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JUNE 1980

MASTER

Geothermal Energy Development in the Eastern United States

TECHNICAL ASSISTANCE REPORT NO. 4 GEOTHERMAL SPACE HEATING— PITTSVILLE MIDDLE/ELEMENTARY SCHOOL PITTSVILLE, MARYLAND

ROY VON BRIESEN
KWANG YU

This work was supported by the Department of Energy under Interagency Agreements EX-76-A-36-1008 and DE-Alo1-79ET27025

THE JOHNS HOPKINS UNIVERSITY ■ APPLIED PHYSICS LABORATORY

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THE JOHNS HOPKINS UNIVERSITY ■ APPLIED PHYSICS LABORATORY
Johns Hopkins Road, Laurel, Maryland 20810
Operating under Contract N00024-78-C-5384 with the Department of the Navy

THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY
LAUREL, MARYLAND

GEOTHERMAL SPACE HEATING
PITTSVILLE MIDDLE/ELEMENTARY SCHOOL
PITTSVILLE, MARYLAND

Preface

This is one in a series of reports on technical assistance in the utilization of geothermal energy. The scope of technical assistance is limited to basic technical and economic feasibility and to assist those interested in deciding whether detailed engineering is warranted now or in the future. This effort is supported by the U.S. Department of Energy's Division of Geothermal Energy, Dr. David B. Lombard, Program Manager. The Laboratory's assistance is limited to the Eastern United States.

The analysis documented in this report was initiated at the request of Mr. Fred G. Livingood from the Board of Education of Wicomico County in concurrence with Mr. Edward P. Phillips, consultant/Maryland Coastal Zone Coordinator; and Mr. John H. Sprinkle of Malone and Williams, Architects, Salisbury, Maryland. Other technical assistance reports are as follows:

1. Geothermal Space Heating - Crisfield High School, APL/JHU Technical Assistance Report No. 1.
2. Geothermal Space Heating - Mariculture Industry on the Eastern Shore of Maryland, APL/JHU Technical Assistance Report No. 2.
3. Geothermal Space Heating - Columbia LNG Corporation, APL/JHU Technical Assistance Report No. 3.

I. Introduction.

The objective of this technical evaluation is to determine whether geothermal energy obtained from a well could be used to space heat the new school building being constructed as well as the existing elementary wing of the Pittsville, Maryland Middle/Elementary School.

The study was done in two parts, plus an addendum. The first part (Case I) deals with space heating the new school building only; the second part (Case II) pertains to space heating the new school building together with the existing elementary school wing. The addendum was added when new well and production pump costs were obtained. APL reports QM-80-055 and QM-80-055A have been incorporated into this report.

Discussion:

The Pittsville School (Fig. X) is being renovated by Malone and Williams Architects who are located in Salisbury, Maryland. The renovations include replacing the original old brick school building with a new well-insulated building that will contain administrative offices, classrooms, combination lunchroom/ auditorium, and a media center. This building will be hot water heated and will house two 600 thousand BTU/hr oil hot water boilers. These boilers will also heat the existing home economics and shop areas. Attached to the new building is the school's elementary classroom wing. This wing is poorly insulated and heated with a 945 thousand BTU/hr oil hot water boiler. The basic plans call for no alterations to this wing. There are, however, proposed construction alternatives for this old wing that would greatly reduce its heating oil consumption.

The new construction for the school will be approximately 35,500 sq. ft. The unchanged elementary wing is 13,000 sq. ft., giving a total of 48,500 sq. ft. for both wings.

To space heat the school with geothermal (GT) hot water, obviously something must be known about the resource. A request for an estimation of subsurface temperatures beneath Pittsville, MD was sent to VPI&SU in Blacksburg, VA. Their reply (Ref. 1) indicated an expected temperature of 127°F at approximately 5,000 ft. depth. Also electric logs from the Hammond well indicate a possible exploitable aquifer at this 5000 ft. depth. The basement at Pittsville is expected to be at 5800 ft. A look at stratigraphic maps from several nearby deep wells (Ref. 2) indicates a possible area for reinjection at 3200 ft.

Using the aforementioned assumptions, a source temperature of 127°F at 5000 ft. in an adequate aquifer having a transmissibility of 0.5 cm^2 or greater (a water quality similar to Crisfield), and being able to reinject at approximately 3200 ft., gives the necessary information to do a feasibility design study for geothermal space heating the Pittsville School.

This study will be in two sections. Case 1 will only cover the new school construction using the peak heat loading furnished by E-B-L Engineers, Inc., who are contracted by Malone and Williams (Ref. 3). Case 2 will add the elementary wing to the new school construction, using the agreed upon heat loading for the elementary wing between APL and Robert H. Stratemeyer of E-B-L Engineers of 1 x 10^6 Btu/hr (Ref. 4). The calculated heat loading for the new construction is 1.0296 x 10^6 Btu/hr. Both heat loadings are with a 10°F outside and a 70°F inside temperature.

The following are assumptions for both Cases 1 and 2:

1. The wellhead temperature is a minimum of 125°F.

2. The aquifer at 5000 ft. has a transmissibility (T) of 0.5 cm^3/sec. or greater.

3. GT water quality is similar to Crisfield well.

4. GT well and reinjection well on-site with little or no piping run.

5. GT well to deliver 70 GPM for the heating season of the school year with a minimum drawdown for Case 1, and 125 GPM for Case 2.

6. The production and reinjection well is designed using water well technology (gravel packed with screen) with an effective diameter of 24 inches for the gravel pack.

7. The price of fuel oil #2 is $1.00/gal.

8. The price of money for school construction is 7% using <u>municipal or state bonds</u> and 5% using <u>Farm Home Administration</u> funding.

9. The GT heating system is in parallel and integrated with the existing boilers and fan coil units (see Fig. V).

10. The temperature where peaking begins has been selected to be 30°F. The GT system should handle 100% of the load to this point. At 30°F outside temperature the GT system can be valved off from the system and the existing boilers will pick up the load. This results in the GT system handling at least 87% of the yearly heat load. Other schemes could be used where the GT system was independent and parallel to the existing boiler/fan coil units. This would allow the GT system to pick up part of the peaking load from the boilers.

Production Well Geothermal Water Pump.

By minimizing well drawdown by the use of a peaking system and the very reasonable size of the building being heated, it is possible to consider vertical shaft turbine pumps rather than submersible down-hole pumps. The vertical pumps are desirable since the annual maintenance is limited to inspection only, and historically their life expectancy is greater than down-hole systems by at least an order of magnitude. Finally, variable speed drives of several designs are commercially available and they are very dependable and reliable. These types of water well pumps have been in great use for irrigation and are applicable almost without modification for geothermal waters with temperatures we expect in the Atlantic Coastal Plain.

The cost of a vertical shaft turbine pump located at approximately 600 ft. in the production well and pumping 70 gal/min. maximum with head sufficient to lift water and circulate it through heat exchanger, namely, 650 ft., is estimated to cost $22K. The life expectancy of the pump motor and variable speed drive is estimated to be in excess of 20 years. In Klamath Falls, Oregon, and in Iceland, where these types of pump-motor variable speed drives are used, an annual inspection should look for bearing or other wear. This inspection is estimated to cost $2.5K/year.

The Geothermal Plate Heat Exchangers (Refs. 6 and 7, and Figures VI, VII, VIII, and IX).

The Alfa-Laval, Inc. Thermal Division in Somerville, NJ, was contacted and asked to size and price plate heat exchangers which would fit the two Pittsville School cases. Figures VI and VII show the size and specifications for Case 1 (new school construction only). Figures VIII and IX show the size and specifications for Case 2 (new school construction and the elementary wing).

Conclusions:

Case 1

Table I shows the cost for a geothermal retrofit for the new school building. Figures I and II show the capital recovery time vs. the oil price escalation rate in %, also vs. any initial grant fraction of the capital cost (Ref. 5). Figure I is calculated using 7% money while Figure II is with 5% money.

Case 2

Table II shows the cost for a geothermal retrofit for the new school building and the elementary wing. Figures III and IV again show the capital recovery times as done with Case 1. The primary differences between Case 1 and 2 for the capital recovery time are because of the need to use more fuel oil to heat the elementary wing. This poorly insulated wing, as it now stands, would require almost as much fuel oil for heating as the new building. The obvious conclusion from this should be to insulate the elementary wing. The savings in fuel oil by doing this would be recovered in less than two years. The curves for both cases show that with the availability of 7 or 5% money and possible grants, the unknown escalation oil price rate (assuming it will be 10% or more per year) makes geothermal space heating of the Pittsville school complex an attractive energy alternative.

If new heat loading is established for the elementary wing, or other changes are being considered, a new look can be taken at geothermal space heating.

References:

1. VPI&SU Ltr from Samuel S. Dashevsky to F. C. Paddison, "Estimation of Subsurface Temperatures Beneath Pittsville, Maryland," November 27, 1979.

2. "Structural and Stratigraphic Framework, and Spatial Distribution of Permeability of the Atlantic Coastal Plain, North Carolina to New York," Brown, Miller, and Swain, Geological Survey Professional Paper No. 796, Section M-M, GPO 1972.

3. Information supplied by E-B-L Engineers, Inc. to JHU/APL, December 17, 1979.

4. Personal communications between Robert Stratemeyer of E-B-L Engineers, Inc. and Roy von Briesen, JHU/APL, February 1980.

5. JHU/APL Memo, QM-80-043, "Capital Recovery Period," K. Yu, March 6, 1980, explains the algorithm for estimating the capital recovery period of geothermal space heating.

6. JHU/APL Ltr CQO-2797, to American Heat Division, Alfa-Laval, from Roy von Briesen, requesting sizing and quotations covering plate heat exchangers that could be used in the Pittsville School complex, January 15, 1980.

7. Response to JHU/APL CQO-2797 from American Heat Division, Alfa-Lavel, Mrs. Barbara Blauth, February 1, 1980.

8. APL/JHU QM-80-079, "Cost of Wells in the Atlantic Coastal Plain," May 21, 1980.

9. Artesian Well and Equipment Co. Ltr to Roy von Briesen, "Cost Estimate, Geothermal Well Pump Application," from Ronald Peterson, April 25, 1980.

Table I (Case 1)

Costs Geothermal Retrofit Pittsville School
New Construction Only

1. Capital Cost

New Wells - Screen and Graval Pack		
Production Well (5,200 ft)	=	$170,000
Reinjection Well (3,200 ft)	=	100,000
Testing and Logging	=	19,000
Well House Pumps, Etc.	=	29,000
Production Pump and Assoc. Equipment	=	28,000
Geothermal Plate Heat Exchanger	=	6,180
Re-Sizing Hx and Piping in School	=	5,000
Architects and Engineering	=	30,000
Total Capital Cost	=	$387,180

2. Annual Operating Cost (M&O)

Electrical Pumping Energy	=	$1,000
Production Pump Inspection and Maintenance	=	3,000
Operational Cost (Personnel, etc.)	=	2,000
		$6,000

3. Peaking System Oil = 2,200 gallons/year

4. Fuel Oil Displaced = 17,353 gallons/year

1980-81 Savings @ $1.00/gallon = $17,350

Table II (Case 2)

Costs Geothermal Retrofit Pittsville School
New Construction and Elementary Wing

1. Capital Cost

New Wells - Screen and Gravel Pack

Production Well (5,200 ft)	=	$170,000
Reinjection Well (3,200 ft)	=	100,000
Testing and Logging	=	19,000
Well House Pumps, Etc.	=	45,000
Production Well Pump	=	35,000
Geothermal Plate Heat Exchanger	=	8,130
Re-Sizing Hx and Piping in Main School	=	5,000
Re-Sizing Hx and Piping in Elementary Wing	=	10,000
Architects and Engineering	=	40,000
		$432,130

2. Annual Operating Cost (M&O)

Electrical Pumping Energy	=	$3,000
Production Pump Inspection and Maintenance	=	3,000
Operational Cost (Personnel, etc.)	=	2,000
		$8,000

3. Peaking System Oil = 4,144 gallons/year

4. Fuel Oil Displaced = 32,560 gallons/year

1980-81 Savings @ $1.00/gallon = $32,560

Capital $387,000 at 7%
Annual maintenance and oper. $6K (1980)
Fuel used 2208 gallons
Fuel saved 17,353 gallons
Annual payment from oil
saved (1980) at $1.00/gal = $17,353

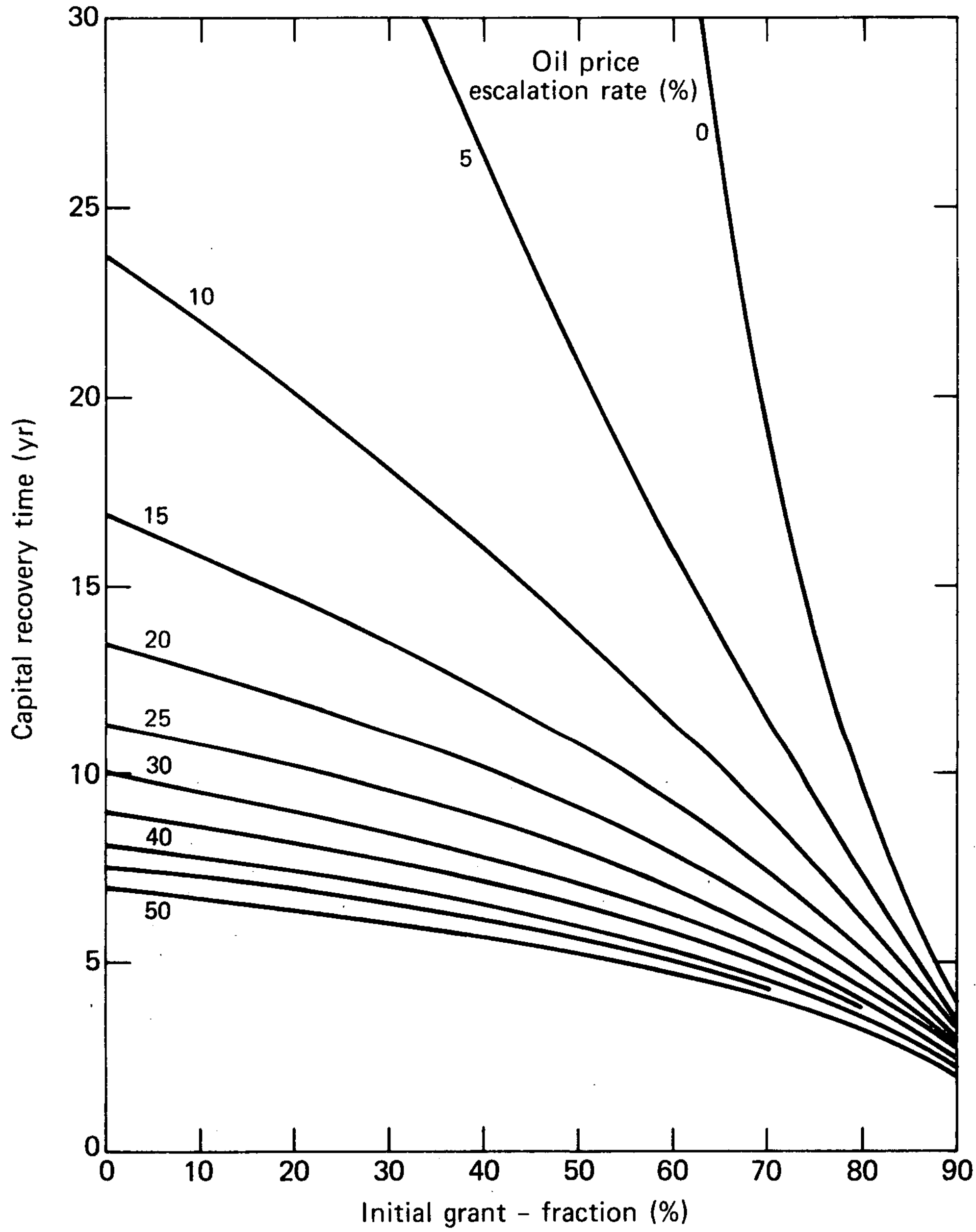


Fig. 1 Pittsville School new construction capital recovery time.

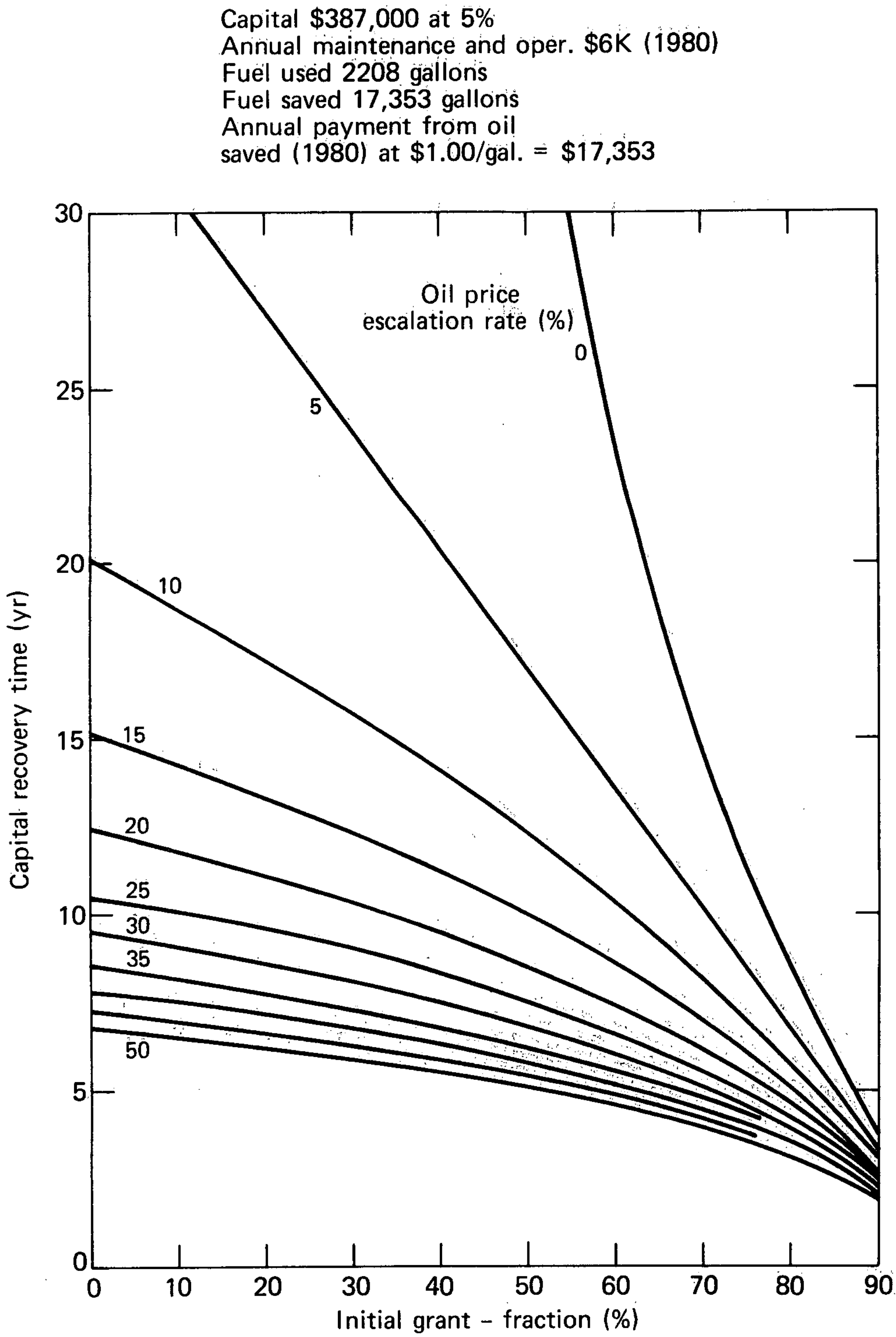


Fig. 11 Pittsville School new construction capital recovery time.

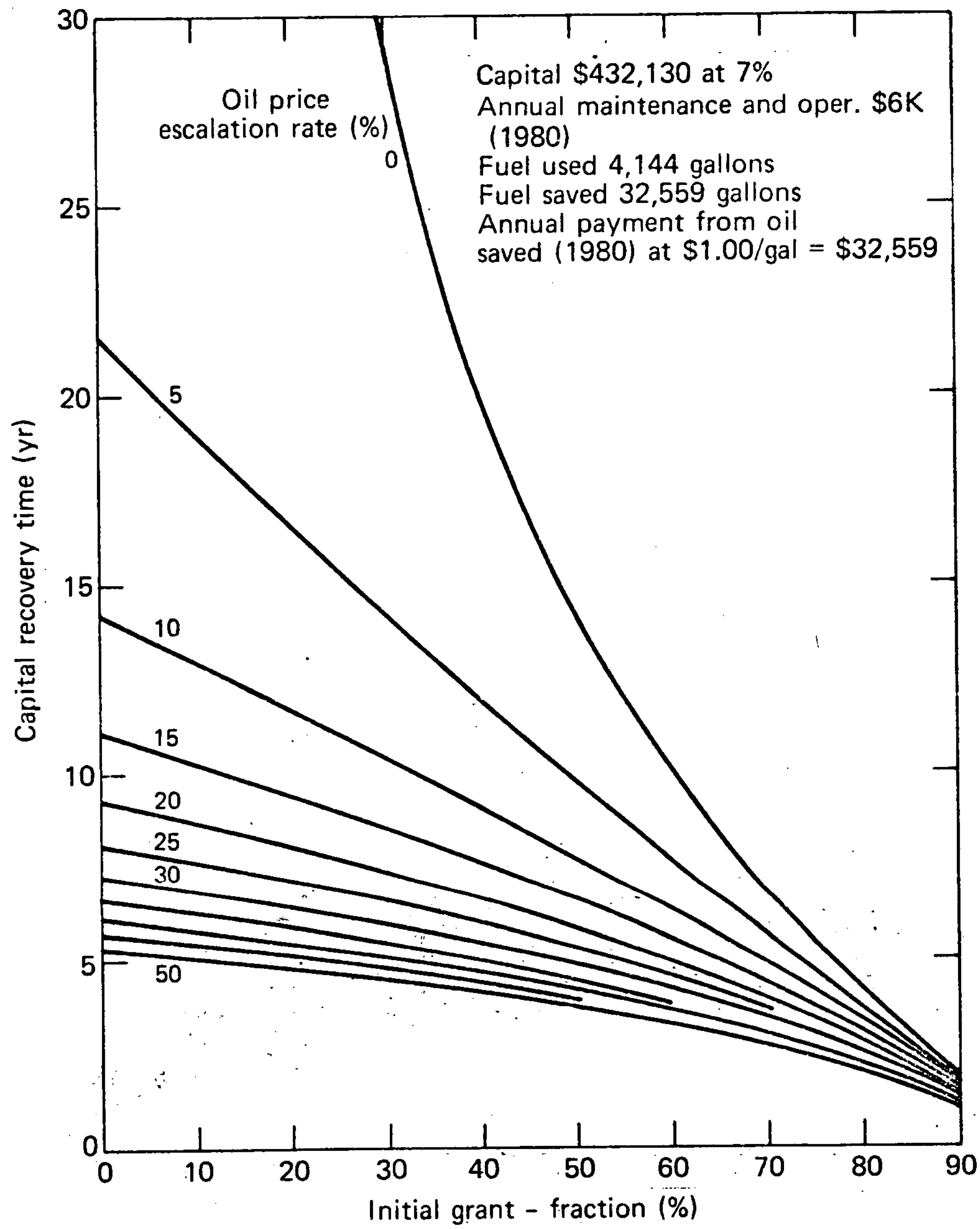


Fig. III **Pittsville School new construction and elementary wing. Capital recovery time.**

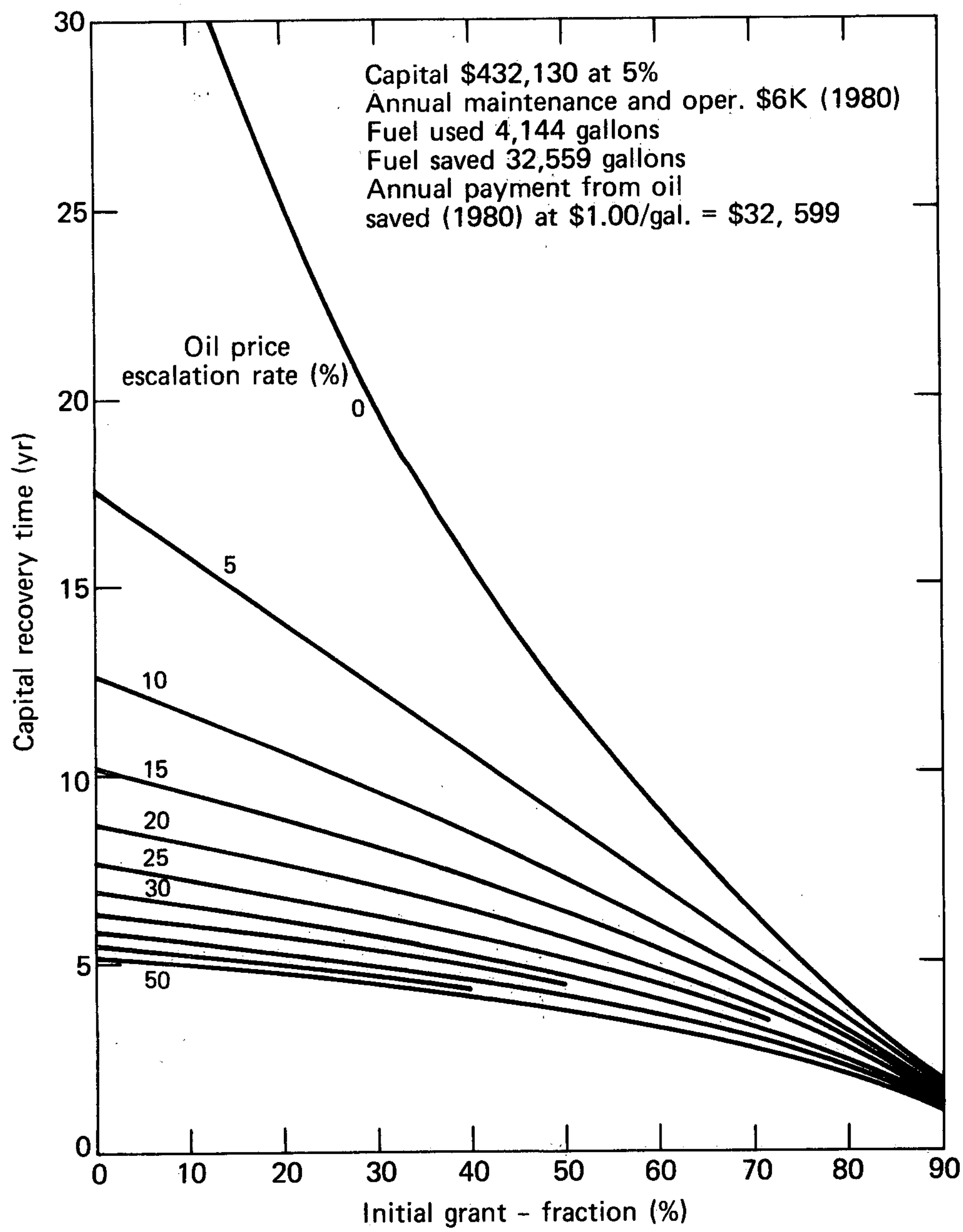


Fig. IV Pittsville School new construction and elementary wing. Capital recovery time.

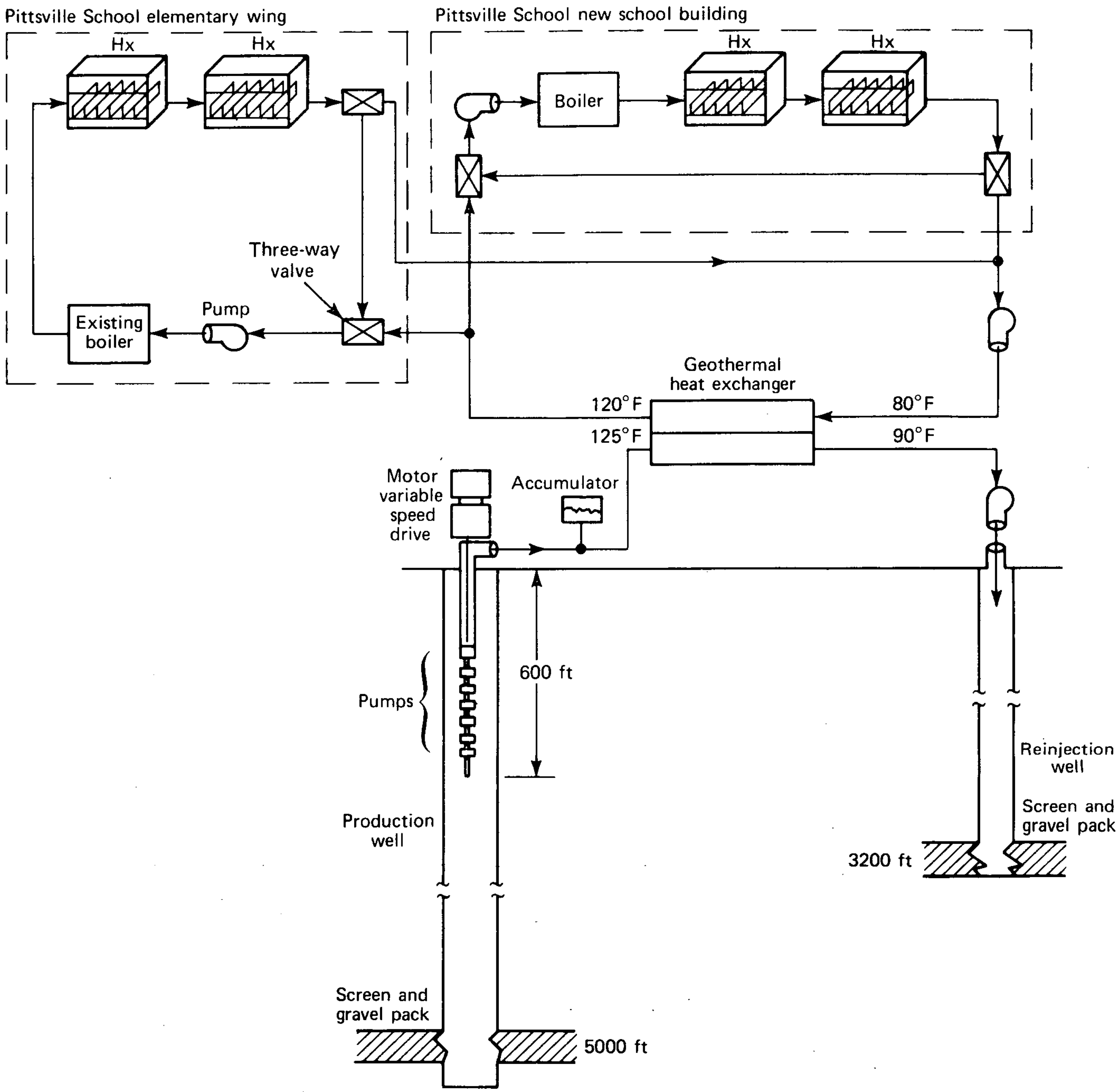


Fig. V Schematic geothermal heating system.

A M E R I C A N   H E A T   R E C L A I M I N G   C O R P O R A T I O N

CUSTOMER HOPKINS		OUR INQUIRY NUMBER	25893
ITEM NO.		DATE	JAN 29, 1980
SERVICE			
UNIT TYPE P31S		AREA PER UNIT	275.6 SQ FT
NO. UNITS IN PARALLEL	1	TOTAL AREA	275.6 SQ FT

CASE 1

		SIDE 1	SIDE 2
DUTY REQUIREMENTS			
FLUID FLOWING		Geothermal WATER	WATER
MASS FLOW RATE	LB/HR	34500.0	30000.0
	US GPM	69.7	60.6
FLOW TYPE		COUNTER CURRENT	
INLET TEMPERATURE	DEG F	125.0	80.0
OUTLET TEMPERATURE	DEG F	90.0	120.2
PHYSICAL PROPERTIES			
SPECIFIC HEAT	BTU/LB-F	0.997	0.997
SPECIFIC GRAVITY		0.989	0.991
THERMAL CONDUCTIVITY	BTU/FT-HR-F	0.367	0.364
VISCOSITY	CST	0.617	0.661
VISCOSITY WALL	CST	0.635	0.640
PERFORMANCE DATA			
HEAT TRANSFERRED	BTU/HR	1204066.	
LMTD	DEG F	7.1	
EFFECTIVE AREA REQD	SQ FT	268.7	
HEAT TRANSFER UNITS	REQD/ACT	4.95/ 5.48	5.69/ 6.29
PRESS. DROP ALLOWED	PSI	15.0	15.0
PRESS. DROP ACTUAL	PSI	4.7	3.4
TOTAL FOULING FACTOR	REQUIRED	0.	
TOTAL FOULING FACTOR	ACTUAL	0.000150	
TOTAL OVER SURFACING	REQUIRED %	10.51	
TOTAL OVER SURFACING	ACTUAL %	10.51	
PLATE DATA PER UNIT			
PASS ARRANGEMENT		2	2
PLATE MATERIAL/TK	MM	AISI 316/0.6	
GASKET MATERIAL		RES.BUTYLE	RES.BUTYLE
CONSTRUCTION DATA			
DESIGN PRESSURE	PSI	100.	
TEST PRESSURE	PSI	150.	
GASKET DESGN. TEMP.	DEG F	250.	
COVER MATERIAL		SA 515-70	
BOLTING MATERIAL		SA-193,B7 (CS)	
CARRYING BAR MTRL.		STAINLESS STEEL	
NOZZLE MATERIAL		AISI 316	C.S.
NOMINAL NOZZLE DIAM.	IN	2.0	2.0

ASME CODE CONSTRUCTION SECTION VIII DIV. 1 1977

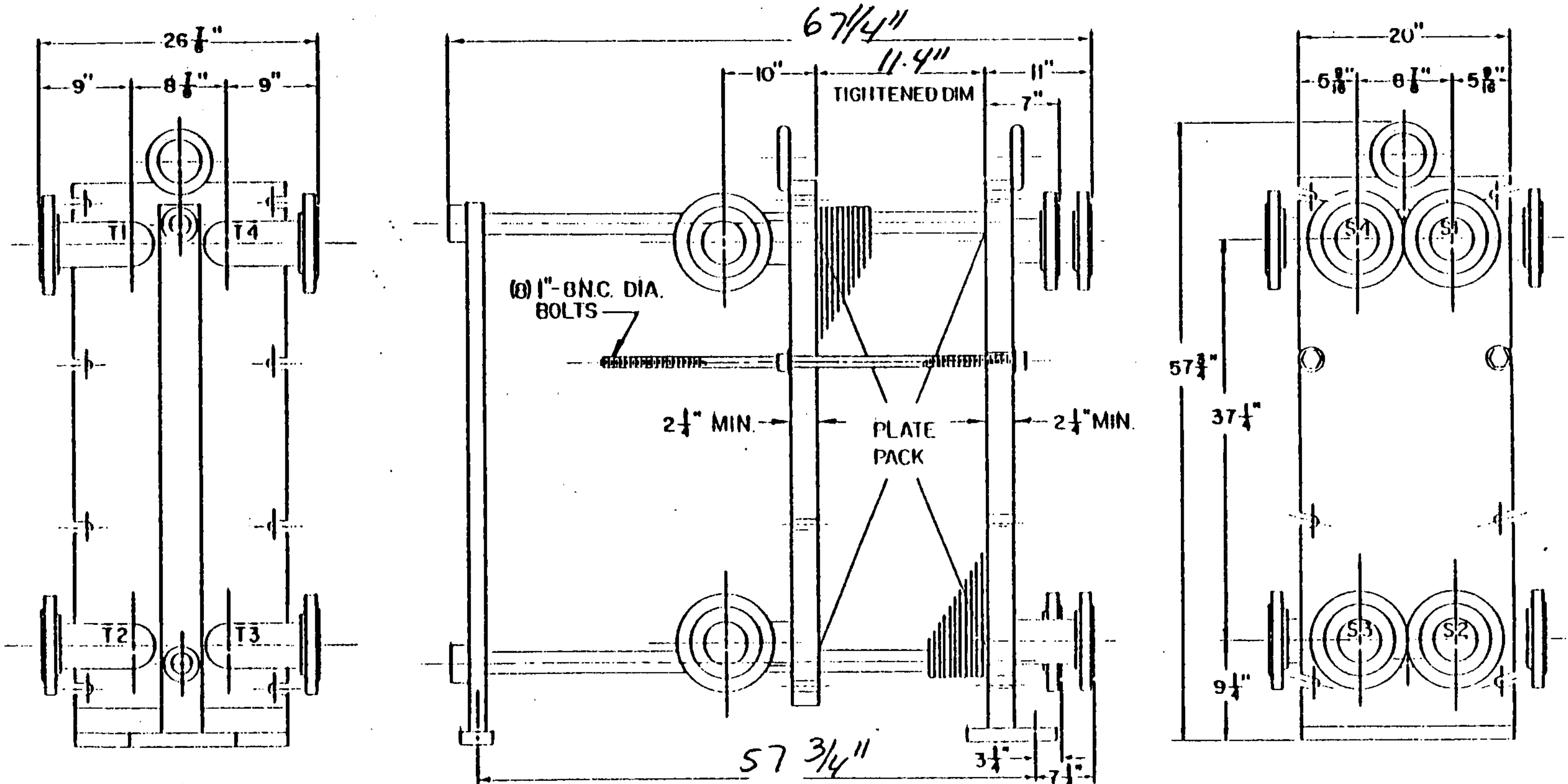
DIMENSIONS
(SEE ATTACHED DIMENSION SKETCH DRAWING NO. 31SA-7601)
"TD" DIMENSION 11.4 IN "UTD" DIMENSION 16.4 IN
NOZZLE LOCATION (S2,)/(T2,) (T3,)/(S3,)
WT. PER UNIT (INCL B&B) 1450. LBS.

"PERFORMANCE IS CONDITIONED ON THE ACCURACY OF CUSTOMER'S DATA AND ABILITY TO SUPPLY EQUIPMENT AND PRODUCT IN CONFORMITY THEREWITH."

Figure VI

QM-80-101

Figure VII



DESIGN PRESSURE 100 PSI
TEST PRESSURE 150 PSI
DESIGN TEMPERATURE 250°F
DESIGNED FOR 156 PLATES

NUMBER OF PLATES 80 TYPE P31/32
PLATE MATERIAL AISI 316 THK. .6mm
GASKET MATERIAL RCB
COVER MATERIAL SA-515,70
BOLT MATERIAL SA-193 B7 NUTS SA-194 2H
WEIGHT, APPROX. 1450 Lbs.
HEATING SURFACE 275.6 Sq.Ft.

NOTE: DO NOT USE THIS DRAWING FOR PIPING OR FOUNDATION LAYOUTS.

DESIGNED, CONSTRUCTED & NATIONAL BOARD STAMPED IN ACCORDANCE WITH A.S.M.E. CODE SECTION VIII-1977

NOZZLE LOCATION		FUNCTION	SIZE	MATERIAL
S	2	HOT SIDE INLET	2"	316 S.S
T	2	HOT SIDE OUTLET	2"	316 S.S
T	3	COLD SIDE INLET	2"	C.S.
S	3	COLD SIDE OUTLET	2"	C.S.

CASE 1

AMERICAN HEAT DIVISION, ALFA-LAVAL THERMAL
P.O. BOX 860 SOMERVILLE, NEW JERSEY 08876

CUSTOMER: Hopkins University	
TYPE-P-31/32 S	DWG # 978363-504
I-25893 ORD #	DATE: 1/31/80

AMERICAN HEAT RECLAIMING CORPORATION

CUSTOMER HOPKINS Univ.		OUR INQUIRY NUMBER	I-25893
ITEM NO. 1		DATE	JAN 29, 1980
SERVICE			
UNIT TYPE P31S		AREA PER UNIT	409.9 SQ FT
NO. UNITS IN PARALLEL	1	TOTAL AREA	409.9 SQ FT

CASE 2 - Geothermal Cooler

		SIDE 1	SIDE 2
DUTY REQUIREMENTS			
FLUID FLOWING		Geothermal WATER	WATER
MASS FLOW RATE	LB/HR	61500.0	54000.0
	US GPM	124.3	109.0
FLOW TYPE		COUNTER CURRENT	
INLET TEMPERATURE	DEG F	125.0	80.0
OUTLET TEMPERATURE	DEG F	90.0	119.8
PHYSICAL PROPERTIES			
SPECIFIC HEAT	BTU/LB-F	0.997	0.998
SPECIFIC GRAVITY		0.989	0.991
THERMAL CONDUCTIVITY	BTU/FT-HR-F	0.367	0.364
VISCOSITY	CST	0.619	0.666
VISCOSITY WALL	CST	0.637	0.643
PERFORMANCE DATA			
HEAT TRANSFERRED	BTU/HR	2146409.	
LMTD	DEG F	7.3	
EFFECTIVE AREA REQD	SQ FT	403.0	
HEAT TRANSFER UNITS	REQD/ACT	4.79/ 5.27	5.45/ 6.00
PRESS. DROP ALLOWED	PSI	15.0	15.0
PRESS. DROP ACTUAL	PSI	6.5	5.1
TOTAL FOULING FACTOR	REQUIRED	0.	
TOTAL FOULING FACTOR	ACTUAL	0.000126	
TOTAL OVER SURFACING	REQUIRED %	10.08	
TOTAL OVER SURFACING	ACTUAL %	10.08	
PLATE DATA PER UNIT			
PASS ARRANGEMENT		2	2
PLATE MATERIAL/TK	MM	AISI 316/0.6	
GASKET MATERIAL		RES.BUTYLE	RES.BUTYLE
CONSTRUCTION DATA			
DESIGN PRESSURE	PSI	100.	
TEST PRESSURE	PSI	150.	
GASKET DESGN. TEMP.	DEG F	250.	
COVER MATERIAL		SA 515-70	
BOLTING MATERIAL		SA-193,B7 (CS)	
CARRYING BAR MTRL.		STAINLESS STEEL	
NOZZLE MATERIAL		AISI 316	C.S.
NOMINAL NOZZLE DIAM.	IN	2.0	2.0

ASME CODE CONSTRUCTION SECTION VIII DIV. I 1977

DIMENSIONS

(SEE ATTACHED DIMENSION SKETCH DRAWING NO. 31S-7601)

"TD" DIMENSION 16.9 IN "UTD" DIMENSION 24.4 IN

NOZZLE LOCATION (S2,)/(T2,) (T2,)/(S2,)

WT. PER UNIT (INCL B&B) 1750. LBS.

"PERFORMANCE IS CONDITIONED ON THE ACCURACY OF CUSTOMER'S DATA AND ABILITY TO SUPPLY EQUIPMENT AND PRODUCT IN CONFORMITY THEREWITH."

Figure VIII

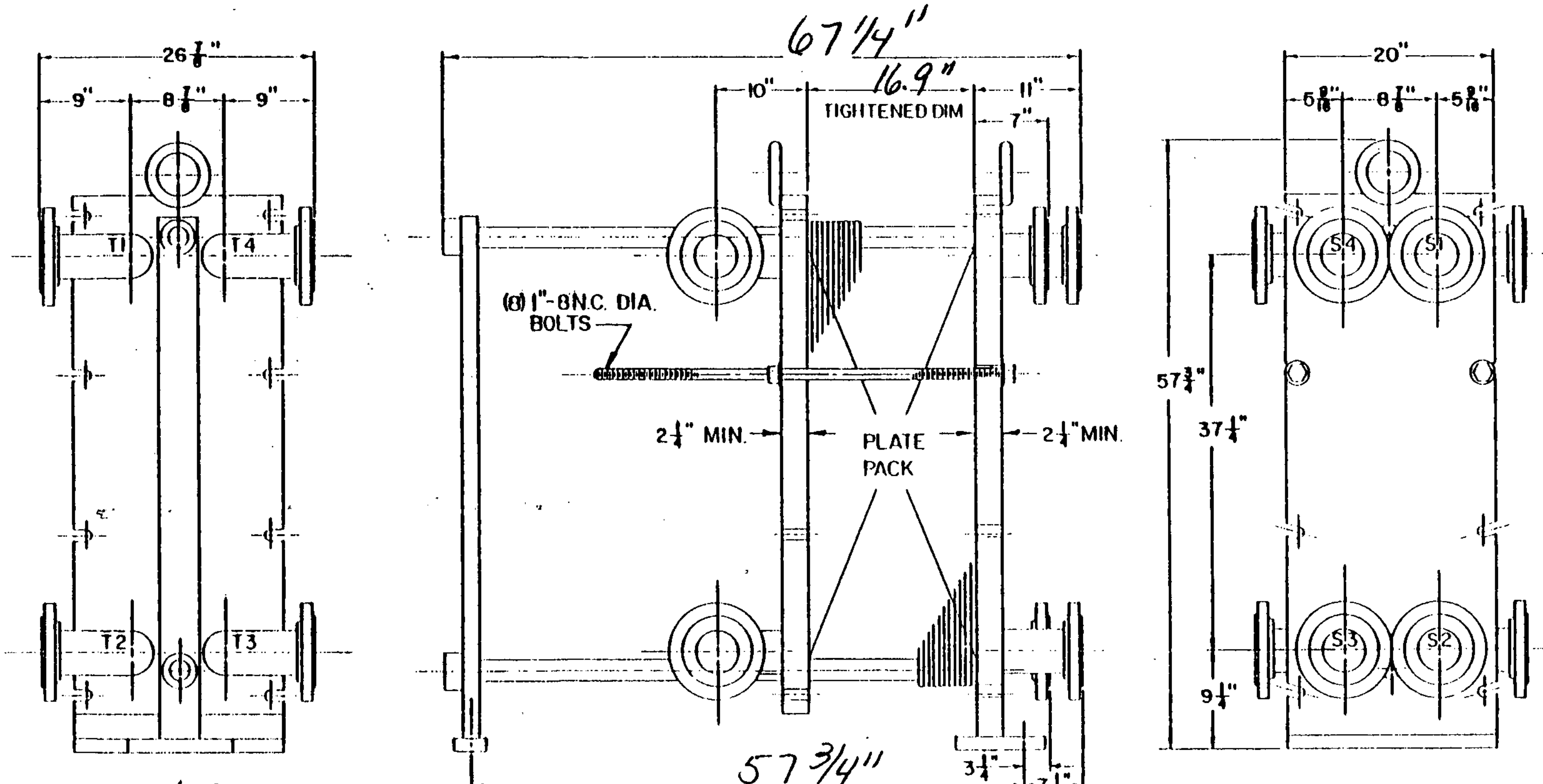


Figure IX

DESIGN PRESSURE 100 PSI
TEST PRESSURE 150 PSI
DESIGN TEMPERATURE 250 F
DESIGNED FOR 156 PLATES

NOZZLE LOCATION		FUNCTION	SIZE	MATERIAL
S	2	HOT SIDE INLET	2"	316SS
T	2	HOT SIDE OUTLET	2"	316SS
T	3	COLD SIDE INLET	2"	C.S.
S	3	COLD SIDE OUTLET	2"	C.S.

NUMBER OF PLATES 119 TYPE P31/32
PLATE MATERIAL AISI 316 THK. .6mm
GASKET MATERIAL RCB
COVER MATERIAL SA-515, 70
BOLT MATERIAL SA-193 B7, NUTS SA-194 2H
WEIGHT, APPROX. 1750 Lbs.
HEATING SURFACE 409.9 Sq.Ft.

NOTE: DO NOT USE THIS DRAWING FOR PIPING OR FOUNDATION LAYOUTS.

DESIGNED, CONSTRUCTED & NATIONAL BOARD STAMPED IN ACCORDANCE WITH A.S.M.E. CODE SECTION VIII - 1977

CASE 2

AMERICAN HEAT DIVISION, ALFA-LAVAL THERMAL
P.O. BOX 860 SOMERVILLE, NEW JERSEY 08876

CUSTOMER: John Hopkins Univ	
TYPE-P-31/32 S	DWG. # 978363-504
I-25893 ORD #	DATE 1/30/80

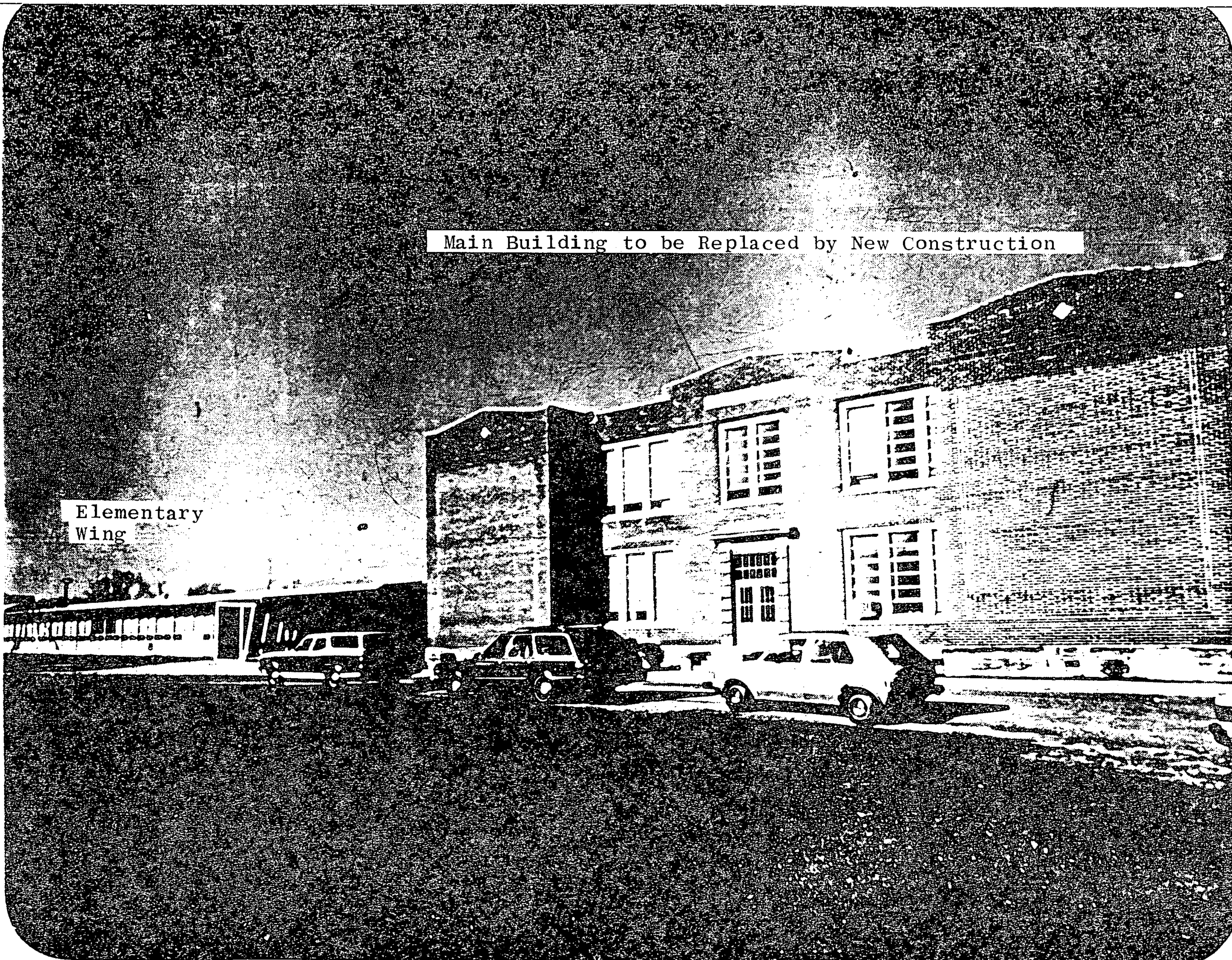


Fig. X. Pittsville School, Wicomico County, Pittsville, Maryland.

Since QM-80-055 was published (March 17, 1980), new cost estimates for deep water well drilling and vertical turbine pumps have been submitted to APL.

A. C. Schultes and Sons, Inc. is a water well drilling company and is among the few drillers that have deep water well experience in the Atlantic Coastal Plain. Schultes and Sons submitted to APL drilling estimates that covered a range of conditions for drilling geothermal production wells into the Potomac formation in the Delmarva area (Ref. 8). These conditions include various depths, well sizes, and development techniques. No well exactly fit the Pittsville School case, but extrapolating the production well would cost approximately $400,000, and the reinjection well would cost approximately $200,000. These costs may be somewhat high, but to get a more accurate estimate, the driller must have been given serious intent by the user for a site-specific well.

A vertical turbine pump for use in a production well at Pittsville has been sized and priced. This is a Peerless Pump, model 6MA, and is handled by Artesian Well and Equipment Company, Inc., Rochelle Park, New Jersey. The pump cost would be from approximately $50,000 to $65,000, depending upon the required withdrawal rate in GPM, the required head needed, and the type of speed controller used with the pump (Ref. 9).

These new estimates of well and pump cost have been incorporated into new curves (Figs. XI - XVI, Tables III and IV) showing the capital recovery time vs. oil escalation rates with loan interest rates of 5, 7, and 10%. The curves show a less favorable situation than existed with the first curves generated in QM-80-055. This essentially is due to the higher drilling cost estimates. Serious intent to purchase, drill, and install geothermal wells at Pittsville would probably put the capital recovery curves between the old and new curves for the same building and loan conditions; e.g., between the curves in Fig. II and Fig. XIV.

Addendum Table III (Case 1)

Costs Geothermal Retrofit Pittsville School
New Construction Only

1. Capital Cost

New Wells - Screen and Gravel Pack		
Production Well (5,200 ft)	=	$400,000
Reinjection Well (3,200 ft)	=	200,000
(Testing and Logging in Well Cost)		
Production Well Pump with Speed Controller	=	50,000
Well House, Pumps, Etc.	=	35,000
Geothermal Plate Heat Exchanger	=	6,180
Re-Sizing Hx and Piping in School	=	5,000
Architects and Engineering	=	35,000
Total Capital Cost	=	$731,180

2. Annual Operating Cost (M&O)

Electrical Pumping Energy	=	$1,000
Production Pump Inspection and Maintenance	=	3,000
Operational Cost (Personnel, etc.)	=	2,000
		$6,000

3. Peaking System Oil = 2,200 gallons/year

Fuel Oil Displaced = 17,353 gallons/year

1980-81 Savings @ $1.00/gallon = $17,353

Addendum Table IV (Case 2)

Costs Geothermal Retrofit Pittsville School
New Construction and Elementary Wing

1. Capital Cost

New Wells - Screen and Gravel Pack		
Projection Well (5,200 ft)	=	$400,000
Reinjection Well (3,200 ft)	=	200,000
(Testing and Logging in Well Cost)		
Production Well Pump with Speed Controller	=	65,000
Well House Pumps, Etc.	=	45,000
Geothermal Plate Heat Exchanger	=	8,130
Re-Sizing Hx and Piping in Main School	=	5,000
Re-Sizing Hx and Piping in Elementary Wing	=	10,000
Architects and Engineering	=	40,000
		$773,130

2. Annual Operating Cost (M&O)

Electrical Pumping Energy	=	$3,000
Production Pump Inspection and Maintenance	=	3,000
Operational Cost (Personnel, etc.)	=	2,000
		$8,000

3. Peaking System Oil = 4,144 gallons/year

4. Fuel Oil Displaced = 32,560 gallons/year

1980-81 Savings @ $1.00/gallon = $32,560

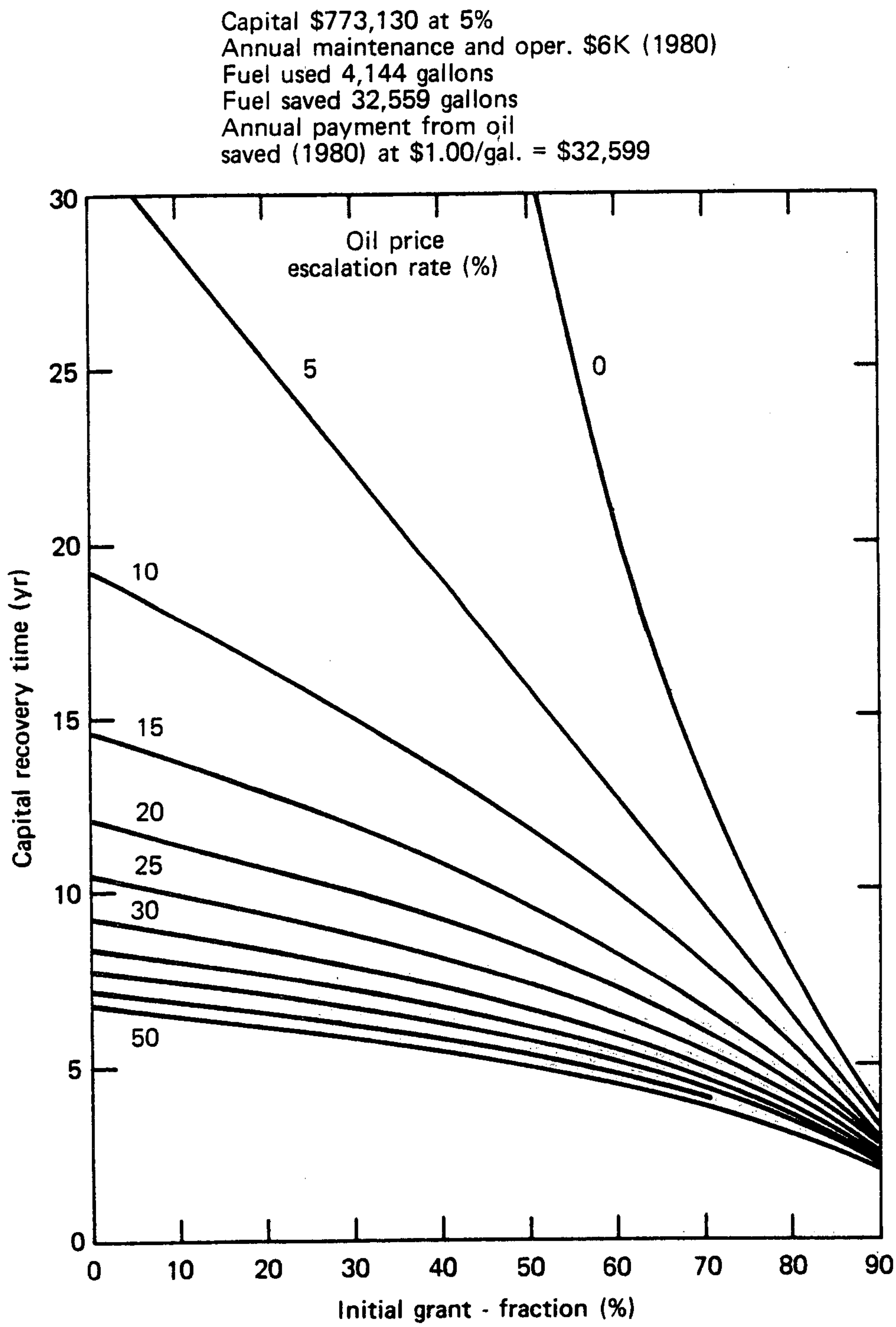


Fig. XI (Case 2) Pittsville School new construction and elementary wing. Capital recovery time.

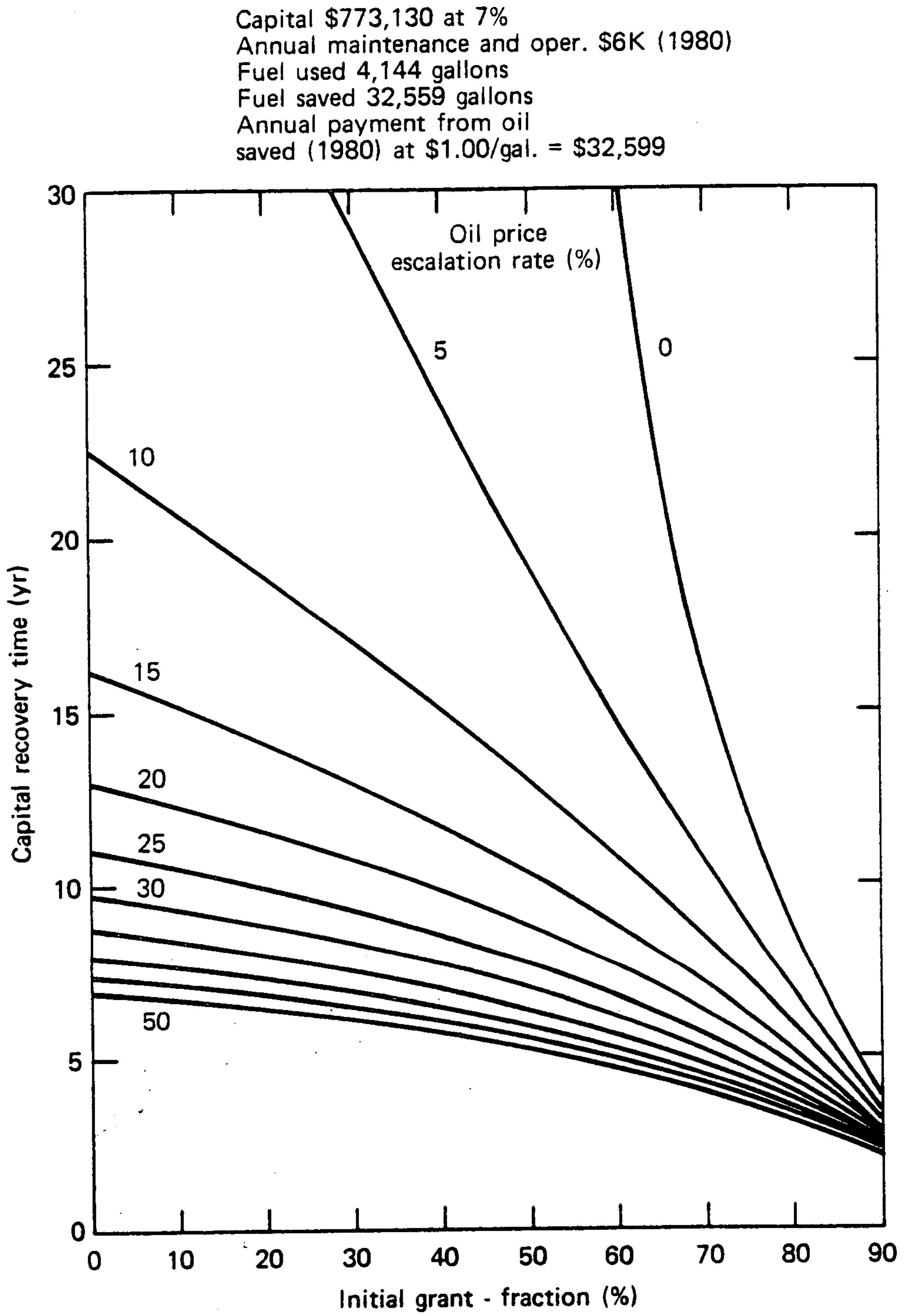


Fig. XII (Case 2) Pittsville School new construction and elementary wing. Capital recovery time.

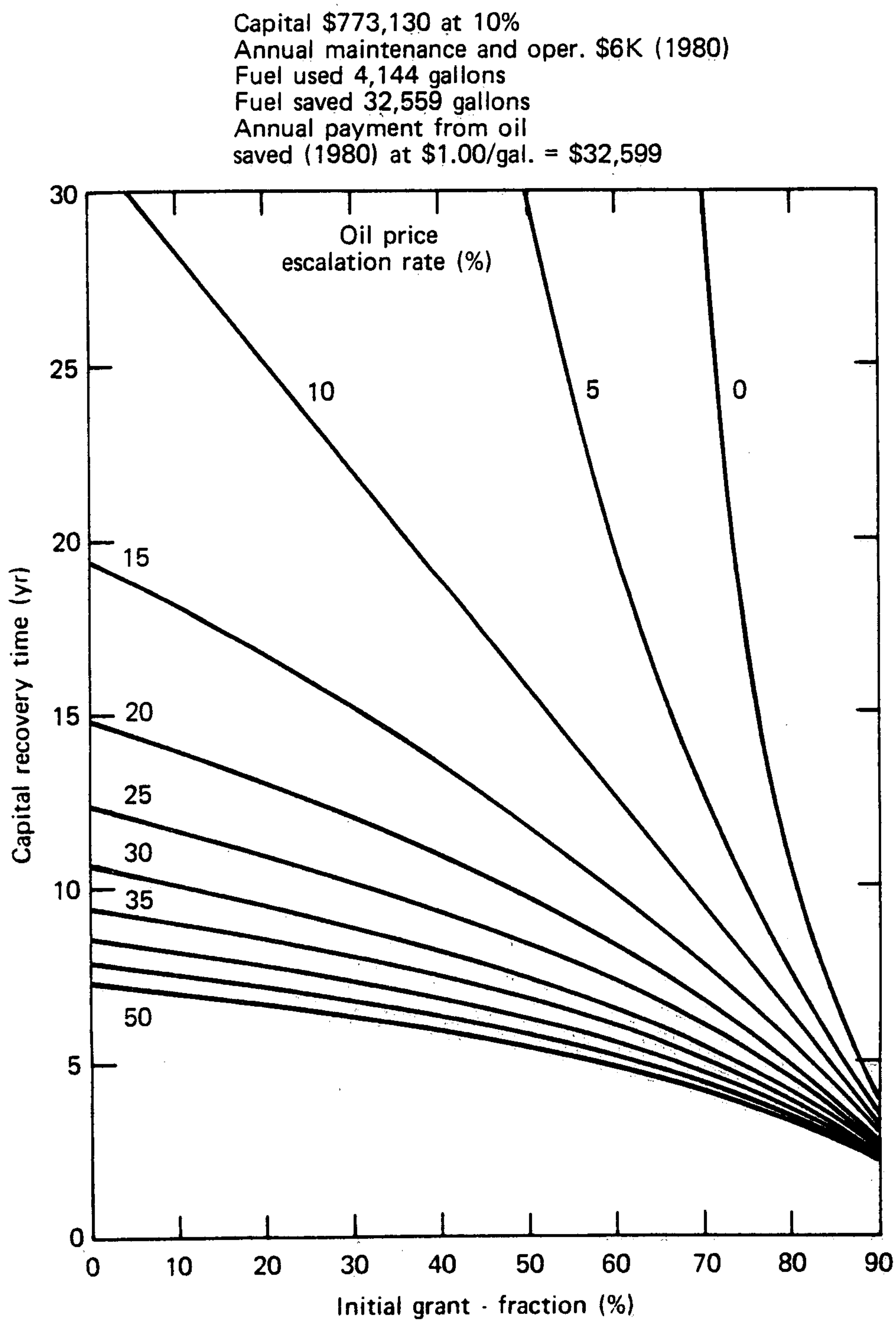


Fig. XIII (Case 2) Pittsville School new construction and elementary wing. Capital recovery time.

Capital $731,180 at 5%
Annual maintenance and oper. $6K (1980)
Fuel used 2208 gallons
Fuel saved 17,353 gallons
Annual payment from oil
saved (1980) at $1.00/gal. = $17,353

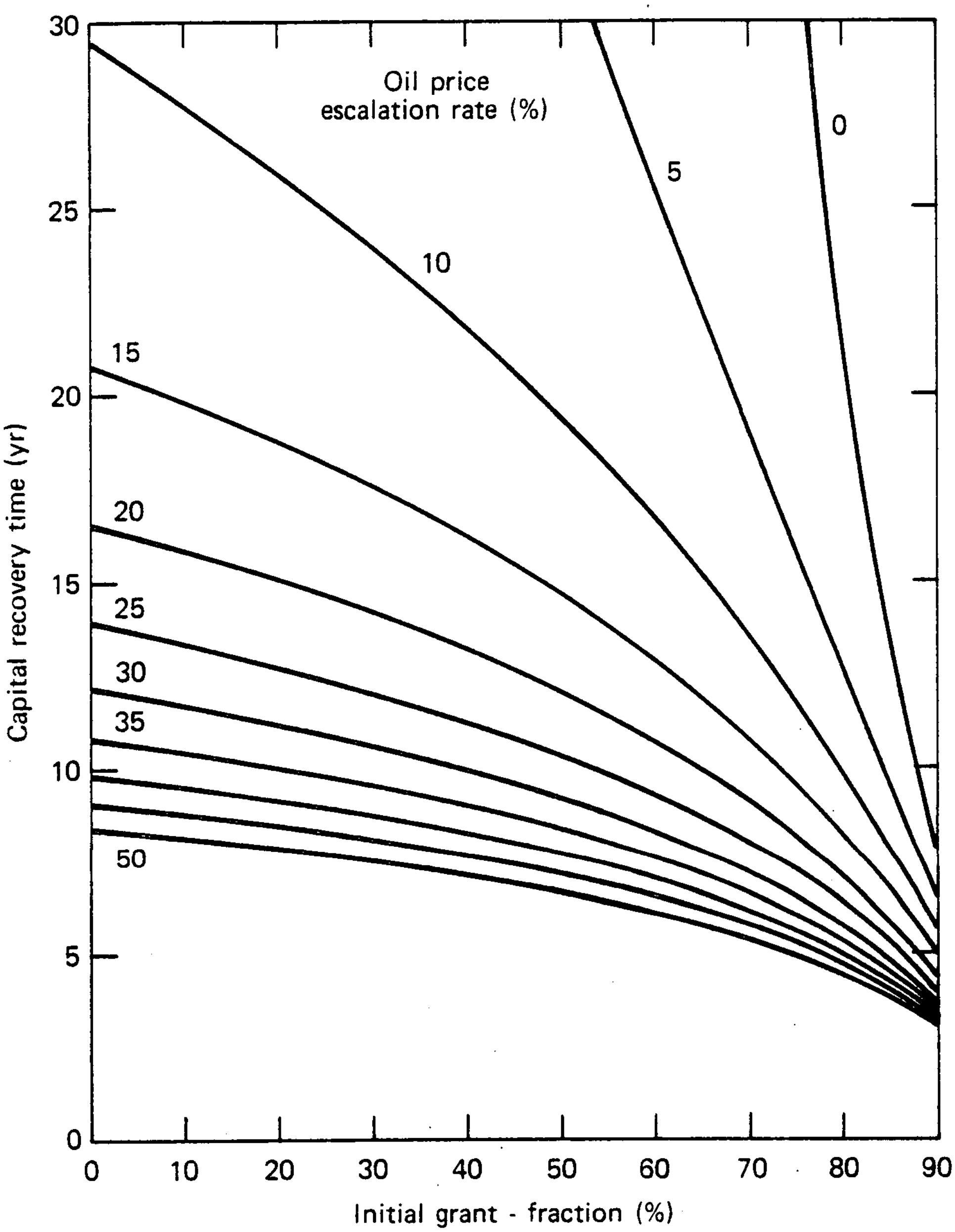


Fig. XIV (Case 1) Pittsville School new construction capital recovery time.

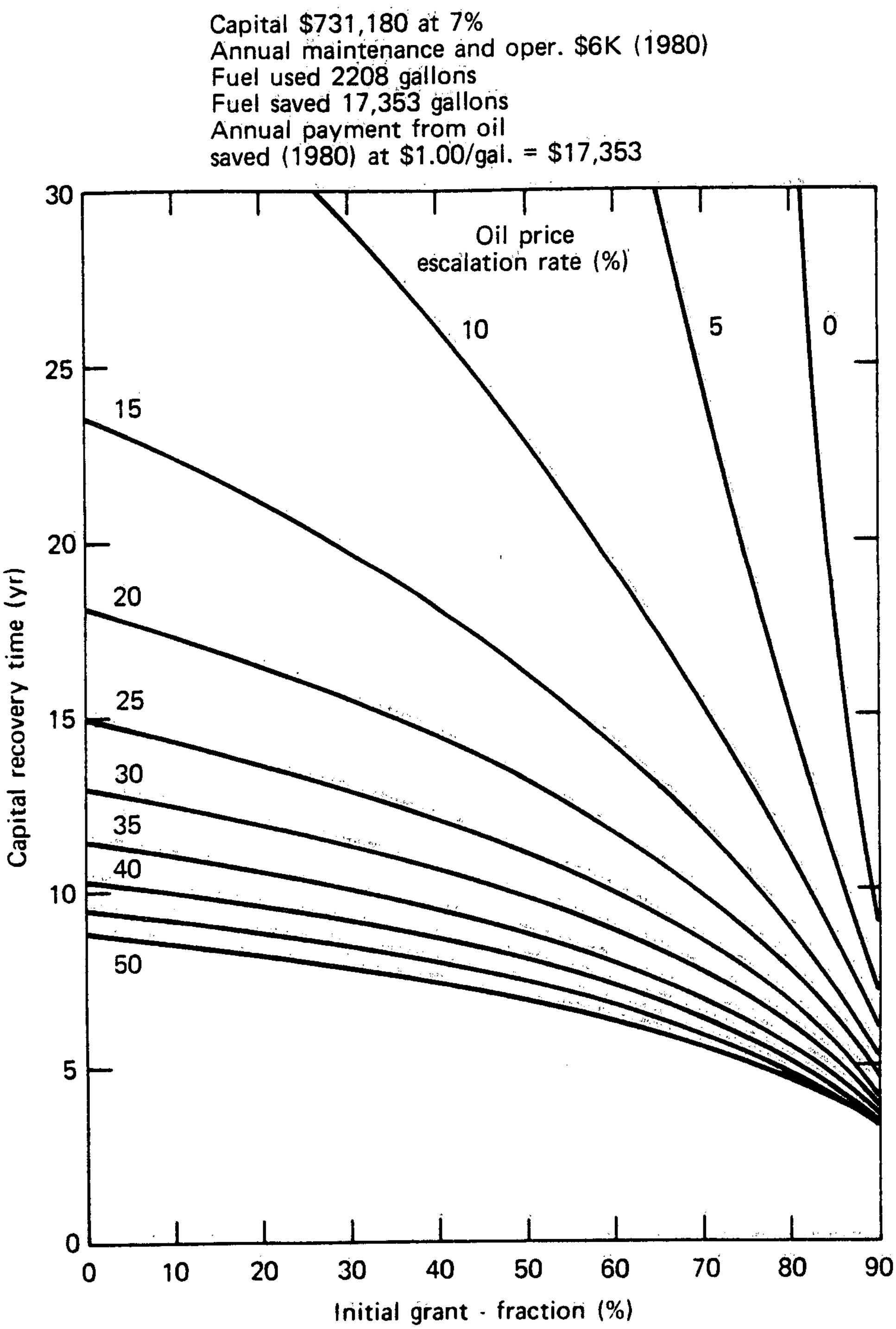


Fig. XV (Case 1) Pittsville School new construction capital recovery time.

Capital $731,180 at 10%
Annual maintenance and oper. $6K (1980)
Fuel used 2208 gallons
Fuel saved 17,353 gallons
Annual payment from oil
saved (1980) at $1.00/gal. = $17,353

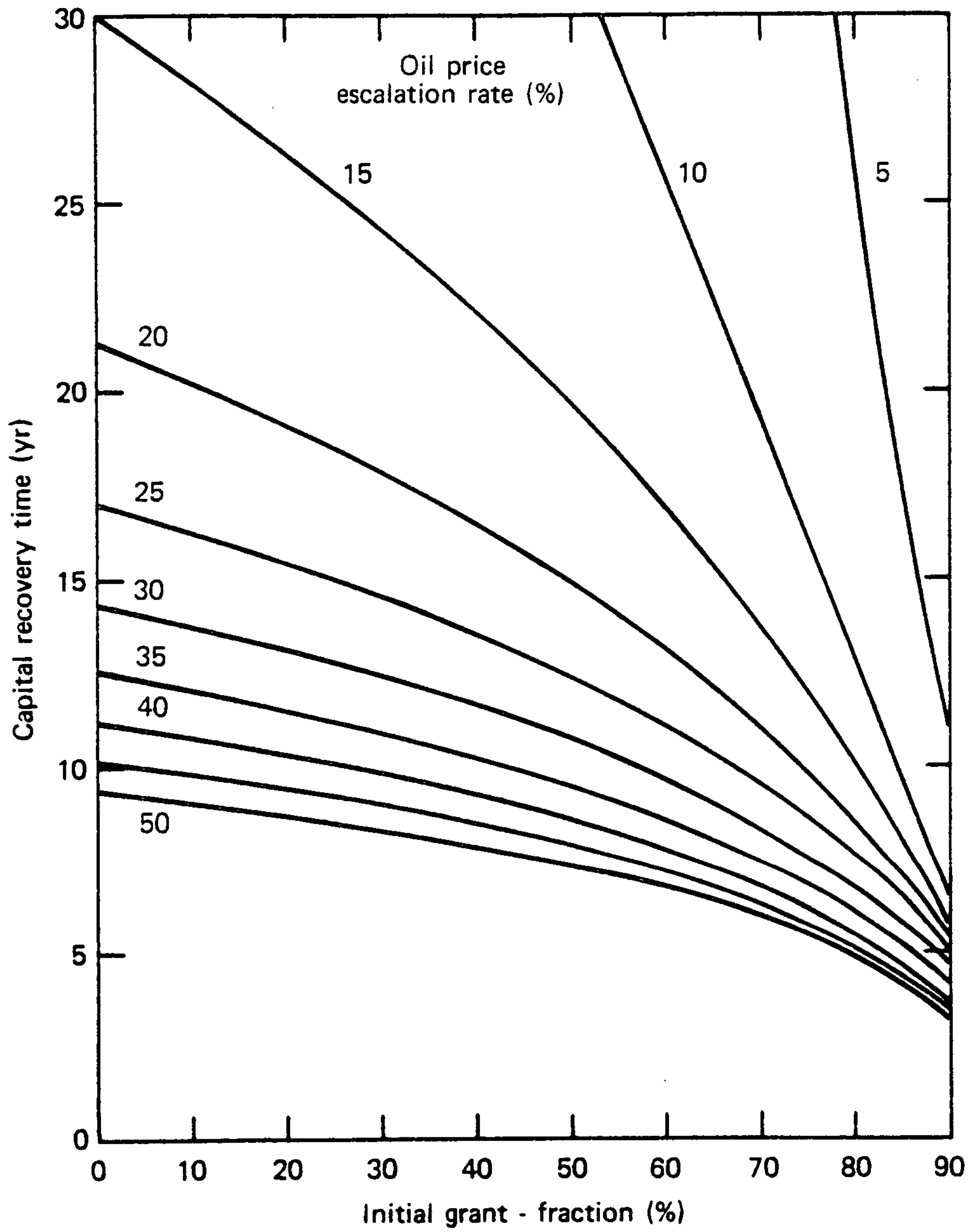


Fig. XVI (Case 1) Pittsville School new construction capital recovery time.

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