV and V show hourly calculations for a one-day period for the subject system in Lubbock in January and July repectively. The time shown is solar but does approximate the central stan-

LUBBOCK
BASED ON 1976 DATA

$$T_{NEW}=T_{OLD}-\frac{1}{83{,}300(.75)}\ Q_{IN}\cdot 62.8(T_{OLD}-T_{AMB})$$

Time (Hour)	Q_{IN} BTU/Hr.	Aug. Ambient Temp.° F	Old Temp.	New Temp.	Δ T	Q_{LOSS} 62.8(ΔT)	Result $Q_{IN}-Q_{LOSS}$	TEMP .000016(Result)
6		26.1	180	179.85	153.9	-9665		-0.15
7		28.7	179.85	179.70	151.15	-9492		-0.15
8		32	179.70	179.55	147.7	-9275		-0.15
9	9072	35.9	179.55	179.56	143.65	-9021	+ 51	+0.01
10	26964	40	179.56	179.85	139.55	-8764	+18,200	+0.29
11	37548	44.1	179.85	180.31	136.75	-8525	+29,023	+0.46
12	42588	48	180.31	180.86	132.31	-8309	+32,279	+0.55
13	42588	51.3	180.86	181.39	129.56	-8136	+34,452	+0.55
14	37548	53.9	181.39	181.86	127.49	-8006	+29,542	+0.47
15	26964	55.5	181.86	182.16	126.36	-7935	+19,029	+0.30
16	9072	56	182.16	182.18	126.16	-7923	+ 1,149	+0.02
17		55.5	182.18	182.05	126.68	-7956		-0.13
18		53.9	182.05	181.92	128.15	-8048		-0.13
19		51.3	181.92	181.79	130.62	-8203		-0.13
20		48	181.79	181.66	133.79	-8402		-0.13
21		44.1	181.66	181.52	137.56	-8639		-0.14
22		40	181.52	181.38	141.52	-8887		-0.14
23		35.9	181.38	181.23	145.48	-9136		-0.15
24		32	181.23	181.08	148.23	-9372		-0.15
1		28.7	181.08	180.93	152.38	-9569		-0.15
2		26.1	180.93	180.77	154.83	-9723		-0.16
3		24.5	180.77	180.61	156.27	-9814		-0.16
4		24	180.61	180.45	156.61	-9835		-0.16
5		24.5	180.45	180.29	155.95	-9794		-0.16
6		26.1	180.29	180.14	154.19	-9683		-0.15
7		28.7	180.14	179.99	151.44	-9510		-0.15
8		32	179.99	179.84	147.99	-9294		-0.15
9	9072	35.9	179.84	179.70	143.94	-9039		-0.14

TABLE IV

Hourly Temperatures in January

Lubbock
BASED ON 1976 DATA

$$T_N = To - \frac{1}{83300(0.75)} Q_{IN} \qquad Q_{IN} = 62.8(To - T_A)$$

Time (Hour)	Q_{IN} BTU/Hr.	Avg. Ambient Temp. °F	Old Temp.	New Temp.	ΔT	Q_{LOSS} 62.8(ΔT)	Result $Q_{IN} - Q_{LOSS}$	Temp. 0.000016(Result)
6	0	67.205	180	179.887	112.795	-7083		-0.113
7	0	68.637	179.887	179.775	111.250	-6986		-0.112
8	0	70.500	179.775	179.665	109.275	-6862		-0.110
9	17892	72.669	179.665	179.844	106.996	-6719	+11,173	+0.179
10	26712	75.000	179.844	180.167	104.844	-6542	+20,170	+0.323
11	35532	77.331	180.167	180.632	102.836	-6458	+29,074	+0.465
12	35532	79.500	180.632	180.099	101.132	-6351	+29,181	+0.467
13	26712	81.363	181.099	181.426	99.736	-6263	+20,449	+0.327
14	17892	82.794	181.426	181.613	98.632	-6194	+11,698	+0.187
15	0	83.694	181.613	181.515	97.919	-6149		-0.098
16	0	84.000	181.515	181.417	97.515	-6124		-0.098
17	0	83.694	181.417	181.319	97.723	-6137		-0.098
18	0	82.794	181.319	181.220	98.525	-6187		-0.099
19	0	81.363	181.220	181.120	99.857	-6271		-0.100
20	0	79.500	181.120	181.018	101.620	-6382		-0.102
21	0	77.331	181.018	180.914	103.687	-6512		-0.104
22	0	75.000	180.914	180.808	105.914	-6651		-0.106
23	0	72.669	180.808	180.699	108.139	-6791		-0.109
24	0	70.500	180.699	180.588	110.199	-6921		-0.111
1	0	68.637	180.588	180.476	111.951	-7031		-0.112
2	0	67.205	180.476	180.362	113.271	-7113		-0.114
3	0	66.306	180.362	180.247	114.056	-7163		-0.115
4	0	66.000	180.247	180.132	114.247	-7175		-0.115
5	0	66.306	180.132	180.018	113.826	-7148		-0.114
6	0	67.205	180.018	179.905	112.813	-7085		-0.113
7	0	68.637	179.905	179.793	111.268	-6988		-0.112
8	0	70.500	179.793	179.683	109.293	-6864		-0.110
9	17892	72.669	179.683	179.862	107.014	-6720	+11,172	+0.179

TABLE V

Hourly Temperatures in July

dard time. Using these tables, the Q_{in} may be summed for total daily solar input and the energy lost through conduction may be added for a daily loss. The tables assume the asphalt was delivered at the sixth hour at 180° F. At this temperature, there is a gradual temperature loss in the tank until solar energy becomes available, then a temperature rise occurs. Also note there is a greater temperature loss in January as compared to July because of the different ambient air temperatures.

Certain assumptions were made in the use of the above procedure and some inaccuracies are inherent. The following are some of the assumptions and inaccuracies:

1. The procedure uses only heat loss by conduction which is loss through tank and insulation. Some convection losses also occur particularly since the wind blows across the insulated tank.

2. The asphalt contained in the tank is a large volume. There must be differential temperatures as the asphalt cools near the edge and is warmer near the interior. No attempt was made to include this variable in the calculations.

3. The tank holds 12,000 gallons of asphalt but 10,000 gallons was arbitrarily selected for analysis. The tank will not be full in this case. Similarly, the tank will be depleted during actual use. It is assumed that the air above the asphalt will be slightly cooler than the asphalt. Since there is less heat loss for a cooler material with the same ambient temperature conditions, it is assumed that a "safe" error exists.

4. The Q_{IN} or solar input used above is the same as that shown to be available from the design. An assumption was made that all the solar energy from the collectors was transferred to the asphalt.

5. It is assumed that no clouds occur during the day which would lower the insolation values.

IV. COST COMPARISONS OF HEATING SYSTEMS

It is probably apparent at this point in the report that if an asphalt tank is to be heated, a large cost differential occurs between insulated and uninsulated tanks. In fact, if rather large quantities of asphalt are used by a district and no external heat is provided, savings will probably occur if a tank is insulated only to retard the energy loss from the heated asphalt as it is delivered. It is possible that heating with solar energy is not practical because of the relatively large initial investment. In an effort to study the costs, four systems were considered.

1. Insulated tank, solar heating with auxiliary system.

2. Insulated tank, auxiliary or a hot water heating system.

3. Insulated tank, diesel fired heater (or use of existing heating methods if available).

4. Uninsulated tank, diesel fired heater (or use of the methods possibly employed at present).

The method used to compare the four systems was to assume the asphalt would be maintained between 140 - 180° F as directed by the district; determine the probable number of times the asphalt in the tank would drop from 180° F to 140 in a one year interval; and calculate the total annual heating cost using the cost for reheating from 140° F to 180° F. For comparison purposes, it was assumed the tank contained 10,000 gallons of RC-2 at all times. A procedure similar to that shown in Tank Temperatures above was used to calculate the number of times the asphalt temperature would drop from 180 to 140° F. The calculations are shown in the Appendix A. It may be observed that system 2 and 3 will have similar activities with the only difference being the manner of reheating the asphalt. The auxiliary or water heater was assumed to have an efficiency of 75 percent (manufactures estimate). The flue-type heat exchanger (with systems 3 and 4), as available in most of the present tanks, was assumed to have an efficiency of 50 percent.(1) The assumptions for the solar system were as reported in Tank Temperatures above (100 percent efficiency for the heat exchanger and no cloud cover throughout the year). The uninsulated or bare tank heat losses were extrapolated from a previous report by Dr. Jones' personnel.(1)

The solar energy shown available to the asphalt was based on the January & July calculations shown in Tables II and III. The solar energy available in the intervening months is a linear extrapolation of the ratio of Q_u to Q (that is, from January to July then July back to January.) The Q, or insolation value, was obtained from "Buying Solar" FEA/G-76/154 published by the Federal Energy Administration.

Figure 1 shows in graphical form the results of the study. Figure 1 indicates that with the solar collector - auxiliary heater (or system #1) the auxiliary heater will never be used. There is some gradual loss of temperature in January and again in November and December; however, this

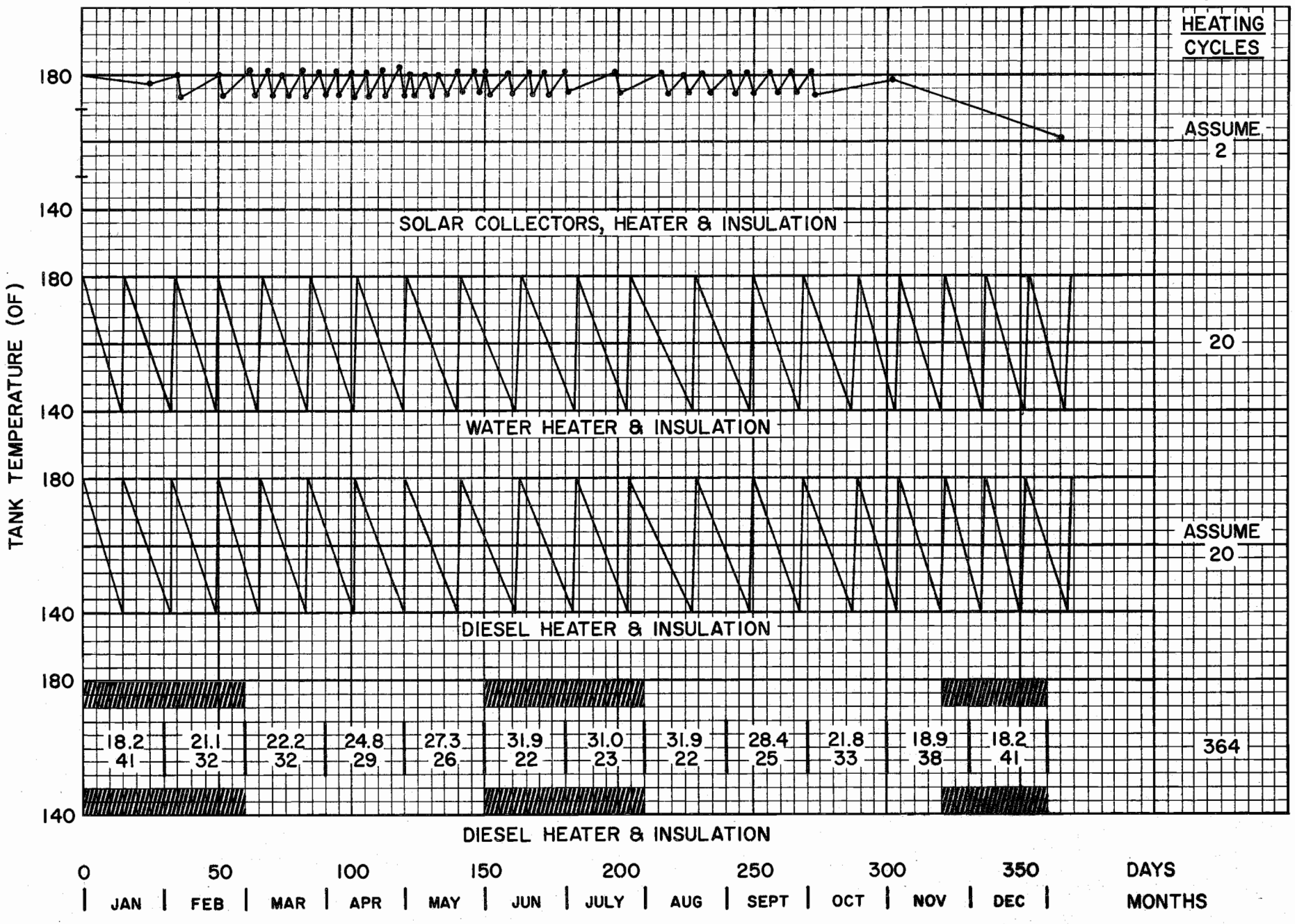


FIGURE I—TEMPERATURE AND COST STUDIES

loss is recuperated beginning around February each year. This may seem to be an over-designed system, however, the assumptions made in the calculations should again be noted. In the only two climatological data sources that could easily be found it was noted that El Paso has about 10 percent cloud cover each year and Brownsville has about 46 percent. One could assume 20 to 30 percent in Lubbock. The heat exchange in the 3/4-inch copper tube system shown in the plans uses the heating agent flowing at about 2 gallons per minute through 10 passes of the tubing. Copper is a good heat conductor and the efficiency should be high. However, based on this data, it is suggested that 2 heat cycles be assumed to be needed for this system (#1).

Approximately 38 hours will be required to heat the tank from 140 to 180° F using the auxiliary heater (see Appendix C). The heater has an efficiency of 75 percent and uses 100,000 Btu/hr; therefore 3,800,000 Btu will be needed in the 38 hours. Natural gas is assumed to cost $3.00 per thousand cubic feet and one thousand cubic feet will produce 1,000,000 Btu. Therefore, the cost per heating interval will be $11.40. The 1/4 H.P. pump will consume about 162 watts per hour. Power is expected to cost about $75.00 per year for the system. The annual cost will be $97.80.

System #2 shows about 20 heating cycles will be needed per year. Since the heating equipment will be the same as the auxiliary heater of System #1, the cost per heating cycle will be $11.40. Electric power for the System will cost about $25.00 per year. The annual cost will be 20 cycles at $11.40 per cycle plus the power cost or $253.00.

System #3 also will have about 20 heating cycles. About 6.6 gallons of diesel will produce 1,000,000 Btu. The flue-type heat exchanger is assumed to have an efficiency of 50 percent; however, the temperature change from 140 to 180° F will probably be faster compared to the hot water type heater. The calculations in Appendix C indicate that approximately 2,700,000 BTU will be needed to reheat the asphalt. With an efficiency of 50% about 5,400,000 BTU will be expended or (5.4 x 6.6 gallons) about 35.64 gallons of diesel. Assuming a cost of $0.45 per gallon for diesel, the cost per cycle will be $16.04 and twenty cycles will cost about $320.80. This type of system will require monitoring by maintenance personnel since adjustments of the burner and temperature checks will be needed. It is estimated that the tank can be increased from 140 to 180° F in about 8 hours with one man needed about one-half time. Assuming a salary of $7.00 per hour, about $28 is used each cycle or $560 in 20 cycles. The yearly cost would be about $880.80. The total cost per cycle is $44.04.

System #4 will have approximately 364 heating cycles at a similar cost of $44.04 per cycle. The annual cost will be $16,030.56.

Table VI offers a cost comparison of the four types of systems studied. The initial costs shown were based on cost estimates obtained from the plans of the solar/auxiliary system. The only difference in initial costs between System #1 and #2 would be the collector panels which are not used in System #2. Similarly, the only difference between System #3 and #4 would be the tank insulation which is not used in System #4.

	System #1	System #2	System #3	System #4
Initial Cost	$20,300	$16,590	$ 8,635	$ 6,835
Annual Heating Cost	97.80	253.00	880.80	16,030.56
1st Year	20,300	16,590	8,635	6,835
	98	253	881	16,031
Total	20,398	16,843	9,516	22,866
5th Year	20,300	16,590	8,635	6,835
	490	1,265	4,405	80,155
Total	20,790	17,855	13,040	86,990
10th Year	20,300	16,590	8,635	6,835
	980	2,530	8,810	160,310
Total	21,280	19,120	17,445	167,145
15th Year	20,300	16,590	8,635	6,835
	1,470	3,795	13,215	240,465
Total	21,770	20,385	21,850	247,300
20th Year	20,300	16,590	8,635	6,835
	1,960	5,060	17,620	320,620
Total	22,260	21,650	26,255	327,455
25th Year	20,300	16,590	8,635	6,835
	2,450	6,325	22,025	400,775
Total	22,750	22,915	31,660	407,610

TABLE VI

COST COMPARISON OF HEATING SYSTEMS

Table VI indicated the total funds expended at the years shown. The difference in initial cost between System #1 and #2 is about $37.10. The difference in the annual heating cost is $155.20. If the initial cost differential is divided by the differential annual heating cost, the number of years required to recoup the initial investment may be found. In this case about 24 years are needed. This fact may also be noted in Table VI, which indicates in 20 to 25 years the total costs will be equal. Note insulation provided to a tank will recoup initial investment in less than one year. A hot water heating system will pay compared to a diesel fired system in about 13 years. Similarly a solar system will pay compared to a diesel fired system in about 15 years. When studying the above cost and "pay-off" periods the administrator will also be aware of other factors such as:

1. For many years the department has been involved in developing energy-saving methods and a solar system would save fossil fuel.

2. Little is known about the "life" of solar collectors or, for that matter, the life of foam insulation on asphalt tanks which are subject to weather and temperature changes.

3. At present the trend in fossil fuel cost is up and future increases in cost could reduce the initial cost "pay-back" interval.

4. The calculations do not include a capital rate of return on the initial investment and this type of calculation tends to offer credibility to systems having lower initial investments.

V. COST ESTIMATE OF THE LUBBOCK SYSTEM

Table VII offers the estimated costs of the proposed system. These costs were estimated from the plans shown in Appendix D. The specifications for the system are included in Appendix E.

The construction of the ~~Lufkin~~ Lubbock system was let in a lump sum type contract. The job was widely advertised in the usual manner and particular emphasis to advertising was given to the Lubbock area. Bidding closed August 11, 1978, The low bid was $24,650; however, this also was the only bid. After a review, the contract was awarded to Aussol of Austin, Texas as low bidder.

TABLE VII

COSTS ASSOCIATED

WITH THE

SOLAR AND AUXILIARY HEATING

COMPONENTS AND INSTALLATION

LUBBOCK

Heating and Data Collection Components:

Item	Quantity	Cost/Unit	Unit	Quantity Cost
Solar Collector Panels	6	$ 546.00	Each	$3,276.00
Circulator Pump	1	224.00	Each	224.00
Control Valves	2	35.00	Each	70.00
Air Vent	1	10.00	Each	10.00
Line Strainer	1	14.00	Each	14.00
Check Valve	1	14.00	Each	14.00
Flow Switch	1	29.00	Each	29.00
Heating Boiler	1	403.00	Each	403.00
Manual Switch	4	3.00	Each	12.00
24 Volt Transformer	1	50.00	Each	50.00
Differential Thermostat	1	30.00	Each	30.00
Safety Thermostat	1	30.00	Each	30.00
Double Throw - Double Pole Relays	4	10.00	Each	40.00
Heat Exchanger	1	300.00	Each	300.00
Expansion Tank	1	50.00	Each	50.00
Pressure Relief Valve	1	10.00	Each	10.00
3/4" Copper Tubing	180	0.55	Feet	99.00
Copper Elbow	15	0.72	Each	10.80
Copper Tee	17	1.33	Each	22.61
Copper Coupling	28	0.33	Each	9.24
3/4" Valves	2	5.00	Each	10.00
Tubing Insulation	180	0.50	Feet	90.00
(Differential) Thermostat	1	30.00	Each	30.00
Recording Thermometer	3	325.00	Each	975.00
Recording Pyranometer	1	1,000.00	Each	1,000.00
				6,808.65
Labor				3,500.00

Foundation:

P.C. Concrete	3	30.00	Cubic Yds.	90.00
½" Reinf. Steel	329	0.50	Feet	164.50
				254.50
Labor				200.00

TABLE VII

(Cont.)

Collector Support Structure

Item	Quantity	Cost/Unit	Unit	Quantity Cost
2" x 2" x 3/16" Angle Iron	335	.61	Foot	$ 204.35
Door Hinge (2")	3	1.00	Each	3.00
Hardware			Bulk	75.00
14 Gage Sheet Iron	5	30.00	4x8 sheet	150.00
Insulation - 2"	100	.10	sq. ft.	10.00
Paint	3	10.00	Gal.	30.00
				$ 472.35
Labor				2,400.00

Storage Tank and Foundation

Tank and Cradle	1	6000.00	Each	6,000.00
Insulation	1	1800.00	Each	1,800.00
P. C. Concrete	3.17	30.00	cubic yards	95.10
				$ 7895.10
Labor				740.00
TOTAL				$22,270.60

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3. Broughton, Jim; "Insulation of Asphalt Storage Tanks"'; Center for Highway Research; Unpublished, 1978.

4. Duffie, John A., Beckman, William A., "Solar Energy Thermal Processes"; Wiley-Interscience Publication; 1974.

APPENDIX A

TANK TEMPERATURES FOR A SOLAR/AUXILIARY SYSTEM

HOT WATER INPUTS
75,000 BTU/HR

2 DAY INTERVALS
LUBBOCK

INSULATION
SOLAR & AUXILIARY

	Time (Days)	Q_{IN}	AVG Ambient Temp	Old Temp	New Temp	ΔT	(A)= (0.08)(785)(48) =3014.4(ΔT)	(B)= (Qin-A)	B (83300)(.75) =0.000016(B)
	2	399,894	40	180	179.65	140.00	422,016	- 22,122	- .35
	4	399,894	40	179.65	179.31	139.65	420,961	- 21,067	- .34
	6	399,894	40	179.31	178.99	139.31	419,936	- 20,042	- .32
	8	399,894	40	178.99	178.68	138.99	418,971	- 19,077	- .31
	10	399,894	40	178.68	178.39	138.68	418,037	- 18,143	- .29
	12	399,894	42	178.39	178.21	136.39	411,134	- 11,240	- .18
	14	399,894	42	178.21	178.04	136.21	410,591	- 10,697	- .17
	16	399,894	42	178.04	177.88	136.04	410,079	- 10,185	- .16
	18	399,894	42	177.88	177.72	135.88	409,597	- 9,703	- .16
Jan	20	399,894	42	177.72	177.58	135.72	409,114	- 9,222	- .15
	22	399,894	47	177.58	177.68	130.58	393.620	+ 6,274	+ .10
	24	399,894	47	177.68	177.78	130.68	393,921	+ 5,972	+ .10
	28	399,894	47	177.78	177.87	130.78	394,223	+ 5,671	+ .09
	30	399,894	47	177.87	177.96	130.87	394,494	+ 5,399	+ .09
	32	455,062	50	177.96	179.07	127.96	385,723	+ 69,339	+1.11
	34	455,062	50	179.07	180.13	129.07	389,069	+ 65,993	+1.06
	36	455,062	50	180.13	173.85	130.13	392,264	-392,264	-6.28
	38	455,062	50	173.85	175.16	123.85	373,333	+ 81,729	+1.31
	40	455,062	50	175.16	176.40	125.16	377,282	+ 77,780	+1.24
	42	455,062	51	176.40	177.63	125.40	378,006	+ 77,056	+1.23
	44	455,062	51	177.63	178.80	126.63	381,713	+ 73,349	+1.17
	46	455,062	51	178.80	179.92	127.80	385,240	+ 69,822	+1.12
	48	455,062	51	179.92	180.98	128.92	388,616	+ 66,446	+1.06
Feb	50	455,062	51	180.98	174.71	129.98	391,812	-391,812	-6.27
	52	455,062	52	174.71	176.07	122.71	369,897	+ 85,165	+1.36
	54	455,062	52	176.07	177.37	124.07	373,997	+ 81,065	+1.30
	56	455,062	52	177.37	178.60	125.37	377,915	+ 77,147	+1.23
	58	455,062	52	178.60	179.78	126.60	381,623	+ 73,439	+1.18
	60	537,120	52	179.78	182.21	127.78	385,165	+151,955	+2.43
	62	537,120	52	182.21	175.93	130.21	392,505	-392,505	-6.28
	64	537,120	52	175.93	178.55	123.93	373,575	+163,545	+2.62
	66	537,120	52	178.55	181.04	126.55	381,462	+155,658	+2.49
Mar	68	537,120	52	181.04	174.82	129.04	388,980	-388,980	-6.22
	70	537,120	52	174.82	177.49	122.82	370,229	+166,891	+2.67
	72	537,120	54	177.49	180.13	123.49	372,249	+164,871	+2.64

HOT WATER INPUTS
75,000 BTU/HR

2 DAY INTERVALS
LUBBOCK

	Time (Days)	Q_{IN}	AVG Ambient Temp	Old Temp	New Temp	Δ T	(A)= (0.08)(785)(48) =3014.4(ΔT)	(B)= (Qin-A)	B (83300)(.75) =0.000016(B)
	74	537,120	54	180.13	174.05	126.13	380,206	-380,206	-6.08
	76	537,120	54	174.05	176.85	120.05	361,879	+175,241	+2.80
	78	537,120	54	176.85	179.52	122.85	370,319	+166,801	+2.67
Mar	80	537,120	54	179.52	182.06	125.52	378,364	+158,756	+2.54
	82	537,120	57	182.06	176.03	125.06	376,981	-376,981	-6.03
	84	537,120	57	176.03	178.88	119.03	358,804	+178,316	+2.85
	86	537,120	57	178.88	181.60	121.88	367,404	+169,716	+2.72
	88	537,120	57	181.60	175.59	124.60	375,581	-375,581	-6.01
	90	537,120	57	175.59	178.46	118.59	357,478	+179,642	+2.87
	92	542,356	60	178.46	181.42	118.46	357,099	+185,257	+2.96
	94	542,356	60	181.42	175.56	121.42	366,021	-366,021	-5.86
	96	542,356	60	175.56	178.66	115.56	348,344	+194,012	+3.10
	98	542,356	60	178.66	181.61	118.66	357,701	+184,655	+2.95
	100	542,356	60	181.61	175.74	121.61	366,595	-366,595	-5.87
Apr	102	542,356	62	175.74	178.93	113.74	342,858	+199,498	+3.19
	104	542,356	62	178.93	181.97	116.93	352,480	+189,876	+3.04
	106	542,356	62	181.97	176.18	119.97	361,632	-361,632	-5.79
	108	542,356	62	176.18	179.35	114.18	344,184	+198,172	+3.17
	110	542,356	62	179.35	182.37	117.35	353,740	+188,616	+3.02
	112	542,356	64	182.37	176.66	118.37	356,815	-356,815	-5.71
	114	542,356	64	176.66	179.90	112.66	339,602	+202,754	+3.24
	116	542,356	64	179.90	182.99	115.90	349,369	+192,987	+3.09
	118	542.356	64	182.99	177.25	118.99	358,683	-358,683	-5.74
	120	542,356	64	177.25	180.47	113.25	341,381	+200,975	+3.22
	122	515,298	65	180.47	174.90	115.47	348,073	-348,073	-5.57
	124	515,298	65	174.90	177.84	109.90	331,283	+184,015	+2.94
	126	515,298	65	177.84	180.64	112.84	340,145	+175,153	+2.80
	128	515,298	65	180.64	175.06	115.64	348,585	-348,585	-5.58
	130	515,298	65	175.06	178.00	110.06	331,265	+183,533	+2.94
May	132	515,298	68	178.00	180.94	110.00	331,584	+183,714	+2.94
	134	515,298	68	180.94	175.49	112.94	340,446	-340,446	-5.45
	136	515,298	68	175.49	178.55	107.49	342,018	+191,280	+3.06
	138	515,298	68	178.55	181.46	110.55	333,242	+182,056	+2.91
	140	515,298	68	181.46	175.99	113.46	342,014	-342,014	-5.47
	142	515,298	72	175.99	179.22	103.99	313,467	+201,831	+3.23

HOT WATER INPUTS
75,000 BTU/HR

2 DAY INTERVALS
LUBBOCK

	Time (Days)	Q_{IN}	AVG Ambient Temp	Old Temp	New Temp	ΔT	(A)= (0.08)(785)(48) =3014.4(ΔT)	(B)= (Qin-A)	B (83300)(.75) =0.000016(B)
	144	515,298	72	179.22	182.29	107.22	323,204	+192,094	+3.07
	146	515,298	72	182.29	176.97	110.29	332,458	-332,458	-5.32
	148	515,298	72	176.97	180.15	104.97	316,422	+198,876	+3.18
	150	515,298	72	180.15	174.93	108.15	326,007	-326,007	-5.22
	152	432,304	75	174.93	177.03	99.93	301,229	+131,075	+2.10
	154	432,304	75	177.03	179.03	102.03	307,559	+124,745	+2.00
	156	432,304	75	179.03	180.93	104.03	313,588	+118,716	+1.90
	158	432,304	75	180.93	175.82	105.93	319,315	-319,315	-5.11
June	160	432,304	75	175.82	177.87	100.82	303,912	+128,392	+2.05
	162	432,304	77	177.87	179.92	100.87	304,062	+128,241	+2.05
	164	432,304	77	179.92	181.84	102.92	310,242	+122,062	+1.92
	166	432,304	77	181.84	176.78	104.84	316,030	-316,030	-5.06
	168	432,304	77	176.78	178.88	99.78	300,777	+131,527	+2.10
	170	432,304	77	178.88	180.88	101.88	307,107	+125,197	+2.00
	172	432,304	76	180.88	175.82	104.88	316,150	-316.150	-5.06
	174	432,304	76	175.82	177.92	99.82	300,897	+131,407	+2.10
	176	432,304	76	177.92	179.92	101.92	307,228	+125,076	+2.00
	178	432,304	76	179.92	181.82	103.92	313,256	+119,048	+1.90
	180	432,304	76	181.82	176.72	105.82	318,983	-318,983	-5.10
	182	339,292	75	176.72	177.24	101.72	306,624	+ 32,667	+0.52
	184	339,292	75	177.24	177.74	102.24	308,192	+ 31,100	+0.50
	186	339,292	75	177.74	178.21	102.74	309,699	+ 29,593	+0.47
	188	339,292	75	178.21	178.66	103.21	311,116	+ 28,176	+0.45
	190	339,292	75	178.66	179.08	103.66	312,472	+ 26,819	+0.42
July	192	339,292	75	179.08	179.49	104.08	313,739	+ 25,553	+0.41
	194	339,292	75	179.49	179.88	104.49	314,975	+ 24,317	+0.39
	196	339,292	75	179.88	180.25	104.88	316,150	+ 23,142	+0.37
	198	339,292	75	180.25	175.17	105.25	317,266	-317,266	-5.08
	200	339,292	75	175.17	175.77	100.17	301,952	+ 37,339	+0.60
	202	339,292	76	175.77	176.39	99.77	300,747	+ 38,545	+0.62
	204	339,292	76	176.39	176.98	100.39	302,616	+ 36,676	+0.59
	206	339,292	76	176.98	177.54	100.98	304,394	+ 34,898	+0.56
	208	339,292	76	177.54	178.07	101.54	306,082	+ 33,210	+0.53
	210	339,292	76	178.07	178.57	102.07	307,680	+ 31,612	+0.50
	212	339,292	77	178.57	179.10	101.57	306,173	+ 33,119	+0.53

HOT WATER INPUTS
75,000 BTU/HR

2 DAY INTERVALS
LUBBOCK

	Time (Days)	Q_{IN}	AVG Ambient Temp	Old Temp	New Temp	ΔT	(A)= (0.08)(785)(48) =3014.4 (ΔT)	(B)= (Qin-A)	B (83300)(.75) =0.000016(B)
	214	402,116	77	179.10	180.61	102.10	307,770	+ 94,346	+1.51
	216	402,116	77	180.61	175.61	103.61	312,322	-312,322	-5.00
	218	402,116	77	175.61	177.29	98.61	297,250	+104,866	+1.68
	220	402,116	77	177.29	178.89	100.29	302,314	+ 99,802	+1.60
Aug	222	402,116	77	178.89	180.41	101.89	307,137	+ 94,979	+1.52
	224	402,116	77	180.41	175.42	103.41	311,719	-311,719	-4.99
	226	402,116	77	175.42	177.11	98.42	296,677	+105,439	+1.69
	228	402,116	77	177.11	178.72	100.11	301,772	+100,344	+1.61
	230	402,116	77	178.72	180.36	101.72	306,625	+ 95,491	+1.63
	232	402,116	75	180.36	175.28	105.35	317,567	-317,567	-5.08
	234	402,116	75	175.28	176.88	100.28	302,284	+ 99,832	+1.60
	236	402,116	75	176.88	178.40	101.88	307,107	+ 95,009	+1.52
	238	402,116	75	178.40	179.85	103.40	311,689	+ 90,427	+1.45
	240	402,116	75	179.85	181.23	104.85	316,060	+ 86,056	+1.38
	242	402,116	73	181.23	176.01	108.23	326,249	-326,249	-5.22
	244	440,118	73	176.01	178.08	103.01	310,513	+129,605	+2.07
	246	440,118	73	178.08	180.05	105.08	316,753	+123,365	+1.97
	248	440,118	73	180.05	174.89	107.05	322,692	-322,692	-5.16
	250	440,118	73	174.89	177.02	101.89	307,137	+132,981	+2.13
	252	440,118	70	177.02	178.90	107.02	322,601	+117,517	+1.88
Sept	254	440,118	70	178.90	180.69	108.90	328,268	+111,850	+1.79
	256	440,118	70	180.69	175.35	110.69	333,664	-333,664	-5.34
	258	440,118	70	175.35	177.31	105.35	317,567	+122,551	+1.96
	260	440,118	70	177.31	179.18	107.31	323,475	+116,643	+1.87
	262	440,118	65	170.18	180.71	114.18	344,184	+ 95,934	+1.53
	264	440,118	65	180.71	175.13	115.71	348,796	-348,796	-5.58
	266	440,118	65	175.13	176.86	110.13	331,976	+108,142	+1.73
	268	440,118	65	176.86	178.51	111.86	337,191	+102,927	+1.65
	270	440,118	65	178.51	180.08	113.51	342,165	+ 97,953	+1.57
	272	440,118	60	180.08	174.29	120.08	361,969	-361,969	-5.79
	274	390,336	60	174.29	175.02	114.29	344,516	+ 45,820	+ .73
	276	390,336	60	175.02	175.72	115.02	346,716	+ 43,620	+ .70
	278	390,336	60	175.72	176.38	115.72	348,826	+ 41,510	+ .66
Oct	280	390,336	60	176.38	177.01	116.38	350,816	+ 39,520	+ .63
	282	390,336	53	177.01	177.27	124.01	373,816	+ 16,520	+ .26

HOT WATER INPUTS
75,000 BTU/HR

2 DAY INTERVALS
LUBBOCK

	Time (Days)	Q_{IN}	AVG Ambient Temp	Old Temp	New Temp	ΔT	(A)= (0.08)(785)(48) =3014.4 (ΔT)	(B)= (Qin-A)	B (83300)(.75) =0.000016(B)
	284	390,336	53	177.27	177.52	124.27	374,599	+ 15,737	+.25
	286		53	177.52	177.72	124.52	375,353	+ 14,983	+.24
Oct	288		53	177.72	177.95	124.72	375,956	+ 14,380	+.23
	290		53	177.95	178.16	124.95	376,649	+ 13,687	+.21
	292		49	178.16	178.18	129.16	389,340	+ 996	+.02
	294		49	178.18	178.19	129.18	389,400	+ 936	+.01
	296		49	178.19	178.20	129.19	389,430	+ 905	+.01
	298		49	178.20	178.21	129.20	389,460	+ 875	+.01
	300		49	178.21	178.22	129.21	389,490	+ 845	+.01
	302		46	178.22	178.09	132.22	398,563	- 8,228	-.13
	304		46	178.09	177.96	132.09	398.172	- 7,836	-.13
	306	366,748	46	177.96	177.46	131.96	397,780	- 31,032	-.50
	308		46	177.46	176.99	131.45	396,243	- 29,495	-.47
	310		46	176.99	176.54	130.99	394,856	- 28,108	-.45
	312		43	176.54	175.97	133.54	402,543	- 35,794	-.57
	314		43	175.97	175.43	132.97	400,825	- 34,077	-.54
	316		43	175.43	174.92	132.43	399,197	- 32,449	-.51
Nov	318		43	174.92	174.43	131.92	397,660	- 30,912	-.49
	320		43	174.43	173.96	131.43	396,183	- 29,435	-.47
	322		42	173.96	173.47	131.96	397,780	- 31,032	-.49
	324		42	173.47	173.00	131.47	396,303	- 29,555	-.47
	326		42	173.00	172.55	131.00	394,886	- 28,138	-.45
	328		42	172.55	172.13	130.55	393,530	- 26,782	-.42
	330		42	172.13	171.72	130.13	392,264	- 25,516	-.41
	332		41	171.72	171.29	130.72	394,042	- 27,294	-.43
	334		41	171.29	170.88	130.29	392,746	- 25,998	-.41
	336	349,652	41	170.88	170.21	129.88	391,510	- 41,858	-.67
	338		41	170.21	169.57	129.21	389,491	- 39,839	-.64
	340		41	169.57	168.96	128.57	387,561	- 37,909	-.61
	342		40	168.96	168.34	128.96	388,737	- 39,085	-.62
Dec	344		40	168.34	167.74	128.34	386,868	- 37,216	-.60
	346		40	167.74	167.17	127.74	385,059	- 35,407	-.57
	348		40	167.17	166.63	127.17	383,341	- 33,689	-.54
	350		40	166.63	166.12	126.63	381,713	- 32,061	-.51
	352		40	166.12	165.63	126.12	380,176	- 30,524	-.49

HOT WATER INPUTS 2 DAY INTERVALS 6
75,000 BTU/HR LUBBOCK

	Time (Days)	Q_{IN}	AVG Ambient Temp	Old Temp	New Temp	ΔT	(A)= (0.08)(785)(48) =3014.4(ΔT)	(B)= (Qin-A)	(83300)(.75) =0.000016(B)
	354	349,652	40	165.63	165.17	125.63	378,699	- 29,047	-.46
Dec	356		40	165.17	164.73	125.17	377,312	- 27,660	-.44
	358		40	164.73	164.31	124.73	375,986	- 26,334	-.42
	360		40	164.31	163.91	124.31	374,720	- 25,068	-.40
	362		40	163.91	163.53	123.91	373,514	- 23,862	-.38
	364		40	163.53	163.17	123.53	372,369	- 22,717	-.36
	366		40	163.17	162.83	123.17	371,284	- 21,631	-.34
Estimated Jan. 31, 1977		399,894	40	162.83	162.00				-2.83
Feb., 1977	32	455,062	50	162.00	163.88	112.00	337,613	+117,449	+1.88
	34		50	163.88	165.66	113.88	343,280	+111,782	+1.78
Estimated Feb. 28, 1977			50		185.80				

APPENDIX B

TANK TEMPERATURES FOR AUXILIARY SYSTEM

HOT WATER INPUTS
75,000 BTU/HR

2 DAY INTERVALS
LUBBOCK

INSULATED TANK
NO SOLAR HEAT
WITH AUXILIARY

	Time (Days)	Q_{IN}	AVG AMBIENT TEMP	OLD TEMP	NEW TEMP	ΔT	(A)= (0.08)(785)(48) =3014.4(ΔT)	(B)= (Q_{IN} - A)	B / (83300)(.75) =0.000016(B)
	2	0	40	180	173.25	140	422,016	---	- 6.75
	4	0	40	173.25	166.82	133.25	401,669	---	- 6.43
	6	0	40	166.82	160.70	126.82	382,286	---	- 6.12
	8	0	40	160.70	154.88	120.70	363,838	---	- 5.82
	10	0	40	154.88	149.34	114.88	346,294	---	- 5.54
	12	0	42	149.34	144.16	107.34	323,566	---	- 5.18
JAN	14	0	42	144.16	139.23	102.16	307,951	---	- 4.93
	16	- 2,843,100 15	42	139.23	180.03	97.23	293,098	2,550,000	+40.80
	18	0	42	180.03	173.37	138.03	416,078	---	- 6.66
	20	0	42	173.37	167.03	131.37	396,010	---	- 6.34
	22	0	47	167.03	161.24	120.03	361,830	---	- 5.79
	24	0	47	161.24	155.73	114.24	344,367	---	- 5.51
	28	0	47	155.73	150.49	108.73	327,756	---	- 5.24
	30	0	47	150.49	145.50	103.49	311,948	---	- 4.99
	32	0	50	145.50	140.89	95.50	287,872	---	- 4.61
	34	- 2,718,366 33	50	140.89	180.00	90.89	273,991	2,444,375	+39.11
	36	0	50	180.00	173.73	130.00	391,872	---	- 6.27
	38	0	50	170.73	164.76	123.73	372,972	---	- 5.97
	40	0	50	164.76	159.22	114.76	345,940	---	- 5.54
	42	0	51	159.22	154.00	108.22	326,218	---	- 5.22
FEB	44	0	51	154.00	149.03	103.00	310,485	---	- 4.97
	46	0	51	149.03	144.30	98.03	295,508	---	- 4.73
	48	0	51	144.30	139.80	93.30	281,249	---	- 4.50
	50	- 2,780,179 49	51	139.80	180.00	88.80	267,679	2,512,500	+40.20
	52	0	52	180.00	173.83	128.00	385,843	---	- 6.17
	54	0	52	173.83	167.95	121.83	367,234	---	- 5.88
	56	0	52	167.95	162.36	115.95	349,533	---	- 5.59
	58	0	52	162.36	157.04	110.36	332,662	---	- 5.32
	60	0	52	157.04	151.97	105.04	316,625	---	- 5.07
	62	0	52	151.97	147.15	99.97	301,362	---	- 4.82
	64	0	52	147.15	142.56	95.15	286,815	---	- 4.59
	66	- 2,612,987 65	52	142.56	180.00	90.56	272,987	2,340,000	+37.44
	68	0	52	180.00	173.83	128.00	385,843	---	- 6.17
	70	0	52	173.83	167.95	121.83	367,234	---	- 5.88
	72	0	54	167.95	162.45	113.95	343,504	---	- 5.50
MAR	74	0	54	162.45	157.22	108.45	326,912	---	- 5.23
	76	0	54	157.22	152.24	103.22	311,145	---	- 4.98
	78	0	54	152.24	147.50	98.24	296,140	---	- 4.74
	80	0	54	147.50	142.99	93.50	281,851	---	- 4.51
	82	0	57	142.99	138.84	85.99	259,209	---	- 4.15
	84	- 2,819,206 83	57	138.84	180.00	81.84	246,706	2,572,500	+41.16
	86	0	57	180.00	174.07	123.00	370,771	---	- 5.93
	88	0	57	174.07	168.42	117.07	352,889	---	- 5.65
	90	0	57	168.42	163.05	111.42	335,876	---	- 5.37
	92	0	60	163.05	158.08	103.05	310,622	---	- 4.97
	94	0	60	158.08	153.35	98.08	295,653	---	- 4.73
	96	0	60	153.35	148.85	93.35	281,394	---	- 4.50
	98	0	60	148.85	144.56	88.85	267,829	---	- 4.29

HOT WATER INPUTS
75,000 BTU/HR

2 DAY INTERVALS
LUBBOCK

	Time (Days)	Q_{IN}	AVG AMBIENT TEMP	OLD TEMP	NEW TEMP	ΔT	(A)= (0.08)(785)(48) =3014.4(ΔT)	(B)= (Q_{IN} - A)	B (83300)(.75) =0.000016(B)
	100	0	60	144.56	140.48	84.56	254,912	---	- 4.08
	102	- 2,706,574	101 62	140.48	180.00	78.48	236,574	2,470,000	+39.52
	104	0	62	180.00	174.31	118.00	355,699	---	- 5.69
	106	0	62	174.31	168.89	112.31	338,544	---	- 5.42
	108	0	62	168.89	163.73	106.89	322,219	---	- 5.16
APR	110	0	62	163.73	158.82	101.73	306,668	---	- 4.91
	112	0	64	158.82	154.25	94.82	285,835	---	- 4.57
	114	0	64	154.25	149.90	90.25	272,039	---	- 4.35
	116	0	64	149.90	145.76	85.90	258,929	---	- 4.14
	118	0	64	145.76	141.82	81.76	246,449	---	- 3.94
	120	- 2,620,821	119 64	141.82	180.00	77.82	234,571	2,386,250	+38.18
	122	0	65	180.00	174.45	115.00	346,656	---	- 5.55
	124	0	65	174.45	169.17	109.45	329,937	---	- 5.28
	126	0	65	169.17	164.15	104.17	314,013	---	- 5.02
	128	0	65	164.15	159.37	99.15	298,865	---	- 4.78
	130	0	65	159.37	154.82	94.37	284,463	---	- 4.55
	132	0	68	154.82	150.63	86.82	261,706	---	- 4.19
	134	0	68	150.63	146.64	82.63	249,088	---	- 3.99
MAY	136	0	68	146.64	142.85	78.64	237,052	---	- 3.79
	138	0	68	142.85	139.24	74.85	225,619	---	- 3.61
	140	- 2,762,246	139 68	139.24	180.00	71.24	214,746	2,547,500	+40.76
	142	0	72	180.00	174.79	108.00	325,555	---	- 5.21
	144	0	72	174.79	169.83	102.79	309,854	---	- 4.96
	146	0	72	169.83	165.11	97.83	294,906	---	- 4.72
	148	0	72	165.11	160.62	93.11	280,671	---	- 4.49
	150	0	72	160.62	156.35	88.62	267,134	---	- 4.27
	152	0	75	156.35	152.43	81.35	245,209	---	- 3.92
	154	0	75	152.43	148.70	77.43	233,405	---	- 3.73
	156	0	75	148.70	145.15	73.70	222,148	---	- 3.55
	158	0	75	145.15	141.77	70.15	211,447	---	- 3.38
JUN	160	0	75	141.77	138.55	66.77	201,262	---	- 3.22
	162	- 2,776,161	161 77	138.55	180.00	61.55	185,536	2,590,625	+41.45
	164	0	77	180.00	175.03	103.00	310,483	---	- 4.97
	166	0	77	175.03	170.30	98.03	295,508	---	- 4.73
	168	0	77	170.30	165.80	93.30	281,249	---	- 4.50
	170	0	77	165.80	161.52	88.80	267,679	---	- 4.28
	172	0	76	161.52	157.40	85.52	257,783	---	- 4.12
	174	0	76	157.40	153.47	81.40	245,359	---	- 3.93
	176	0	76	153.47	149.73	77.47	233,538	---	- 3.74
	178	0	76	149.73	146.17	73.73	222,262	---	- 3.56
	180	0	76	146.17	142.79	70.17	211,532	---	- 3.38
	182	0	75	142.79	139.52	67.79	204,346	---	- 3.27
	184	- 2,724,490	183 75	139.52	180.00	64.52	194,490	2,530,000	+40.48
	186	0	75	180.00	174.94	105.00	316,512	---	- 5.06
	188	0	75	174.94	170.12	99.94	301,247	---	- 4.82
	190	0	75	170.12	165.53	95.12	286,730	---	- 4.59
JUL	192	0	75	165.53	161.16	90.53	272,901	---	- 4.37
	194	0	75	161.16	157.00	86.16	259,732	---	- 4.16

HOT WATER INPUTS
75,000 BTU/HR

2 DAY INTERVALS
LUBBOCK

	Time (Days)	Q_{IN}	AVG AMBIENT TEMP	OLD TEMP	NEW TEMP	ΔT	(A)= (0.08)(785)(48) =3014.4(ΔT)	(B)= (Q_{IN} - A)	B / (83300)(.75) =0.000016(B)
	196	0	75	157.00	153.04	82.00	247,194	---	- 3.96
	198	0	75	153.04	149.28	78.04	235,259	---	- 3.76
	200	0	75	149.28	145.70	74.28	223,897	---	- 3.58
	202	0	76	145.70	142.34	69.70	210,097	---	- 3.36
	204	0	76	142.34	139.14	66.34	199,971	---	- 3.20
	206	- 2,744,081	203 76	139.14	180.00	63.14	190,331	2,553,750	+40.86
	208	0	76	180.00	174.98	104.00	313,498	---	- 5.02
	210	0	76	174.98	170.21	98.98	298,377	---	- 4.77
	212	0	77	170.21	165.71	93.21	280,960	---	- 4.50
	214	0	77	165.71	161.43	88.71	267,421	---	- 4.28
	216	0	77	161.43	157.36	84.43	254,510	---	- 4.07
	218	0	77	157.36	153.48	80.36	242,231	---	- 3.88
	220	0	77	153.48	149.79	76.48	230,554	---	- 3.69
AUG	222	0	77	149.79	146.28	72.79	219,422	---	- 3.51
	224	0	77	146.28	142.94	69.28	208,835	---	- 3.34
	226	0	77	142.94	139.76	65.94	198,765	---	- 3.18
	228	- 2,704,183	227 77	139.76	180.00	62.76	189,183	2,515,000	+40.24
	230	0	77	180.00	175.03	103.00	310,483	---	- 4.97
	232	0	75	175.03	170.21	100.03	301,537	---	- 4.82
	234	0	75	170.21	165.62	95.21	287,000	---	- 4.59
	236	0	75	165.62	161.25	90.62	273,159	---	- 4.37
	238	0	75	161.25	157.09	86.25	259,990	---	- 4.16
	240	0	75	157.09	153.13	82.09	247,452	---	- 3.96
	242	0	73	153.13	149.27	80.13	241,546	---	- 3.86
	244	0	73	149.27	145.59	76.27	229,894	---	- 3.68
	246	0	73	145.59	142.09	72.59	218,820	---	- 3.50
	248	0	73	142.09	138.76	69.09	208,262	---	- 3.33
	250	- 2,775,727	249 73	138.76	180.00	65.76	198,227	2,577,500	+41.24
	252	0	70	180.00	174.69	110.00	331,584	---	- 5.31
SEPT	254	0	70	174.69	169.64	104.69	315,591	---	- 5.05
	256	0	70	169.64	164.83	99.64	300,356	---	- 4.81
	258	0	70	164.83	160.26	94.83	285,869	---	- 4.57
	260	0	70	160.26	155.91	90.26	272,068	---	- 4.35
	262	0	65	155.91	151.53	90.91	274,030	---	- 4.38
	264	0	65	151.53	147.36	86.53	260,823	---	- 4.17
	266	0	65	147.36	143.39	82.36	248,256	---	- 3.97
	268	0	65	143.39	139.61	78.39	236,292	---	- 3.78
	270	- 2,749,281	267 65	139.61	180.00	74.61	224,906	2,524,375	+40.39
	272	0	60	180.00	174.21	120.00	361,728	---	- 5.79
	274	0	60	174.21	168.70	114.21	344,282	---	- 5.51
	276	0	60	168.70	163.46	108.70	327,670	---	- 5.24
	278	0	60	163.46	158.47	103.46	311,862	---	- 4.99
	280	0	60	158.47	153.72	98.47	296,829	---	- 4.75
OCT	282	0	53	153.72	148.86	100.72	303,613	---	- 4.86
	284	0	53	148.86	144.24	95.86	288,967	---	- 4.62
	286	0	53	144.24	139.84	91.24	275,023	---	- 4.40
	288	- 2,771,769	287 53	139.84	180.00	86.84	261,769	2,510,000	+40.16
	290	0	53	180.00	173.87	127.00	382,829	---	- 6.13

HOT WATER INPUTS
75,000 BTU/HR

2 DAY INTERVALS
LUBBOCK

	Time (Days)	Q_{IN}	AVG AMBIENT TEMP	OLD TEMP	NEW TEMP	ΔT	(A)= (0.08)(785)(48) =3014.4(ΔT)	(B)= (Q_{IN} - A)	B (83300)(.75) =0.000016(B)
	292	0	49	173.87	167.85	124.87	376,422	---	- 6.02
	294	0	49	167.85	162.12	118.85	358,253	---	- 5.73
	296	0	49	162.12	156.66	113.12	340,983	---	- 5.46
OCT	298	0	49	156.66	151.47	107.66	324,543	---	- 5.19
	300	0	49	151.47	146.53	102.47	308,877	---	- 4.94
	302	0	46	146.53	141.68	100.53	303,031	---	- 4.85
	304	- 2,683,422	303 46	141.68	180.00	95.68	288,422	2,395,000	+38.32
	306	0	46	180.00	173.54	134.00	403,930	---	- 6.46
	308	0	46	173.54	167.39	127.54	384,448	---	- 6.15
	310	0	46	167.39	161.54	121.39	365,915	---	- 5.85
	312	0	43	161.54	155.82	118.54	357,313	---	- 5.72
	314	0	43	155.82	150.38	112.82	340,094	---	- 5.44
	316	0	43	150.38	145.20	107.38	323,682	---	- 5.18
	318	0	43	145.20	140.27	102.20	308,075	---	- 4.93
NOV	320	- 2,776,338	319 43	140.27	180.00	97.27	293,213	2,483,125	+39.73
	322	0	42	180.00	173.34	138.00	415,987	---	- 6.66
	324	0	42	173.34	167.01	131.34	395,924	---	- 6.33
	326	0	42	167.01	160.98	125.01	376,816	---	- 6.03
	328	0	42	160.98	155.24	118.98	358,653	---	- 5.74
	330	0	42	155.24	149.78	113.24	341,355	---	- 5.46
	332	0	41	149.78	144.53	108.78	327,901	---	- 5.25
	334	0	41	144.53	139.54	103.53	312,092	---	- 4.99
	336	- 2,825,779	335 41	139.54	180.00	98.54	297,029	2,528,750	+40.46
	338	0	41	180.00	173.30	139.00	419,002	---	- 6.70
	340	0	41	173.30	166.92	132.30	398,793	---	- 6.38
	342	0	40	166.92	160.80	126.92	382,586	---	- 6.12
	344	0	40	160.80	154.97	120.80	364,135	---	- 5.83
	346	0	40	154.97	149.42	114.97	346,577	---	- 5.55
	348	0	40	149.42	144.14	109.42	329,850	---	- 5.28
DEC	350	0	40	144.14	139.12	104.14	313,927	---	- 5.02
	352	- 2,853,779	351 40	139.12	180.00	99.12	298,779	2,555,000	+40.88
	354	0	40	180.00	173.25	140.00	422,016	---	- 6.75
	356	0	40	173.25	166.82	133.25	401,662	---	- 6.43
	358	0	40	166.82	160.70	126.82	382,296	---	- 6.12
	360	0	40	160.70	154.88	120.70	363,828	---	- 5.82
	362	0	40	154.88	149.34	114.88	346,291	---	- 5.54
	364	0	40	149.34	144.07	109.34	329,593	---	- 5.27
	366	0	40	144.07	139.05	104.07	313,698	---	- 5.02
	368	- 2,857,954	367 40	139.05	180.00	99.05	298,579	2,559,375	+40.95
				180.00					

APPENDIX C

ESTIMATES OF AUXILIARY HEATING INTERVAL

ESTIMATES OF AUXILIARY HEATING INTERVAL

$$T_n = T_T r + \frac{1}{(M)(C)} [Q_{in} - (U)(A)(t)\ (T_T - T_a)];\ t = \text{time (hrs)}$$

$$\frac{1}{(M)(C)} = \frac{1}{83300(.75)} = 0.000016$$

$$(U)(A) = 0.08(785\ ft^2) = 62.8$$

$$T_n = T_T\ 0.000016\ [Q_{in} - 62.8\ t\ (T_T - T_a)]$$

$$Q_{IN} = \frac{T_N - T_T}{0.000016} + 62.8\ t\ (T_T - T_a)$$

Raise tank temp from 140° to 180°

$$Q_{IN} = \frac{180 - 140}{0.000016} + 62.8\ t\ (140 - T_a)$$

$$Q_{IN} = 2{,}500{,}000 + 62.8t\ (140 - T_a)$$

Need 2.5 MMBTU input + Amt energy lost while adding the 2.5 MMBTU
Hot water heater will need to run:

$$\frac{2{,}500{,}000\ BTU}{75{,}000 BTU/HR} + \frac{62.8\ t\ (140 - T_a)}{75{,}000 BTU/HR} = 33\text{-}1/3\ HRS + \frac{62.8t\ (140 - T_a)}{75000}$$

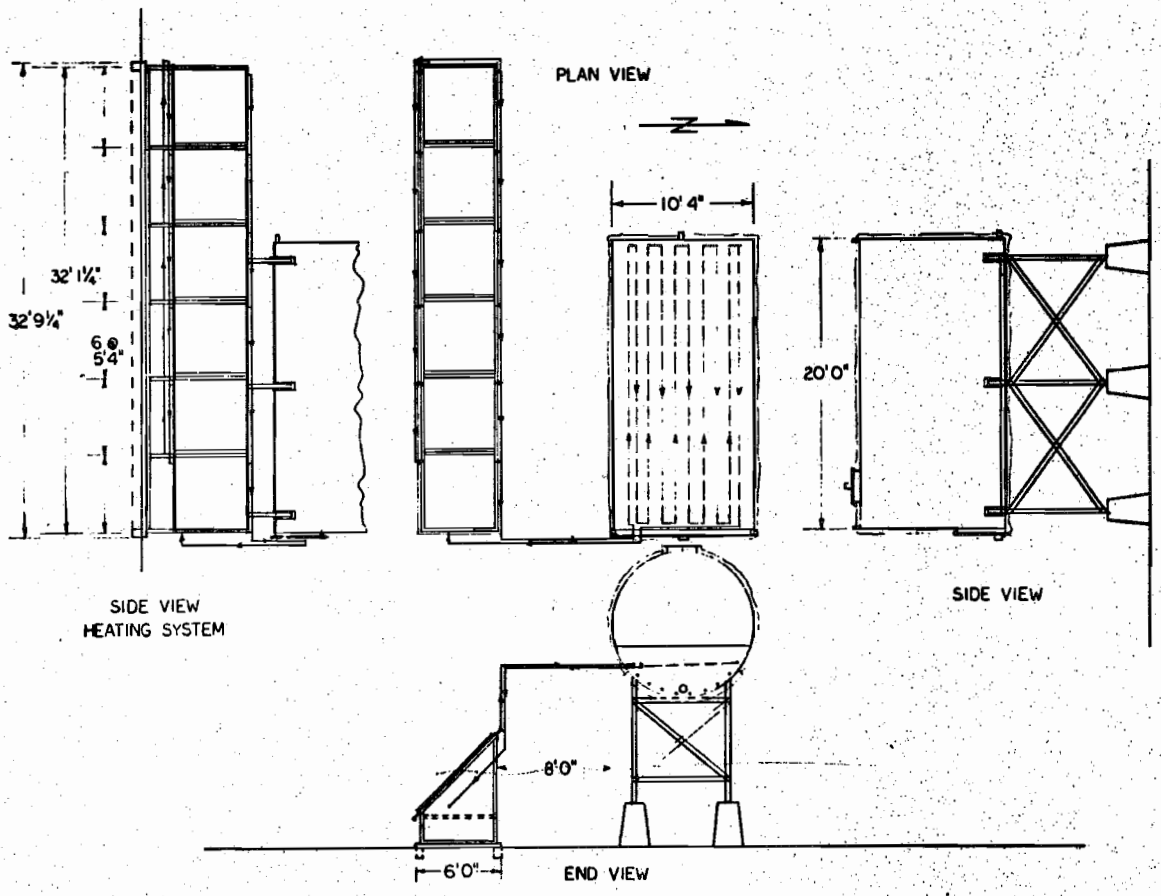
$\therefore$ the heater would need to run 33-1/3 hrs, if there were no energy loss from the tank during this 33-1/3 hrs.

Amt energy loss in 33-1/3 hrs in JULY = (62.8)(33-1/3)(140 - 75) = 136,067 BTU
Amt energy loss in 33-1/3 hrs in JANUARY=(62.8)(33-1/3)(140 - 40) = 209,333 BTU

Heater needs to be on approx. 35 - 36 hrs. in JULY
Heater needs to be on approx. 37 - 38 hrs. in JANUARY

APPENDIX D

PLANS FOR THE LUBBOCK SOLAR-HEATED TANK

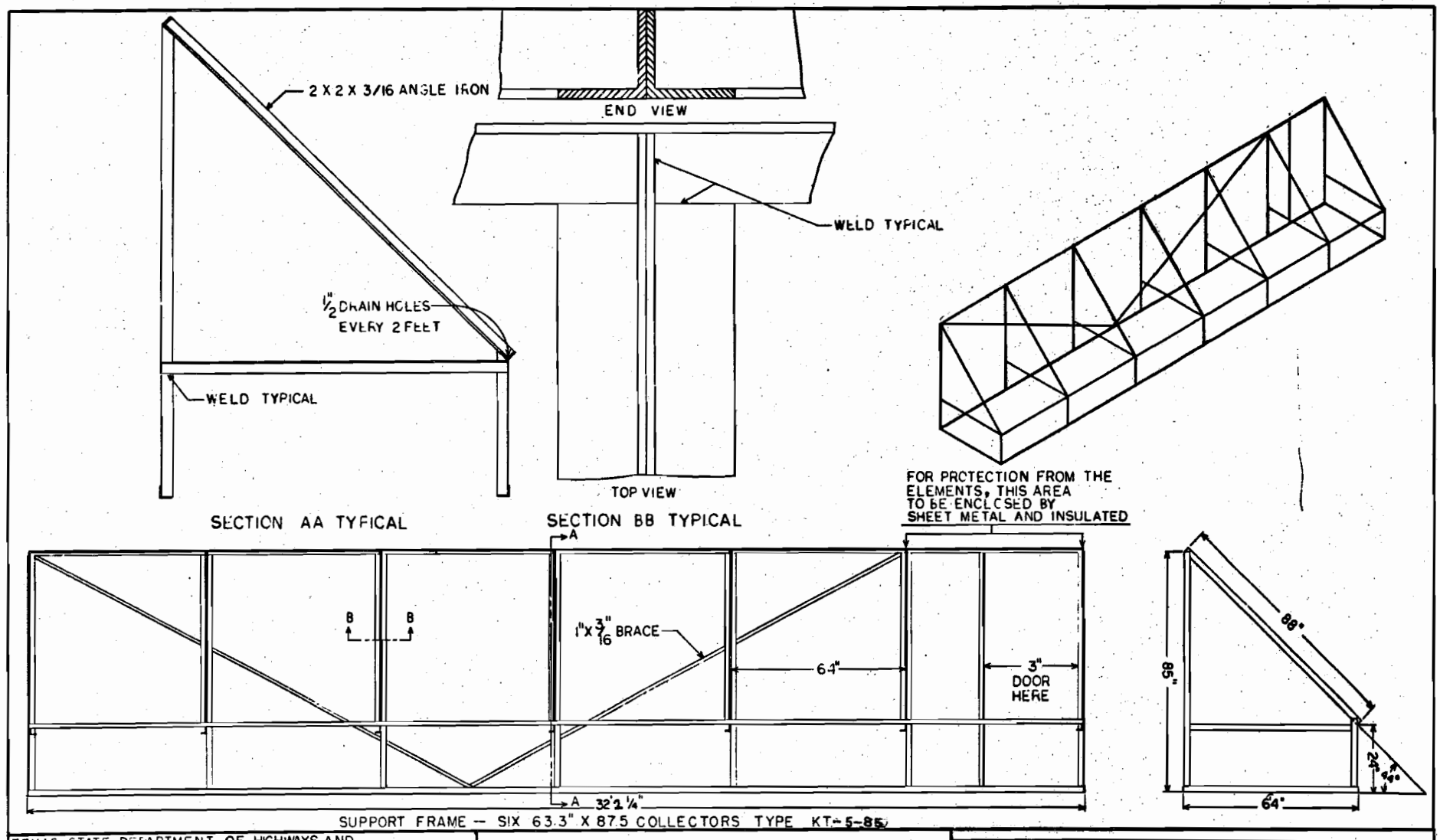


TEXAS STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
D-10 RESEARCH SECTION

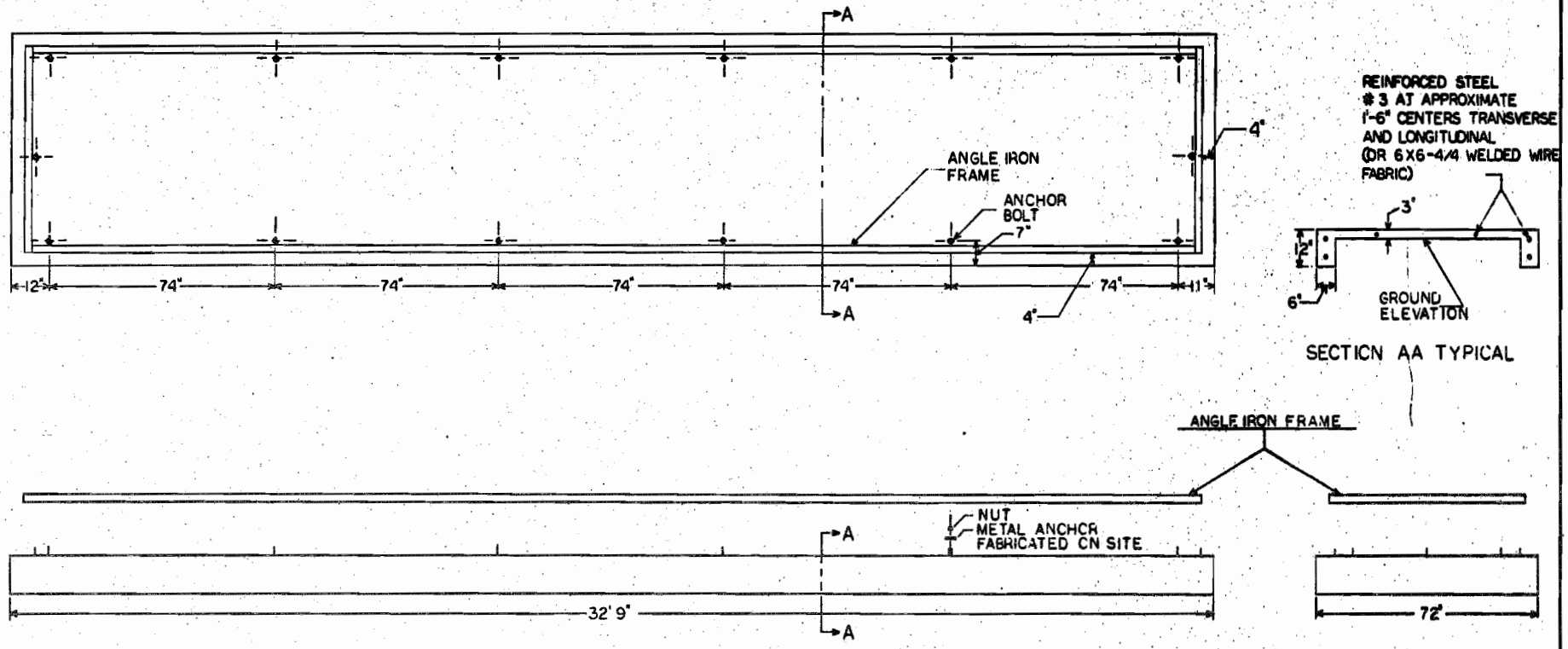
DRAWING BY ROGER STIEFER MARCH 1978

GENERAL LAYOUT OF
COLLECTOR AND TANK SYSTEM

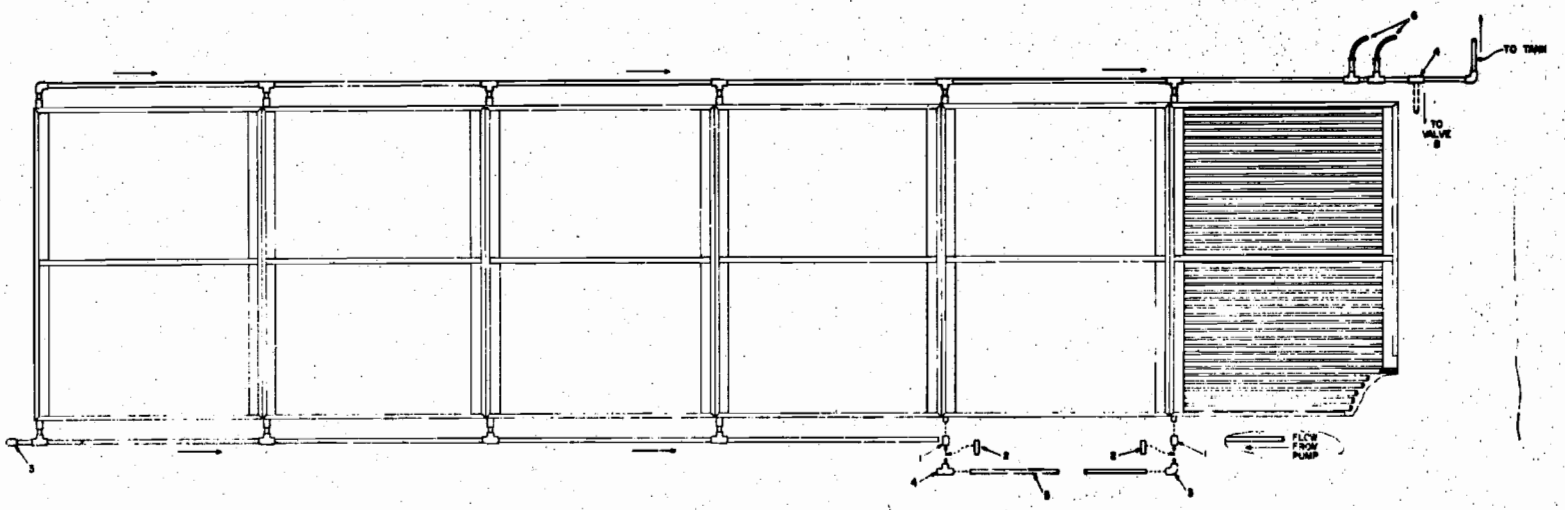
SCALE: 1in.=4 ft.
SIX COLLECTORS OR 216 SQ. FT. OF AREA
INSULATED ASPHALT TANK
10 PASS COPPER TUBE HEAT EXCHANGER



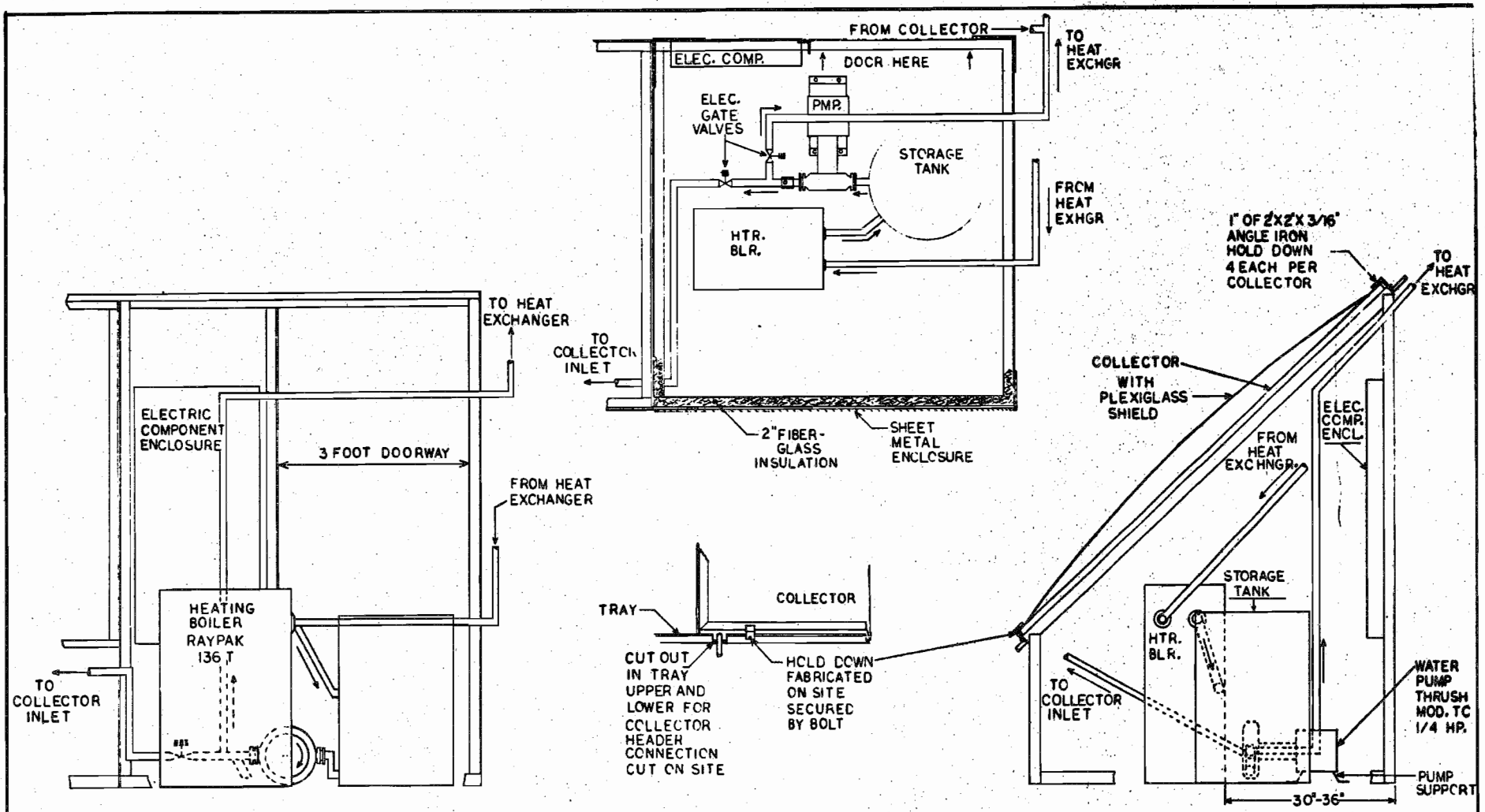
TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION D-10 RESEARCH DRAWN BY : RANDY BECK MARCH 1978	SOLAR COLLECTOR SUPPORT FRAME OF METAL CONSTRUCTION	2"X2"X3/16" ANGLE IRON STRUCTURE EAST END OF STRUCTURE IS ENCLOSED WITH SHEET METAL SOLAR COLLECTOR TO BE ROOF OF ENCLOSURE



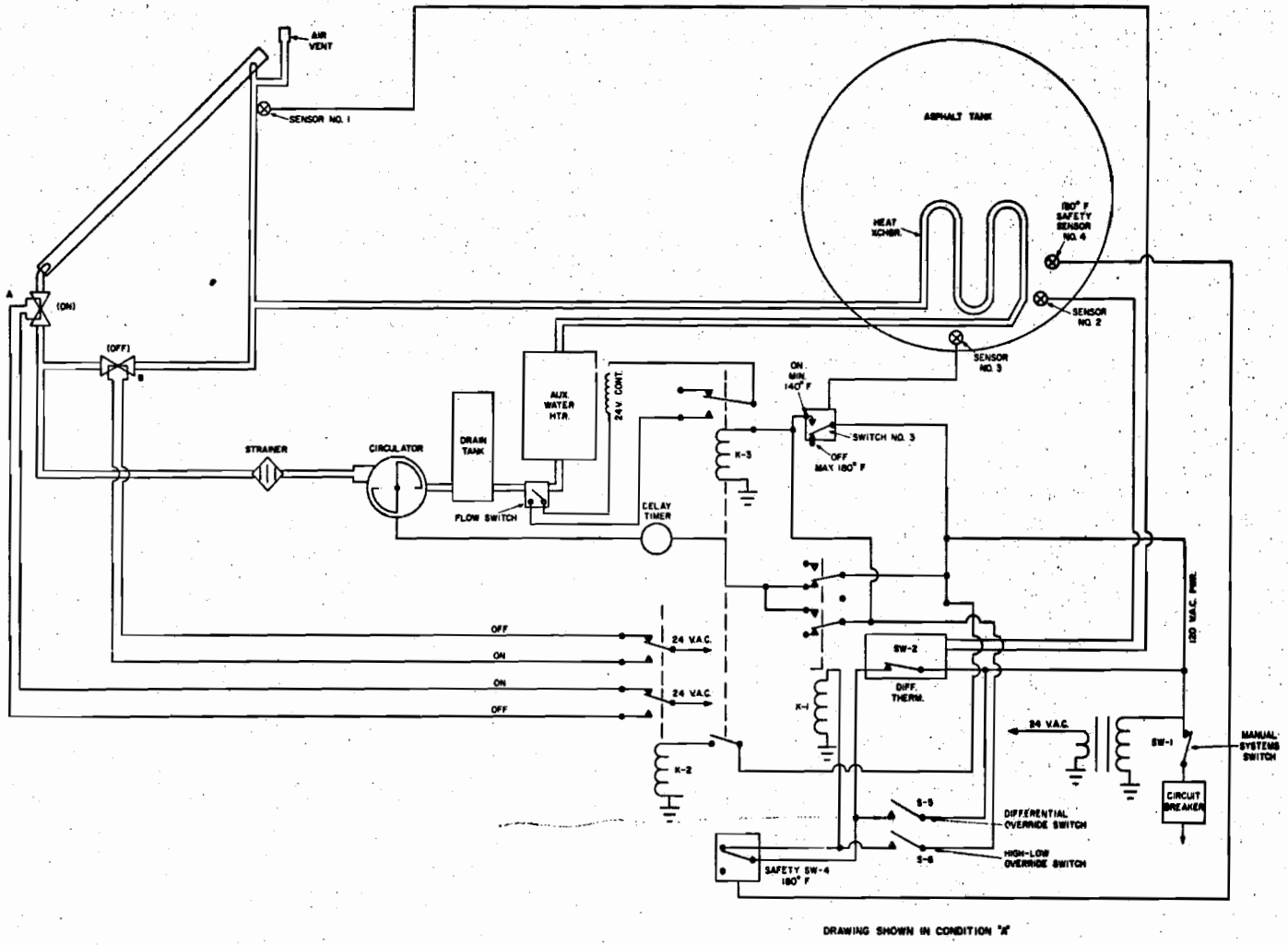
TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION D-10 RESEARCH DRAWN BY: RANDY BECK MARCH 1978	CONCRETE FOUNDATION FOR SOLAR PANEL SUPPORT	SCALE: ½ in. = 1'-0" ½ in. GALVANIZED ANCHOR BOLTS METAL ANCHOR SECURES ANGLE IRON SUPPORT TO SLAB



TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION D-10 RESEARCH SECTION DRAWN BY RANDY BECK JANUARY 1978 REDRAWN BY ROGER STIEFER MARCH 1978	PERPENDICULAR VIEW OF COLLECTORS AND COPPER HEADERS WITH DIRECTIONAL FLUID FLOW	SCALE: 3/8 in. = 1 ft 1. COUPLING 2. EXTENSION (4 in. long) 3. ELBOW (90°) 4. TEE 5. HEADER TUBING 3/8 COPPER TYPE "L" HARD TEMPER 81 5/8" LONG 6. TEMP PROBES

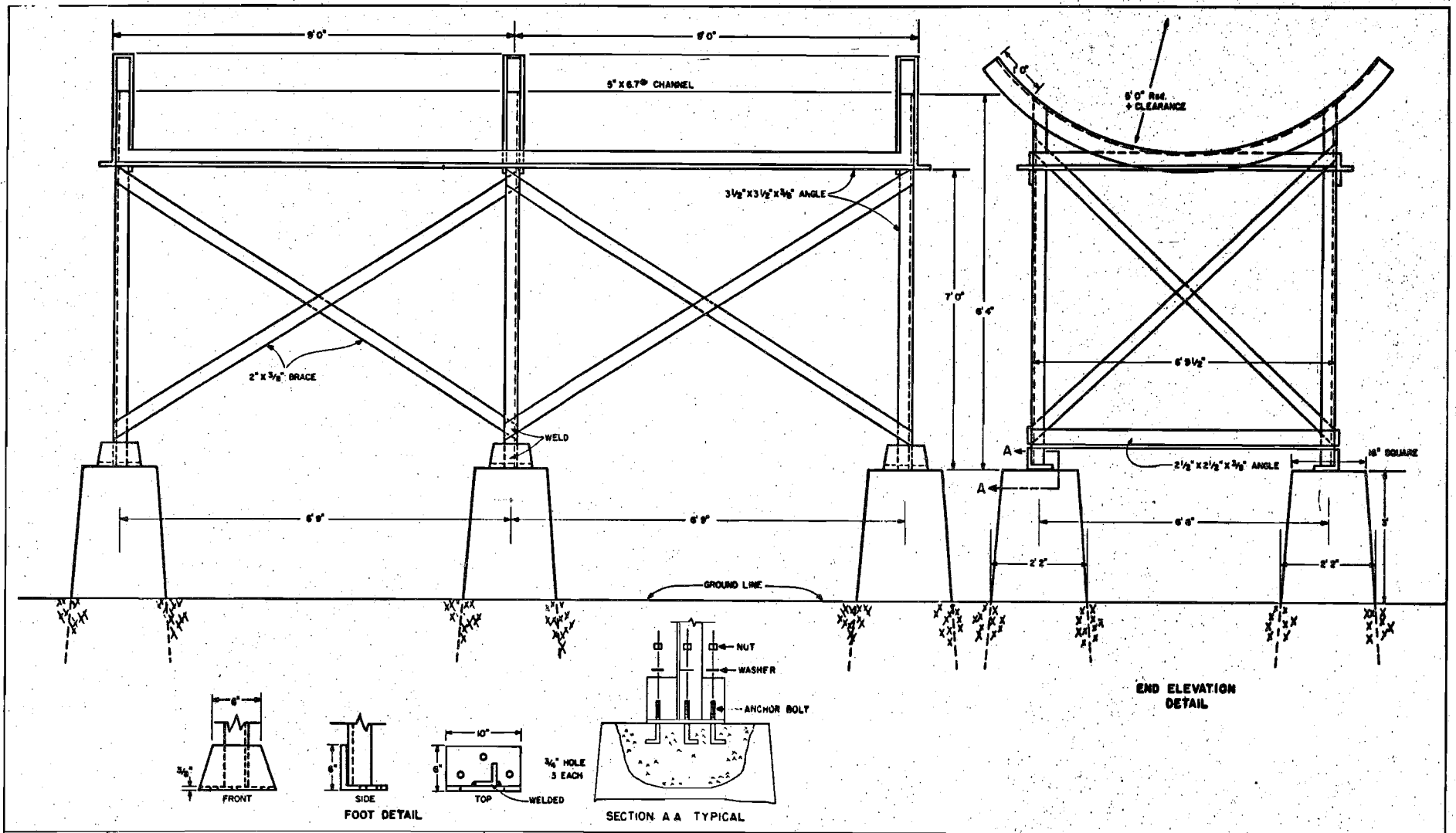


TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION D-10 RESEARCH DRAWN BY: RANDY BECK MARCH 1978	CIRCULATORY AND CONTROL COMPONENTS, AND PIPING LAYOUT	COLLECTORS TO BE PLACED IN TRAYS FORMED BY ANGLE IRON

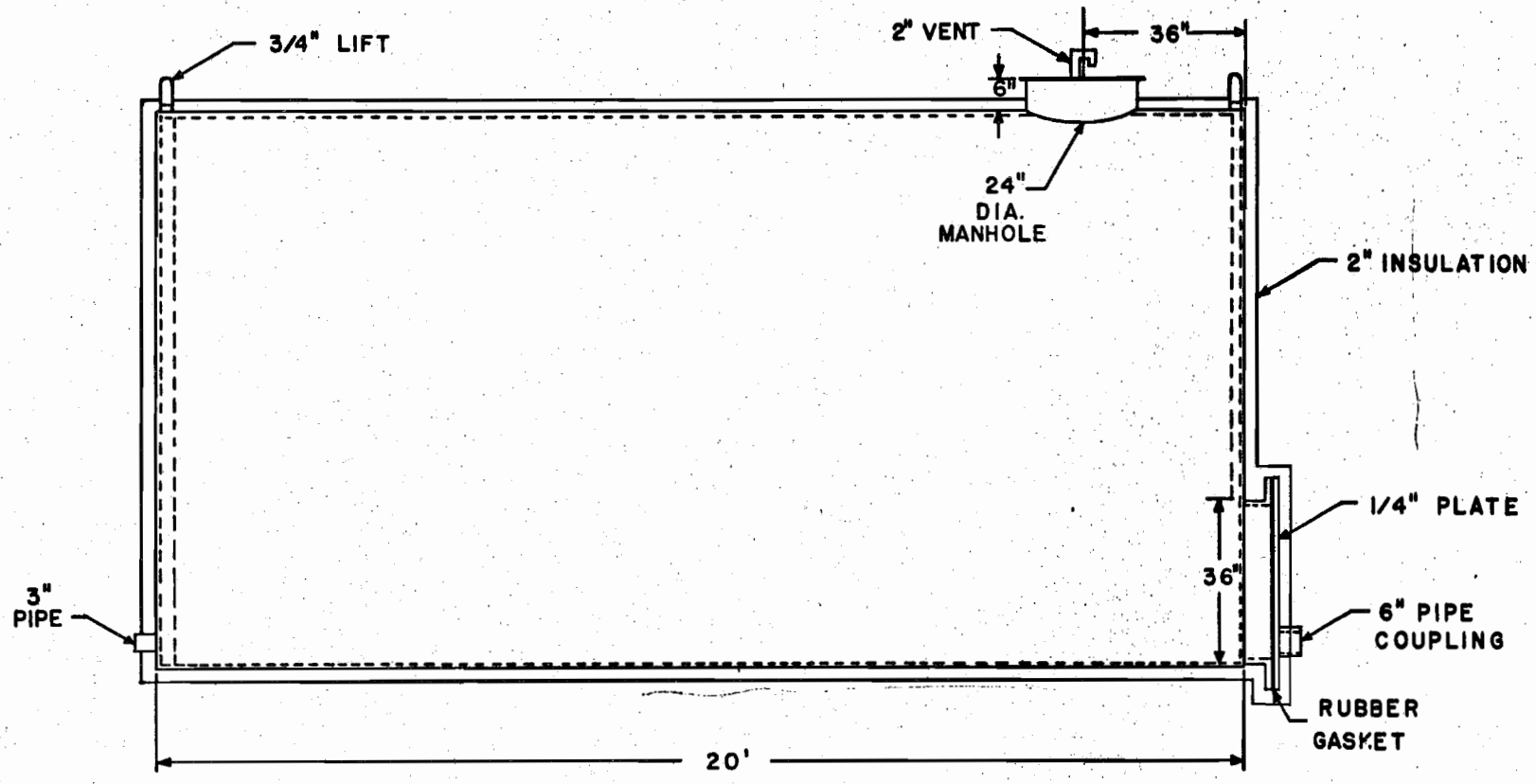


DRAWING SHOWN IN CONDITION "A"

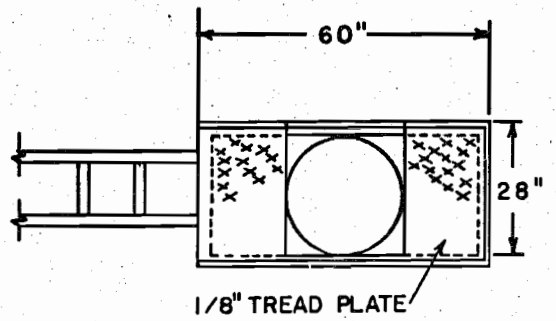
TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION D-10 RESEARCH SECTION	SOLAR HEATING ELECTRIC CONTROL SYSTEM	SCHEMATIC BY CURTIS GOSS DRAWN BY RANDY BECK JANUARY 1978 REDRAWN BY ROGER STIEFER MARCH 1978

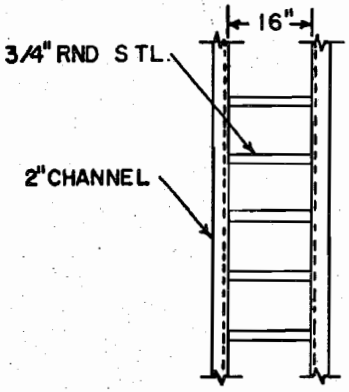


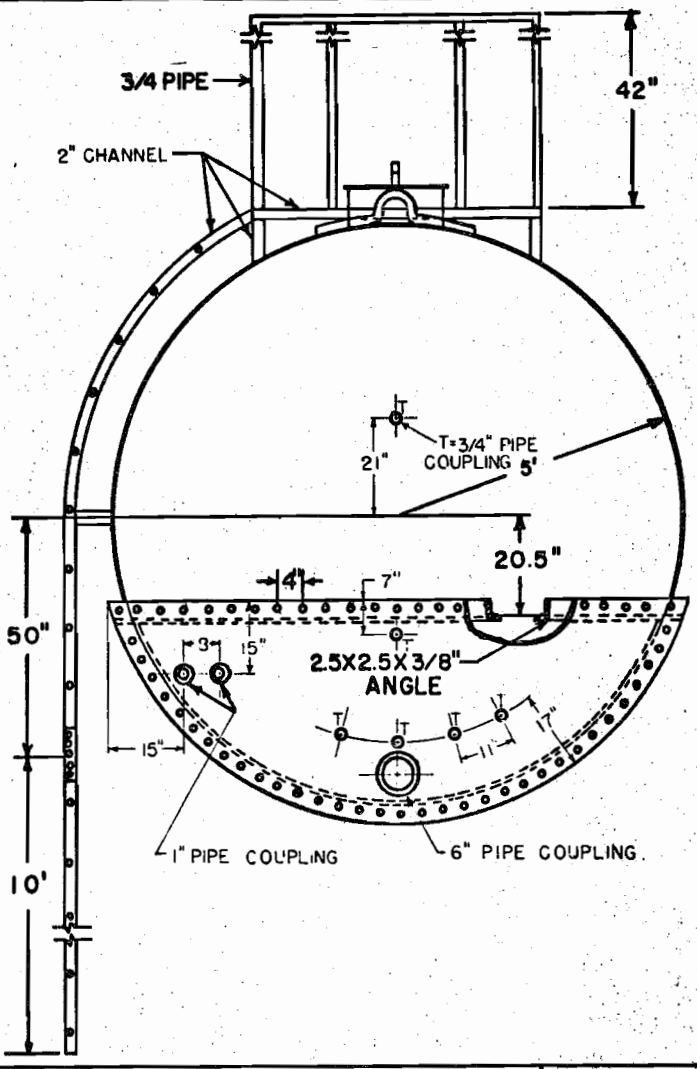
TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION D-10 RESEARCH SECTION DRAFTING BY ROGER STIEFER MARCH 1978	**ASPHALT TANK SUPPORT** **12,000 GALLON CAPACITY**	DRAWN BY BOB CANNADAY JANUARY 1978 NOTE: Measurements are as given, some parts of drawing not to scale

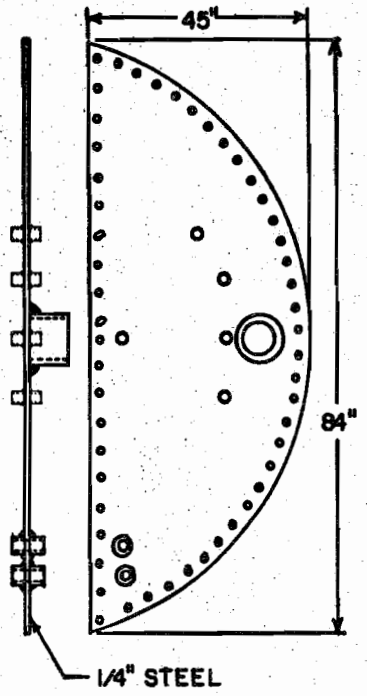


TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION D-10 RESEARCH SECTION	ASPHALT STORAGE TANK	DRAWN BY BOBBY CANNADAY SCALE: 1 inch = appx. 1 foot NOTE: All measurements are as given. REDRAWN BY RANDY BELL

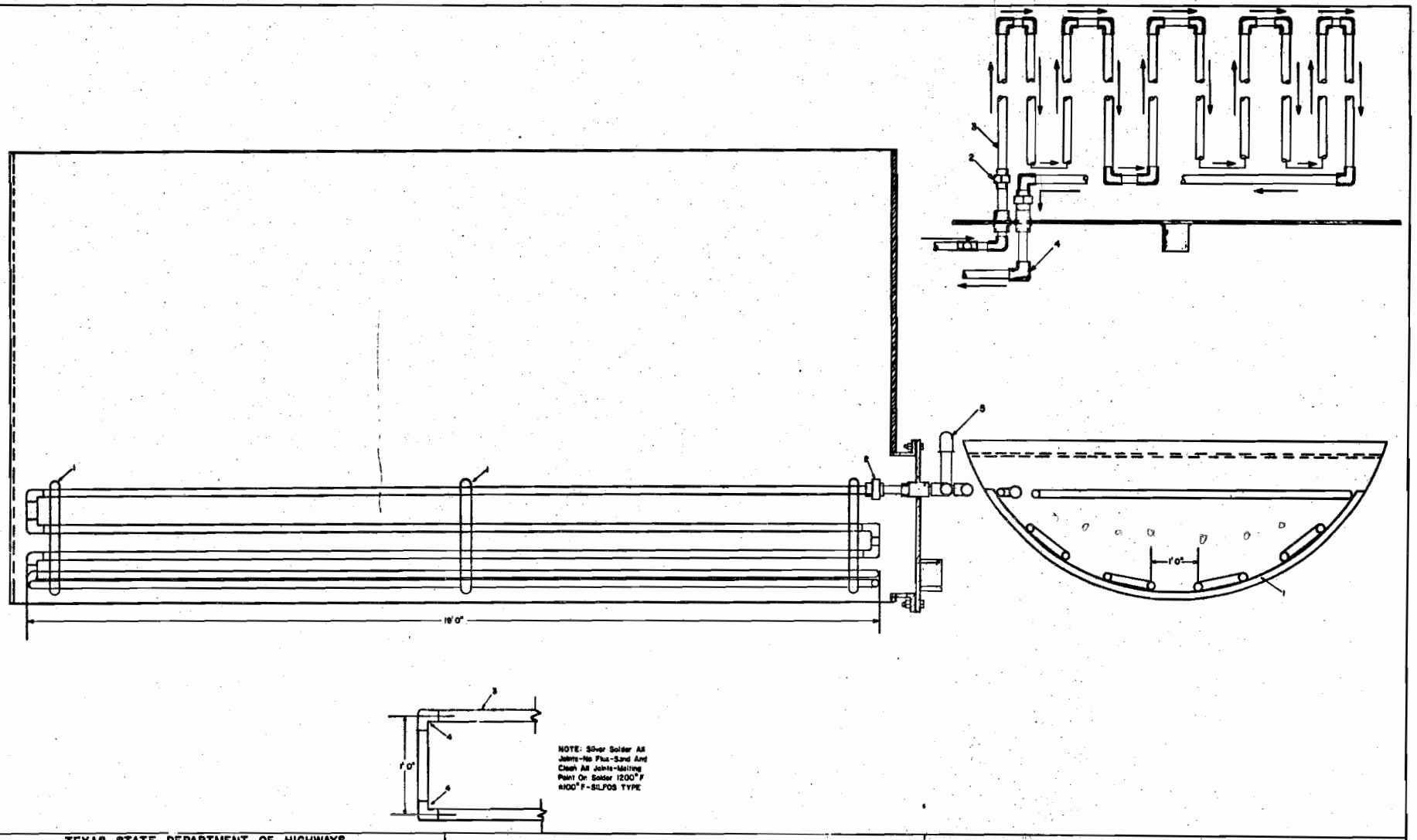








TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION D-10 RESEARCH SECTION	ASPHALT STORAGE TANK	CAPACITY 12000 GAL.
DRAWN BY BOBBY CANNADAY & RANDY BECK JANUARY 1978		



TEXAS STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
D-10 RESEARCH SECTION

FLOW DETAIL BY RANDY BECK
DRAWN BY BOB CANNADAY JANUARY 1978

COPPER HEAT EXCHANGER
3/4" COPPER TUBING

1. 1" COPPER STAND-OFF FROM BOTTOM OF TANK
2. ¾" COPPER UNION
3. ¾" O.D. COPPER
4. ¾" COPPER 90° ELBOW
5. AIR VENT

NOTE: Drawing not to scale, all measurements are as given.

INKING AND LETTERING BY ROGER STIEFER

APPENDIX E

SPECIFICATIONS FOR THE LUBBOCK SOLAR-HEATED TANK

INDEX

SOLAR ENERGY HEATED ASPHALT STORAGE TANK SYSTEM PROJECT FOR STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION LUBBOCK COUNTY, TEXAS

SECTIONS

STATE DEPARTMENT OF
HIGHWAYS AND PUBLIC TRANSPORTATION
NOTICE TO
BUILDING CONTRACTORS
STATE PROJECT _____
LUBBOCK COUNTY, TEXAS

Sealed proposals addressed to the District Engineer, State Department of Highways and Public Transportation, for the construction of a Solar Energy Heated Asphalt Storage Tank System, located at the Lubbock Northeast Maintenance site, 2705 Loop 289 NE, Lubbock, Lubbock County, Texas will be received at the office of the District Engineer, 601 Slaton Road, Lubbock, Texas, until 2:30 P. M., local time, _____
AND THEN PUBLICLY OPENED AND READ.

Plans and Specifications including minimum wage rates as provided by law will be furnished to any Contractor desiring to submit a bid and must be secured from George C. Wall, Jr., District Engineer, State Department of Highways and Public Transportation, 601 Slaton Road, Lubbock, Texas, 79408.

Usual rights reserved.

Proposals shall be submitted in sealed envelopes as furnished with the proposal. All data in lower left hand corner of envelope shall be properly filled in showing County, Project Number, Time and Date of Letting, also signature and address of bidders.

The State Department of Highways and Public Transportation hereby notifies all bidders that the applicable State Laws pertaining to discriminatory practices in bidding and awarding this work will be strictly adhered to.

STATE PROJECT

LUBBOCK COUNTY, TEXAS

ENGINEER: Mr. George C. Wall, Jr.
District Engineer

, ADDRESS: 601 Slaton Road
Or
P. O. Box 771
Lubbock, Texas
79408

Plans and Specifications for the work may be examined at the following location.

State Department of Highways and
Public Transportation
601 Slaton Road
Lubbock, Texas

CONTRACT FOR MAINTENANCE WORK

This agreement made this _____ day of _____, 1978, by and between the State of Texas, represented by the State Engineer-Director, State Department of Highways and Public Transportation, party of the first part, and _____

_____

his/their executors, administrators, heirs, successors or assigns, the Contractor, party of the second part.

WHEREAS, the State desires to enter into a contract for construction of a Solar Energy Heated Asphalt Storage Tank System, as shown and described in the plans, specifications and special provisions included herein, and

WHEREAS, the Contractor has been engaged in and now does such work and represents that he is fully equipped, competent and capable of performing the desired and herein outlined work and is ready and willing to perform such work in accordance with the lump sum price listed herein and the provisions of the herein included specifications, special provisions and plans, now

WITNESSETH: That for and in consideration of the Lump Sum price set forth in the Contractor's bid proposal, which said proposal is incorporated herein and made a part of this contract, the Contractor agrees to do, at his own proper cost and expense, all the work necessary for the contract work as shown and described in the plans and in accordance with the provisions of the specifications and special provisions which are a part of this contract.

And the State in consideration of the full and true performance of said work by the Contractor hereby agrees and binds itself to pay to the Contractor for the work performed in compliance with this contract at the respective Lump Sum price set forth in said bid proposal.

It is acknowledged and agreed by the parties hereto that this contract is the full and complete contract for the construction of the work called for and described herein.

The undersigned signature for the Contractor hereby represents and warrants that the signatory is an officer of the organization for which he has executed this contract and that the officer has full and complete authority to enter into this contract on behalf of the Contractor.

IN WITNESS WHEREOF, the parties hereto have set their hands the date herein named.

CONTRACTOR
Party of the Second Part

_____
(Print Firm Name)

BY: _____

Address: _____

_____

_____

STATE OF TEXAS
Party of the First Part

Certified as being executed for the purpose and effect of activating and/or carrying out of the orders, established policies, or work programs heretofore approved and authorized by the State Highway and Public Transportation Commission:

By: _____

RECOMMENDED FOR EXECUTION

_____
Director, Finance

_____
Chief Engineer of Maintenance Operations

_____
District Engineer

District No. Five

Project _____

Location Lubbock Northeast

Maintenance Section

County Lubbock

PROPOSAL

TO

THE STATE HIGHWAY AND

PUBLIC TRANSPORTATION COMMISSION

FOR THE CONSTRUCTION OF Solar Energy Heated Asphalt Storage Tank System

IN Lubbock COUNTY, TEXAS.

The undersigned, as bidder, declares that the only person or parties interested in this proposal as principals are those named herein; that this proposal is made without collusion with any other person, firm, corporation; that he has carefully examined the form of contract, instructions to bidders, profiles, grades, specifications, and the plans therein referred to, and has carefully examined the locations, conditions and classes of materials of the proposed work; and agrees that he will provide all the necessary machinery, tools, apparatus, and other means of construction, and will do all the work and furnish all the materials called for in the contract and specifications in the manner prescribed therein and according to the requirements of the Engineer as therein set forth.

STATE DEPARTMENT OF

HIGHWAYS AND PUBLIC TRANSPORTATION

PEOPOSAL OF _____
(Name)

_____
(Address)

Date _____

LUMP SUM BID

Lump sum bid for the entire construction of a Solar Energy Heated Asphalt Storage Tank System.

The sum of _____

_____ Dollars ($_____

* NOTE: Bid should be filled out in ink. Signature must appear on next page of this proposal.

Fill out bid forms in this book and return the entire book as your proposal.

DO NOT TEAR OUT ANY PAGES

In the event of the award of a contract to the undersigned, the undersigned will secure proper compliance with the terms and provisions of the contract, and to insure and guarantee the work until final completion and acceptance, and to guarantee payment of all lawful claims for labor performed and materials furnished in the fulfillment of the contract.

The work proposed to be done shall be accepted when fully completed and finished to the entire satisfaction of the Owner.

The undersigned certifies that the bid prices contained in this proposal have been carefully checked and are submitted as correct and final.

_____
(Print Firm Name)

* Signed by: _____

_____
(Title)

_____
(Address) (Zip Code)

_____
(Address) (Zip Code)

*The proposal bid must be filled out and signed in ink by the person or persons making or authorized to make the bid. If executed in the name of an individual the name should be printed beneath the signature. If executed in the name of a corporation it must be executed by an officer of the corporation authorized to execute such document giving his title and the name and title should be printed beneath the signature.

SAMPLE

TAX EXEMPTION CERTIFICATE

The undersigned hereby claims an exemption from payment of taxes under Chapter 20, Title 122A, Revised Civil Statutes of Texas, for the purchase of the tangible personal property described below or on attached order or invoice, which is made a part hereof:

_____

_____

_____

_____

_____

Purchased from: _____
(Name of Firm)

Address: _____

This purchase is for the exclusive use of a tax exempt State Agency or is to be incorporated in a Construction Contract for a tax-exempt State Agency, identified as follows:

_____
(Name of State Agency)

_____
(Project Identification Number)

_____
(Location of State Project)

The purchaser will be liable for payment of the Limited Sales, Use and Use Tax if the Purchaser uses the tangible personal property in some other manner or for some use other than reason listed above, and shall pay the tax based on the price paid for the tangible personal property.

EXECUTED this the _____ day of _____, 19____.

Purchaser _____
(Name of Firm)

Address _____

Purchasing Agent _____
(Signature)

UNIFORM GENERAL CONDITIONS
for all
STATE OF TEXAS
BUILDING CONSTRUCTION CONTRACTS
Revised August 29, 1977

ARTICLE I. GENERAL PROVISIONS

The following provisions, together with the drawings, specifications and agreement between the Owner and the Contractor, are complementary to the Contract, each with the other, as if therein specifically reiterated.

ARTICLE II. DEFINITIONS

Whenever the following terms are used in these Specifications or in the Contract, the intent and meaning shall be interpreted as follows:

1. Owner: The Owner is the State of Texas acting through any responsible instrumentality of the State of Texas. Hereinafter, the term "Owner: refers to the Agency responsible for the execution of this Contract in the name of the State.

2. Engineer: A person licensed as a professional engineer pursuant to Acts of the 45th Legislature, Regular Session, 1937, Chapter 404, as amended (compiled as Article 327a of Vernon's Texas Civil Statutes) employed to provide professional engineering services and having overall responsibility for the design of a project. The term "Engineer" standing by itself may, unless the context clearly indicates otherwise, mean an engineer employed by the Owner on a salary basis or an engineer in private practice retained for a specific project under a contractual agreement with the Owner. The term "private engineer" shall specifically and exclusively refer to a registered engineer in private practice retained for a specific project under a contractual agreement with the Owner.

3. Contractor: The individual, corporation, company, partnership, firm or other organization that has contracted to furnish the materials and to perform the Work under the Contract with the Owner.

4. Subcontractor: A person or organization who contracts under, or for the performance of part or all of, the Contract between the Owner and Contractor. The subcontract may or may not be direct with the Contractor.

5. Project: The term "Project" shall include the construction of any structure or any facility or utility appurtenant thereto, including original equipment and original furnishings thereof, and of any addition to, alteration, rehabilation or repair of any structure, or any facility or utility appurtenant thereto.

6. Work: All labor, plant, materials, facilities, and all other things that are necessary or proper for or incidental to the construction required by the Contract Documents.

7. Date of Substantial Completion: The Date of Substantial Completion of the Work, or designated portion thereof, is the date certified by the Engineer when construction is sufficiently complete, in accordance with the Contract Documents, so the Owner may occupy the Work, or designated portion thereof, for the use for which it is intended.

ARTICLE III. STATE SALES TAX

The Owner qualifies for exemption from State and Local Sales Tax pursuant to the provisions of Article 20.04 (F) of the Texas Limited Sales, Excise and Use Tax Act.

The Contractor may claim exemption from payment of applicable State Sales Taxes by complying with such procedures as may be prescribed by the State Comptroller of Public Accounts.

ARTICLE IV. LAWS GOVERNING CONSTRUCTION

A. COMPLIANCE WITH LAWS: In the execution of this contract, the Contractor must comply with all applicable state and federal laws, including but not limited to laws concerned with labor, equal employment opportunity, safety and minimum wages.

B. WAGE RATES: The Contractor is required to pay not less than the minimum wage scale of the various classes of labor as shown on the "Minimum Wage Schedule" provided by the Owner. The specified wage rates are minimum rates only, and the Owner will not consider any claims for additional compensation made by any Contractor because of payment by the Contractor of any wage rates in excess of the applicable rate contained in this Contract.

Pursuant to the provisions of Section 2 of Article 5159a, Vernon's Civil Statutes, "The Contractor shall forfeit as a penalty to the State, county, city and county, city, town, district or other political subdivision on whose behalf the contract is made or awarded, Ten Dollars ($10.00) for each laborer, workman or mechanic employed, for each calendar day, or portion thereof, such laborer, workman or mechanic is paid

less than the said stipulated rates for any work done under said contract, by him, or by any subcontractor under him, and the said public body awarding the contract shall cause to be inserted in the contract a stipulation to this effect."

ARTICLE V. CONTRACT DOCUMENTS AND RELATED ITEMS

The Contract Documents consist of the General Conditions, including Notice and Instructions to Bidders, Supplementary and Special Conditions, the Drawings and Specifications, including all modifications by Addenda, the Agreement between the Owner and the Contractor, and Change Orders as issued and approved. The Contract represents the entire Agreement between the Owner and the Contractor and supercedes all prior negotiations, representations, or agreements, either written or oral.

The submission of a Bid Proposal is indicative that the Contractor has visited the site, familiarized himself with the local conditions under which the Work is to be performed, and correlated his observations with the requirements of the Contract Documents.

The Contract Documents are complementary, and what is required by any one document shall be as binding as if required by all. The intention of the documents is to include all labor, materials, facilities and services necessary for the proper execution and completion of the Work.

The Contractor shall carefully examine the Drawings and Specifications and secure from the Owner such additional requisite information as is necessary for him to form a clear and full understanding of the work.

The Owner and the Contractor each binds himself, his partners, successors, assigns and legal representatives to the other party hereto and to the partners, successors, assigns and legal representatives of such other party in respect to all covenants, agreements and obligations contained in the Contract Documents. The Contractor shall not assign the Contract or sublet it as a whole without the written consent of the Owner, nor shall the Contractor assign any moneys due or to become due to him hereunder, without the previous written consent of the Owner.

A. Insurance: The Contractor shall not commence Work under this Contract until he has obtained all the insurance required hereunder and certificates of such insurance have been filed with and approved by the Owner. Approval of the insurance by the Owner shall not relieve or decrease the liability of the Contractor.

Unless otherwise provided for in the Supplementary General Conditions, the Contractor shall provide and maintain, until the Work covered in this Contract is completed and accepted by the Owner, the minimum insurance coverages as follows:

Type of Coverage	Limits of Liability	
1. Workmen's Compensation	Statutory	
2. Employer's Liability	$100,000	$300,000
3. Comprehensive General Liability		
a. Bodily Injury	$300,000 Each Occurrence	
b. Property Damage	$25,000 Each Occurrence	$100,000 Aggregate

B. Shop Drawings and Samples: Shop Drawings are drawings, diagrams, illustrations, schedules, performance charts, brochures and other data which are prepared by the Contractor or any Subcontractor, manufacturer, supplier, or distributor, and which illustrate some portion of the Work.

Samples are physical examples furnished by the Contractor to illustrate materials, equipment or workmanship, and to assist in the establishment of standards by which the Work will be judged.

The Contractor shall review and designate (stamp) his approval and submit, with reasonable promptness and in orderly sequence, all Shop Drawings and samples required by the Contract Documents, or subsequently by the Engineer as covered by modifications.

Shop Drawings and samples shall be properly identified, as specified, or as the Engineer may require. At the time of submission, the Contractor shall inform the Engineer in writing of any deviation in the Shop Drawings or samples from the requirements of the Contract Documents.

By approving and submitting Shop Drawings and samples, the Contractor thereby represents that he has determined and verified all field measurements, field construction criteria, materials, catalog numbers and similar data, or will do so, and that he has checked and coordinated each Shop Drawing and sample with the requirements of the Work and of the Contract Documents.

The Engineer and the Owner will review and approve the Shop Drawings and samples with reasonable promptness, but only for conformance with the design concept of the Project and with the information given in the Contract Documents. The approval of the Engineer and the Owner of a separate item shall not indicate approval of an assembly in which the item functions. The approval of

the Engineer and the Owner of the Shop Drawings or samples shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents unless the Contractor has informed the Engineer and the Owner in writing of such deviation at the time of submission and the Engineer and Owner have given written approval to the specific deviation, nor shall the approval of the Engineer and Owner relieve the Contractor from responsibility for errors or omissions in the Shop Drawings or samples.

C. Equal Materials: It is not the intent of these Specifications to limit materials to the product of any particular manufacturer. Where definite materials, equipment and/or fixtures have been specified by name, manufacturer or catalog number, it has been done so as to set a definite standard and a reference for comparison as to quality, application, physical conformity, and other characteristics. It is not the intention to discriminate against or prevent any dealer, jobber or manufacturer from furnishing materials, equipment, and/or fixtures which meet or exceed the characteristics of the specified items. Substitution of materials shall not be made without prior written approval from the Owner and the Engineer.

D. Copies Furnished and Ownership of Drawings and Specifications: The Contractor will be furnished, free of charge, up to thirty (30) complete sets of the Contract Drawings and Specifications exclusive of those required to be filed to obtain building permits. Additional complete sets of Drawings and Specifications, if required, will be furnished at reproduction cost.

All Drawings, Specifications and copies thereof furnished by the Engineer are and shall remain his property. They are not to be used on any other project, and with the exception of one contract set for each party to the Contract, are to be returned to the Engineer upon request following completion of the Work.

ARTICLE VI. SEPARATE CONTRACTS

The Owner reserves the right to award other contracts in connection with other portions of the Project under these or similar conditions of the Contract.

When separate contracts are awarded for different portions of the Project, "the Contractor" in the Contract Documents in each case shall be the Contractor who signs each separate Contract.

This Contractor shall properly connect and coordinate his Work with the work of other contractors. If any part of this Contractor's Work depends for proper execution or proper results on the work of any other separate contractor, this Contractor shall inspect and promptly report to the Engineer any discrepancies or defects he may find in such other work that render it unsuitable for such proper execution and results. Failure of this Contractor to so inspect and report shall constitute and acceptance of the other contractor's work as fit and proper to receive his work, except as to defects which may develop in the other separate contractor's work after the execution of this Contractor's Work.

Should this Contractor cause damage to the work or property of any separate contractor on the Project, this Contractor shall, upon due notice, endeavor to settle with such other contractor by agreement. If such separate contractor sues the Owner on account of any damage alleged to have been so sustained the Owner shall notify this Contractor who shall defend such proceedings and pay all costs in connection therewith, and if any judgment against the Owner arises therefrom this Contractor shall pay or satisfy it.

This Contractor shall afford other contractors reasonable opportunity for the introduction and storage of their materials and equipment and the execution of their work and shall properly connect and coordinate his Work with theirs.

ARTICLE VII. ROYALTIES AND PATENTS

The Contractor shall pay all royalties and license fees. He shall defend all suits or claims for infringement of any patent rights and shall save the Owner harmless from loss on account thereof, except that the Owner shall be responsible for all such loss when a particular design, process or the product of a particular manufacturer or manufactures is specified, but if the Contractor has reason to believe that the design, process or product specified is an infringement of a patent, he shall be responsible for such loss unless he promptly gives such information to the Engineer.

ARTICLE VIII. ADMINISTRATION OF THE CONTRACT

The Engineer will provide general administration of the Contract and will be the Owner's representative during construction and until final payment.

The Engineer has the authority to act on behalf of the Owner to the extend provided in the Contract Documents, unless otherwise modified by written instrument which will be shown to the Contractor. The Engineer will advise and consult with the Owner and all the Owner's instructions to the Contractor will be issued through the Engineer.

A. Access to and Inspection of the Work: The Contractor shall provide sufficient, safe and proper facilities at all reasonable times for the observation and/or inspection of the Work by the duly authorized representative of the Owner.

The Engineer and the Owner will make periodic visits to the site to familiarize themselves generally with the progress and quality of the Work and to determine in general if the Work is proceeding in accordance with the Contract Documents.

B. Owner's Right to Carry Out the Work: Should the Contractor at any time refuse or neglect to supply a sufficiency of properly skilled workmen or materials of the proper quality, or fail in any respect to prosecute the Work with promptness and diligence, or fail in the performance of any of the agreements herein contained, the Owner shall be at liberty, after ten (10) days Certified U. S. Mail written notice to the Contractor, and his sureties at their stipulated contractual and sureties address, to provide any such required labor or materials and to deduct the cost thereof from any money then due or thereafter to become due to the Contractor under this Contract. In such case, an appropriate Change Order will be issued deducting from the payments then or thereafter due the Contractor the cost of correcting such deficiencies, including the cost of additional services of the Engineer made necessary by such default, neglect or failure. If the payments then or thereafter due the Contractor are not sufficient to cover such amount, the Contractor shall pay the difference to the Owner.

C. Arbitration: In case arbitration is entered into, all claims, disputes, and other matters in question arising out of or relating to this Contract, or the breach thereof, shall be decided by arbitration in a manner as mutually agreed upon.

ARTICLE IX. CONTRACTOR'S RESPONSIBILITY FOR WORK

The Contractor shall supervise and direct the Work using his best skill and attention. He shall be solely responsible for all construction means, methods, techniques, sequences and procedures, and for coordinating all portions of the Work under his Contract.

The Contractor shall employ a competent superintendent who shall be in attendance at the Project site during the progress of the Work.

The superintendent shall be satisfactory to the Owner, and shall not be changed except with the approval of the Owner or if he leaves the employment of the Contractor. The superintendent shall represent the Contractor and shall have full authority to act on his behalf. All communications given to the superintendent shall be as binding as if given to the Contractor. Important communications will be confirmed in writing. Other communications will be so confirmed upon written request in each case.

The Contractor shall be responsible for acts and omissions of his employees and his subcontractors, their agents and employees.

A. Conditions at Site or Building: The Contractor is responsible for having visited the Site and having ascertained pertinent local conditions such as location, accessibility, and general character of the site or buildings, the character and extent of existing work within the adjacent to the site, and any other work being performed thereon at the time of the submission of his proposal.

If, in the performance of the Contract, sub-surface or latent conditions at the site are found to be materially different from those indicated by the Drawings and Specifications or unknown conditions of an unusual nature are disclosed differing materially from the conditions usually inherent in Work of the character shown and specified, the attention of the Engineer shall be called immediately to such conditions before they are disturbed. Upon such notice, or upon his own observation of such conditions, the Engineer with the approval of the Owner will promptly make such changes in the Drawings and Specifications as he deems necessary to conform to the different conditions, and any increase or decrease in the cost of the Work resulting from such changes will be adjusted subject to the prior approval of the Owner by Change Order.

B. Laws, Permits and Regulations:, The Contractor shall make himself familiar with and at all times shall observe and comply with all Federal, State and local laws, ordinances and regulations which in any manner affect the conduct of the Work and shall indemnify and save harmless the State and its official representatives against any claim arising from violation of any such law, ordinance or regulation by himself or by his employees.

The Contractor shall cooperate with applicable city or other governmental officials and inspectors at all times where their jurisdiction prevails. If such official or inspector deems special inspection necessary, the Contractor shall provide assistance and facilities that will expedite his inspection.

C. Tests: If the Contract Documents, laws, ordinances, rules, regulations, or orders of any public authority having jurisdiction require any Work to be inspected, tested or approved, the Contractor shall give the Engineer timely notice of its readiness and of the date arranged so the Engineer may observe such inspection, testing or approval.

If after the commencement of the Work, the Engineer determines that any Work requires special inspection, testing or approval, he will, upon written authorization from the Owner, instruct the Contractor to order such special inspection, testing or approval. If such special inspection or testing reveals a failure of the Work to comply with the requirements of the Contract Documents, laws, ordinances, rules, regulations or orders of any public authority having jurisdiction, the Contractor shall bear all costs thereof including the services of the Engineer made necessary by such failure; otherwise the Owner shall bear such costs and an appropriate Change Order will be issued.

D. Safety Precautions and Programs: The Contractor shall be responsible for initiating, maintaining and supervising safety precautions and programs in connection with the Work.

The Contractor shall take reasonable precautions for the safety of, and shall provide protection to prevent damage, injury or loss to:

a. All employees on the Work and all other persons who may be affected thereby.

b. All the Work and all materials to be incorporated therein, whether in storage on or off the site.

c. Other property at the site or adjacent thereto including trees, shrubs, lawns, walks, pavements, roadways, structures and utilities not designated for removal, relocation or replacement in the course of construction.

The Contractor shall comply with all applicable laws, ordinances, rules, regulations and orders of any public authority having jurisdiction for the safety of persons or property to protect them from damage, injury or loss.

E. Materials and Workmanship: All Work shall be executed in accordance with the Contract Documents, complete in all parts and in accordance with approved practices and customs, and of the best finish and workmanship. Unless otherwise specified, all materials and equipment incorporated in the Work under the Contract shall be new.

Owner may at any time request test specimens of various materials. The test specimens shall be furnished by the Contractor and tests will be made by the Owner at the expense of the Owner. When directed by the Owner, materialcompliances with the specifications shall be made by one of the following:

1. Manufacturer's certificate of compliance.
2. Mill certificate.
3. Testing laboratory certifications.
4. Report of actual laboratory test from the Owner's laboratory or from a laboratory satisfactory to the Owner. Samples tested shall be selected by or in the presence of the Owner and the method of testing shall comply with the professional societies' standard specifications.

F. Removal of Defective Work: If any materials furnished under this Contract are condemned by the Engineer, the Contractor shall, within a reasonable time after having received notice from the Engineer to that effect, proceed to remove from the grounds or buildings all condemned materials, whether worked or unworked and to take down all protions of the Work which the Engineer shall by like written notice condemn as unsound or improper or as in any way failing to conform to the Drawings and Specifications and shall make good all Work damaged or destroyed thereby.

G. Cleaning: The Contractor shall at all times keep the premises free from accumulation of waste materials or rubbish caused by the work under this contract.

Upon completion of the Project, and prior to the final inspection, the Contractor shall have the premises in a neat and clean condition.

ARTICLE X. CHANGES IN THE WORK

The Owner, without invalidating the Contract, may order changes in the Contract, the Contract Sum being adjusted accordingly. All such changes in the Contract shall be authorized by Change Order.

A Change Order is a written order signed by the Contractor, Owner and the Engineer issued after the execution of the Contract, authorizing a change in the Contract. No alterations shall be made unless in pursuance of a written order from the Owner and no claim for an addition to the Contract Sum will be valid unless so ordered. Changes ordered shall be mutually agreed on between the Contractor and the Owner. The Contractor shall prepare a detailed breakdown of the cost for the changes, showing separately any credit and the cost for the material, labor, overhead and profit.

All Work covered by Change Order shall be executed under the conditions of the original Contract Documents.

ARTICLE XI. PAYMENTS

Upon execution of the Contract by the Owner and the Contractor, the Contractor shall submit to the Engineer form 132, Monthly Statement for the lump sum bid price. No payments will be made until final acceptance of the completed Contract, or as amended.

ARTICLE XII. CLAIMS FOR UNPAID LABOR AND MATERIALS

When the value of the Contract between the Owner and the Contractor is not in excess of $25,000.00, claimants are referred to Article 5472-a, Revised Civil Statutes, for requirements that are prerequisite to the filing of a valid lien on funds unpaid to the Contractor at the time of filing of the claim.

ARTICLE XIII. FEDERALLY-FUNDED PROJECTS

The Owner may waive, suspend or modify any Article in these General Conditions which shall be in conflict with any federal statute or any rule, regulation or administrative procedure of any federal agency where such waiver, suspension or modification shall be essential to the receipt of federal funds for any project. In the case of any project wholly financed from federal funds, any standards required by the enabling federal statute or required by the rules and regulations of the administering federal agency shall be controlling.

INDEX

TO

SUPPLEMENTARY GENERAL CONDITIONS

SUPPLEMENTARY GENERAL CONDITIONS

Art. 1 SPECIAL NOTE: The Uniform General Conditions shall form a part of this contract, together with these Supplementary General Conditions and Special Conditions. A copy of the Uniform General Conditions is bound herein.

The Supplementary General Conditions and the Specifications bound herein shall be subject to all the requirements of the Uniform General Conditions of The Contract, except that these Supplementary General Conditions shall modify and/or supplement the Uniform General Conditions but do not void or suspend any portion thereof and shall be used in conjunction with them as a part of the Contract Documents.

Art. 2 DEFINITIONS: The following definitions shall prevail in addition to those set forth in Article II of the foregoing Uniform General Conditions:

2.1 Contract. The agreement between the State and the Contractor covering the furnishing of materials and performances of the work. The contract will include the Notice to Bidders, Plans, Specifications, Uniform General Conditions, Supplementary General Conditions, Special Conditions.

2.2 State. The State of Texas, Party of the First Part, represented by the State Engineer-Director for Highways and Public Transportation or his duly authorized representative, herein referred to as "Owner."

2.3 Commission. The State Highway and Public Transportation Commission of Texas.

2.4 Bidder. An individual, firm or corporation submitting a proposal.

2.5 Superintendent. The representative of the Contractor authorized to receive and fulfill instructions from the Owner, and who shall supervise and direct the construction.

2.6 Laboratory. The testing laboratories of the Owner or any other testing laboratory that may be designated or approved by the Owner.

2.7 Proposal. The offer of the bidder, made out on the prescribed form, giving prices for performing the work described in the plans and specifications.

2.8 Plans. The drawings approved by the Owner, which show the location, character, dimensions, and details of the work and which are a part of the contract.

2.9 Specifications. The directions, provisions and requirements contained herein or supplemented by such "Addenda" as may be issued or made pertaining to the method and manner of performing the work or to quantities and qualities of materials to be furnished under the contract. Where the phrase "or as directed by the Owner" occurs, it is to be understood that the directions, orders, or instructions to which they relate are within the limitations of, and authorized by the contract. Where reference is made to specifications of authoratative technical institutes, societies or federal bureaus, it shall be construed to mean the latest standard or tentative standard in effect on the date of the proposal.

2.10 Supplemental Agreements. Written agreements entered into between the Contractor and the State, covering alterations and changes in plans and/or specifications which are outside the provisions of the contract, but which are necessary to the proper completion of the work.

2.11 Working Day. A working day is defined as a calendar day, not including Saturdays, Sundays or legal holidays authorized in the list prepared by the Owner for contract purposes, in which weather or other conditions not under the control of the Contractor will permit the performance of the principal units of work underway for a continuous period of not less than 7 hours between 7 a.m. and 6 p.m. For every Saturday on which the Contractor chooses to work, one day will be charged against the contract working time when weather conditions will permit 7 hours of work as delineated above. A principal unit of work shall be that unit which controls the completion time of the contract. Nothing in this item shall be construed as prohibiting the Contractor from working on Saturdays if he so desires. Work on Sunday will not be permitted except in cases of extreme emergency, and then only with the written permission of the Owner. If Sunday work is permitted, working time will be charged on the same basis as week days.

2.12 Written Notice shall be deemed to have been duly served if delivered in person to the individual or to a member of the firm or to an officer of the corporation for whom it is intended, or if delivered at or sent by registered mail to the last business address known to him who gives the notice.

2.13 The law of the place of building and of the State of Texas shall govern the construction of this Contract.

2.14 ASTM. American Society for Testing Materials.

2.15 Screens and Sieves. As defined by ASTM.

2.16 AWS. American Welding Society.

2.17 NEMA. National Electrical Manufacturers Association.

2.18 IES. Illuminating Engineering Society.

2.19 AISC. American Institute of Steel Construction.

2.20 ACI. American Concrete Institute.

2.21 AGA. American Gas Association.

2.22 ASHRAE. American Society of Heating, Refrigeration & Air Conditioning Engineers.

2.23 ASME. American Society of Mechanical Engineers.

2.24 ARI. Air-conditioning & Refrigeration Institute.

2.25 UL. Underwriters Laboratory, Inc.

2.26 AWG. American Wire Gage.

2.27 NBFU. National Board of Fire Underwriters.

2.28 NEC. National Electrical Code (Published by NBFU).

Art. 3 INSTURCTIONS TO BIDDERS

3.1 Examination of Plans, Specifications, Special Provisions and Site of Work. Before submitting a bid, the bidder shall examine carefully the proposal, plans, specifications, special provisions, and the form of contract to be entered into for the work contemplated. He shall examine the site of work and satisfy himself as to the conditions which will be encountered relating to the character, quality, and quantity of work to be performed and materials to be furnished. The submission of a bid by bidder shall be conclusive evidence that he has complied with these requirements.

3.2 Interpretation by Addendum. If any person comtemplating submitting a bid for the proposed Contract is in doubt as to the true meaning of any part of plans, specifications, or other proposed contract documents, he may submit to the Owner a written request for the interpretation thereof not later than 6 days before the bidding date. The person submitting the request will be responsible for its prompt delivery. Any interpretation of the proposed documents will be made only by addendum duly issued and a copy of such addendum will be mailed or delivered to each person receiving a set of such documents within 3 days prior to bidding date.

The Owner will not be responsible for any other explanations or interpretations of the proposed documents.

3.3 Preparation of Proposal. The Bidder shall submit his proposal on the form furnished. The blank spaces for each lump-sum item as required in the proposal shall be filled in by writing in words in ink. The bidder shall submit a price for each lump-sum item for which a bid is requested. Where "Unit Prices" are requested, the bidder shall submit a price for each item called for. The proposal shall be executed with ink in the complete and correct name of the individual, firm, corporation, or combination thereof making the proposal and be signed by the person or persons authorized to bind the individual, firm, corporation or combination thereof.

3.4 Rejection of Proposals Containing Alterations, Erasures or Irregularities. Proposals may be rejected if they show any alteration of words or figures, additions not called for, conditional or uncalled for alternate bids, incomplete bids, any alteration of words or figures or erasures not initialed by the person or persons signing the proposal, or irregularities of any kind. The entire bound specification should be submitted as the bidder's proposal. Proposals that are submitted separately from the specifications will be considered irregular.

3.5 Public Opening of Proposals. Proposals will be opened and read publicly at the time and place indicated in the Notice to Contractors.

3.6 Disqualification of Bidder. More than one proposal involving an individual, firm or corporation, or any combination thereof under the same or different names will not be considered. Reasonable grounds for believing that any bidder is interested in more than one proposal for the work contemplated will be cause for the rejection of all proposals in which such bidder is interested. Any or all proposals will be rejected if there is reason for believing that collusion exists among the bidders, and all participants in such collusion will not be considered in future proposals for the same work. Contracts will be awarded only to responsible bidders.

Art. 4 AWARD AND EXECUTION OF CONTRACT

4.1 Consideration of Bids. For the purpose of award, after the proposals are opened and read, the amount of the bid will be considered to be that which is bid on each division of work or combinations thereof. The bids will then be compared and the results made public. Until the award of the contract is made, the right will be reserved to reject any or all proposals and to waive such technicalities as may be considered for the best interest of the State.

4.2 Award of Contract. The award of the contract, if it be awarded, will be to the lowest responsible bidder. The award, if made, will be within thirty (30) days after the opening of the proposal.

The Owner will award a contract on the entire work or separate contracts on division of the work as stipulated in the Notice to Bidders.

4.3 Approval of Contract. The Contract will be approved and signed under authority of the Commission.

4.4 Execution, Correlation, and Intent of Documents. The Contract shall be executed in duplicate by the Owner and the Contractor and approved by the Commission.

4.5 Failure to Execute Contract and Bonds. Should the bidder to whom the contract is awarded refuse or neglect to execute and file the contract within 15 days after written notification of the award of the contract, the proposal guaranty filed with the bid shall become the property of the State, not as a penalty, but as liquidated damages.

4.6 Beginning of Work. The Contractor shall not begin work until authorized by the Owner in writing to do so.

Art. 5 CONTRACT DRAWINGS AND TECHNICAL SPECIFICATIONS

5.1 Interpretation of Plans, Specifications. The specifications, the accompanying plans, and supplemental agreements are essential parts of the contract, and a requirement occuring in one is as binding as though occuring in all. They are intended to be cooperative and do describe and provide for a complete work. In cases of disagreement, figured dimensions shall govern over scaled dimensions, and specifications shall govern over plans.

Reference shall be made to the drawings for all measurements. The Contractor is hereby made responsible for checking all dimensions on the drawings and for verifying dimensions at the building. Any discrepancies shall be reported at once to the Owner. The Contractor is responsible for examining the site and verifying all conditions and situations.

Should any items on the drawings or in the specifications require further explanation, or should any questions arise respecting the true meaning of the drawings and specifications, reference shall be made by the General Contractor promptly to the Owner. In no case shall work proceed when the Contractor is in doubt concerning the intent of the drawings and specifications.

Failure to examine the plans of this project, and to report discrepancies shall not relieve the Contractor of this responsibility. No extra charge or compensation will be allowed on account of this negligence.

5.2 Detailed Drawings and Instructions The Owner will furnish with reasonable promptness, additional instructions, by means of drawings or otherwise; necessary for the proper execution of the work. All such drawings and instructions shall be consistent with the Contract, true developments thereof, and reasonably inferable therefrom.

The work shall be executed in conformity therewith and the Contractor shall do no work without proper drawings and instructions.

The Contractor and the Owner, if either so requests, shall jointly prepare a schedule, subject to change from time to time in accordance with the progress of the work, fixing the dates at which the various detail drawings will be required, and the Owner shall furnish them in accordance with that schedule. Under like conditions, a schedule shall be prepared, fixing the dates for the submission of shop drawings, for the beginning of manufacture and installation of materials and for the completion of the various parts of the work.

Art. 6 REQUIREMENTS PERTAINING TO MATERIALS AND/OR EQUIPMENT

6.1 Approval of Materials and/or Equipment. All materials and/or equipment proposed to be used shall be approved by the Owner prior to its incorporation in the work. The Contractor shall furnish all samples and technical data as may be necessary or as hereinafter requested. The work shall be in accordance with approved samples and any work in which materials and/or equipment are used without

prior test and approval or written permission of the Owner may be ordered removed and replaced at the contractor's expense.

Unless otherwise specified, all materials shall be new and both workmanship and materials shall be of good quality. The Contractor shall, if required, furnish satisfactory evidence as to the kind and quality of materials.

6.2 Storage of Materials. Materials shall be so stored as to insure the preservation of their quality and fitness for the work. When considered necessary by the Owner, they shall be placed on wooden platforms or other hard, clean surfaces and not on the ground. They shall be placed under cover when so directed. Stored materials shall be so located as to facilitate prompt inspection.

6.3 Defective Materials and/or Equipment. All materials not conforming to the requirements of these specifications will be rejected and shall be removed immediately from the site of the work unless permitted to remain by the Owner. Upon failure on the part of the Contractor to comply with any order of the Owner made under the provisions of this Item, the Owner will have authority to remove and replace defective material and to deduct the cost of removal and replacement from any money due or to become due the Contractor. Materials or equipment which after approval have in any way become defective or unfit for use shall not be used in the work.

Art. 7 WORK REQUIREMENTS

7.1 Responsibility of Contractors. The Contractor will be held responsible for the execution of a satisfactory and complete piece of work in accordance with the true intent of the drawings and specifications. If the Contractor has good reason for objecting to the use of any material, appliance or method of construction as shown or specified, he shall make a report of such objection to the Owner, and obtain proper interpretation before material is purchased, and shall proceed with the work, only with the understanding that a satisfactory job will be required.

Work specified, and not shown; or drawn and not specified, is to be executed as fully as if described in both ways, and any work or material which is not directly or indirectly noted in the specifications and drawings, but is necessary for the proper carrying out of the obvious intention is to be understood as implied and to be provided for by the Contractor in his proposal as fully as if specifically described or delineated. Any discrepancies between drawings and specifications must be reported to the Owner for correction and interpretation before the work is executed.

7.2 Workmen and Equipment. All workmen employed by the Contractor shall have such skill and experience as will enable them to properly perform the duties assigned them. Any person employed by the Contractor or a subcontractor who, in the opinion of the Owner, does not perform his work in a proper and skillful manner, or who is disrespectful, intemperate, disorderly, or otherwise objectionable, shall at the written request of the owner be forthwith discharged and shall not be employed again on any portion of the work without the written consent of the Owner. The Contractor shall furnish such suitable machinery, equipment, and construction forces as may be necessary, in the opinion of the Owner, for the proper prosecution of the work, and failure to do so may cause the Owner to withhold all estimates which have or may become due or the Owner may suspend the work until his requests are complied with.

The Contractor shall at all times enforce strict discipline and good order among his employees.

7.3 Changes in the Work. Changes in the work under this contract, which necessitate an adjustment to the contract price, shall be executed under a Change Order or under a Supplemental Agreement, depending on the circumstances outlined below.

Change Orders may be issued by the Owner in accordance with Article X of the foregoing Uniform General Conditions for changes in the work which do not change the scope of the original contract and for which adjustments to the contract price fall within the limits of the Contingency Sum set forth on the Contractor's Proposal.

A Supplemental Agreement to the contract must be executed to cover any change in the work which either increases or decreases the scope of the original contract. Adjustments to the contract price shall, in this case, be as negotiated in the Supplementary Agreement.

It shall be understood that the Owner shall have authority to give instructions during the progress of the work which may result in minor changes in the work, not involving an adjustment of costs and not inconsistant with the intent and purposes of the contract documents, in which cases written Change Orders may or may not be issued.

The value of changes in the work, whether executed under a Change Order or by Supplemental Agreement, shall be determined in one of the following ways:

(1) By estimate and acceptance in a lump sum.

The Contractor shall furnish the Owner an itemized breakdown of the quantities and prices used in computing the value of any change that might be ordered.

(2) By unit prices named in the contract or subsequently agreed upon.

7.4 Claims for Extra Cost. If the Contractor claims that any instructions by drawings or otherwise involve extra cost under this contract, he shall give the Owner written notice thereof within a reasonable time after the receipt of such instructions, and in any event before proceeding to execute the work, except in emergency endangering life or property, and the procedure shall then be as provided for changes in the work. No such claim shall be valid unless so made.

7.5 Temporary Suspension of Work. The Owner will have authority to suspend the work, wholly or in part, for such period as he may consider necessary, and the "Time Charge" will be suspended during such period. Notice of such suspension with the reasons therefor will be given the Contractor in writing. The Contractor shall not suspend work without written authority of the Owner.

7.6 Correction of Work Before Final Payment. The Contractor shall promptly remove from the premises all materials condemed by the Owner as failing to conform to the Contract, whether incorporated in the work or not, and the Contractor shall promptly replace and re-execute his own work in accordance with the contract and without expense to the Owner and shall bear the expense of making good all work of other Contractors destroyed or damaged by such removal or replacement.

If the Contractor does not remove such condemned work and materials within a reasonable time, fixed by written notice, the Owner may remove them and may store the material at the expense of the Contractor. If the Contractor does not pay the expenses of such removal within ten days time thereafter, the Owner may, upon ten days written notice, sell such materials at auction or at private sale and shall account for the net proceeds thereof, after deducting all costs and expenses that should have been borne by the Contractor.

7.7 Correction of Work After Final Payment. Neither the final certificate, nor payment nor any provisions in the Contract Documents shall relieve the Contractor nor his Surety of responsibility for faulty materials of workmanship and, unless otherwise specified, he shall remedy any defects due thereto and pay for any damage to other work resulting therefrom, which shall appear within a period of one year from the date of completion. The Owner shall give notice of observed defects with reasonable promptness.

7.8 Installation of Special Equipment. The Owner reserves the right to execute or cause same to be done, any work not included in the Contract but considered necessary to the completion of the plant for the purpose for which it is intended, during the course of construction.

Art. 8 ABANDONMENT OF WORK OR DEFAULT OF CONTRACT

8.1 If the Contractor fails to begin the work within the time specified; or fails to perform the work with sufficient workmen and equipment; or has insufficient materials to insure the completion of the work within the contract time; or shall perform the work unsuitably; or shall neglect or refuse to remove materials or perform anew such work as may have been rejected as being defective or unsuitable; or shall discontinue the prosecution of the work without authority; or shall become insolvent or be declared bankrupt; or shall commit any act of bankruptcy or insolvency; or shall make an unauthorized assignment for the benefit of any creditor; or from any other cause whatsoever shall not carry on the work in an acceptable manner, the Owner may give notice in writing to the Contractor of such delay, neglect, or default, specifying the same. If the Contractor within a period of ten (10) days after such notice shall not proceed in accordance therewith, then the party of the first part shall, upon written certificate from the Owner of the fact of such delay, neglect, or default and the Contractor's failure to comply with such notice, have full power and authority, without violating the contract to take the prosecution of the work out of the hands of the Contractor and to appropiate or use any or all materials and equipment on the ground as may be suitable and acceptable, and enter into an agreement for the completion of the contract according to the terms and provisions thereof or use such other methods as in his opinion may be required for the completion of the contract in an acceptable manner. All costs and charges incurred by the party of the first part, together with the costs of completing the work under the contract, shall be deducted from any money due, or which may become due, the Contractor. In case the cost so incurred by the party of the first part shall be less than the amount which would have been payable under the contract if it had been completed by the Contractor, the Contractor will be entitled to receive the difference. In case such cost shall exceed the amount which would have been payable under the contract, then the Contractor shall be liable and shall pay to the party of the first part the amount of such excess.

Art. 9 PAYMENTS

9.1 Payment and Compensation for Altered Quantities. When alterations in plans or quantities of work not requiring supplemental agreements, as hereinbefore provided for, are ordered and performed, the Contractor shall accept payment in full according

to the terms of a mutually agreed and properly executed "Change Order" as outlined under Article 7.3 above. The amount paid will be for direct cost of labor and materials only, exclusive of profit and overhead, unless otherwise stipulated.

9.2 Payment for Added or Delected Work. Work not within the limit of the contract amount will be paid for according to the terms of a "Supplemental Agreement" executed in accordance with Article 7.3 above.

Art. 10 INSURANCE AND BONDS

10.1 Waiver of Liens Against Property. It is distinctly understood that by virtue of this contract no mechanic, Contractor, subcontractor, material supplier, artisan or laborer whether skilled or unskilled, or combination thereof, shall ever in any manner have claim or acquire any lien upon the building, or any of the improvements of whatever nature or kind so erected by virtue of this contract nor upon any of the land which said building or any of the improvements are so erected, built or situated.

10.2 Safety of Building or Work. It is to be understood by the Contractor that the work is entirely at his risk, until the same is accepted, and he will be liable for its safety to the amount of money paid him by the Owner on account of the same.

10.3 Insurance Required. Contractor shall secure and maintain insurance coverage for the duration of this contract as required by Article V of the foregoing Uniform General Conditions. Modifications to coverages and amounts of insurance required for this project shall be as specified in the Special Conditions section of this specification.

10.4 Assignment. Neither party to the contract shall assign the contract or sublet it as a whole without the written consent of the other, nor shall the Contractor assign any moneys due or to become due to him hereunder. No subcontract will, in any case, relieve the Contractor of his responsibility under the contract and bond.

Art. 11 RESPONSIBILITY OF CONTRACTOR

11.1 Separate Contracts. The Owner reserves the right to let other contracts in connection with this work. The Contractor shall afford other Contractors reasonable opportunity for the introduction and storage of their materials and the execution of their work, and shall properly connect and coordinate his work with theirs.

If any part of the Contractor's work depends for proper execution or results upon the work of any other contractor, the Contractor shall inspect and promptly report to the Owner any defects in such work that render it unsuitable for such proper execution and results. His failure to so inspect and report shall constitute an acceptance of the other Contractor's work as fit and proper for the reception of his work, except as to defects which may develop in the other Contractor's work after the execution of his work.

To insure the proper execution of his subsequent work the Contractor shall measure work already in place and shall at once report to the Owner any discrepancy between the executed work and the Drawings.

11.2 Mutual Responsibility of Contractors. The Contractor shall be responsible for all damages to persons or property that occur as a result of his fault or negligence in connection with the prosecution of the work and shall be responsible for all materials delivered and work performed until completion and final acceptance. All work whether completed or not that is in any way damaged shall be restored to its original condition at the cost of the Contractor causing such damage and be free of charge to other contractors or the Owner.

Upon completion of the contract the work shall be delivered complete and undamaged.

11.3 Protection of Adjoining Property. The Contractor shall take proper measures to protect the adjacent or adjoining property which might be injured by any process of construction, and, in case of any injury or damage, he shall restore at his own expense the damaged property to a condition similar or equal to the existing before such injury or damage was done, or he shall make good such injury or damage in an acceptable manner.

11.4 Responsibility for Damage Claims. The Contractor shall save harmless the State from all suits, actions or claims brought on account of any injuries or damages sustained by any person or property in consequence of any neglect in safe-guarding the work by the Contractor; or on account of any claims or amount recovered for any infringement of patent, trademark, or copyright, except as herein elsewhere specifically provided; or from any claims or amounts arising or recovered under the "Workmen's Compensation Laws: or any other laws. He shall be responsible for all damage or injury to property of any character occuring during the prosecution of the work resulting from any act, omission, neglect, or misconduct on his part in the manner or method of executing the work; or from his failure to properly execute the work; or from defective work or materials. He shall not be released from such responsibility until all claims have been settled and suitable evidence to that effect furnished the Owner.

11.5 Subcontracts. The Contractor shall, as soon as practicable after the execution of the contract, notify the Owner in writing of the names of subcontractors proposed for the principal parts of the work and for such others as the Owner may direct and shall not employ any that the Owner may within a reasonable time object to as incompetent or unfit.

The Owner shall, on request, furnish to any subcontractor, wherever practicable, evidence of the amounts certified on his account.

The Contractor is fully responsible to the Owner for the acts and omissions of his subcontractors and of persons either directly or indirectly employed by them, as he is for the acts and omissions of persons directly employed by him.

Nothing contained in the contract documents shall create any contractural relation between any subcontractor and the Owner.

11.6 Contractor's Responsibility for Work. Until the acceptance of the work by the Owner, as evidenced in writing, it shall be under the charge and care of the Contractor. The Contractor shall rebuild and make good at his own expense all injuries and damages to the work occurring before its completion and acceptance. In case of suspension of work for any cause, the Contractor shall be responsible for the preservation of all materials and completed work included in his contract.

11.7 Personal Liability of Public Officials. In carrying out the provisions of the contract or in exercising any power or authority granted thereunder, that shall be no liability upon the State Engineer-Director of Highways and Public Transportation or his authorized assistants, either personally or otherwise, as they are agents and representatives of the State.

Art. 12 LABOR REQUIREMENTS

12.1 Type of Project. This is a "Public Works" Project, as defined in House Bill No. 54 of the 43rd Legislature of the State of Texas and House Bill No. 115 of the 44th Legislature of the State of Texas, and as such is subject to the provisions of said House Bills. No provisions herein are intended to be in conflict with the provisions of said Acts.

In accordance with provisions of said House Bills, the Commission has ascertained and indicated in the special provisions the regular rate of per diem wages for an eight (8) hour working day prevailing in this locality for each craft or type of "laborer",

"workman", or "mechanic" considered necessary to execute the contract, which wage rates shall, as herein provided, apply as minimum wage rates on this contract.

12.2 Minimum Wages, Hours, and Conditions of Employment.

All "laborers", "workmen", and "mechanics" necessary for the satisfactory completion of any phase of the work for which the Contractor is responsible to the State shall be construed as being within the purview of these specifications.

Whenever and wherever practical, preference in the selection of labor shall be given to local citizens.

Each employee on the work covered by this contract shall lodge, board, and trade where and with whom he elects, and neither the Contractor nor his agents, nor his employees shall directly or indirectly require, as a condition of employment, that any employee shall lodge, board, or trade at a particular place, or with a particular person.

No fee of any kind shall be charged or accepted by the Contractor, or any of his agents, from any person who obtains work on the project, nor shall any person be required to pay any fee to any person or agency obtaining employment for him on the project.

No charge shall be made for tools or equipment used in connection with the duties performed, except for loss or damage of property. No charge shall be made for necessary camp water.

No charge shall be made for any transportation furnished by the Contractor, or his agents, to any person employed on the work.

These provisions shall also apply where work is performed by piece work, station work, etc. The minimum wage paid shall be exclusive of equipment rental or any shipment which the worker or subcontractor may furnish in connection with his work.

The Contractor will be held responsible for carrying out the requirements of this specification and it shall be his responsibility to see that each subcontractor working on the project complies with its provisions.

Any form of subterfuge, coercion, or deduction designed to evade, reduce, or discount the established minimum wage scales will be considered a violation of this contract.

The contract for this project is made upon the basis of eight (8) hours constituting a day's work. The time consumed by the "laborer", "workman", or "mechanic" in going to and returning from the place of work shall not be considered as part of the hours of work. Any laborer, workman or mechanic required or permitted to work in excess of eight (8) hours per calendar day, under the emergency exceptions to House Bill No. 115 of the 44th Legislature invoked by HCR No. 201 of the 47th Legislature, shall be paid on the basis of eight (8) hours constituting a day's work, and all such labor so employed shall be paid at the rate of one and one half (1-1/2) times the regular rate for every hour worked in excess of forty (40) hours per week.

The general rates of per diem wages prevailing in this locality for each class and type of "laborer", "workman" and "mechanic" whose services are considered necessary to fulfill the contract are indicated in the special provisions, and these rates shall govern as minimum wage rates on this contract. Furthermore, any Contractor who fails to pay these rates will be required to forfeit the sum of ten dollars per day, per worker. When making payments to the Contractor, the Department shall withhold and retain therefrom all sums and amounts which shall have been forfeited.

Claim for additional cost due to performing work after regular working hours will not be allowed unless such work has been specifically ordered and/or approved by an authorized representative of the Owner.

Any "laborer", or "workman," or "mechanic" employed and whose position is not listed shall be paid not less than the per diem wage rate established on this project for the "laborer," "workman," or "mechanic" whose duties are most nearly comparable to those of such employees.

12.3 Record and Inspections. The Contractor and all subcontractors shall keep, or cause to be kept, weekly payrolls showing the name, occupation, number of hours worked each day and per diem wage paid each "laborer," "workman," and "mechanic" together with a complete record of all deductions made from such wages. During the construction period, the Contractor shall keep a copy of each weekly payroll available in the immediate vicinity of the project site and shall allow inspection of such payrolls at all reasonable hours by any authorized representative of the Owner.

Art. 13. TAX EXEMPTIONS

13.1 Federal Transportation Tax. The State is not liable for the Federal tax imposed by Section 3475 of the Internal Revenue Code on Transportation charges on materials purchased by the State.

The contract for this project is made upon the basis of eight (8) hours constituting a day's work. The time consumed by the "laborer", "workman", or "mechanic" in going to and returning from the place of work shall not be considered as part of the hours of work. Any laborer, workman or mechanic required or permitted to work in excess of eight (8) hours per calendar day, under the emergency exceptions to House Bill No. 115 of the 44th Legislature invoked by HCR No. 201 of the 47th Legislature, shall be paid on the basis of eight (8) hours constituting a day's work, and all such labor so employed shall be paid at the rate of one and one half (1-1/2) times the regular rate for every hour worked in excess of forty (40) hours per week.

The general rates of per diem wages prevailing in this locality for each class and type of "laborer", "workman" and "mechanic" whose services are considered necessary to fulfill the contract are indicated in the special provisions, and these rates shall govern as minimum wage rates on this contract. Furthermore, any Contractor who fails to pay these rates will be required to forfeit the sum of ten dollars per day, per worker. When making payments to the Contractor, the Department shall withhold and retain therefrom all sums and amounts which shall have been forfeited.

Claim for additional cost due to performing work after regular working hours will not be allowed unless such work has been specifically ordered and/or approved by an authorized representative of the Owner.

Any "laborer", or "workman," or "mechanic" employed and whose position is not listed shall be paid not less than the per diem wage rate established on this project for the "laborer," "workman," or "mechanic" whose duties are most nearly comparable to those of such employees.

12.3 Record and Inspections. The Contractor and all subcontractors shall keep, or cause to be kept, weekly payrolls showing the name, occupation, number of hours worked each day and per diem wage paid each "laborer," "workman," and "mechanic" together with a complete record of all deductions made from such wages. During the construction period, the Contractor shall keep a copy of each weekly payroll available in the immediate vicinity of the project site and shall allow inspection of such payrolls at all reasonable hours by any authorized representative of the Owner.

Art. 13. TAX EXEMPTIONS

13.1 Federal Transportation Tax. The State is not liable for the Federal tax imposed by Section 3475 of the Internal Revenue Code on Transportation charges on materials purchased by the State.

The Contractor is specifically authorized to consign the construction materials to be incorporated in this contract to the State Department of Highways and Public Transportation since the materials are deemed to have been purchased by the State of Texas.

By virtue of the State granting this authority, the Internal Revenue Department has ruled that the tax will not be collected provided the materials purchased by the Contractor are consigned to the State.

This proviso is not intended and shall not be construed as relieving the Contractor of any and all costs in connection with the furnishing of such materials to the project, including all transportation costs and incurred demurrage.

13.2 State Sales Tax. This contract qualifies for exemption from State and Local Sales Tax by reason of being with a tax exempt State agency, in accordance with Chapter 20, Title 122A, Revised Civil Statutes of Texas.

The Contractor performing this contract may purchase, rent or lease all materials, supplies, equipment used or consumed in the performance of this contract by issuing to his suppliers an exemption certificate in lieu of the tax, said exemption certificate complying with State Comptroller of Public Accounts Ruling No. 95-0.07.

The above mentioned tax exemption certificates shall be prepared in typewritten form by the Contractor and shall be basically in the form set out on the sample certificate included with the sample forms bound within this specification.

Further information regarding sales tax exemptions, procedures, etc., may be obtained from the Comptroller of Public Accounts at the following address:

Bob Bullock
Comptroller of Public Accounts
Division No. 95
Capitol Station
Austin, Texas 78701

Art. 14 MISCELLANEOUS REQUIREMENTS

14.1 Use of Premises. The Contractor shall confine his apparatus, the storage of material and the Operations of his workmen to limits indicated by law, ordinances, permits or directions or the Owner and shall not unreasonably encumber the premises with his materials.

The Contractor shall not load or permit any part of the structure to be loaded with a weight that will endanger its safety.

The Contractor shall enforce the Owner's instructions regarding signs, advertisements, fires and smoking.

14.2 Cutting and Patching. The Contractor shall do all cutting, fitting or patching of his work that may be required to make its several parts come together properly and fit to receive or be received by work of other Contractors shown upon, or reasonably implied by, the Drawings and Specifications for the completed structure, and he shall make good after them as the Owner may direct.

Any cost caused by defective or ill-timed work shall be borne by the party responsible therefor.

The Contractor shall not endanger any work by cutting, digging, or otherwise, and shall not cut or alter the work of any other Contractor save with the consent of the Owner.

14.3 Measurements. Before ordering any material or doing any work, the Contractor shall verify all measurements on the project and shall be responsible for their correctness. No extra charge or compensations will be allowed on account of difference between actual dimensions and those indicated on drawings; any difference which may be found shall be submitted to the Owner for consideration before proceeding with the work.

14.4 Shop and Erection Drawings. Complete shop and erection drawings where called for in any section of this specifications, shall be submitted to the Owner for approval. See the various sections for shop drawings required.

14.5 Equipment, Scaffolding, etc. Except as otherwise specified, the Contractor shall furnish at his own cost and risk, all tools, apparatus, hoists, derricks, including power for same and all temporary work and materials required for the proper execution of his work, including work provided under allowance.

14.6 Municipal Requirements. It shall be the responsibility of each bidder to verify the conformance of these plans and specifications to the applicable requirements of the local utility companies, city building codes, plumbing codes and electrical codes before submitting his bid for this project. After the contract is let, any changes in the specified work and materials made necessary by the requirements of local code rules or utility company requirements shall be made at the Contractor's expense.

The Contractor shall obtain and pay for the building permit where such permit is required.

Each Contractor whose work requires connection to public services including water, gas, electricity and sanitary sewers, etc. shall bear all costs for inspection fees, taps, pavement cuts and permits as established by that Agency having jurisdiction.

14.7 State Antiquities Law. The Antiquities Code of Texas of 1970 states that historical sites and Archaeological Landmarks on land belonging to the State may not be altered, destroyed or excavated without a permit from the Texas Antiquities Committee.

If, during the course of this contract, sites of historical, archaeological, educational or scientific interest are discovered, operations in that particular area shall cease immediately and the site shall be investigated and evaluated by the Owner. An extension of the contract time will be granted, if necessary, for delays caused by these investigations and evaluations. It is specifically understood, however, that if the Contractor is delayed by virtue of an investigation and evaluation that this delay will not be considered as a basis for claim by the Contractor, other than claims for extension of contract time.

14.8 Freezing Weather. No concrete work, masonry work, plastering, or exterior painting shall be done when outside temperature is 40° F. or is approaching 40° F. and falling.

MINIMUM PREVAILING WAGE RATES FOR
BUILDING CONSTRUCTION FOR LUBBOCK COUNTY, TEXAS
AND VICINITY, BASED ON EIGHT (8) HOUR WORKING DAY FOR
LABORERS, WORKMEN AND MECHANICS

CLASSIFICATION	HOURLY WAGE RATE
Truck Driver, Single Axle	3.25
Concrete Finishers (Structures)	4.45
Electricians	9.95
Iron Workers	8.83
Common Laborers	3.00
Power Equipment Operators	
Light Equipment	4.70
Heavy Equipment	5.05
Painters	
Brush	7.89
Spray	8.64
Plumbers	10.54
Welder	5.50

Any "laborer", or "workman", or "mechanic" employed and whose position is not listed shall be paid not less than the per diem wage rate established on this project for the "laborer", or "workman", or "mechanic" whose duties are most nearly comparable to those of such employees.

WORK BY OWNER

The State Department of Highways and Public Transportation, designated as the Owner, will furnish the following work and materials.

The Owner will do initial rough grading of the site as outlined in the Section on Excavation.

The Owner will stake out one corner, and one line of orientation of the solar installation and will establish the elevation of the finished floor lines of the solar collector support and the storage tank footing. As shown on the plans, the solar collectors will be placed at an angle from the horizontal (tilt) of 44 degrees. It is also necessary that the collectors be oriented with the bottom of the collector to the south and the top of the collector to the north for east-west sun passage. Therefore, the Owner shall provide the contractor the orientation and specific location of the facility; however, other construction measurements and staking shall be provided by the contractor. The foundation, and collector support shall be placed in a horizontal manner or as shown on the plans. The tank shall be tilted slightly with the end having the 6-inch pipe placed 1-inch lower in elevation than the end having the 3-inch pipe inlet.

Natural gas and electricity will be furnished to the construction site by the Owner at no charge to the contractor. The contractor will connect to these sources and otherwise complete the construction of the facility.

The solar and auxiliary heating system will use a fifty percent water - fifty percent ethylene glycol (anti-freeze) solution as the heating agent. The contractor will charge the system with the heating agent.

The 3-inch and 6-inch fill and discharge valves for the asphalt tank shall be furnished by the Owner.

The above constitutes the limits of the work to be performed and materials to be supplied by the Owner in connection with the installation. The Contractor shall furnish all other material, equipment, shipping and labor required to complete the installation in accordance with the plans and specifications.

EXCAVATION

Art. 1. GRADES AND LEVELS: The Contractor shall do all fine grading, filling, excavating, sloping, compacting, shaping and trimming required for the installation of foundations, slabs and incidentals.

The Owner will establish the elevation of the finish floor slab for the building and will locate one corner of the building before work is started. The drawings show the location of finish grades and the relation of the storage tank to the solar support and heating systems.

Art. 2. GENERAL EXCAVATION: All foundation walls shall be formed true to line with straight sides and all other details formed into shapes shown on plans. Trenches for forming the foundation shall be lined with building paper mopped with hot asphalt or shall be plastered with cement grout to prevent caving of sides, etc. if required.

Art. 3. SURPLUS MATERIAL: The Contractor shall remove all surplus excavated fill material from around the installation and shall stock-pile same at a point on the site as designated by the Owner.

Only clean surplus fill material shall be stock-piled on the site. All broken concrete, trash and construction debris shall be removed from the site by the Contractor.

Art. 4. INSPECTION: All excavation shall be inspected and approved by the Owner before any concrete is poured.

CONCRETE AND FORM WORK

Art. 1. SCOPE:

a. Furnish all labor, materials, and equipment to perform all operations in connection with the installation of concrete work, complete, in strict accordance with this specification and the applicable drawings.

Art. 2. MATERIALS:

The following materials specifications are to be utilized unless otherwise directed by the Owner.

a. Cement: Shall be Type I Portland and meet all the requirements of ASTM - C150.

b. Water: Shall be clear, potable and free of all substances that would be harmful to the concrete.

c. Aggregates: Coarse aggregates shall be free of excess salt, alkali, vegetable matter or objectionable material, either free or as an adherent coating on the aggregate. It shall contain not more than 0.25 percent by weight of clay lumps, not more than 1.0 percent by weight of shale, nor more than 5 percent by weight of laminated and/or friable (soft) particles.

The size of coarse aggregate shall be graded as follows:

Percent Retained on Each Sieve

2 in.	1-1/2 in.	3/4 in.	No. 4
0	0 to 5	20 to 70	95 to 100

Fine aggregate shall consist of natural sand, a combination of natural sand and manufactured sand or a combination of natural sand and mineral filler, or natural sand, manufactured sand, and mineral filler.

When tested by approved methods, the fine aggregate shall conform to the following grading requirements.

Percent Retained on Each Sieve

3/8 in.	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100
0	0 to 5	0 to 20	15 to 50	40 to 75	70 to 90	90 to 100

Loss by decantation shall not exceed 4%.

d. Reinforcing: Shall meet the requirements of one of the following.

(1) Specification for Billett-Steel Bars for Concrete Reinforcement, ASTM-A615 - Grade 40.

(2) Specifications for Rail-Steel Bars for Concrete Reinforcement, ASTM-A616 - Grade 50 or 60. (Shall be used for straight bars only.)

(3) Specifications for Welded Steel Wire Fabric for Concrete Reinforcement. (ASTM-A185)

All bars shall be deformed in accordance with all requirements of ASTM-A305.

e. Admixtures: The use of concrete accelerators, retardants, or other admixtures intended to expedite the concrete work shall be in strict accordance with the recommendations and directions of the manufacturer of the proposed admixture with the consent of the Owner.

Only admixtures approved by the Owner may be used on this project. No additional payment or credit shall be allowed to the Contractor should it become necessary to include an admixture in the concrete mix.

f. Storage of Materials: Cement and aggregates shall be stored in such a manner as to prevent deterioration or intrusion of foreign matter. Liquid admixtures shall be protected from freezing and from settling out of solution. Any deteriorated or damaged material shall not be used for concrete.

Art. 3. PROPORTIONING, CONSISTENCY & ALLOWABLE STRESSES:

a. The Contractor shall furnish the mix design for the strength of concrete specified, using the absolute volume design and within the limits outlined below. The mix design shall be based on the properties of materials to be used on this project. The proportions shall produce a mixture that will work readily into the corners and angles of the forms and around reinforcing. Segregation of materials in the mixture shall not be permitted nor the collection of excess free water on the surface.

The mix design shall be subject to the approval of the Owner prior to placing any concrete. The Owner's acceptance of the concrete design will in no way relieve the Contractor of the responsibility of complying with all sections of these specifications.

b. The concrete shall be uniform and consistent, and shall conform to the following:

Cement	----	5 bags per cu. yd. (Min.)
*Water	----	7 gals. per bag of cement (Max.)
Slump	----	4 inches maximum; will be varied as determined necessary by Owner.

*Maximum allowable water content is the total water in the mixture at the time of mixing including water absorbed by the aggregate.

c. The concrete mix will be designed with the intent of producing concrete which, when cured and tested in accordance with ASTM methods, will have 28 day compressive strength equal to or greater than 3000 p.s.i., or a 7 day flexural strength equal to or greater than 500 p.s.i. The design must not be changed without approval of the Owner.

d. If the strength required for the concrete being produced is not secured with the minimum cement content specified, additional cement shall be used or other aggregates provided at the Contractor's expense.

Art. 4. MIXING AND PLACING:

a. Mixing: Properly weighed materials in the quantities allowed by the rated mixing capacity of the mixer shall be thoroughly incorporated by mixing at the speed and for the length of time required to produce concrete of uniform consistency, paste distribution and aggregate grading from the beginning to the end of the discharge. The mixer shall be maintained free of hardened concrete, leaks and excessive wear.

b. Ready-Mix: Concrete will be acceptable if of the same design and of no less strength than called for above. The plant and trucks shall be approved by the Owner. Concrete which does not meet the slump, workability and consistency, requirements shall not be placed in the structure. Elapsed time between mixing and placing in forms shall be 45 minutes maximum. Adequate stand-by trucks shall be required to provide a continuous placement operations.

c. Preparation: Before placement, all equipment for mixing and transporting the concrete shall be cleaned, and all debris shall be removed from the places to be occupied by the concrete. Forms shall be thoroughly wetted or oiled. The reinforcing shall be thoroughly cleaned of dirt, rust, scale or other coatings. Water shall be removed from place of deposit before concrete is placed.

Contractor shall notify the Owner 12 hours in advance of concrete placement to permit ample time for checking forms and reinforcement. Under no circumstances shall concrete be placed until the Owner has been notified and he shall have inspected the work and authorized the placing of concrete.

d. Conveying: Concrete shall be handled from the mixer to the place of final deposit without delay and by methods which will prevent separation. Where chutes are used, they shall be metal or metal-lined and shall be used with moderate slope. Baffles shall be used as necessary to prevent segregation.

Concrete shall be deposited as nearly as practicable in its final position and in such a manner as to maintain a plastic surface which is more or less horizontal.

Substantial elevated runways or hoists shall be provided to convey the concrete to points of deposit, in order not to disturb the forms or reinforcing. Conveying equipment shall not be wheeled directly over any reinforcing. Concrete and mortar shall not be dropped free more than 4 feet. Drop chutes shall be made of rubber or metal and shall be provided in sections so that the outlet may be adjusted to proper heights during placing operations.

e. Consolidation: All concrete shall be thoroughly compacted during the operation of placing, and shall be thoroughly worked around the reinforcement and embedded fixtures and into the corners of the forms. Care shall be taken to prevent segregation due to over-vibration.

f. Curing: Freshly placed concrete shall not be exposed to temperatures below 40° F. and shall be maintained in a moist condition for at least the first 7 days after placing. Methods for curing shall be one of the following or a combination of the following:

1. Leaving forms on vertical surfaces in place.

2. Ponding with water, apply as soon as the concrete surface has hardened sufficiently not to be damaged by the water.

3. Cover surfaces with cotton mats or burlap blankets and keep water-soaked for 7 days.

4. Wet all surfaces thoroughly and immediately cover with non-staining water-proof paper or plastic sheeting. Anchor down sheeting to prevent wind from blowing off.

5. Commercial curing compounds meeting ASTM C-309 Type 1 with fugitive dye may be used only as directed by Owner and only with the written consent of the Owner. Where hardening or dust-proofing or finish flooring on concrete is to be applied, do not use curing compound.

g. Cold Weather Requirements: Adequate equipment shall be provided for heating the concrete materials and protecting the concrete during freezing or near-freezing weather. All concrete materials and all reinforcement, forms, fillers and ground with which the concrete is to come in contact shall be free from frost. No frozen materials or materials containing ice shall be used.

h. Hot Weather Requirements: During the hot weather, steps shall be taken to reduce water evaporation by proper attention to ingredients, production methods, handling, placing, protection and curing.

Art. 5. FORMS AND DETAILS OF CONSTRUCTION:

a. General: Forms shall be built mortar-tight and shall be true to shape and size and with sufficient strength and rigidity to prevent bulging between supports, or other deformation. They shall be set and maintained to conform with the lines and grades of concrete shown on plans. The upper edges of straight forms for exposed concrete shall be brought to string line before and after concrete is placed. Forms and form lumber shall be maintained clean and in good condition as to smoothness of surface. Faces of forms shall be coated before erection to prevent absorption of moisture from the fresh concrete and to facilitate removal of forms. Forms and/or sub-grade shall be wetted just before concrete is placed. Earth cuts may be used as forms for non-exposed vertical surfaces where the earth is stable and will stand without caving.

   A deflection greater than 1/4 inch in any form after concrete is in place shall be cause for removal of all concrete against the deflected form, at the direction of the Owner's Representative and the realigning and re-shoring of that form.

b. Sheathing: Form sheathing may be lumber, plywood or patented forms.

c. Form Removal: The removal of forms shall be subject to the Owner's approval and shall not be started until the concrete has attained the necessary strength to support its own weight and imposed construction live loads safely.

d. Reinforcement Support and Protection: Bar supports, spacers, high chairs, etc., shall be constructed of wire properly sized in accordance with ACI-315. Reinforcement in slab-on-fill shall be supported on concrete block especially pre-cast for the purpose.

e. Cleaning, Bending and Placement of Reinforcement: Reinforcement at the time concrete is placed, shall be free from rust, scale or other coatings that will destroy or reduce the bond, and kept in this condition until encased in concrete.

   Place reinforcement accurately in position as shown on the placing and structural drawings. Securely fasten and support to prevent displacement during the placing of the concrete. Reinforcement shall be tied at intersections with tie wire or clips.

   No concrete shall be placed until the steel placement has been approved. During the placing of the concrete, the Contractor shall have competent mechanics watch and keep the reinforcement in place. Splices in reinforcement shall conform to ACI-315.

Art. 6. CONCRETE FINISHES:

The finish of the floor slab shall be obtained with a darby, a float or a light brush to leave a non-slip uniform surface.

WELDING AND SHEET METAL WORK

Art. 1. SCOPE OF WORK: Contractor shall furnish all labor, materials, services, equipment and incidentals required to complete all work under this section as shown on plans and as specified.

This work shall include the support structure of the solar collector and the instrumentation housing.

Art. 2. SHEET METAL WORK: All workmanship shall be strictly first class in every respect and any defective or careless work shall be removed and properly replaced by the Contractor. The various sections shall be uniform, lines shall be plumb or level, joints at corners and angles shall be carefully mitered and the different sections accurately fitted and secured with sheet metal screws of adequate size. The finished instrumentation housing shall be dry and weather proof.

Art. 3. WELDING: Both shop and field welding shall be performed by proficient welders approved by the owner. All welding shall conform to the requirements of the "Code For Arc and Gas Welding of the American Welding Society." Loose slag shall be brushed from the welds using manual or power means.

Art. 4. MATERIALS: The structural iron used in the collector support structure shall be A-36 Hot Rolled Steel of a size conforming to the plans and as specified. The sheet iron shall be 18 gauge A-36 Hot Rolled Steel.

PAINTING

Art. 1. SCOPE OF WORK: Contractor shall furnish and install all materials, accessories, labor, services, equipment and incidentals required for the work under this section as shown on plans and as specified.

Art. 2. MATERIALS: All paints must be delivered to the site in the original containers with the seals unbroken and labels intact. All materials shall be of the best quality manufactured and approved by the Owner.

Painting materials shall be stored only in areas assigned for this purpose and necessary fire prevention measures shall be taken.

The following manufacturer's materials may be used on this project; any other manufacturer's materials must have the written approval of the Owner before they can be used for this work.

Exterior gloss enamel: Benjamin Moore Impervo Gloss Enamel, Devoe Mirrolac Gloss Alkyd Interior/Exterior Enamel, Series 7000 or Sherwin-Williams Kem Lustral Enamel.

Iron primer: Benjamin Moore IronClad Zinc Chromate Primer, Devoe 13,800 Zinc Chromate Primer or, Sherwin-Williams E41N1 Kromik Metal Primer.

Art. 3. WORKMANSHIP: The workmanship shall be of the very best. All materials shall be applied under adequate illumination, evenly spread and smoothly flowed on without runs or sags.

All surfaces, before being primed, shall be thoroughly cleaned of all dirt, oil, grease, dust, scale or other foreign matter. This cleaning and preparation shall be done with sand paper, steel wool, scrapers, or wire brushes as the particular case may require.

The solar collectors and prefinished mechanical equipment will not be painted and shall be protected from damage.

All surfaces shall be clean and dry before painting. No painting shall be done in dusty, damp, windy, or cold weather. Ample time shall be given for each coat to thoroughly dry before applying the next coat. All surfaces shall receive the coats specified, especially those facing the concrete foundation.

Upon completion of work, remove all equipment and debris caused by this work from the site.

Art. 4. PAINTING SCHEDULE: Apply the following finishes to the collector support and instrumentation housing. Reduce and mix only in strict accordance with manufacturer's directions.

The metal collector support structure and instrumentation housing shall have a first coat of metal primer.

The structure and housing shall then recieve 2 finish coats of exterior enamel. Color shall be a light grey or as directed by the Owner.

All reducing oils and thinners shall be as prescribed by the manufacturer of the product being used.

SUPPLEMENTARY PROVISIONS FOR MECHANICAL AND ELECTRICAL WORK

Art. 1. SPECIAL NOTE: Read and comply with the General Conditions, Special Conditions, and all other pertinent sections of these specifications.

Art. 2. GENERAL:

a. In general, the various lines to be installed by the contractor under this specification shall be run as indicated, as specified herein, as required by particular conditions at the site, and as required to conform to the generally accepted standards so as to complete the work in a neat and satisfactorily workable manner. The following is a general outline concerning the running of various lines and is to be excepted where the drawings or conditions at the building necessitate deviating from these standards.

b. All interior gas piping shall be generally run exposed. It shall not be run in underhouse areas or concealed in chases or furring.

c. All other interior plumbing lines shall be run exposed with the exception of insullation.

d. Unless otherwise noted conduits shall run exposed.

e. The construction details of the structure are illustrated on the plans.

f. The mechanical and electrical plans do not give exact details as to elevations of lines, exact locations, etc., and do not show all the offsets and other installation details. The Contractor shall carefully lay out his work at the site to conform to the structural conditions and as closely as possible to the plans, to provide proper grading of lines, to avoid all obstructions, to conform to the details of installation supplied by the manufacturers of the equipment to be installed and thereby to provide an integrated, satisfactorily operating installation.

g. The plans do not give exact locations of outlets. Minor relocations necessitated by the conditions at the site or directed by the Owner shall be made without any additional cost to the Owner.

h. All work shall be executed in accordance with all local, state and national codes, ordinances and regulations governing the particular class of work involved. The Contractor shall be responsible for the final execution of the work to suit these requirements. Where these specifications and the accompanying drawings conflict with these requirements, the Contractor shall report the matter to the Owner, shall prepare any supplemental drawing required illustrating how the work may be installed so as to comply and on approval of the change by the Owner, shall install the work in a satisfactory

manner without additional cost to the Owner. On completion of the various portions of the work the installation shall be inspected by the constituted authorities and approved, and on completion of the work, the Contractor shall obtain and deliver to the Owner a final certificate of acceptance.

i. Before submitting his bid, the Contractor shall personally acquaint himself with the site and all existing conditions as well as with the details and contingencies of the proposed work. No additional payment will be allowed the Contractor for any work which is necessary for the proper completion of the project and which is omitted by the Contractor from his original bid.

Art. 3. SUBSTITUTION OF MATERIALS:

a. Where manufacturer's names are mentioned in these specifications, it has been done in order to establish a standard. The product of the particular manufacturer mentioned is of satisfactory construction and any substitution must be approved by the Owner prior to its installation.

b. On being awarded the contract, the Contractor shall submit for approval a complete list of the materials he proposes to use within twenty (20) calendar days after the date time charges begin. This list shall give manufacturer's names and designations corresponding to each and every item and where submitted material is different from that specified by name, the submission shall be accompanied by complete descriptive literature and/or any supplementary data, drawings, etc. necessary to give full and complete details.

c. Any substituted item rejected on account of unsuitability or inferior quality must be replaced by an acceptable item within a week following notification of the Contractor of such rejection. If no satisfactory material is substituted within that one week period, then the Owner reserves the right to notify the Contractor as to type and make of material he shall be required to furnish.

Art. 4. EXCAVATION AND BACKFILLING: The Contractor for the work under each section of these specifications shall do all the excavation required in connection with the installation of his work. After the work has been installed, tested and approved, he shall backfill all excavations with suitable material under the direction of the Owner.

Art. 5. HANGERS AND SUPPORTS:

a. All pipes and tubing throughout the facility, both horizontal and vertical, shall be adequately supported from the construction. Horizontal lines shall be individually supported on hangers described as follows:

1) Hangers supporting and contacting brass or copper lines shall be hinged ring hangers with adjusters.

2) Other special types of hangers may be employed where required by particular conditions. In the latter case the hangers must be approved by the Owner.

b. Each hanger shall be properly sized to fit the outside of the insulation on the pipe or tubing.

c. All hangers shall be so located as to properly support horizontal lines without appreciable sagging of these lines. The following table gives minimum hanger spacing for copper tubing, but hangers shall be more closely spaced where necessitated by the conditions.

Size of Line	Hanger Spacing in Feet
3/4" and smaller	5
1"	6
1-1/4" and 1-1/2"	8
2" to 4"	10

ELECTRICAL WORK

Art. 1. SPECIAL NOTE: The Supplementary Provisions for Mechanical and Electrical Work are part of this section of the specification and contain specific data relating to the Electrical Work.

Art. 2. SCOPE OF WORK: The work under this contract shall include the furnishing of all labor, materials, equipment and incidentals required in the complete installation of electrical work on the project as described herein and illustrated on the drawings. The work shall include, but is not limited to, the following principle items:

(1) A complete system for the control of the storage tank heating including solar, auxiliary and manual. The system will include wiring for lighting and power, panelboards, thermostats, temperature controls, feeders, switches, outlets and all incidental devices as required.

(2) The furnishing and installing of a lighting fixture complete with hanger and lamp and of all other electrical equipment as specified herein or scheduled on the plans.

Art. 3. SERVICE ENTRANCE: A three wire service entrance shall be provided by the Owner. From this the Contractor shall furnish all labor, material and equipment required for the complete electrical work as herein described and shown on plans, including all conduit and wiring required to provide service to the facility.

Art. 4. PLANS: The plans include a schematic which is not intended to give complete details in regard to location of components. Exact location of the components are subject to the conditions on the job and the approval of the Owner.

Art. 5. DISTRIBUTION EQUIPMENT: Circuit breaker panelboards shall meet Federal Specification W-P-115a Type 1, Class 1. Main lugs shall be arranged for distribution of phases. Cabinets shall be of code gauge galvanized steel with doors hung on continuous type hinges and shall be finish painted with baked enamel.

The circuit breakers shall be quick-make, quick-break, thermal-magnetic type with ambient compensating mechanism. The breaker can be bolted to buss bars, however, plug-in or clip-on type connections will be acceptable. The breakers shall be 15 amp.

Each distribution panel shall have a neatly typewritten directory of circuits mounted in a card holder on cover door.

Art. 6. CONDUITS: All wiring of every description shall be run in conduit or electrical metallic tubing unless noted or specified otherwise.

All conduits shall be of such size and shall be so installed that the conductors may be drawn in without injury or excessive strain.

All rigid conduits, where they enter panel boxes shall be secured in place by galvanized locknuts, INSIDE AND OUTSIDE, and shall have galvanized bushings inside.

Art. 7. GROUNDING: All conduit work and service entrance equipment shall be securely and permanently grounded as required by local inspection department and as recommended by the National Electrical Code.

Art. 8. OUTLET BOXES: Provide at each outlet or device of whatever character a metal outlet box in which conduits shall terminate. Boxes shall be of Crouse-Hinds, or Steel City manufacture. Each box shall be of the size, type and design best suited to the purpose. Sectional type gang boxes will not be permitted. All outlet boxes shall be made of galvanized or cadmium plated steel. Outlets for ceiling mounted light fixtures in exposed conduit systems shall be of plated pressed steel construction. A minimum of four dual outlet boxes shall be provided in the space for the instrumentation housing.

Art. 9. CONDUCTORS: All wire shall be of soft drawn annealed copper, having a conductivity of not less than 98% of that of pure copper. Each wire shall be continuous without weld, splice or joint throughout its length, shall be uniform in cross-section free from flaws, scales, and other imperfections.

All wire No. 16 or smaller in the control panel shall be stranded. All receptacle circuits and motor circuits shall be wired with No. 12 conductors unless otherwise scheduled or noted. All lighting circuits shall be wired with the proper sizes of conductors to limit the voltage drop.

All conductors shall be insulated and protected as required by the National Electrical Code for the service for which they are to be used.

All 120 volt circuits shall have black phase wires, white neutral conductors.

Art. 10. WIRING DEVICES: The following wiring devices are specified to establish the general style and quality which will be required on this project.

Minimum rating for all wall switches and receptacles shall be 15 amp at 120 volts, a.c.

Wall switches shall be Bryant Series 4800 or 4900, or Hubbell Series 1200.

Art. 11. SOLAR AND AUXILIARY HEATING CONTROLS: The asphalt heating system will use solar energy when possible, however when the asphalt temperature decreases to 140°F the auxiliary heater will be activated and will remain the heating source until 180°F is achieved. Asphalt temperatures greater than 180°F will not be permitted.

a. Safety features for temperatures in excess of 180°F shall be provided by Safety Thermostat SW-4. Safety Thermostat SW-4 shall be a Honeywell T675A1128 or equivalent. The thermostat shall contain a remote sensing bulb for contact sensing with a 20 ft. tube. The thermostat shall be adjustable over a range of 160°F to 260°F and shall have an adjustable differential temperature of 3°F to 10°F. The controller shall have a single pole, double throw switch with 8 amp. contact rating. The controller shall be housed in a suitable case and have a properly marked dial with a 2°F resolution.

The remote sensing bulb shall be fitted to the lower portion of the asphalt tank and the thermostat shall be adjusted such that the internal switch will be open when the sensing bulb registers asphalt temperatures in excess of 180°F. At temperatures less than 180°F the internal switch will close. If the internal switch in SW-4 is open, relay K-1 will not be activated and the circulator will not pump.

b. Auxiliary heating will be controlled through Control Thermostat Switch #3 and Relay K-3 which activates Relay K-2. Control Thermostat Switch #3 shall be a Honeywell T636A1013 Crop-Trol Controller or equivalent. The control thermostat shall contain a remote sensing bulb attached to a 20-foot tube. The device shall have a built in SPDT switch enabling either rising or falling temperature control. The switch contacts should be rated at 120 VAC, 8 amps. The device shall have an external adjustment control for a range of 80°F to 220°F and an internal differential temperature adjustment from 10°F to 60°F.

Relay K-2 and K-3 shall be a Potter and Brumfield KRP11AG double pole, double throw, 120 volt AC, 60 Hz., 10 amp contact rating. The K-2 and K-3 relays shall be an eight pin plug-in type with receptacle.

The remote sensing bulb of Control Thermostat Switch #3 shall be fitted to the lower portion of the asphalt storage tank. Switch #3 shall be adjusted to close when the asphalt temperature falls to 140°F, thus activating Relay K-3 and K-2. Activation of K-3 will close a circuit causing the Heating Boiler burner to ignite. Activation of Relay K-2 causes the control valves to switch positions. If SW-3 is closed and Relay K-1 is open the circulator will be activated.

c. Solar Heating is controlled through Differential Thermostat SW-2 and Relay K-1. Differential Thermostat SW-2 shall be a Heliotrope General Model DELTA-TT3410 or equivalent. The thermostat shall have two remote temperature sensing bulbs. The thermostat temperature range shall be at least 140°F to 180°F with an external adjustment for the "High" limit. The thermostat shall have an adjustable turn-on differential with a fixed turn-off of 1.5°F. An indicator light for the on condition shall be included.

Relay K-1 shall be a Potter and Brumfield KRP11AG double pole, double throw, 120 Volt A.C., 60 Hz with a 10 amp contact rating. The K-1 relay shall be an eight pin plug-in type with receptacle.

One remote sensing bulb shall be fitted to the copper tube on the outlet header of the solar collectors and as close as possible to the last collector. The second sensing bulb will be fitted to the lower portion of the asphalt storage tank.

Thermostat SW-2 shall be adjusted such that the internal switch will close when a temperature differential of +20°F or greater is sensed with the collector sensing bulb having the higher temperature. Thermostat SW-2 shall be adjusted such that the internal switch will open when the temperature differential reduces to +2°F or less.

d. The Flow Switch is a safety feature which prevents the Heater Boiler burner from being ignited unless the heating agent is flowing in the copper tube or the pump is activated.

   The Flow Switch shall be a McDonnell FS4-3 or equivalent. The Heating Boiler is equipped with a 24 volt D.C. control system.

e. The control valves are powered by 24 volts D.C. The 24 Volt Transformer shall be a Dormeyer DCT-20-120 or equivalent.

f. The manual systems include switches SW-1, S-5 and S-6. These switches shall be a Carling switch 2FB54-73 SPDT 125 Volt, 15 amp or equivalent. SW-1 controls power to the system whereas S-5 is an override bypassing Thermostat SW-2 and S-6 is an override bypassing Thermostat SW-4.

g. The temperature measuring system shall be composed of three single channel time sharing Rustrak Model 2155A/F137 strip chart recorders with a 0-250°F range using a Type J thermocouple. Six Rustrak Model 1551 Type J thermocouples shall be used to measure tank temperature at three levels, ambient temperature, collector inlet and collector outlet temperatures. All thermocouples with the exception of that measuring ambient temperature shall use a Rustrak Model 1553 pressure fitting with 1/2-inch NPT. Thermocouples leads shall be of sufficient length to extend from thermocouple to recorder as directed by the owner. The recorders shall emit chart paper at a rate of one-inch per hour. A two year supply of chart paper shall be provided the owner.

h. A control panel shall be fabricated and attached to the interior wall of the instrumentation housing. The control panel shall include the plug-in relays, thermostats, switches, pilot lights and terminals. The manual switches shall be clearly labeled as to function. The pilot lights shall be provided to indicate (1) solar system activation, (2) auxiliary system activation or (3) no system is activated. The pilot lights shall be Chicago 5789-523-430 110 volt A.C. with a neon bulb and with faceted lenses or equivalent. The pilot lights shall be fitted with a (1) green lense for solar system activation, (2) a yellow lense for auxiliary system activation, (3) a red lense for the condition where neither system is activated.

i. An adjustable time delay relay shall be used as a timer to assure a selected run period for the circulator when the circulator motor is activated. The adjustable time relay shall be a Magnecraft W211ACPSRX-60 or equivalent. The time delay relay shall be 110 volt A.C. with plug-in mounting, nylon dust cover, solid state hybrid circuitry, DPDT and a 10 amp contact rating. The time delay relay shall delay upon release and the delay shall be adjustable from 1 minute to 15 minutes with an external knob. The contractor shall connect and adjust the delay to assure the circulator motor runs for a five minute period each time the circulator motor is activated.

j. An Eplab Black and White Model 8-48 pyranometer shall be installed to measure solar energy (insolation or global radiation). The pyranometer installation angle shall be in the same plane as that of the collector face(s). The pyranometer output shall be recorded on a Rustrak Model 288 single channel strip chart with a voltage range of 0 to 25 millivolts. The recorder shall emit chart paper at a rate of one-inch per hour. A two year supply of chart paper shall be provided the owner.

PLUMBING WORK

Art. 1. SPECIAL NOTE: The "Supplementary Provisions for the Mechanical and Electrical Work" are a part of this section of the specifications.

Art. 2. SCOPE OF WORK: This work shall consist of furnishing all labor, materials, fixtures, fittings and equipment necessary for a complete job and to connect to the outside facilities. The work shall include, but not be limited to, the following systems.

1. The heat exchange system inside the asphalt storage tank.

2. The solar collector and auxiliary heating system.

Art. 3. PLUMBING CODE: All necessary permits and inspections required from local authorities shall be obtained by the Contractor.

Art. 4. MATERIALS: The system shall be installed using the following materials.

a. The LINE STRAINER shall be a Thrush Line Strainer Model No. 80B. The line strainer shall be fabricated from brass with 3/4-inch inlet and outlet connections for installatiion in copper tubing. The screen shall be Monel 80 mesh size. The strainer shall be capable of use in a water working pressure of 250 psi and a temperature of 300°F.

b. The HORIZONTAL FLOW CONTROL CHECK VALVE shall be a Thrush #113HB. The horizontal flow control check valve shall be basically of brass construction with 3/4 inch inlet and outlet connections for installation in copper tubing. The valve shall be capable of assuring one way flow of water under a pressure of at least 125 psi. The maximum length shall be 3-1/2 inches. The maximum height shall be 2-3/4 inches and the maximum width shall be 4 inches.

c. The CONTROL VALVES shall be Thrush #91 units. The control valve shall be basically fabricated from brass with 3/4 inch inlet and outlet connections suitable for controlling water. The inlet and outlet connections shall be suitable for attaching 3/4 inch copper tubing with solder. The control valve shall be motor controlled with 24 volts A.C. and with 3 wire connections. One wire shall be a common ground, with the other two wires providing power for opening and closing. The control valve weight shall be three pounds or less.

d. The CIRCULATOR PUMP shall be a Thrush Model TCB. The pump shall be designed to circulate a water or water/glycol solution. The pump shall be constructed of bronze, have a bronze or brass impeller, chromed steel shaft, and have double sleeve bronze bearings. The mechanical construction shall be such that seals are easily replaceable. The pump frame shall be attached to the motor with a connecting "barrel" spring for the motor/pump shaft connection. The motor shall be a 1/4 H.P. 1750 RPM, 115 V.A.C., 60 HZ. single

phase motor. The motor shall have bronze sleeve bearings with oiling receptacles. The pump shall be capable of delivering a minimum of 8 gallons per minute at 15-feet of head pressure.

e. The HEATING BOILER shall be a Raypak Model 136-T. The heater/boiler shall be a commercial type water heater, housed in a suitable metal cabinet, with removable front panel for easy access to burners and controls. The metal cabinet shall be galvanized with baked on enamel finish.

The heater shall have an input capacity of 136,000 BTU/HR, with 80% efficiency.

The heater shall be capable of heating water to a temperature of 240 Deg. F., and shall have a minimum flow rate of 6 GPM, and a maximum flow rate of 50 GPM.

The heater shall conform to the following specifications:

HEAT EXCHANGER: The heat exchanger shall be constructed of 1" copper finned tubing and cast iron headers. Thermal shock damage shall be eliminated by using a single bank design, and floating return header. 75 PSI working pressure.

COMBUSTION CHAMBER: The combustion chamber shall use interlocked refactory panels, which will provide for maximum heat retention. The refractory panels shall be made from a light weight composition of vermiculite, high temperature cement, asbestos, and refractory clay.

BURNER MODULE: The burner shall be designed for use with natural gas. It shall be easily accessible, and have slide-out burner assembly, with stainless steel burners. The burners shall fire only on demand with no standby loss.

CONTROL STRING: The system shall have completely enclosed, but not inaccessable, controls to protect them from dust, moisture, and nuisance pilot outage. The controls shall have facilities for external switching control. The controls shall be operated from and have as part of the controls, a 24 volt a.c. transformer. In addition to the above, the control system shall also include 45 PSI pressure relief valve, combination gas valve, 100% pilot safety, 120 Deg. F. to 240 Deg. F. modulating gas valve, secondary electric Hi-limit switch and shall be adaptable to additional controls such as flow switches, freeze protection and electric ignition.

A temperature and pressure gage shall be included as part of the instrumentation package.

ADDITIONAL REQUIREMENTS: The heating boiler shall have a 2 pass copper tube heat exchanger, a low profile draft diverter and shall use gas modulating burners which will modulate as low as 20% of total capacity.

f. The SOLAR COLLECTORS shall be KTA Corporation No. 540 panels. The solar panels shall be designed for the purpose of heating a water/glycol solution using a Solar concentration method, as opposed to the conventional flat plate method.

The collectors shall be constructed of glass and metal parts, using no wood. They shall have a supporting framework constructed of high strength aluminum, suitable for mounting, and shall have interconnecting copper plumbing with suitable external plumbing connections.

The collector panels shall consist of a parallel array of glass tubes, with each tube reflectorized internally over its entire length in a semi-cylindrical fashion, to provide a circular-cylindrical reflector 2" in diameter by 57" long.

These reflectorized tubes shall be interconnected in the panel in a series/parallel fashion to obtain maximum efficiency.

The solar collectors shall have a minimum expected useful life of 15 years; shall carry a minimum of 12 months warranty on manufacturing defects and shall be guaranteed to meet the manufacturers published performance standards when installed according to recognized solar engineering practice.

SEALING SYSTEM: Shall use high temperature, structural epoxy adhesive, and high temperature silicone rubber.

WORKING FLUID: Water or water/glycol solution.

LINE PRESSURE: 125 P.S.I.

WEIGHT: Shall not exceed 4.2 lbs. per square foot.

NORMAL OPERATING TEMP.: -25 Deg. F. to 230 Deg. F.

STAGNATION TEMP.: 450 Deg. F.

CONSTRUCTION: The collector container shall support the cover plates, absorber and contain the insulation. The container shall include all necessary side enclosures, back cover, coverplate seals, coverplate clamps, supports for the absorber and seals around external piping connections. Wood construction should not be employed neither should any ferrous metals be used.

The collectors should be encased in an architectural aluminum alloy, for lightweight, and weather resistance.

The container shall be designed to minimize shading of the absorber plate. The net collector area should not be less than 87% of the gross collector area. There shall not be more than 2% shading reduction or reduction of net collector area at a 45 Deg. incident angle in any direction.

PLUMBING: All plumbing connections shall be chosen for continuous operating capacity at high stagnation temperatures and shall be sealed with high temperature silver brazing alloy.

All pipes and fittings shall be copper and shall have external header connections of no less than 7/8" O.D.

SOLAR HEAT ABSORBERS: The absorbers shall have copper waterways and shall be arranged for complete air venting at the designed tilt angle. The maximum design temperature difference between any point on the absorber and fluid temperature within the passage shall not be greater than 15 Deg. F.

The absorber shall be designed for water flow rates of 5 lb./hr./sq. ft. to 20 lbs./hr./sq. ft. and the passages shall be designed to maintain turbulent flow at all times.

High flow rates shall not cause corrosion in the waterways.

The thermal expansion of the absorber in the range of -25 Deg. F. to stagnation temperatures shall not effect the thermal or mechanical performance of the collector.

The solar absorber coating shall be black chrome and shall have an absorptivity reading of 95% with a corresponding emissivity value of not more than 7%. The coating shall not be susceptible to peeling melting or otherwise deteriorating over the useful life of the collector and shall not deteriorate due to the effect of condensation or other moisture.

COVERPLATE: "Coverplate" is defined as one or more sheets of glass or transparent plastic mounted over or around the solar absorbers.

The Coverplate shall be two 008 soda-lime glass tubes to protect the heat absorber. These glass tubes shall have a solar spectrum transmissivity of 92% and a solar spectrum reflectivity of no more than 4%. Infrared transmissivity should be 1.6% at 5 microns. The glass should have a high resistance to water corrosion and should have a glass density of 2.7 grams per cubic centimeter.

The glass coverplates shall not be susceptible to breakage over the operating temperatures of the absorbers.

INSULATION: The header insulation shall be isocyanurate polyurethane foam, meeting the mechanical and performance criteria, and shall be tested for continuous usage at 300 Deg. F.

The method of insulation shall provide for a total U value of no greater than 0.08 Btu./hr./sq. ft./deg. F. at 100 Deg. F.

The thermal insulation value shall not diminish due to moisture and shall exhibit no physical or chemical breakdown of the insulation at absorber stagnation temperature, or 350 Deg. F., whichever is higher.

g. The AIR VENT shall be a Thrush #8.

h. The DRAINAGE TANK may be a commercial product or fabricated. The tank volume shall be at least 30 gallons and be capable of withstanding an internal pressure of 250 psi. The tank shall be fitted with 3/4 inch inlet and outlet connections for copper tube installation. The drainage tank shall be coated with 2 inches of polyurethane foam insulation or equivalent.

i. Dielectric fittings shall be furnished and installed at each point of contact between dissimilar metals including the points where the heat exchanger enters or leaves the asphalt storage tank.

j. The piping of the systems carrying the solar or auxiliary heating shall be Type L nominal 3/4 inch hard drawn copper tubing. The tees, elbows and other tubing fixtures shall be hard drawn copper. Tubing shall be supplied in nominal 20-foot lengths.

Art. 5. TUBING CONNECTIONS: With the exception of the connections of some of the solar or auxiliary heating hardware, the connections are to be sweated or soldered. All connections shall be cleaned and sanded prior to soldering. A high quality silver solder having a melting point of 1200°F $\pm$ 100°F will be used in the connections.

Art. 6. GAS DISTRIBUTION SYSTEM: The Contractor shall connect the auxiliary heating system to the existing gas line as shown on the plans and shall furnish and install a cutoff valve on the supply at the entrance to the facility.

Gas piping within the facility shall run exposed, supported on hangers if necessary.

Art. 7. GAS PIPING SYSTEM: This shall be very carefully tested by the Contractor. These piping systems shall first be subject to a pneumatic pressure test of fifty (50) pounds per square inch. While the systems are subjected to this air pressure, all joints shall have soapy water solution applied. If leaks are found, they shall be repaired with new fittings if necessary. Alternate testing and repairing operations shall be repeated until the piping

systems are absolutely tight. The entire gas piping system shall be subject to a pneumatic test pressure of 40 p.s.i. for a period of 8 hours to demonstrate the system to be absolutely tight.

Make all other tests required by local ordinances, by the Plumbing Inspector and by the Owner to prove that the equipment and the installation are satisfactory in every respect.

Any equipment defects or malperformance shall be remedied in an appropriate manner.

The Owner shall be afforded the opportunity to inspect each section of the piping system while they are being tested and observe all tests made on equipment performance. He shall have the right to accept or reject the work or the equipment items on the basis of the performance during those tests.

Art. 8. REPAIRS: The heat exchanger for the asphalt storage tank shall be pressure tested before the unit is installed in the storage tank and before the storage tank is insulated or connections are performed. The pressure testing will be with compressed air at a pressure of 75 psi for a period of 10 minutes before checking joints. All joints shall have a soapy water solution applied. If leaks are found they shall be repaired with new fittings if necessary. Alternate testing and repairing shall be repeated until the joints and tubing of the heat exchanger are absolutely tight.

Similarly the piping for the solar and auxiliary heating shall be pressure tested after the system has been completed and is in place. The pressure testing will be with compressed air at a pressure of 75 psi for a period of 10 minutes before checking joints. All joints shall have a soapy water solution applied. If leaks are found they shall be repaired with new fittings if necessary. Alternate testing and repairing shall be repeated until the joints and tubing are absolutely tight.

The solar and auxiliary heating piping shall be connected with the heat exchanger piping and the entire heating system shall be subject to a pneumatic test pressure of 40 psi for a period of 8 hours to demonstrate the system is absolutely tight. Leaks shall be repaired and alternate testing and repairing shall be performed until the system is demonstrated to be absolutely tight.

Leaks in soldered joints shall be repaired by remaking the joint and no soldering or brazing over existing joints will be permitted. Leaks in screwed joints shall be repaired by tightening the joint until the leak has stopped, or by remaking the joint if the tightening fails to stop the leaks.

Any equipment defects or malperformance shall be remedied in an appropriate manner.

The Owner shall be afforded the opportunity to inspect each section of the piping system while they are being tested and all tests made on equipment performance. He shall have the right to accept or reject the work or the equipment items on the basis of the performance during those tests.

Art. 9. COVERING AND INSULATION: The copper tubing, whether inside or outside of the collector support structure, shall be insulated. Valves and other hardware not containing external moving parts or being in the interior of the asphalt tank will also be insulated.

The tubing insulation shall be a closed cell tubular insulation. The tubing insulation shall have a 3/4-inch wall thickness with an inside diameter to match the outside diameter of the tubing to be covered. The minimum shipping length of the tubing insulation shall be five feet.

Where tubing insulation is to be split lengthwise for installation, the tubing shall be wrapped with tape at one foot intervals. The end joints of the tubing shall also be wrapped with tape. Care should be maintained not to significantly deform the insulation. The tape shall be capable of withstanding weather and wrapping should be long-lived and durable.

Art. 10. GUARANTEE: This Contractor shall guarantee his material, and workmanship for a period of one year from date of completion, and shall correct any defects which occur in the system during this period without cost to the Owner. On completion, he shall leave all fixtures clean and complete as specified.

ASPHALT STORAGE TANK

Art. 1. SCOPE OF WORK: The Contractor shall furnish and install all materials, labor, equipment, services, shipping, accessories and incidentals under this section as shown on the plans or as specified.

This work shall include the tank fabrication, tank support, tank insulation, tank installation, lines, levels and scaffolding as required during the prosecution of the work.

Art. 2. CONCRETE AND FORM WORK: All concrete material and concrete form work as specified and included in this specification.

Art. 3. WELDING: All welding as specified and included in this Specification.

Art. 4. TANK ELEVATION: The East end of the asphalt storage tank shall be 1-inch lower in elevation as compared to the West end to insure drainage. Therefore the East end of the tank shall be 10-feet higher than ground elevation or as shown on the plans.

Art. 5. ASPHALT STORAGE TANK INSULATION: The asphalt storage tank will be insulated with at least two inches of polyurethane foam material. Before applying the foam insulation, the outer surface of the tank will be sandblasted to remove slag, rust or other surface contaminants harmful to the foam application and life. Care will be exercised to prevent sand from entering the tank or harming other components of the system. When the prime is applied, sufficient drying time will be utilized before application of the foam. The foam shall receive a weather protection composed of a butyl rubber of 20 mil. thickness.