ENERGY EFFICIENT DESIGN CONCEPT FOR MESQUITE INDEPENDENT SCHOOL DISTRICT

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ABSTRACT

Mesquite is a suburb located on the east side of Dallas with a population of approximately 110,000. The school district covers over 60 square miles with a student population of 22,500. The 32 schools consist of 23 elementary, 5 middle and 4 high schools, with one additional elementary school scheduled to open in the Fall of 1988. The school district facilities cover approximately 2.4 million square feet with an annual energy budget of $1.8 million (natural gas and electric).

Utility Rates:
Electric - Texas Utilities Company MS Rate $15/mo per meter + KWH charge. On peak monthly average (June 86 thru September 86) $.0676/KWH. Off peak monthly average (October 86 thru May 87) $.0481/KWH.

Natural Gas - Lone Star Gas Company - September 86 thru August 87 monthly average $3.71/MCF.

The outdoor design conditions of the Dallas, Texas area as taken from the ASHRAE Handbook 1985 Fundamentals Volume are: Summer - 100^{o} D.B. and 78^{o} W.B. and Winter - 18^{o} D.B.

ENERGY MANAGEMENT PROGRAM

During the early 1980's Mesquite Independent Schol District (MISD) adopted an energy-efficient design concept for new schools built in the district. The features of the energy-conscious design concept include:

1. The use of Direct Digital Control.
2. Less than 5% area is glass.
3. The average U value is .05 BTU/ft^{2}-hr-^{o}F.
4. Thermal storage heating and cooling.
5. Variable speed drives on pumping and ventilation air handling units.
6. Closed circuit cooling towers.
7. Four pipe heating and cooling systems.
8. Hydropulse boilers for domestic hot water and space heating.
9. Heat recovery on walk-in freezers and refrigerators.
10. Occupancy sensors for lighting and HVAC control.
11. Electrical distribution system broken down into HVAC, lighting, and miscellaneous loads with each load submetered.
12. All the meters and submeters can be remotely read through the energy management system.
13. All exterior lighting is high -pressure sodium.
14. All interior lighting is 34w fluorescent with energy efficient ballasts and electronic ballasts are under construction for future applications.
15. District Energy Management System.

Schools Occupied or Under Construction Using The MISD Design Concept

SCHOOL	SQUARE FEET	DATE OCCUPIED
Kimball E.S.	32,200	10/85
Poteet H.S.	114,642	6/86
A.C. New M.S.	93,780	8/87
Pirrung E.S.	35,400	9/87
Cannaday E.S.	45,000	9/88
Black E.S.(Add.)	12,000	9/88

Each of these schools utilize the following types of thermal storage.

Kimball E.S.	Static Ice Builder
Poteet H.S.	Chilled Water
A.C. New M.S.	Dynamic Ice Harvester
Pirrung E.S.	Static Ice Builder
Cannaday E.S.	Dynamic Ice Harvester
Black E.S.	Dynamic Ice Harvester

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Cash Incentive Payments

The following cash incentive payments have been received, or will be received, from Texas Utilities Electric Company for Thermal Storage Projects from 1986 through 1988:

SCHOOL	KW REDUCTION	AMOUNT
Kimball E.S.	71	$ 17,750
Poteet H.S. Phases I & II	210	52,250
A.C. New M.S.	184	64,400
Pirrung E.S.	76	26,600
Poteet H.S. Phase III	140	49,000
Kimball E.S. Phase II	20	7,000
Black E.S.	37	12,950
Cannaday E.S.	90	31,850
TOTAL	828	$262,050

DR. RALPH H. POTEET HIGH SCHOOL

A project description of Poteet High School is that of a totally integrated energy conserving concept utilizing a weather impervious envelope, minimal internal loads, and highly efficient mechanical systems coupled with heating and cooling thermal storage to generate, store, and distribute thermal energy in the most efficient and cost effective manner.

By utilizing occupancy sensing equipment all elements of the energy consuming environmental comfort systems of the facility respond instantly to the utilization desires of its occupants never necessitating preplanning for equipment operation or seasonal operating mode selection. More importantly, all energy consuming equipment is automatically de-energized within a few minutes in the areas that occupants leave. The systems are so effective that a single individual can go to his or her office after hours without prior arrangements with total facility energy consumption only increasing proportionately.

A detailed listing of all the specific features are as follows:

I. Envelope

Less than 5% thermal glazing, average U value for walls and roof is 0.05 with vestibules on all entrances with radiant heating.

II. Electrical Systems & Equipment

A. Variable frequency drives on chiller, cooling tower fans, chilled water distribution pump and ventilation air unit.

B. High pressure sodium fixtures used on all exterior lighting.

C. Electrical distribution is divided according to function and submetered for HVAC loads, lighting loads, and process loads.

III. Mechanical Systems & Equipment

A. Chilled Water Storage Tank- 280,000 gallon concrete vertical stratification without separation. Temperature measurement at six equally spaced elevations. Charged by chiller or hydronic vent cycle.

B. Hot Water Storage Tank - Concrete lined steel 17,000 gallon with four headers arranged for dual temperature storage.

C. Chiller - Variable frequency drive, 196 ton rated at 38° F. Sized for full site development peak day load.

D. Boilers - Pulse fired high efficiency units sized for continuous operation at peak requirement. 440,000 BTU/HR output.

E. Closed Circuit Cooling Tower- Operates in three modes. Rejects heat from chiller, generates cooling effect for facility directly or indirectly through charging of chilled water storage tanks.

F. Distribution Pumping - Variable frequency drive heating and cooling pumps controlled to maintain proper differential across system load elements. Hot

water pump operates below 70° F during occupancy periods or for facility warm up cycle. Chilled water pump operates during occupancy or cool down cycle. System differential set points varied according to supply water temperatures and outside air conditions.

G. Ventilation - Variable frequency drive unit providing air to only the occupied rooms. Provides supplemental cooling anytime outside air is below 55° F. Supply temperature drops to 40° F before heating coil is controlled to maintain that minimum temperature. Gym and auditorium dampers are controlled for supplemental cooling. All ventilation is set for 5 CFM per occupant minimum.

H. Air Units/Fan & Coil Units- Units start automatically when area served is occupied.

I. DDC Control System - Controls equipment, provides system operation information, generates historical data files for meter readings and selected system points.

The greatest innovation of this project is its ability to utilize existing technology to enable the school district to efficiently cope with the current rising energy costs. The project is a 114,642 square foot high school containing classrooms, a gymnasium and a fieldhouse. The electrical systems feature high efficiency motors and variable frequency drives on the chiller, cooling tower fans, distribution pumps, and the ventilation air units. The majority of the interior lighting uses 34 watt lamps and high efficiency ballasts. Occupancy sensors control the lighting and air conditioning units for most areas.

Both the cooling load and hot water requirements are satisfied from storage systems. The chilled water storage tank uses stratification and low velocity headers to store and utilize 280,000 gallons, which represents 130 percent of the maximum daily cooling load. The hot water storage tank has dual storage at 190° F and 120° F, the upper-level is filled from the boilers, while the bottom-level is filled by waste heat recovery from kitchen refrigeration units. The chiller is sized to recharge the storage tank during a 16 hour full-load period from 8 p.m. to 12 noon. To increase efficiency, a VFD for the chiller compressor takes advantage of lower night-time condensing temperatures rather than part-load conditions. A closed circuit cooling tower is used to reject condenser heat or to provide hydronic free cooling directly to the storage tank.

See Figures 1 and 2 for chilled and hot water system configurations.

A School Built in Phases

The school complex consists of Phases I and II that have been occupied since June 1986, and Phase III which is under construction and scheduled for occupancy August 1988. The future plans for the site are two more additions (Phases IV and V) when required by the area student census.

Phases Occupied Since 6/86 (114,642 Sq. Ft.):

Phase I - two story academic wing, major mechanical equipment room, and hot and chilled water above ground thermal storage tanks.

Phase II - Gymnasium and Athletic Complex.

Phases Under Construction Scheduled for Occupancy 9/88 (73,600 Sq. Ft.):

Phase III - Kitchen, Cafeteria, Library and Vocational Wing.

Future Phases (Approximately 112,000 Sq.Ft.):

Phase IV - Auditorium, Band and Choral Facility and New Administration Area.

Phase V - Two Story Academic Wing

When all five phases are complete the complex will be approximately 300,000 square feet. The major mechanical equipment and the thermal storage tanks were designed for the complete facility (300,000 sq.ft.) and installed under the Phase I project.

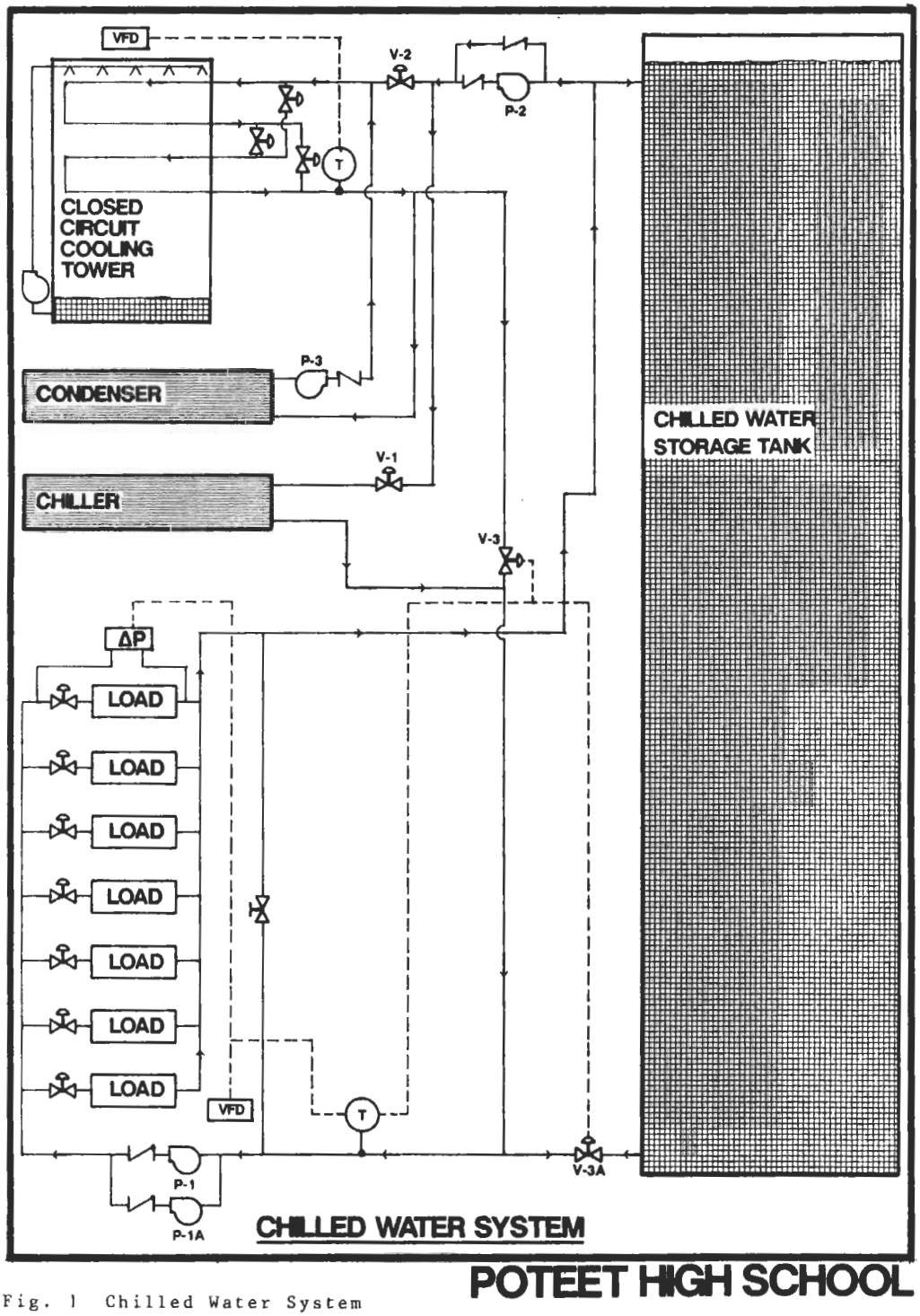

Fig. 1 Chilled Water System

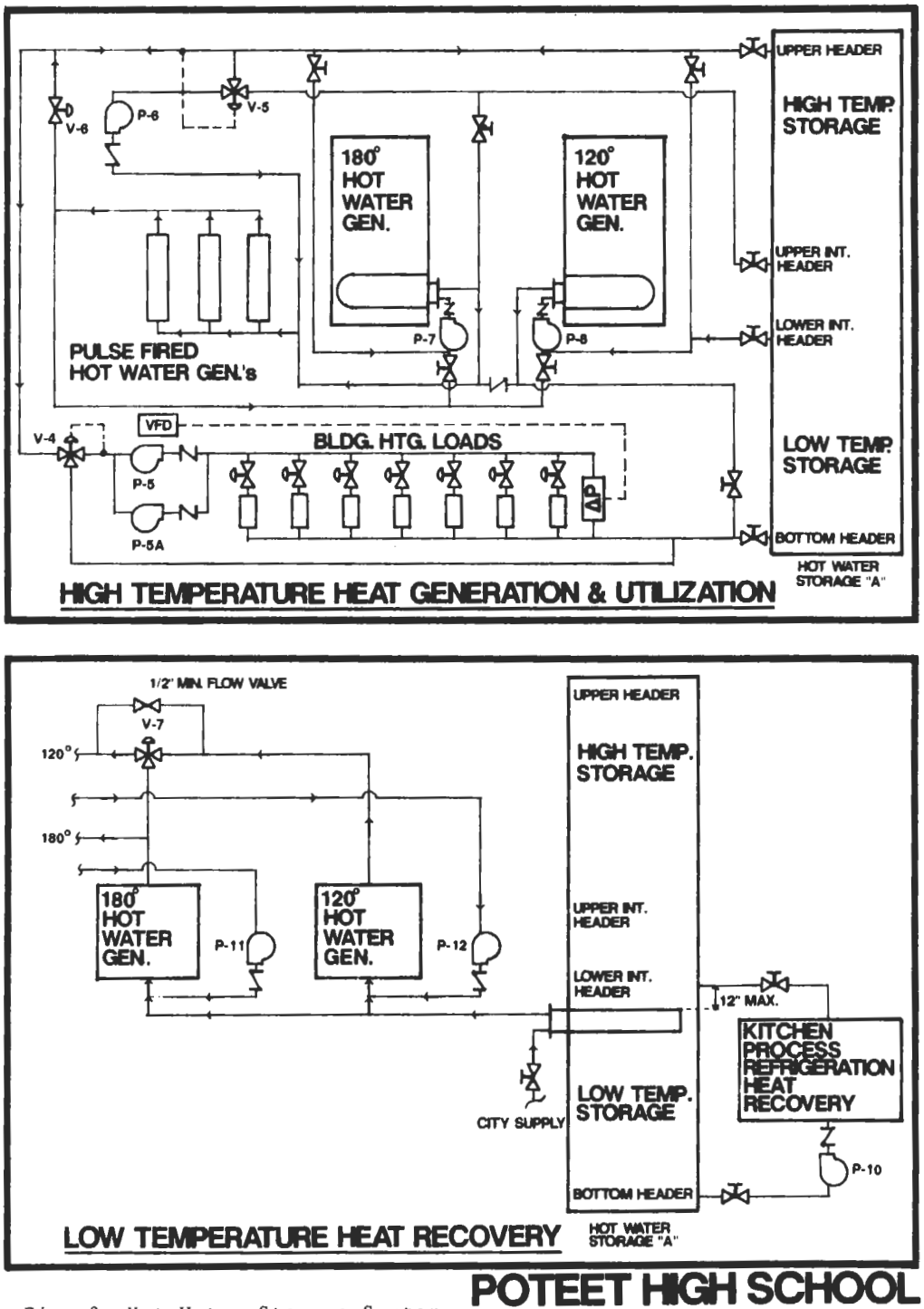

Fig. 2 Hot Water Storage System

COMPARISON OF ENERGY COSTS FOR POTEET HIGH SCHOOL AND THE SCHOOL DISTRICT'S THREE OTHER HIGH SCHOOLS

(Data for comparison from electric & natural gas bills - September 1986 through August 1987)

SCHOOL/SQ.FEET	BTU* SQ.FT/YR	$ SQ. FT/YR	SAVINGS** COST	BTU
Poteet (114,642)	40,029	.46	--	--
NMHS (262,915)	56,491	.55	16%	29%
WMHS (190,214)	57,948	.68	32%	31%
MHS (230,609)	78,146	.77	40%	49%
Three H.S. Avg.	64,212	.67	31%	38%

* Site BTU Consumption Data was used in calculations.

** Poteet High School savings per square foot compared to existing schools - Energy cost avoidance for Poteet High School as compared to the three existing high schools average is $24,075. See Figures 3 and 4.

MESQUITE INDEPENDENT SCHOOL DISTRICT HIGH SCHOOL HVAC SYSTEMS

Poteet High School - Occupied 6/86 - 114,642 square feet. Four pipe hot water and chilled water thermal storage system.

North Mesquite High School - Occupied 9/69 - 262,915 square feet. Area cooling and ventilating air handling units with room electric reheat.

West Mesquite High School - Occupied 8/76 - 190,214 square feet. Two pipe hot/chilled water system with room diverting boxes (an early version of VAV boxes).

Mesquite High School - Occupied 9/63 - 230,609 square feet. Two pipe hot/chilled water system.

COMPARISON OF %MPE OF GENERAL CONTRACT SUM ON POTEET HIGH SCHOOL AND A NEIGHBORING SCHOOL DISTRICT HIGH SCHOOL THAT IS UNDER CONSTRUCTION AT THIS TIME

Poteet High School Phases I, II and III

General Contract Total**	$14,666,590
Mechanical, Plumbing and Electrical	3,587,250*

MPE = 24% of General Contract

*Includes cost of hot and chilled water storage tanks complete (also includes tunnel and piping from tanks to mechanical room).

**Under the Phase III contract a backup chiller and pumps were installed.

Neighboring School District High School

General Contract Total	$18,150,170
Mechanical, Plumbing and Electrical	4,294,383

MPE = 24% of General Contract

NOTES: Bids for the Neigboring School District High School were taken about the same time that Poteet Phase III bids were taken. Data shown above is from the architect who designed both schools.

ECONOMIC IMPACT

The concepts utilized in the Dr. Ralph H. Poteet High School have unlimited transferability to all educational facilities, up to and including colleges and universities. In addition, they could be cost effectively applied to all other environmentally controlled facilities.

The economic impact is felt by all taxpayers in the school district, since this facility can operate on an energy budget that can be at least 30% less than for the existing schools in the same school district. When demand charges are added to the utility rate structure it will operate at 50 to 60 per cent less cost.

COMPARISON OF ENERGY COST AND CONSUMPTION

POTEET HIGH SCHOOL MONTH	KW	KWH	$/ELEC	MCF	$/GAS	$/TOTAL	CENTS SQ.FT.	BTU SQ.FT.
SEP.86	303	87,330	5,907.77	91.1	313.38	6,221.15	5.43	3,418.40
OCT.86	355	87,900	4,838.51	203.2	721.36	5,559.87	4.85	4,442.50
NOV.86	330	74,460	3,781.90	268.8	895.10	4,657.00	4.06	4,631.70
DEC.86	360	79,050	3,239.21	224.6	799.58	4,038.79	3.52	4,371.30
JAN.87	323	66,330	3,384.70	222.5	774.30	4,159.00	3.63	3,973.70
FEB.87	323	66,330	2,546.42	183.3	637.88	3,184.30	2.78	3,621.60
MAR.87	323	66,330	3,179.34	146.3	517.90	3,697.24	3.23	3,289.10
APR.87	198	67,350	3,225.03	110.6	397.05	3,622.08	3.16	2,998.80
MAY.87	384	91,500	4,986.02	74.0	259.74	5,245.76	4.58	3,388.90
JUN.87	384	77,790	5,099.59	27.0	94.08	5,193.67	4.53	2,558.50
JUL.87	303	59,280	3,896.66	1.0	5.99	3,902.65	3.40	1,773.80
AUG.87	287	45,780	3,016.33	22.0	78.77	3,095.10	2.70	1,560.60
TOTAL	3,873	869,430	47,081.48	1,574.4	5,495.13	52,576.61	45.87	40,028.90

NORTH MESQUITE HIGH SCHOOL MONTH	KW	KWH	$/ELEC	MCF	$/GAS	$/TOTAL	CENTS SQ.FT.	BTU SQ.FT.
SEP.86	1,043	295,350	19,944.34	560.3	1,927.43	21,871.77	8.32	6,029.10
OCT.86	1,059	247,500	13,596.56	570.8	2,026.34	15,622.90	5.94	5,449.10
NOV.86	939	185,700	9,359.61	888.9	2,960.04	12,319.65	4.69	5,893.00
DEC.86	875	173,550	7,093.59	1,120.8	3,990.05	11,083.64	4.22	6,643.80
JAN.87	946	171,900	8,747.87	1,039.6	3,617.81	12,365.68	4.70	6,304.30
FEB.87	872	169,800	6,495.25	953.5	3,318.18	9,813.43	3.73	5,939.60
MAR.87	825	129,150	6,176.23	663.4	2,348.44	8,524.67	3.24	4,278.40
APR.87	913	203,850	9,730.90	527.6	1,894.08	11,624.98	4.42	4,713.20
MAY.87	1,038	250,950	13,648.62	392.9	1,379.08	15,027.70	5.72	4,796.90
JUN.87	1,046	136,800	8,956.66	204.6	712.01	9,668.67	3.68	2,577.40
JUL.87	434	96,150	6,310.91	5.0	29.95	6,340.86	2.41	1,267.80
AUG.87	722	153,600	10,085.02	154.3	552.39	10,637.41	4.05	2,598.40
TOTAL	10,712	2,214,300	120,145.56	7,081.7	24,755.80	144,901.36	55.12	56,491.00

WEST MESQUITE HIGH SCHOOL MONTH	KW	KWH	$/ELEC	MCF	$/GAS	$/TOTAL	CENTS SQ.FT.	BTU SQ.FT.
SEP.86	796	246,540	16,665.80	230.8	794.95	17,460.75	9.18	5,673.50
OCT.86	811	224,070	12,325.84	214.1	760.06	13,085.90	6.88	5,179.80
NOV.86	800	168,585	8,513.37	395.9	1,318.34	9,831.71	5.17	5,168.70
DEC.86	502	153,750	6,301.01	612.2	2,179.44	8,480.45	4.46	6,073.70
JAN.87	503	135,945	6,936.29	669.8	2,330.91	9,267.20	4.87	6,066.20
FEB.87	497	137,535	5,278.89	481.8	1,676.67	6,955.56	3.66	5,076.70
MAR.87	513	132,660	6,358.68	347.8	1,231.21	7,589.89	3.99	4,263.60
APR.87	813	154,470	7,392.35	296.5	1,064.44	8,456.79	4.45	4,377.10
MAY.87	814	198,930	10,837.46	213.4	749.03	11,586.49	6.09	4,725.00
JUN.87	789	194,985	12,648.59	188.7	656.68	13,305.27	6.99	4,520.40
JUL.87	760	183,540	11,869.77	8.6	51.51	11,921.28	6.27	3,339.80
AUG.87	745	163,215	10,567.17	102.5	366.95	10,934.12	5.75	3,483.60
TOTAL	8,343	2,094,225	115,695.22	3,762.1	13,180.19	128,875.41	67.76	57,948.10

MESQUITE HIGH SCHOOL MONTH	KW	KWH	$/ELEC	MCF	$/GAS	$/TOTAL	CENTS SQ.FT.	BTU SQ.FT.
SEP.86	1,095	306,970	20,803.39	198.7	683.52	21,486.91	9.32	5,430.60
OCT.86	1,063	276,734	15,275.78	275.7	978.75	16,254.53	7.05	5,327.00
NOV.86	1,079	170,203	8,654.79	1,067.8	3,555.78	12,210.57	5.29	7,288.30
DEC.86	610	165,942	6,858.29	1,789.1	6,369.20	13,227.49	5.74	10,446.80
JAN.87	592	154,446	7,936.17	2,162.7	7,526.19	15,462.36	6.71	11,945.40
FEB.87	593	153,610	5,952.38	1,549.5	5,392.26	11,344.64	4.92	9,194.10
MAR.87	566	158,582	7,655.33	842.0	2,980.68	10,636.01	4.61	6,107.70
APR.87	608	140,216	6,772.96	665.1	2,387.71	9,160.67	3.97	5,045.80
MAY.87	1,064	260,541	14,244.68	196.3	689.01	14,933.69	6.48	4,732.80
JUN.87	966	348,045	22,839.26	116.0	396.72	23,235.98	10.08	5,669.10
JUL.87	771	207,027	13,646.14	53.7	321.67	13,967.81	6.06	3,303.80
AUG.87	842	225,637	14,881.28	70.5	252.39	15,133.67	6.56	3,654.30
TOTAL	9,849	2,567,953	145,520.45	8,987.1	31,533.88	177,054.33	76.79	78,145.70

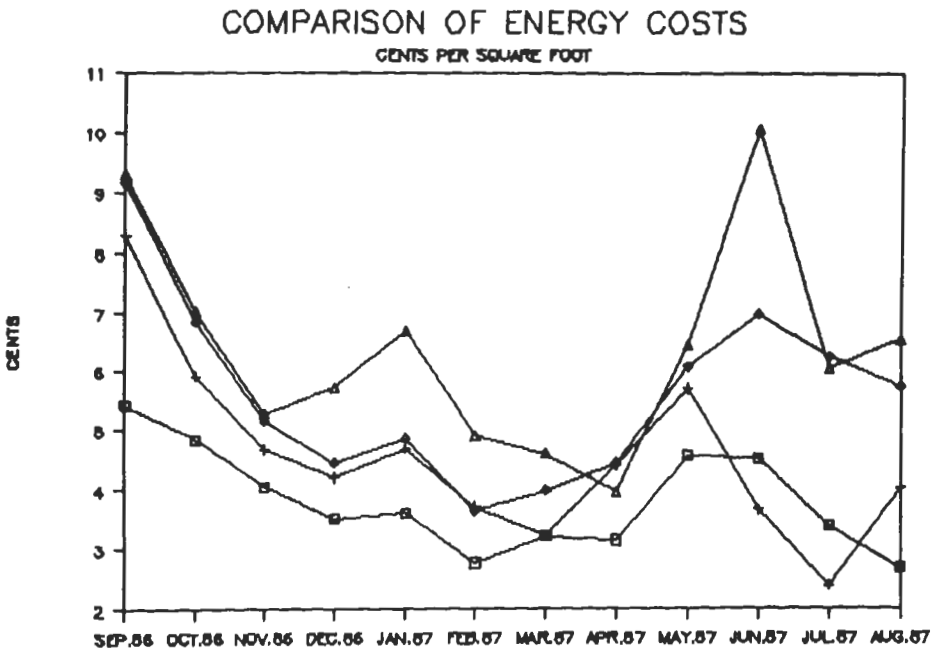

Fig. 3 Comparison of Energy Costs

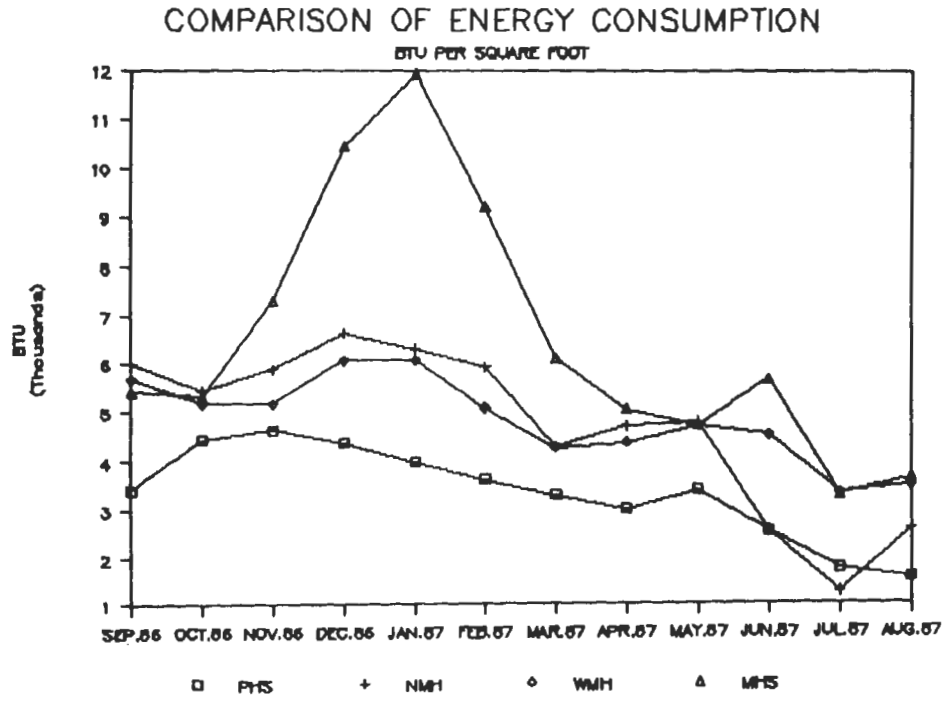

Fig. 4 Comparison of Energy Consumption

AWARDS RECEIVED BY THE M.I.S.D. ENERGY MANAGEMENT PROGRAM

The Energy Management Program for the Mesquite Independent School has received the following awards in 1987 and 1988:

1. Regional VIII Energy Award for New Commerical Institutional or Public Assembly Buildings, presented at the ASHRAE Chapter Regional Conference in Tulsa, Oklahoma - 1987.

2. First Place in State Competition in the National and State Awards Program for Energy Innovation. Top five award winners in the state were entered in national competition - 1987.

3. U. S. Department of Energy National Award in the National Awards Program for Energy Innovation, presented at a national ceremony in Washington, D.C. - 1987.

4. 1987 Texas Industrial Energy Efficiency Award in recognition of exceptional achievements in the application of energy conservation technology. Presented by the Energy Systems Laboratory of Texas A & M University at the 9th Annual Industrial Energy Technology Conference and Exhibition in Houston, Texas.

5. ASHRAE International Energy Award - Second Place in the New Commercial, Institutional, or Public Assembly Buildings category. Award presented at the ASHRAE Winter Meeting in January 1988 held in Dallas, Texas.

6. The Reuben Trane Energy Fitness Award for innovative comfort system engineering in the Joey Pirrung Elementary School presented to the MISD School Board in February 1988.

Information regarding the design concept was obtained from A.L. Utesch, Cybernetic Systems Management Corporation, Argyle, Texas (System Design Engineer).