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DEPARTMENT OF PUBLIC WORKS AND BUILDINGS

DIVISION OF HIGHWAYS

RESEARCH AND DEVELOPMENT REPORT NO. 21

FINAL REPORT OF EXPERIMENTAL USE OF URETHANE FOAM INSULATION TO CONTROL BRIDGE DECK ICING

(IHR - 79)

RESEARCH & DEVELOPMENT

ILLINOIS DIVISION OF HIGHWAYS

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State of Illinois
DEPARTMENT OF PUBLIC WORKS AND BUILDINGS
Division of Highways
Bureau of Research and Development

FINAL REPORT OF EXPERIMENTAL USE OF URETHANE FOAM INSULATION TO CONTROL BRIDGE DECK ICING

Project No. IHR-79

Conducted by the
Illinois Division of Highways
in cooperation with the
U.S. Department of Transportation
Federal Highway Administration
Bureau of Public Roads

June 1969

EXPERIMENTAL USE OF URETHANE FOAM INSULATION TO CONTROL BRIDGE DECK ICING

INTRODUCTION

The development of frost and ice on bridge floors without a similar development on adjoining pavement surfaces is a known hazard that has contributed to many serious accidents. When this unsafe condition occurs, the unsuspecting motorist accustomed to driving on a relatively clear pavement is unaware that a potential hazard lies ahead. With little or no warning, he suddenly finds himself on a slippery bridge deck, traveling too fast to take protective action.

Differential icing has been found to occur mostly in periods of declining air temperature when the surface of the bridge floor cools at a faster rate than the adjoining pavement. Bridge decks, being comparatively thin with both top and bottom surfaces directly exposed to the atmospheric environment, are highly sensitive to changes in environmental temperature. Temperature variations within roadway pavements, on the other hand, are moderated by the underlying subgrade materials. The average temperatures of approach pavements, therefore, tend to remain more stable through periods of either rising or declining temperatures.

Several attempts have been made to determine effective means of correcting the problem of differential frosting and icing. In the early 1960's, a number of highway agencies joined manufacturers in investigating the potential of insulative materials sprayed on the underside of bridge decks as a means for overcoming the hazard. When approached by the Barrett Division of Allied Chemicals Corporation in 1961, the Illinois Division of Highways in cooperation with the U. S. Bureau of Public Roads undertook an investigation of the application of urethane foam insulation to the underside surface of bridge decks for this purpose. Technical data furnished by the company indicated that the material offered a possibility for keeping the deck temperature of a bridge comparable with that of the adjacent roadway surface during critical periods.

On August 7, 1961, the Division entered into a contract with Barrett for a trial application of the insulating material on 8100 sq. ft. of surface at a cost of about 72 cents per sq. ft. Application was completed on November 6, 1961.

This report describes the application of the foam material to the bridge deck and presents, for the record, the results of the experimentation. The insulative material as applied in this study was found not to be sufficiently beneficial for further use.

RESEARCH OBJECTIVE

The general objective of this project was to determine the usefulness of foam insulation as a means of reducing the formation of frost and ice on bridge decks. The specific aim was to evaluate its effectiveness in producing temperature conditions approximating those of the approach pavement, thereby lessening the problem of differential frosting and icing.

An attempt also was made to determine the effect of insulation thickness on the degree of protection offered. Uniform design thicknesses of 3/4 and 1 inch were proposed for the trial installation for the purpose of comparison.

PROJECT DESCRIPTION

The location of dual bridges constructed as part of Interstate 74 in East Peoria, Illinois, was selected as the site for the trial installation. The bridges were built under the construction project identified as Section 90-11 VB, Tazewell County, to carry the eastbound and westbound lanes of FAI 74 over the Toledo, Peoria and Western Railroad.

The bridges are three-span, modified continuous, steel wide flange beam structures with the beams pin-connected at the 0.8 points of the outer spans (Figure 1).

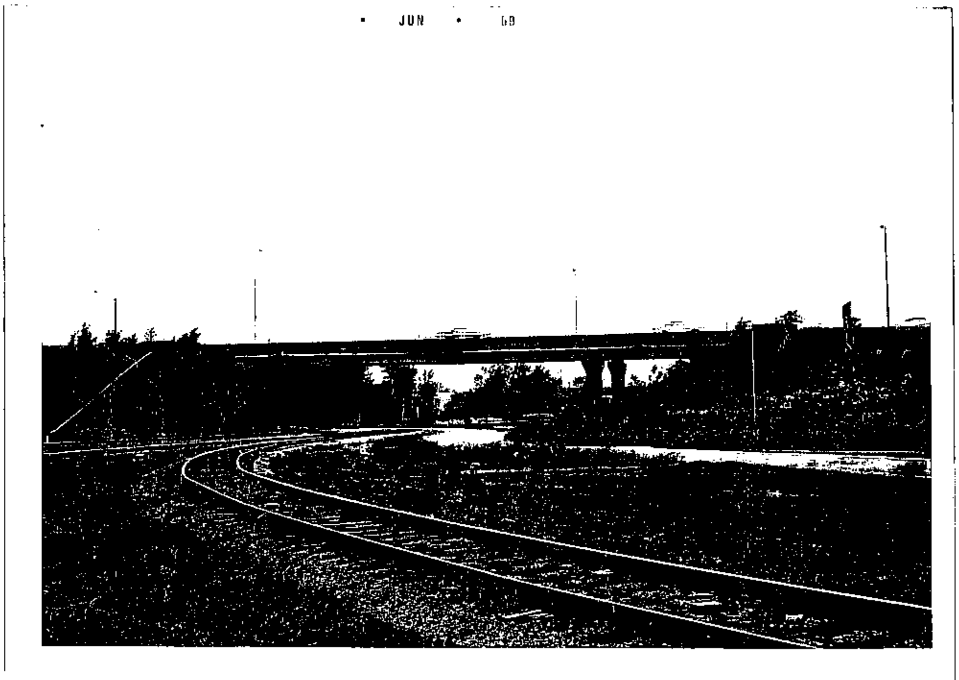


Figure 1. TP&W RR overpass with insulated bridge deck

Open joints are provided at the abutments between the bridge deck and the approach pavements. Transverse deck joints filled with premolded joint filler also are provided near the pin connections.

The south bridge was chosen for the experimental application of the foam insulation while the north bridge was left untreated to serve as a control. A design thickness of 1 inch was proposed for the west half of the experimental structure, and 3/4 inch for the east half, for investigating the relative effects of foam thickness.

The climatic environment of the site is typical of much of Illinois. During the winter, the daily average temperature varies between 25° and 40° F. The winter maintenance program requires extensive use of de-icing salts during periods of snow and ice removal. Field conditions of the test site are considered reasonably representative of current highway practices throughout the State.

INSTRUMENTATION

Prior to applying the insulation, 16 thermocouples were installed in pairs to obtain continuous readings of concrete temperatures (Figures 2 and 3). Eight locations were selected with two in each of the following areas:

(1) Insulated Bridge - Portion with 3/4-inch insulation

(2) Insulated Bridge - Portion with 1-inch insulation

(3) Uninsulated Bridge

(4) West Approach Pavements

The air temperature was determined by two additional thermocouples, one placed above and the other below the insulated bridge deck.

The thermocouples consisting of 20-gauge copper-constantan wire with soldered heads were installed in accordance with the details shown in Figure 3. A 1 1/2-inch hole was drilled through the existing concrete slabs, and two thermocouples, each

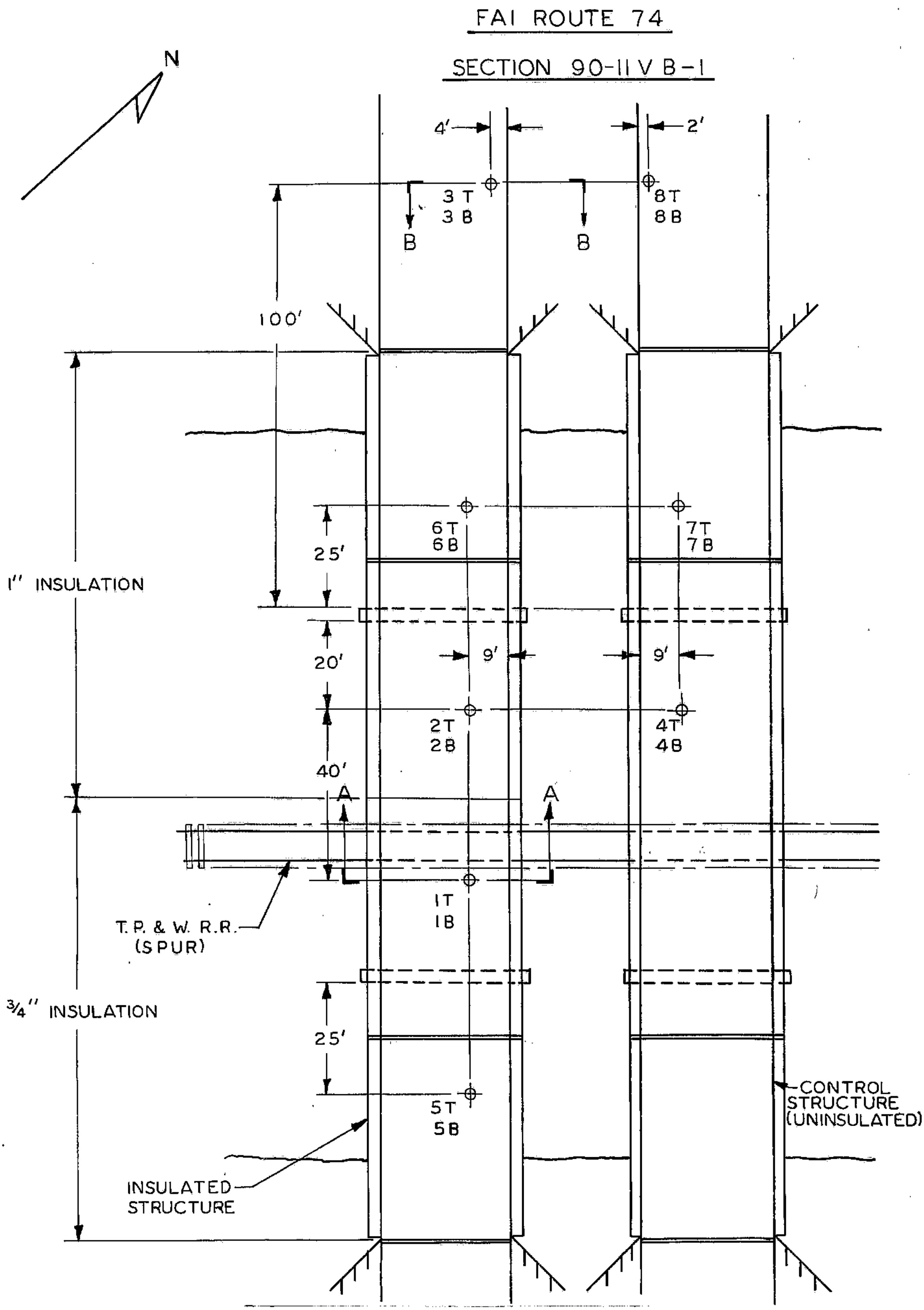


Figure 2. Location of Thermocouples

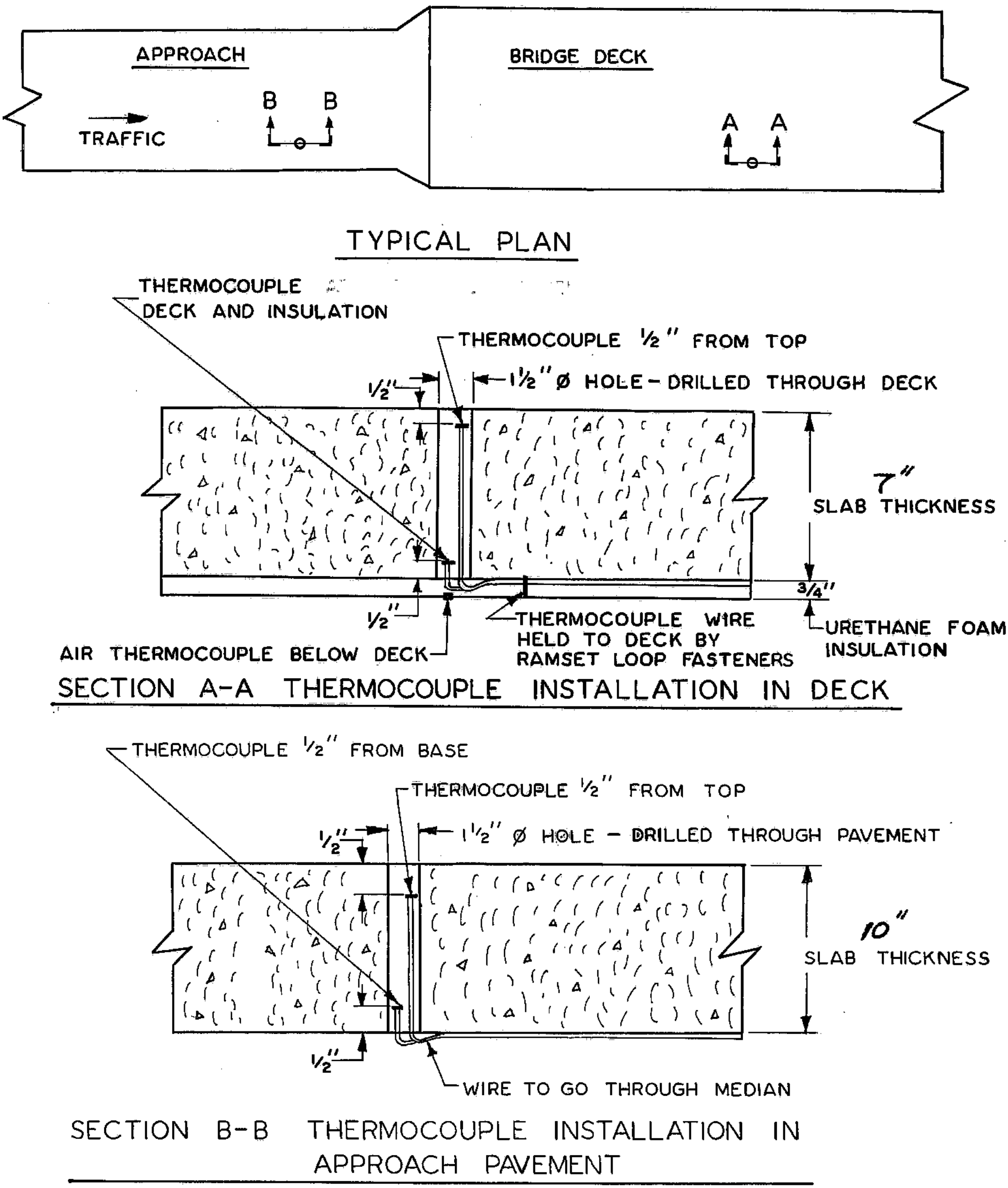


Figure 3. Thermocouple Installation

approximately 1/2 inch from the top or bottom surface, were placed in each hole. Epoxy grout was used to hold the thermocouple wire in place and to fill the hole. The wire leads from all of the thermocouples were fastened beneath the bridge decks and all lines were conducted to a control box located at the west pier of the south structure. Provisions were made at the control box to connect a continuous temperature recorder to collect the temperature data.

A Giannini Datex Data System having a tape punch readout was used for monitoring and collecting the data. This equipment was constructed by G. M. Giannini and Company, Monrovia, California, in 1958, for special data acquisition during the AASHO Road Test conducted near Ottawa, Illinois. The major component is a Bristol Dynamaster which measures and indicates thermocouple voltage, and converts the voltage to a shaft position. The system has a rated accuracy of $\pm$ 2°F as specified by the manufacturer.

An automatic scanning cycle of 1-hour intervals was established and logged at the start of each cycle. The scanning rate used for registering the thermocouple readings was one cycle per 30 seconds. With this setting, it took approximately 10 minutes to complete the scanning cycle.

A 115-volt AC single-phase generator driven by a gas engine was used as a power source for operating the temperature recording equipment. The unit has a 2000-watt capacity with the voltage regulated to within $\pm$ 5 percent at normal operating temperature.

URETHANE FOAM MATERIAL

Urethane foam is a thermosetting plastic produced by the chemical reaction of two organic components (an isocyanete and polyol) and by the physical interaction of a foaming agent. A catalyst is added to promote the reaction of the two chemical elements.

The heat generated by the reaction causes the foaming agent to change to an expanding gas, thereby creating a cellular structure of closed voids. The formation of these interlocking voids within the material accounts for the low rate of thermo-conductivity for the insulating foam.

The foam material used on this project was purchased from two different manufacturing sources. The first supply was furnished by the Chase Chemical Corporation who supplied 4200 pounds of components A & B (Nafil Resin, SE 557). The material was received with the catalyst premixed at the manufacturer's plant. When this supply was exhausted, 400 pounds of Phelan's Resin from the Phelan Faust Paint Manufacturers Company in St. Louis, Missouri, was obtained. The catalyst for this second source of material was added at the jobsite.

The following properties of the urethane foam composition were given in a technical data sheet published by Barrett Division of Allied Chemical Corporation:

Density	2.0-2.6 lb./cu.ft.
% Closed Cells	95%
Compressive Strength at Yield Point	13 PSI (ave.)
Compressive Strength at 10% Compressive	22 PSI (ave.)
Dimensional Stability Vol.	Change
After 24 hrs. at 158°F	±4%
After 24 hrs. at -22°F	No change
After 3 days at 100°F	No change
100% Relative Humidity	
After 24 hrs. at 158°F	±7%
100% Relative Humidity	
Moisture Vapor Transmission	1-3 perms/in.
Water Absorption	None
"K" Value	0.15-0.16
(BTU hr./sq.ft. 1 in thickness/of)	
Combustibility Rating (ASTM D1692 -- Self Extinguishing)	

Cellosolve Solvent made by the Union Carbide Chemical Company was used for cleaning the spray gun and other pieces of equipment. This solvent which contains ethylene glycol monothyl ether worked very well in keeping the equipment clean and operative.

EQUIPMENT USED FOR APPLICATION

The equipment used by the Barrett Division of Allied Chemical Corporation was developed during their experimentation in the laboratory, and was later modified for use in the field. The operation was centered about a 5 ton, GMC 620, truck with a stake flat bed, complete with all necessary equipment needed for preparing and applying the urethane foam.

Mounted on the frame of the truck was a Teale & Company hydraulic lift with a caged platform and an auxiliary power unit for operating the lift. The use of the lift was limited by the placement of the truck and length of the platform boom. On this particular project, the center span and limiting portions of the outer span were easily reached by the elevating platform. Areas within the outer spans that could not be reached by the platform were accessible from the top of the slopewall through the use of scaffolding. Except for these inaccessible areas, the equipment seemingly was adaptable for applying the insulating materials to most structures involving grade separations. Stream crossings, however, would require in many instances more extensive use of scaffolding and other additional equipment.

An Ingersoll-Rand Air Compressor (Model GRES) operating at 190 psi was used for pressurizing the pumping equipment and for supplying air to the operator's breathing mask. Moisture was removed from the air by a Van-Air Dryer attached to the output line.

A Binks Model 101-3000 Formulator "B" was used to proportionally pump the two components to the spray gun. The formulator originally was designed to accommodate one- and five-gallon shipping containers. The Binks Manufacturing Company suggests in their Bulletin No. A 101-4R that the unit can be modified to pump resins from 55-gallon drums by connecting a plastic tube to the foot valve of the pump and to an adapter at the drum bung. This modification, however, requires removal of the straining screens from the bottom of the foot valves. When the contractor changed his procedure to operating from 55-gallon drums, considerable difficulty was encountered with the passing of foreign material through the system. Because of this difficulty, the contractor resumed his original procedure of pumping from five-gallon shipping containers with the screens attached to ends of the pumps.

The following gauge settings on the formulator were used during normal operations:

(1) Air pressure supplied to gun - 80 psi

(2) Air pressure supplied to air motor - 40 psi

(3) Pressure on A component of urethane foam at pump - 200 psi

(4) Pressure on B component of urethane foam at pump - 400 psi

The material hoses used to transfer the two components from the formulator to the spray gun were nylon rated at 2000 psi, and were supplied by the Binks Manufacturing Company. The following sizes were used on both lines:

(1) first 50 feet .... 1/2-inch I.D.

(2) second 50 feet .... 3/8-inch I.D.

Whenever operations were suspended, the two lines were kept full and under pressure to reduce the possibility of the material drying within the hose. This procedure eliminated the necessity of cleaning the hoses at irregular intervals and after completing each day of operation.

A Binks two-component spray gun (Model 18F) was used throughout the entire operation for mixing and applying the material to the deck. Designed primarily for the spray application of polyether spray foam systems, the gun internally mixes the spray foam resins using its atomizing air as a mixer. A continuous air bleed system within the gun keeps the mixing nozzle from clogging during normal spraying. If the spraying was interrupted for any length of time, the system was flushed with the Cellosolve Solvent to prevent the mixing nozzle from clogging. The mixing nozzle was also frequently disassembled from the gun to remove any buildup of material within the mixing chamber and discharge port.

SPECIAL EQUIPMENT FOR COLD WEATHER OPERATION

Special heating equipment was installed by the Barrett Division of Allied Chemical Corporation to extend their normal operating season. By controlling the temperature of the two components as they entered the mixing chamber of the gun, it was believed that the system could operate at lower air temperatures.

Multi-strand thermo wire was wrapped around the component supply lines leading from the formulator to the gun, and the lines were insulated with a rubber hose cover. Temperature-sensitive control devices were placed at the end of hoses near the gun, and a panel of two Chromalax Precision Thermistor Temperature Controllers was used for regulating the temperature of the supply lines.

External heaters also were provided around the 55-gallon storage drums to preheat the component before placing the material in the five-gallon formulating containers. Heating of the drums was controlled by a temperature-sensitive probe inserted through a vent in the top of the drum and placed near the mass center of the material. Heating elements also were placed around the formulating containers to retain the heat of material as it was being pumped through the formulator.

The source of power for the heating unit was a 115/230-volt Kohler gas-operated generator with a 65 amp rating. Power was supplied through a control panel mounted on the side of the truck.

APPLICATION OF URETHANE FOAM

The Barrett Division of Allied Chemical Corporation began applying urethane foam to the underside of the bridge deck on October 17, 1961. Because of poor weather conditions which later developed, many problems were encountered which delayed the normal operation.

It was observed that when the air temperature was below 60°F, control of the application of the urethane foam was very poor (Table 1). The foaming action was affected to the extent that considerable variation of foam thickness occurred, apparently because the concrete deck absorbed most of the heat needed for chemical reaction to take place. During days of high humidity, poor bond was observed between the insulating material and the concrete. Most of the material applied under these adverse conditions had to be removed and later replaced. Areas of unacceptable application or unwanted deposits from overspray were removed immediately before hardening. Hardened material was found difficult to remove.

Although some benefit was gained by preheating the material, the operation was not improved to any great extent. Difficulties in obtaining satisfactory results were still encountered during the cool weather periods. Even with the material heated to a reasonable reactive temperature, the cooling effect of deck temperature was too great for the heat to be retained within the mixed components. An attempt to preheat the prepared surface with heat lamps also was unsuccessful.

The best results were obtained during the afternoon of the first day when the ambient temperature reached 70°F and the humidity was low. The material applied easily and appeared to bond well to the deck. The operator also was able to control the thickness of the insulating material within reasonable limits.

DATA COLLECTION

The instrumentation was completed at the test bridge in December 1961 with the installation of a temperature van which housed the Giannini Datex Data System and the gasoline power generator for operating the Giannini equipment.

TABLE 1

APPLICATION OF FOAM INSULATION

Date	Average Air Temperature °F	Humidity (%)	Area Covered (sq. ft.)	Average Thickness (in.)	Required Thickness (in.)	Remarks
10-17-61	62	50	563.25	1	3/4	Good application with good texture and good bond.
10-18-61	58	61	1115.75	1	3/4	Operation stopped for 2 hours because of poor temperature control of material. Poor application at start but improved as air temperature increased.
10-19-61	43	79	None	0	3/4	Operation stopped because of poor foaming action and poor bond. All material applied had to be removed.
10-20-61	44	89	None	0	3/4	Operation stopped because of poor foaming action and poor bond. All material applied had to be removed.
10-21-61	45	96	None	0	3/4	No application because of poor weather. Heat lamps directed to deck were tried, but attempt was unsuccessful.
10-22-61	46	100	None	0	3/4	Tried material which had catalyst added in field. Material removed because of poor bond.
10-23-61	44	100	None	0	3/4	No work - rained out.
10-24-61	48	77	1113.75	2	1	Urethane foam went on slow with poor texture and foaming action. Adhesion good except 2 areas which were patched. Operator had no control over foaming action.

Date	Average Air Temperature °F	Humidity (%)	Area Covered (sq. ft.)	Average Thickness (in.)	Required Thickness (in.)	Remarks
10-25-61	48	54	536.25		1	Poor application with poor texture and control of foaming action. Two panels removed and replaced because of poor bond.
10-26-61	42	42	1049.4	1 1/2	3/4	Good application, especially during warmer part of day, but still unable to control foaming action.
10-28-61	52	83	229	2	1	Fair application with good bond but poor texture. Applied material appeared poorly mixed.
10-29-61	64	73	998.75	2 1/2	1	Poor application due to poor mixing in gun. Two panels had to be removed and replaced.
10-30-61	56	87	None		1	Poor application with poor bond. All material applied had to be removed.
10-31-61	53	69	None		1	Poor application because of poor bond. All material applied had to be removed.
11-1-61	54	100	None		1	No work - rained out.
11-2-61	66	71	228	2	1	Patched areas wherepoor bond previously occurred. Applied foam to two panels which went on fairly well.
11-3-61	42	59	228	2	1	Applied form to two panels with good bond but poor control of foaming action.

Date	Average Air Temperature $^{\circ}F$	Humidity (%)	Area Covered (sq. ft.)	Average Thickness (in.)	Required Thickness (in.)	Remarks
11-4-61	37	47	144	2	1	Applied foam to one panel with good bond but poor foaming action.
11-5-61	36	50	-	-	-	Applied foam to areas that had thin coating and to areas that needed patching.
11-6-61	30	61	-	-	-	General cleanup and contractor moved off the job site.

The collection of field data was to consist of gathering continuous hourly readings within the temperature range of 25^{o} and $35^{o}F$, and during anticipated periods of extreme changes in temperature. Visual observations of physical icing and frosting were to be noted during these periods.

Because of the difficulties experienced with the automatic recording equipment, the amount of data collected during the first winter in 1961 to 1962 was limited. The temperature data collected within this season amounted to only five intermittent days of continuous hourly readings. Although the recorded temperatures indicated a greater lag for the insulated deck, a definite relationship between the temperature at the various thermocouple locations could not be established. Also, during these periods of observation, neither icing nor frosting was apparent on either of the bridges or on the approach pavements. Because of insufficient data, the study was extended until more information could be obtained for evaluating the performance of the foam insulation.

In the winter of 1962-63, another attempt was made to obtain the data needed for the evaluation. Processing of the recorded temperatures indicated a malfunction within the instrumented system. The data were considered unreliable and no analysis was made.

During 1962, more effort was concentrated on obtaining comparative visual observations of the surface conditions of the bridge decks. A daily surveillance was made and reported throughout the cold periods of the year. The results of these continuous observations are discussed later in the report.

Since the recorded temperature data were questionable, it was decided to continue the study for at least another year. In October 1963, erratic thermocouple readings were traced to electrical shorts in the rayon-covered thermocouple wiring installed at the beginning of the project. Most of this wire was replaced with plastic insulated material in areas that were accessible. Because of the narrow range established for recording temperatures, the amount of data was again limited and a definite conclusion could not be derived.

During the winter of 1964-65, a last attempt was made to obtain sufficient information for analyzing the effect of the foam insulation. Rather than restricting the activities of data collection to anticipated periods conducive to icing at or near the freezing point, hourly readings were made on a continuous daily basis. This period of continuous daily readings began on February 8, 1965, and ended on April 8, 1965. There exists some discontinuity in the recorded data because of the non-working weekends and equipment breakdowns. Except for thermocouples in three locations (2, 3, and 6 shown in Figure 2), the temperatures recorded were considered reliable for data reduction. The data collected during this period were used as a basis for concluding this report.

DISCUSSION OF RESULTS

Through the period of February 8 to April 8, 1965, 37 days of hourly readings were continuously recorded at two- to five-day intervals. In summarizing the data on an hourly basis, no definite relationship between slab temperature in relation to air temperature could be established from the data collected. Apparently, the complexities of heat radiation are such that no simple relationship exists between slab and air temperatures. An evaluation which considers heat storage capacity based on heat flow and energy loss or gain offers the possibility of a more rational analysis. To undertake this approach, however, was beyond the scope of the present investigation.

The most distinguishable relationship trend that was observed during an analysis of slab temperature data concerned the minimum daily temperatures commonly occurring in the concrete slabs in the early morning before sunrise. During these low temperature periods when conditions were most conducive for frosting, the insulated deck was found to have a tendency to remain somewhat warmer than the uninsulated deck. This phenomenon occurred approximately 78 percent of the time within the scope of the recorded readings. Details of this analysis are presented in Charts 1-16 included as an Appendix to this report.

A similar trend, however, was not apparent for the approach pavement and the uninsulated deck. A comparison of temperatures on the basis of percentage of one above or below the other indicated a close similarity in the behavior of the two slabs.

By the same general interpretation for periods of maximum temperature, a comparative relationship could not be determined for any combination of the three slabs. Variation in maximum temperatures was much less pronounced with no distinct pattern in comparative behavior.

Visual observations made daily during the cold weather periods of 1962 revealed three occasions out of 80 days surveillance when differential frosting was evident between the insulated and uninsulated bridge decks (Table 2). These observations of frost which had occurred on the uninsulated bridge but not the insulated were reported at 7:30 A.M., on November 28 when the ambient air temperature was 27°F and on December 27 and 28 when the air temperatures were 12°F and 11°F, respectively. No periods when both decks were frosted were reported. Salt applications to both bridge decks during periods of snowfall or freezing rain usually obscured the effects, if any, of the urethane foam insulation.

No relationship between slab temperature and insulation thickness could be explored because of the wide variation in the applied thickness of the insulating material.

TABLE 2

DAILY VISUAL OBSERVATIONS
1962

Date	Time	Temp. °F	Weather	Conditions North Bridge	Conditions South Bridge
1-12	11:30 AM	12	Snow Flurries	Wet	Wet
				Both treated with salt	
1-14	1:30 PM	24	Snowing	1" slush	1" slush
				Both treated	
1-15	9:00 AM	11	Clear	Dry	Dry
1-16	10:00 AM	0	Clear	Dry	Dry
1-17	8:30 AM	2	Clear	Dry	Dry
1-18	8:00 AM	0	Cloudy	Dry	Dry
1-19	8:00 AM	5	Snowing 1"	Clear-Dry	Clear-Dry
				No treatment on either bridge	
1-22	9:00 AM	8	Freezing Rain	Wet	Wet
				Both treated	
1-23	8:00 AM	-4	Clear	Dry	Dry
1-29	11:30 AM	35	Clear	Dry	Dry
1-30	8:00 AM	28	Cloudy	Dry	Dry
1-31	8:00 AM	0	Clear	Dry	Dry
2-1	8:00 AM	15	Snow Flurries	Wet	Wet
2-2	8:00 AM	18	Cloudy	Dry	Dry
2-4	12 Noon	50	Clear	Dry	Dry
2-5	8:00 AM	22	Partly Cloudy	Dry	Dry
2-6	7:30 AM	-3	Cloudy	Dry	Dry
2-7	8:00 AM	10	Light Snow	Wet	Wet
				Both treated	
2-14	8:00 AM	30	Fair	Dry	Dry
2-15	8:30 AM		Rain and Sleet	Wet	Wet
				No treatment	
2-16	8:00 AM	32	Cloudy	Dry	Dry
2-17	6:00 PM	32	Light Snow	Wet	Wet
				Both treated	
2-18	7:00 PM	31	Snow 1"	Slush at edge	Slush at edge
2-21	5:30 AM	31	Light Snow	Wet	Wet
2-23	8:00 AM	15	Cloudy	Dry	Dry
2-27	9:00 PM	23	Light Snow	Wet	Wet
				Both treated	
2-28	8:00 AM	2	Cloudy	Dry	Dry
3-1	7:00 AM	-7	Clear	Dry	Dry
3-4	10:00 AM	33	Light Snow	Wet	Wet
3-5	8:00 AM	28	Light Snow	Wet	Wet
3-6	9:00 AM	32	Cloudy	Dry	Dry
3-7	8:00 AM	33	Cloudy	Dry	Dry
3-8	12 Noon	32	Rain and Snow	Wet	Wet
3-11	12 Noon	35	Rain	Wet	Wet
3-13	6:00 AM	28	Light Snow	Wet	Wet
				Both treated	
3-15	8:00 AM	22	Cloudy	Dry	Dry

TABLE 2 (CONT.)

Date	Time	Temp. °F	Weather	Conditions North Bridge	Conditions South Bridge
10-24	7:30 AM	28	Clear-Frost	Dry	Dry
10-25	7:30 AM	27	Clear	Dry	Dry
10-26	7:30 AM	20	Frost	Dry	Dry
10-29	7:45 AM	32	Clear	Dry	Dry
10-30	7:45 AM	40	Clear	Dry	Dry
10-31	7:30 AM	34	Clear	Dry	Dry
11-1	7:30 AM	30	Frost	Clear	Clear
11-2	7:30 AM	28	No Frost	Clear	Clear
11-5	7:30 AM	34	Clear	Dry	Dry
11-6	7:30 AM	34	Frost	Dry	Dry
11-7	7:30 AM	35	Cloudy	Clear	Clear
11-8	7:30 AM	35	Cloudy	Clear	Clear
11-13	7:30 AM	26	Fog and Frost	Clear	Clear
11-14	7:30 AM	35	Clear	Dry	Dry
11-15	7:30 AM	Mild	Cloudy	Dry	Dry
11-16	7:30 AM	40	Light Rain	Clear	Clear
11-19	7:30 AM	33	Cloudy-Damp	Clear	Clear
11-20	7:30 AM	38	Partly Cloudy	Dry	Dry
11-21	7:30 AM	40	Clear	Dry	Dry
11-26	7:30 AM	29	Clear, Light Frost	Clear	Clear
11-27	7:30 AM	32	Partly Cloudy	Clear	Clear
*11-28	7:30 AM	27	Light Frost	Trace of Frost	No Frost
11-29	7:30 AM	33	Clear	Dry	Dry
11-30	7:30 AM	35	Clear	Dry	Dry
12-3	7:30 AM	35	Partly Cloudy	Dry	Dry
12-4	7:30 AM	43	Cloudy	Dry	Dry
12-5	7:30 AM	31	Snow Flurries	Damp	Damp
12-6	7:30 AM	18	Clear - No Frost	Dry	Dry
12-7	7:30 AM	18	Light Frost	Dry	Dry
12-9	7:30 AM	18	Snow Flurries	Dry	Dry
12-10	7:30 AM	9	Partly Cloudy	Dry	Dry
12-11	7:30 AM	2	Clear, Windy	Dry	Dry
12-12	7:30 AM	-10	Clear	Dry	Dry
12-13	7:30 AM	9	Partly Cloudy	Dry	Dry
12-14	7:30 AM		Light Frost	Dry	Dry
12-17	7:30 AM	30	Partly Cloudy	Dry	Dry
12-18	7:30 AM		Clear	Dry	Dry
12-19	7:30 AM	38	Light Fog	Damp	Damp
12-20	7:30 AM	32	Snow Flurries	Damp	Damp
12-26	7:30 AM	-12	Clear	Dry	Dry
*12-27	7:30 AM	12	Clear, Light Frost	Light Frost	Clear
*12-28	7:30 AM	11	Clear, Light Frost	Light Frost	Clear

*Trace of frost on uninsulated deck but not on the insulated deck.

CONDITION OF INSULATION

It was anticipated that the urethane foam insulation would remain tightly bonded to the concrete deck and to the portions of the steel beam supports to which it was applied. Its reported high resistance to the absorption of moisture was expected to have a protective influence against moisture-related deterioration of the concrete.

After the first heavy rain following application, an area of localized deflection in the foam insulation was found near an open joint, and an opening in the material had to be provided for draining the trapped water. Except for this one area, the insulation was in excellent condition within the first year after the application. Inspections made five and six years later revealed the insulating material in good condition, except for excessive peeling near the transverse deck joints. There also was evidence at location near the deck drains that water had become entrapped at the interface of the insulation between the steel stringers and concrete deck. Close examination of the insulated surfaces near the drains and random inspection of other areas failed to disclose any significant deterioration of the concrete or rusting of the structural steel that could be attributed to the presence of the insulation.

CONCLUSIONS

Difficulties that were experienced with the instrumentation that was available to measure slab and air temperatures during the period of the study limited observation of the effect of the urethane foam insulation on slab temperature. One analysis showed the insulated deck to remain fairly consistently at temperatures slightly higher than those of the uninsulated deck when minimal early-morning air temperatures were recorded. No such relationship was observed between the temperatures of the approach pavement and the uninsulated deck.

The foam application process could not be controlled, because of cold weather that interfered with the flow and foaming of the material, to the extent that an intended study comparing the insulative properties of two thicknesses (1 in. and 3/4 in.) of the insulation could be made.

Visual observations of ice and frost accumulation made during a one-year period showed three frost occurrences, all on the uninsulated bridge deck. The application of deicing salts to both decks and to the adjoining pavement surfaces during critical periods of icing hampered visual observation of the insulative effects of the urethane foam.

While the study did not produce all of the information desired, it was sufficient to show that, under the conditions represented, the beneficial effects of urethane foam insulation in allaying frost and ice formation, in relation to its cost and serviceability, are not sufficient to warrant its further use.

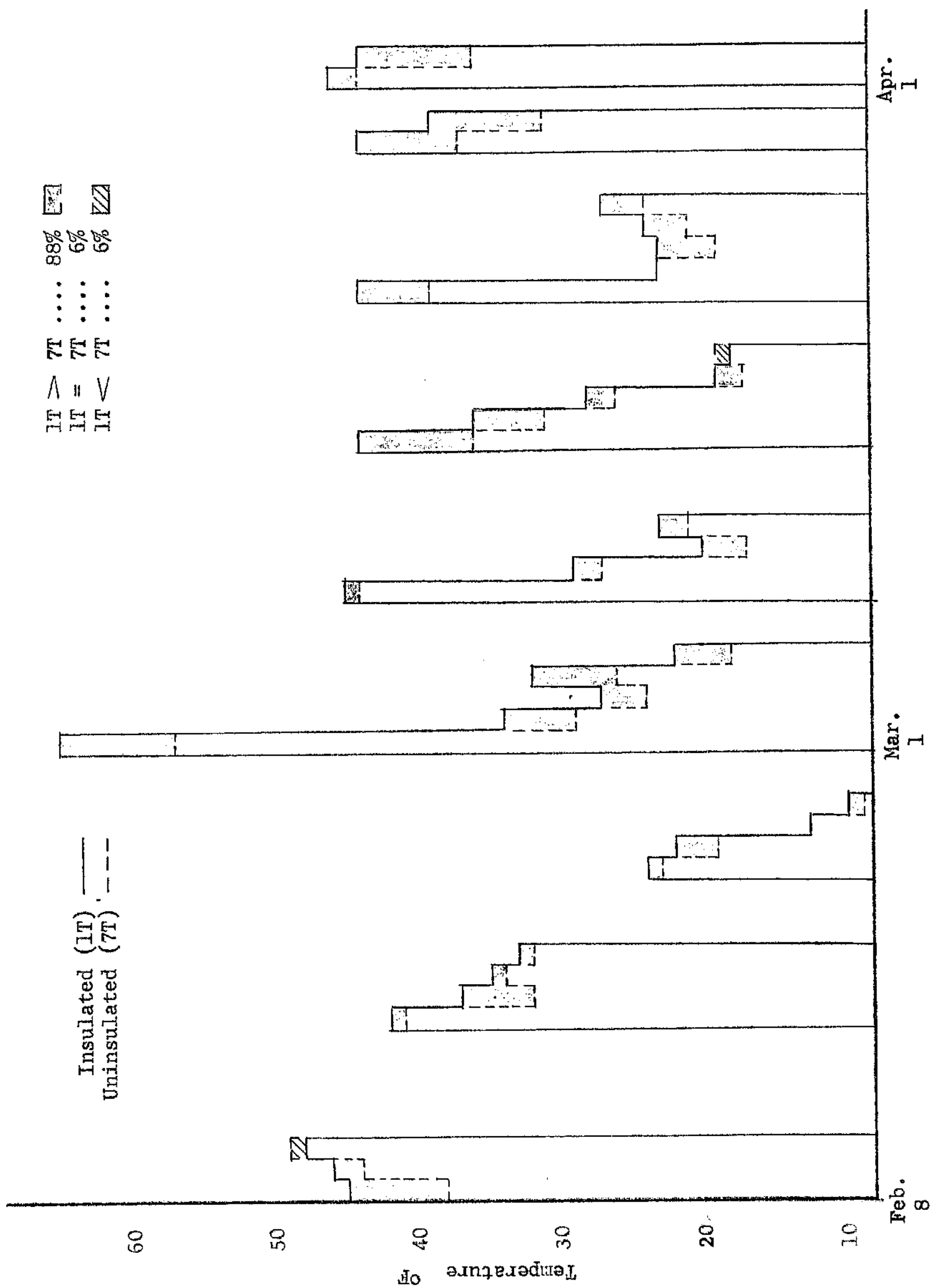
R E F E R E N C E S

1. "Effect of Bridge Deck Insulation on Icing Conditions," New York State Department of Public Works, May 1964.

2. "Research Project Bridge Deck Insulation Final Report 1963-1964," Vermont Department of Highways, Montpelier, Vermont.

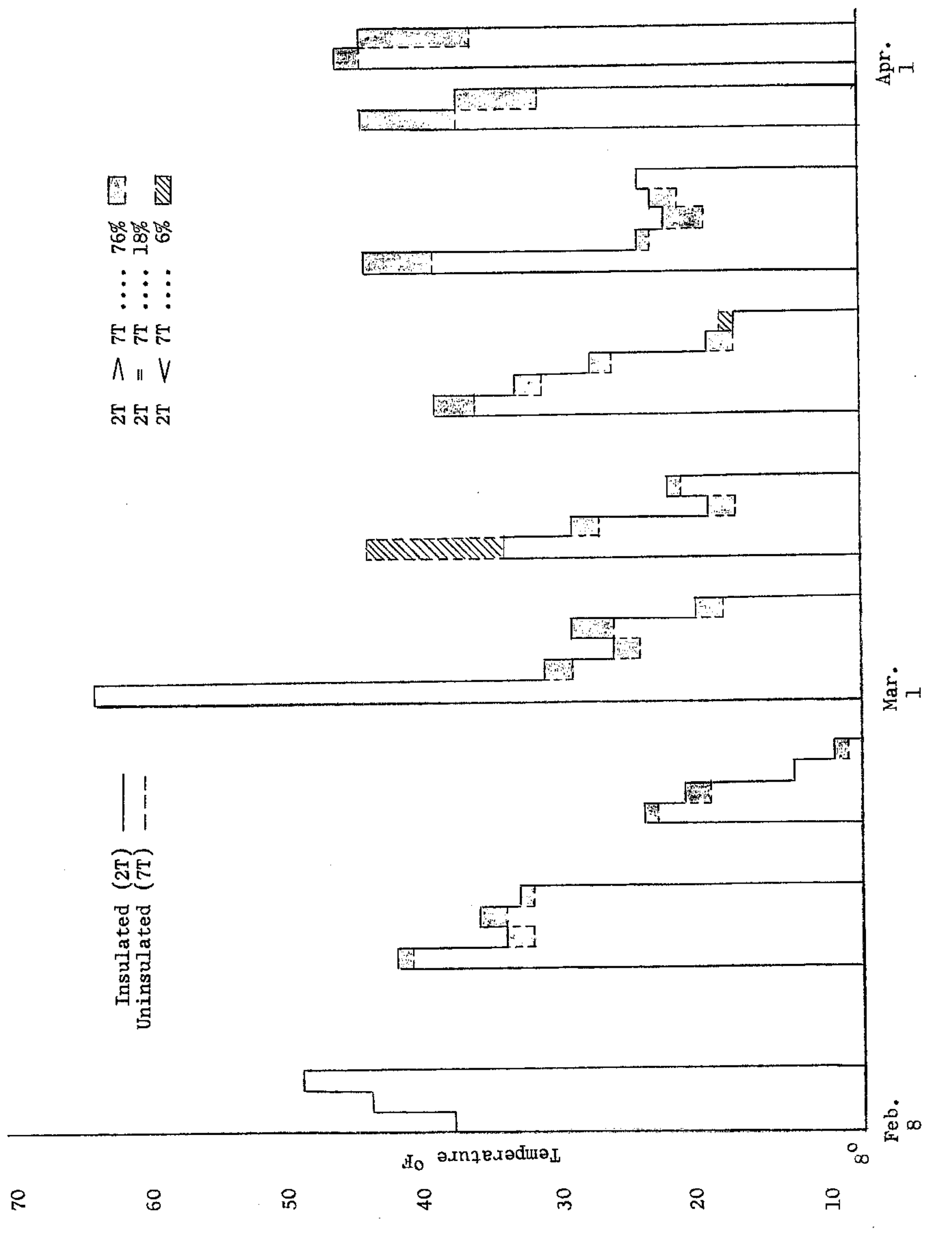
A P P E N D I X

CHART 1



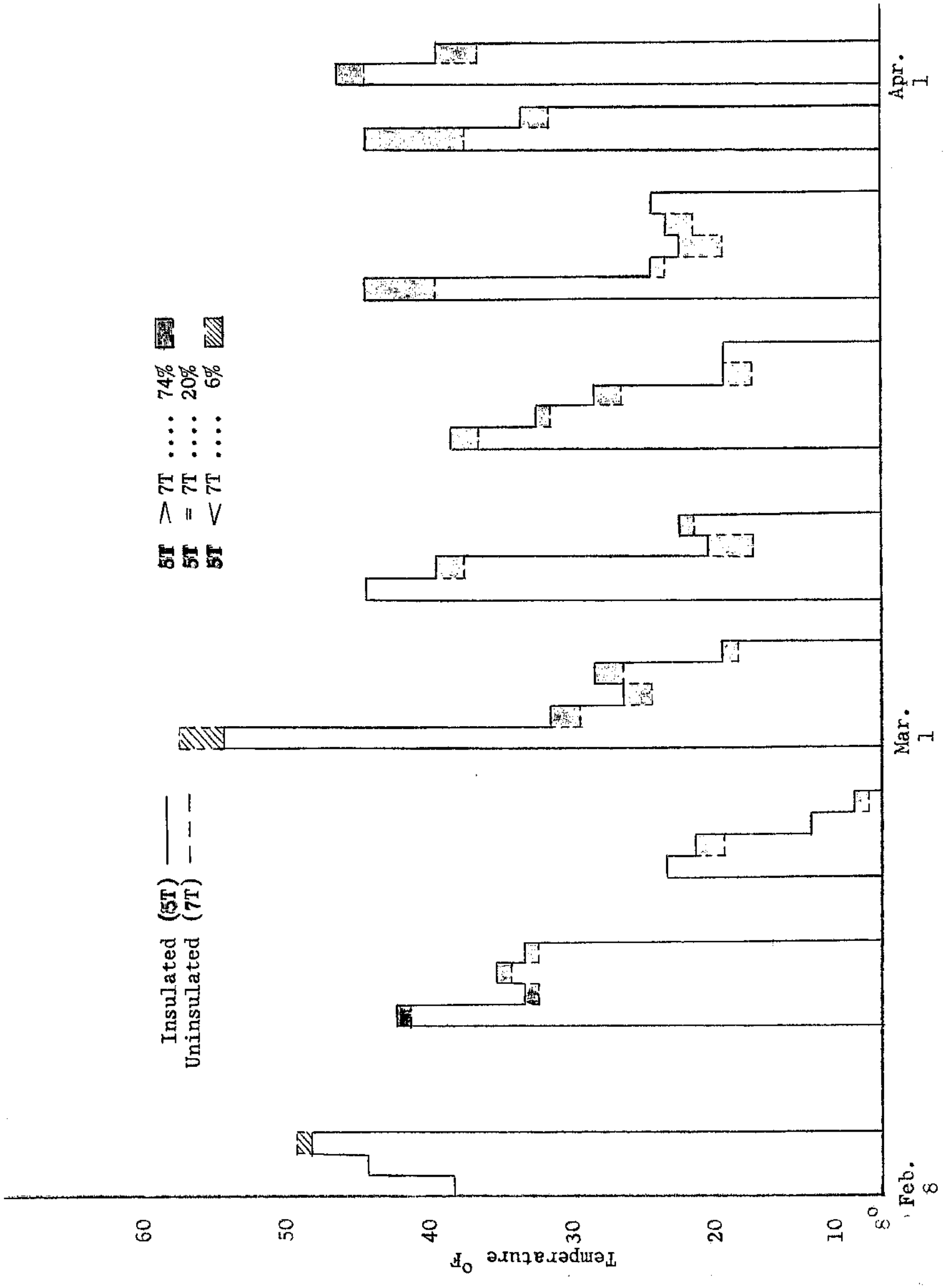
Minimum Daily Temperatures - 1T vs 7T

CHART 2



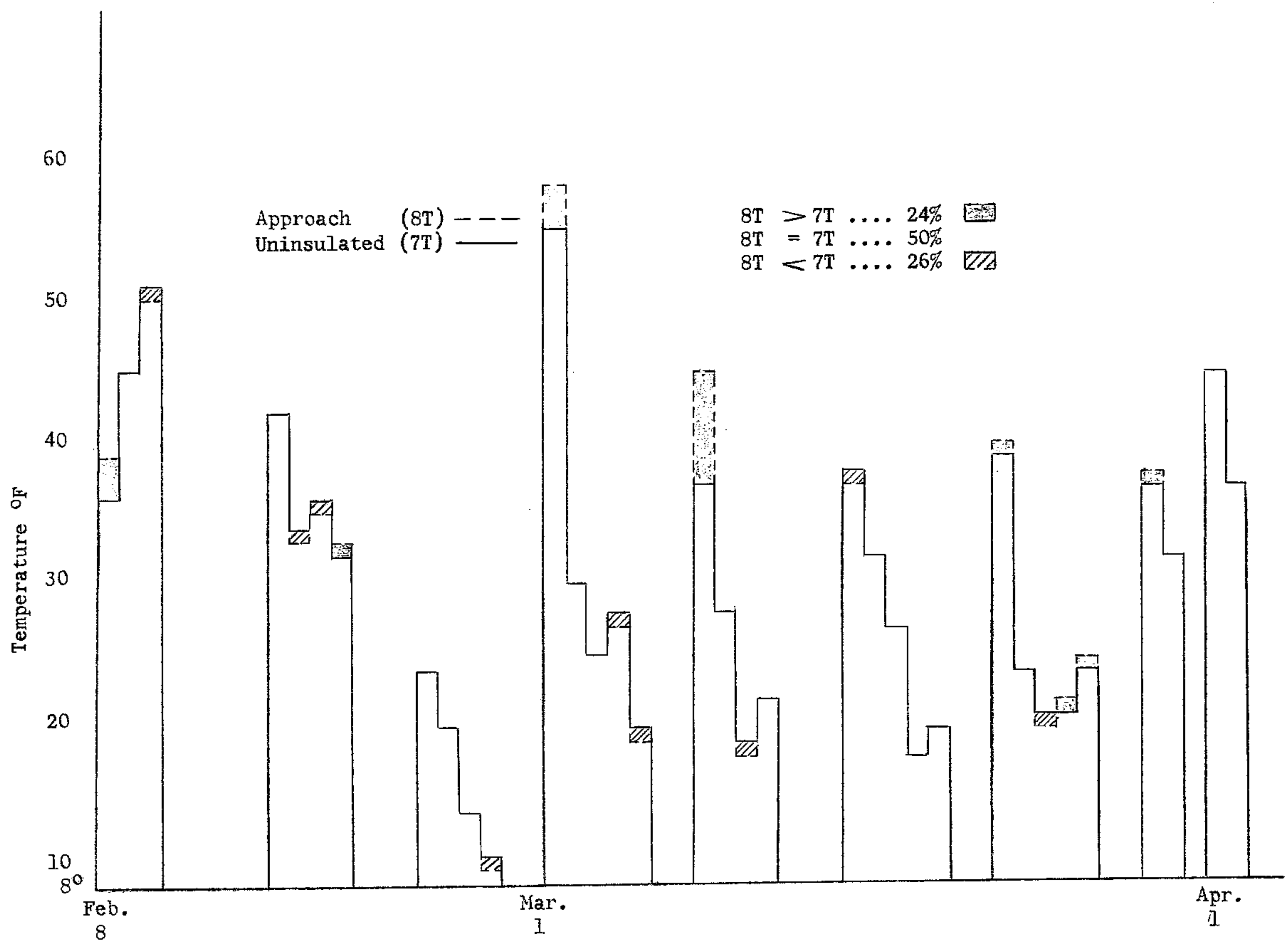
Minimum Daily Temperatures - 2T vs 7T

CHART 3



Minimum Daily Temperature - 5T vs 7T

CHART 4



Minimum Daily Temperature - 8T vs 7T

CHART 5

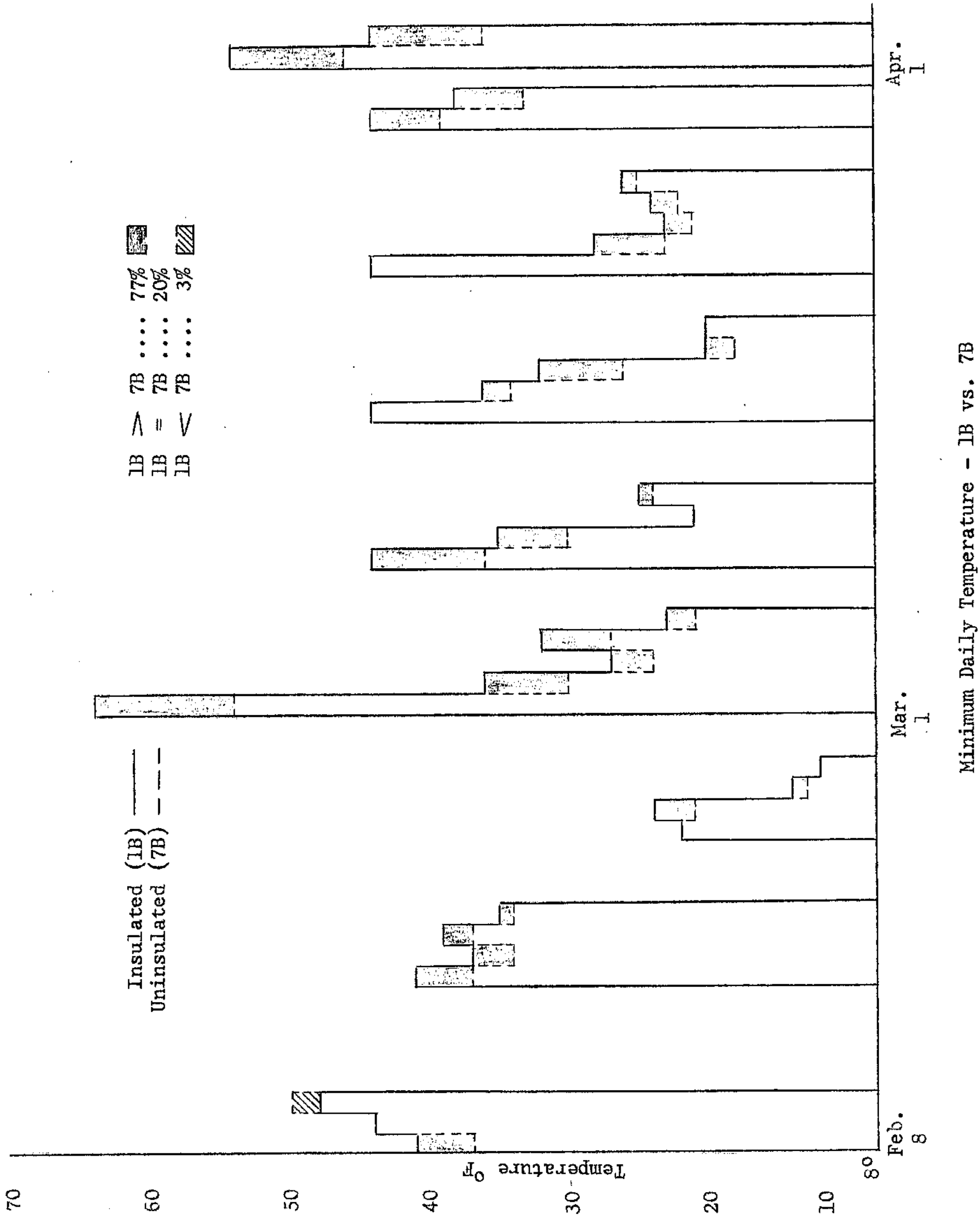

Insulated (1B) ———
Uninsulated (7B) — — —
1B > 7B 77%
1B = 7B 20%
1B < 7B 3%
Temperature °F
70
60
50
40
30
20
10
8°
Feb. 8
Mar. 1
Apr. 1
Minimum Daily Temperature - 1B vs. 7B

CHART 6

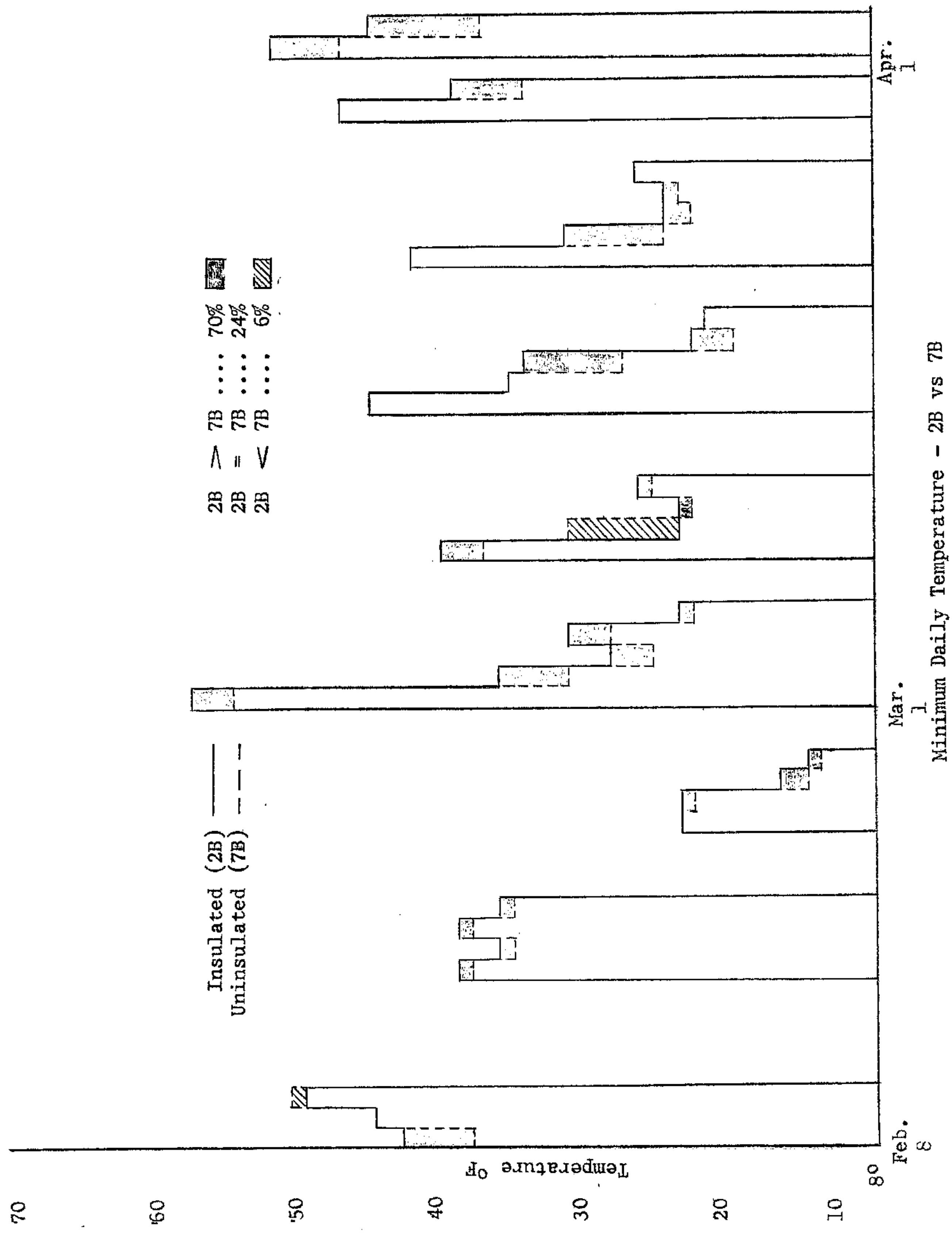
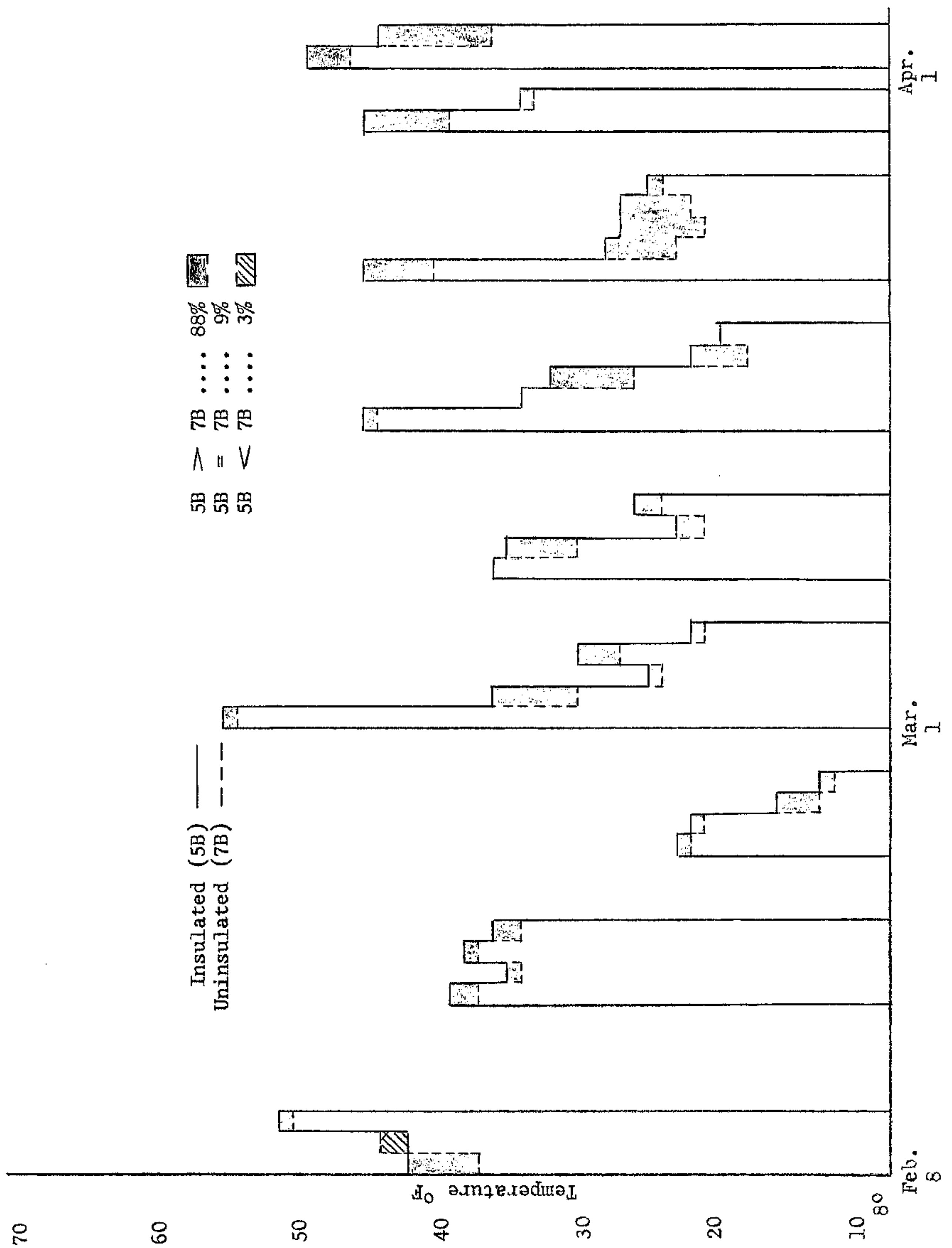

Insulated (2B) ———
Uninsulated (7B) — — —
2B > 7B 70%
2B = 7B 24%
2B < 7B 6%
Temperature °F
80
70
60
50
40
30
20
10
Feb. 8
Mar. 1
Apr. 1
Minimum Daily Temperature - 2B vs 7B

CHART 7



Minimum Daily Temperature - 5B vs 7B

CHART 8

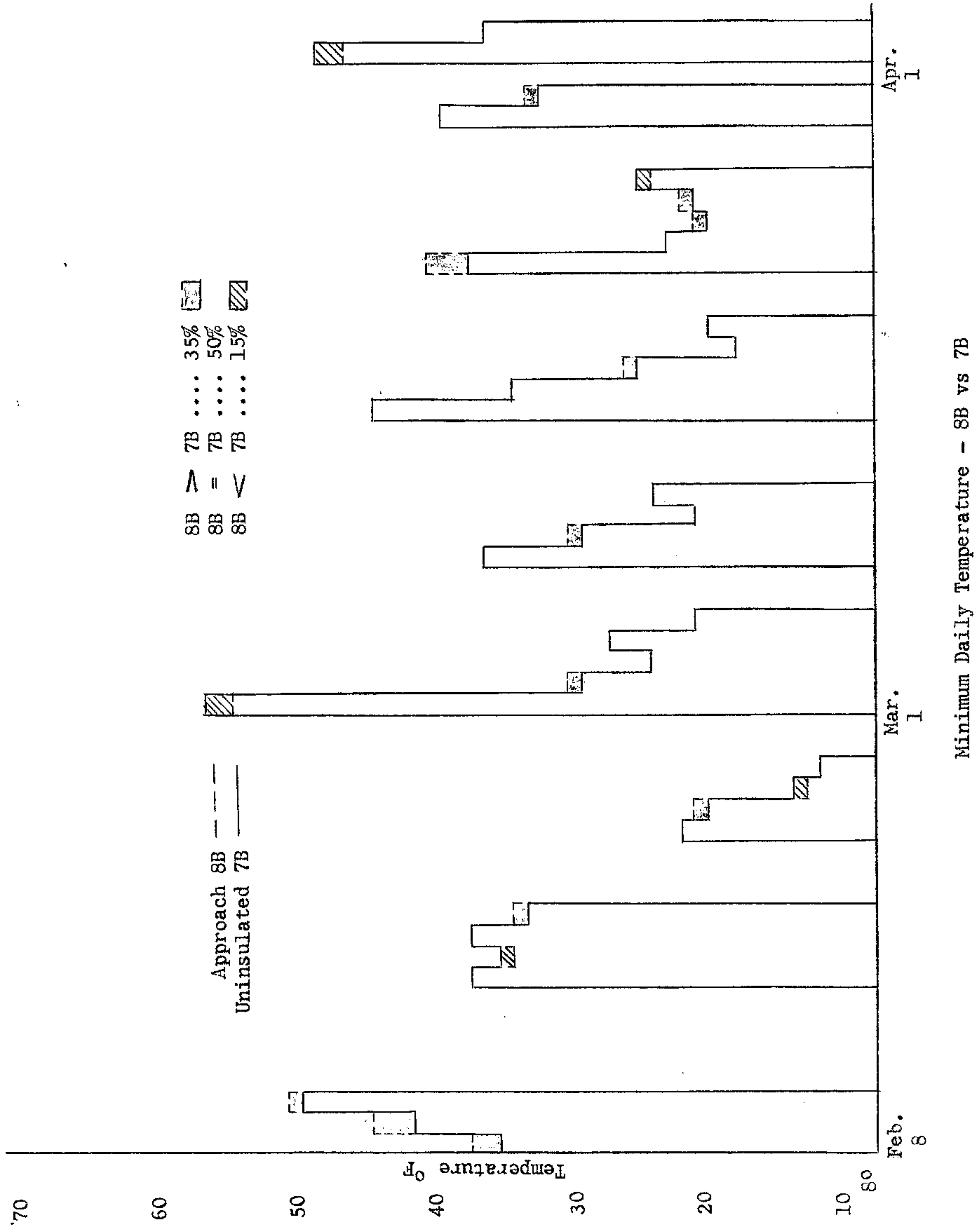
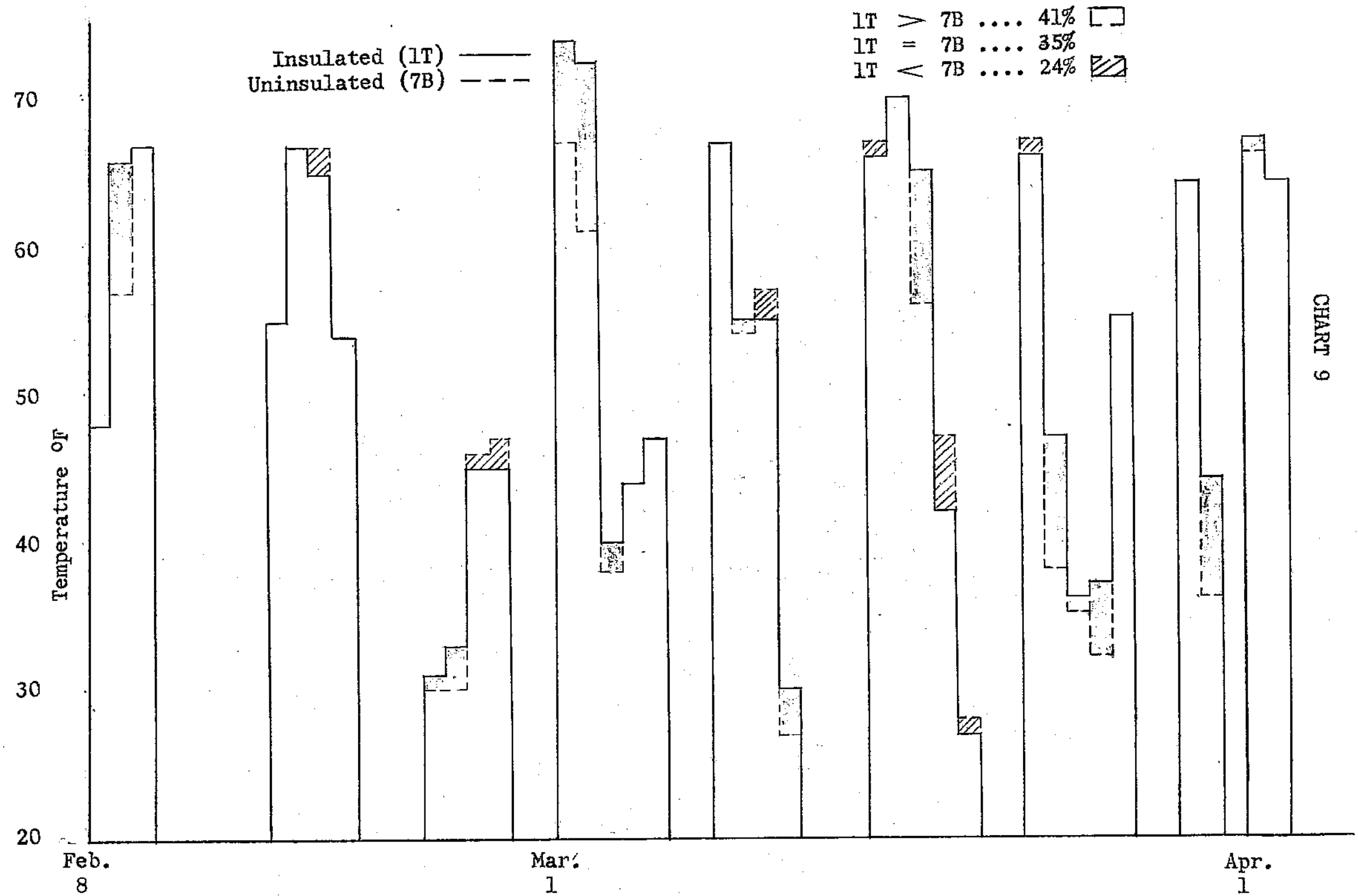
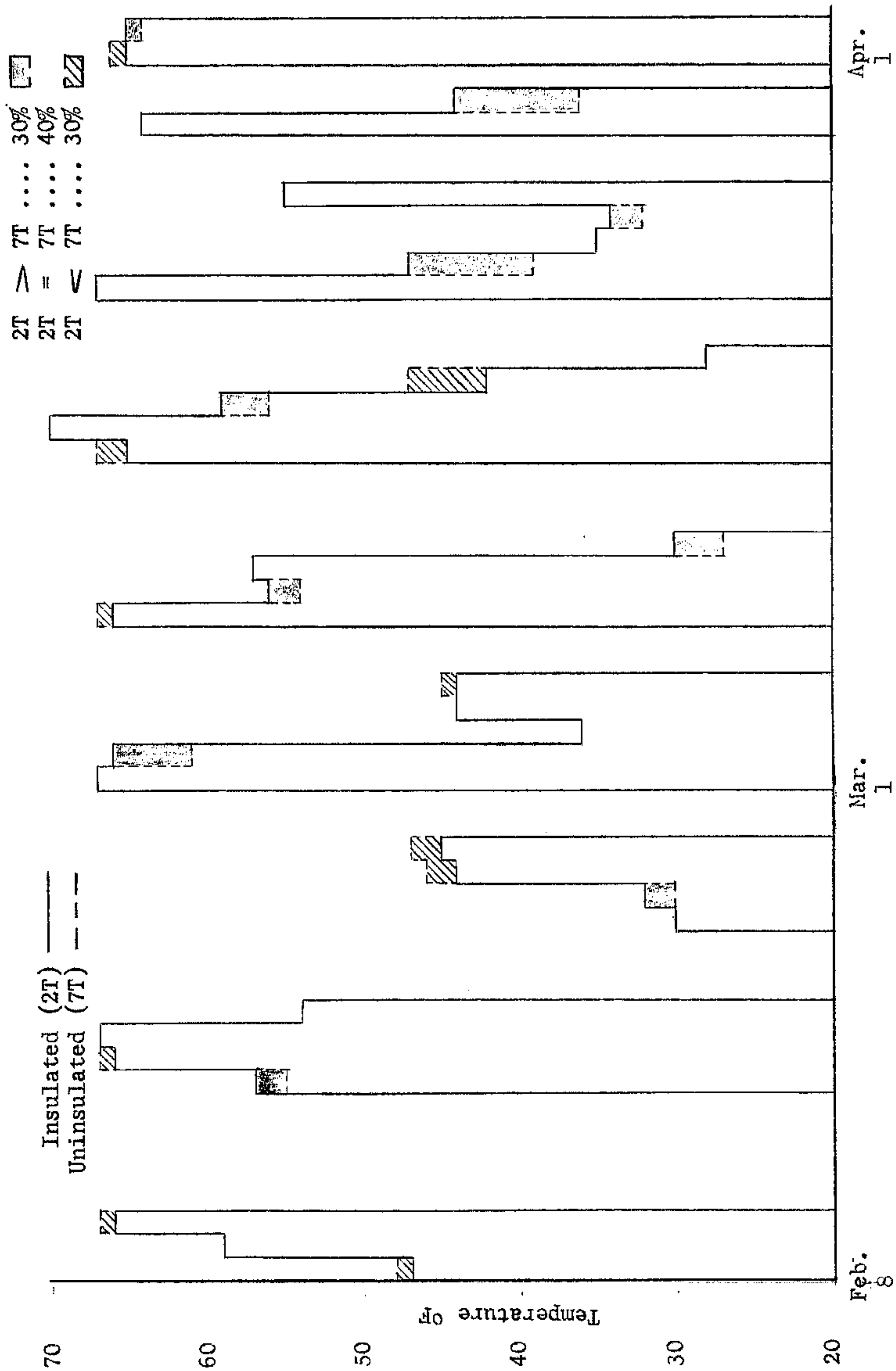

Approach 8B
Uninsulated 7B
8B > 7B 35%
8B = 7B 50%
8B < 7B 15%
Temperature °F
70
60
50
40
30
20
10
Feb. 8
Mar. 1
Apr. 1
Minimum Daily Temperature - 8B vs 7B

CHART 9



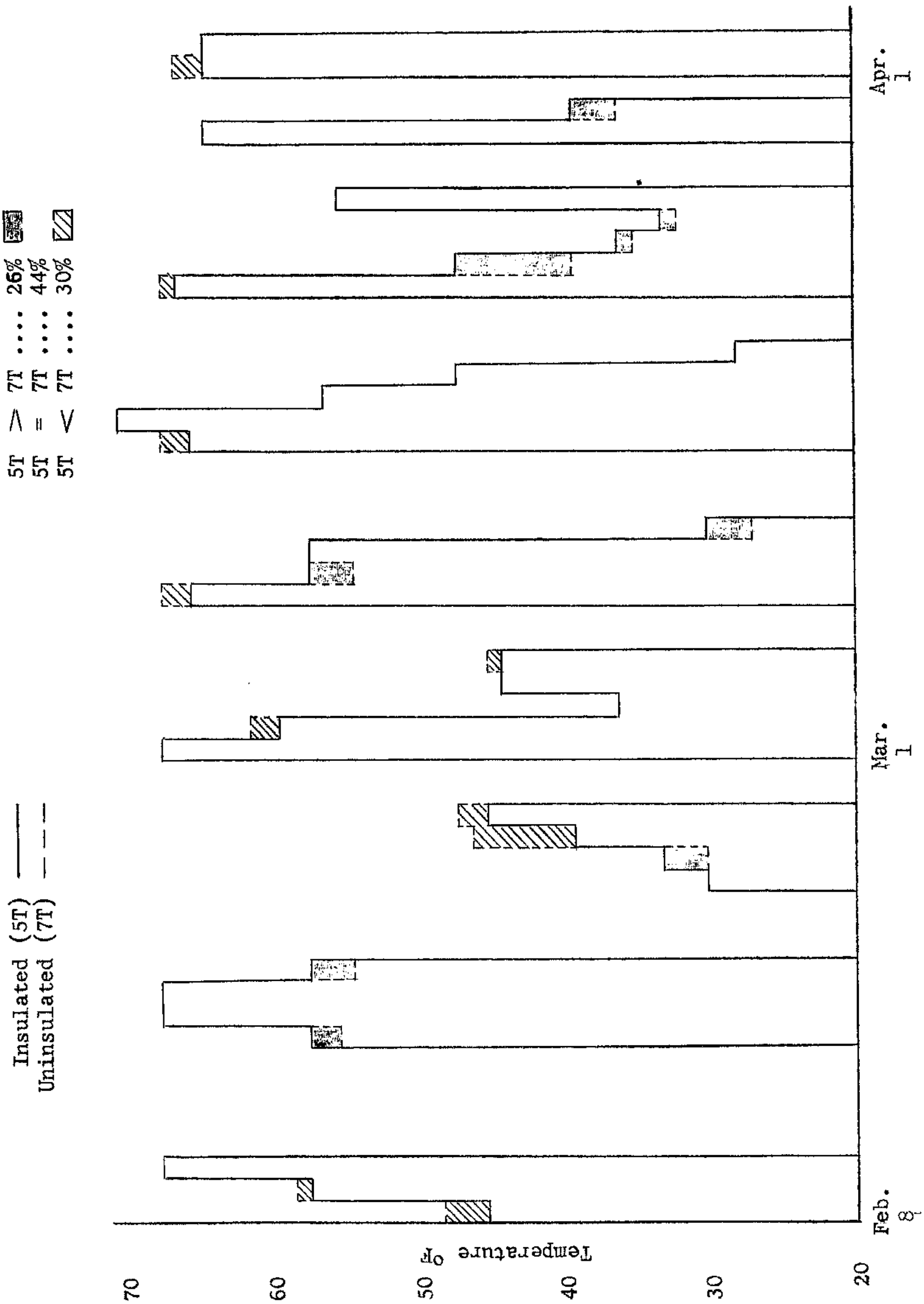
Maximum Daily Temperature - 1T vs 7B

CHART 10



Maximum Daily Temperature - 2T vs 7T

CHART 11



Maximum Daily Temperature - 5T vs 7T

CHART 12

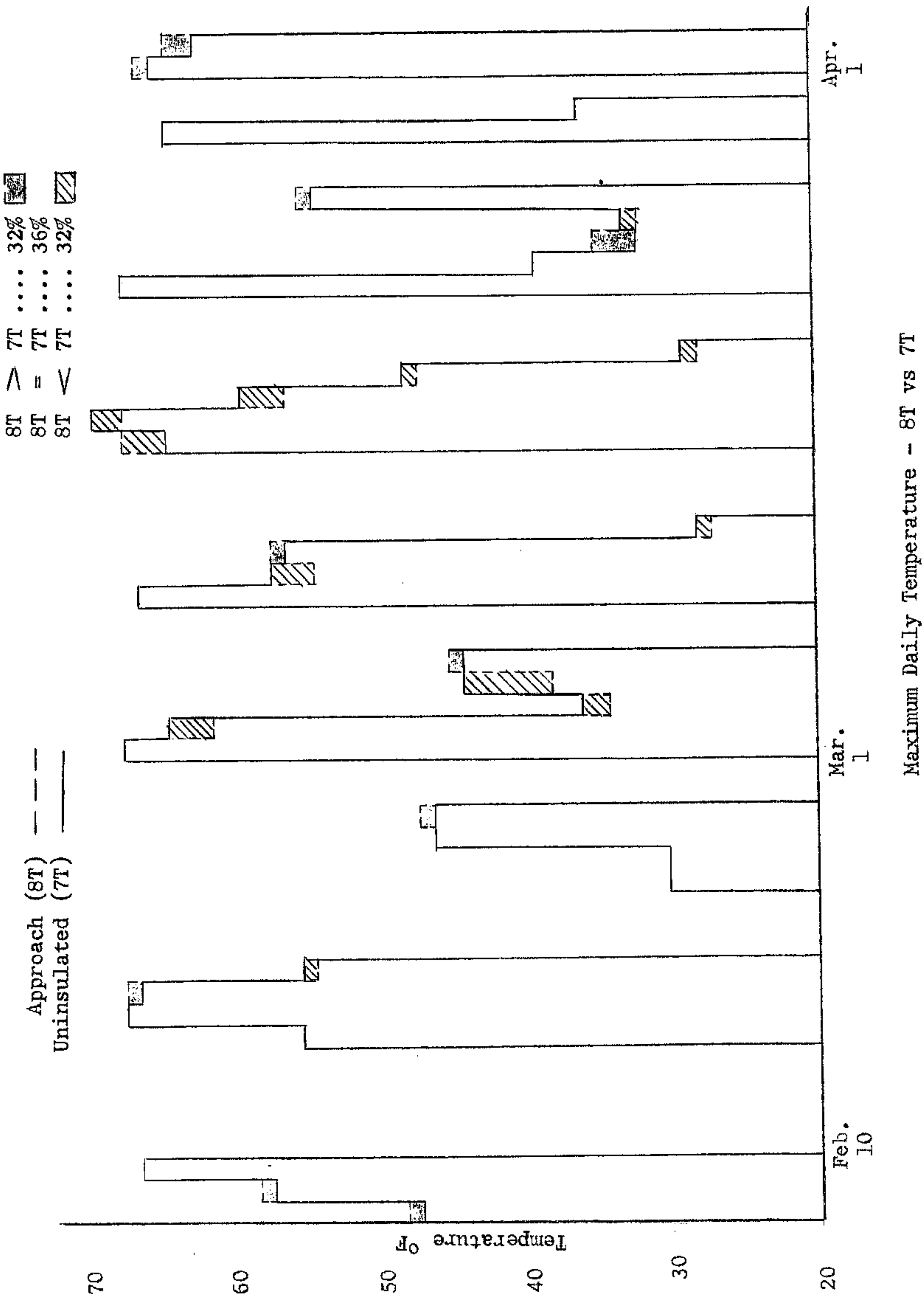
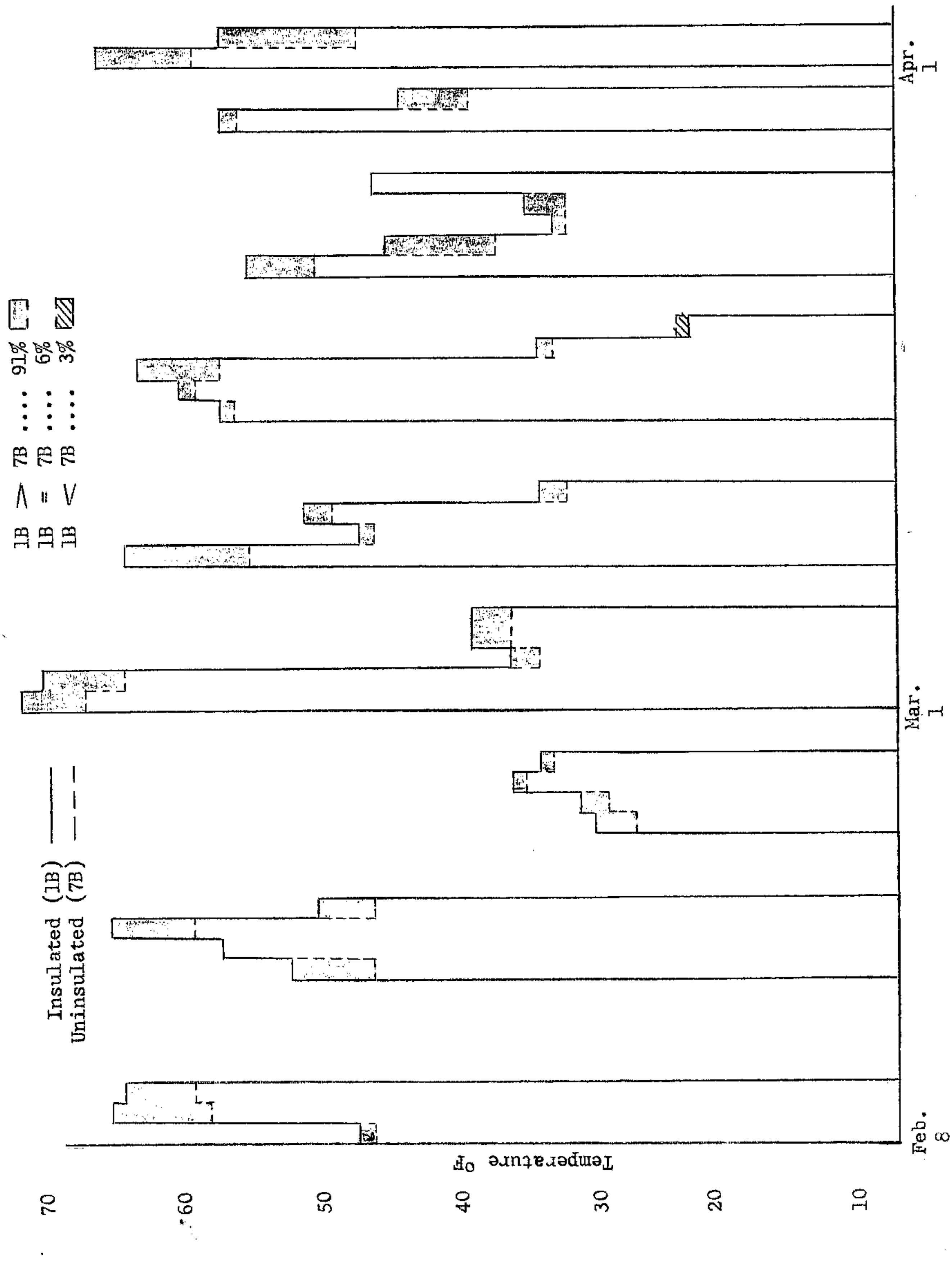

Approach (8T)
Uninsulated (7T)
8T > 7T 32%
8T = 7T 36%
8T < 7T 32%
Feb. 10
Mar. 1
Apr. 1
Temperature °F
70
60
50
40
30
20
Maximum Daily Temperature - 8T vs 7T

CHART 13



Maximum Daily Temperature - 1B vs 7B

CHART 14

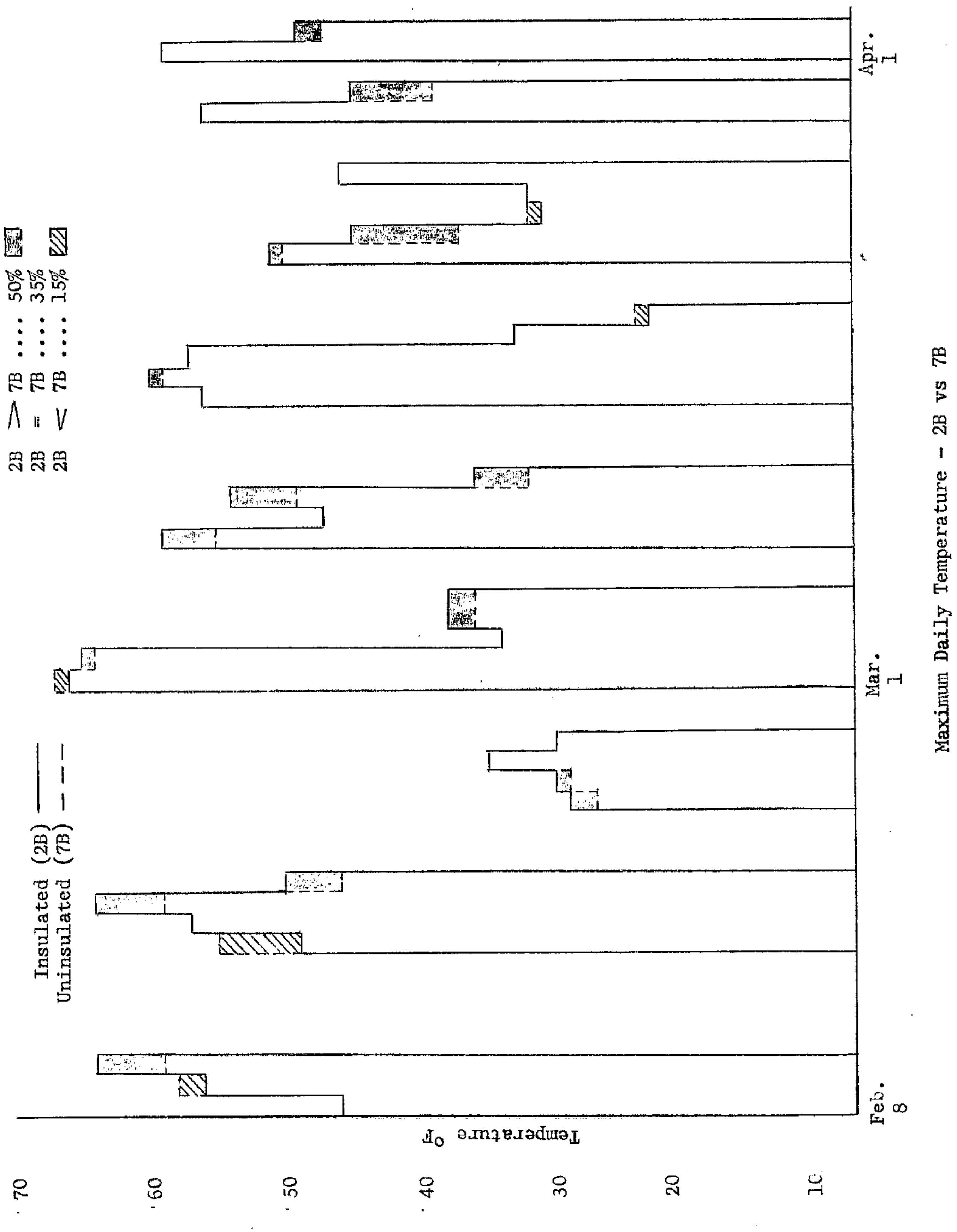
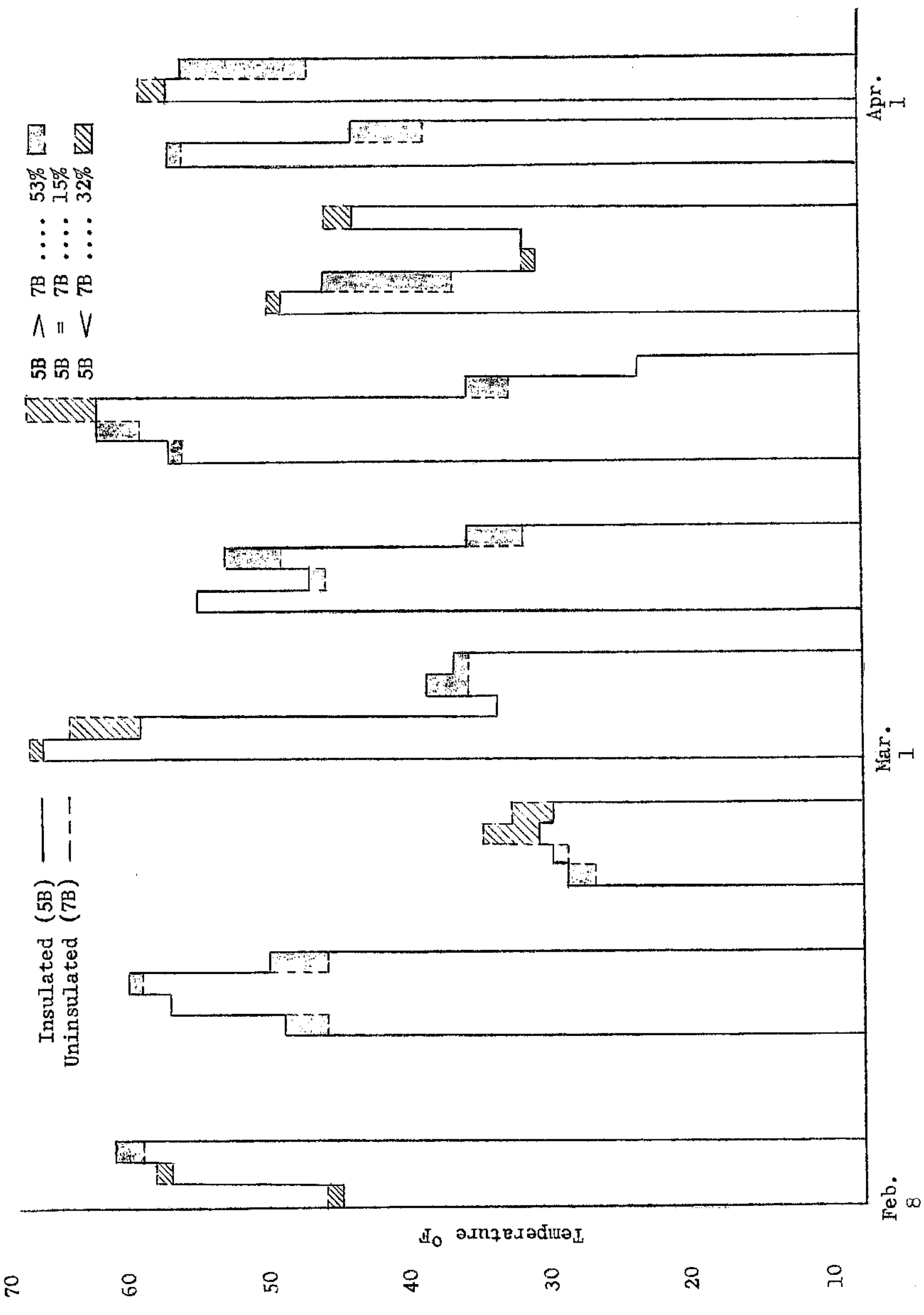
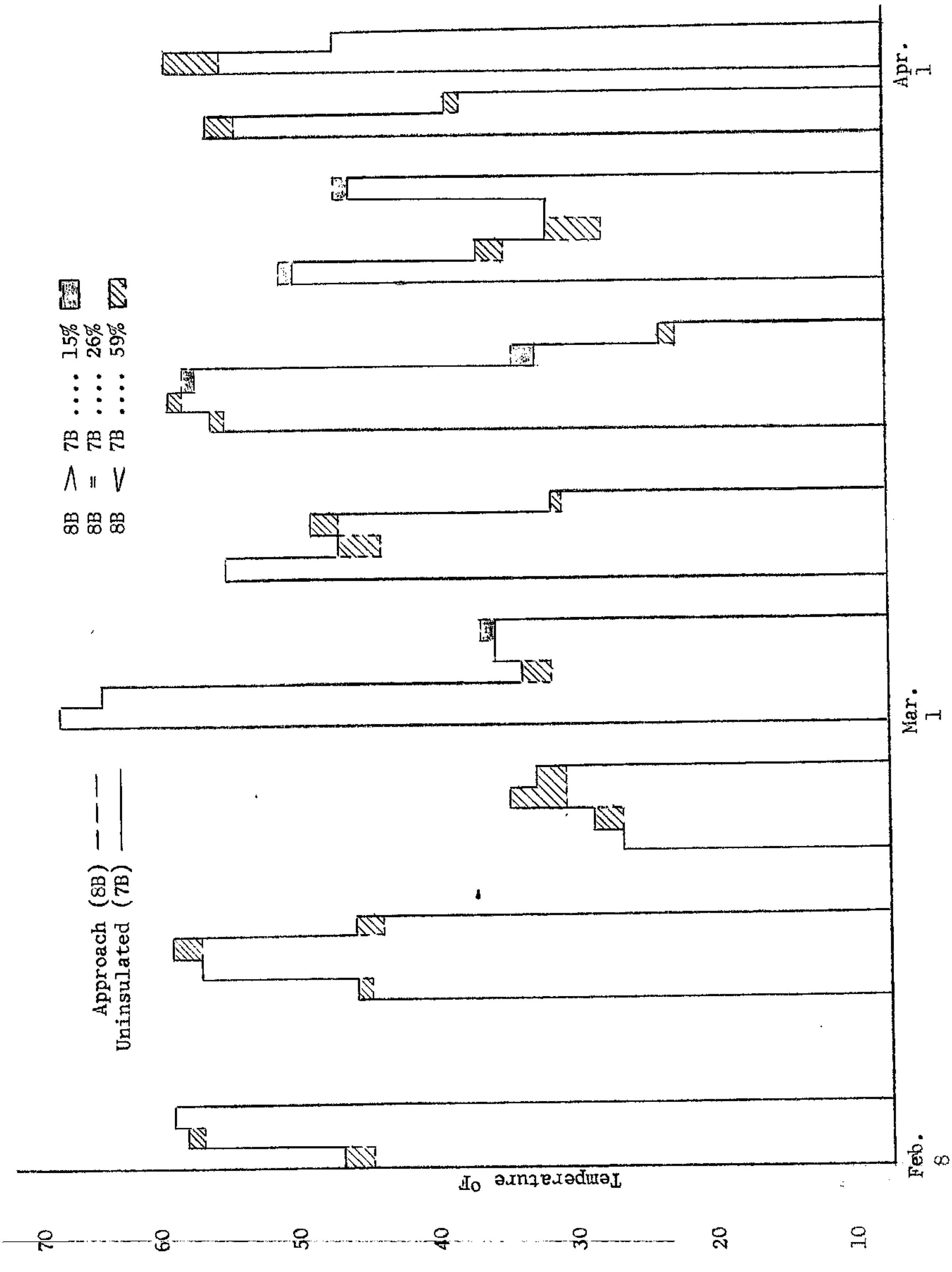

Insulated (2B) ———
Uninsulated (7B) – – –
2B > 7B 50%
2B = 7B 35%
2B < 7B 15%
Temperature °F
70
60
50
40
30
20
10
Feb. 8
Mar. 1
Apr. 1
Maximum Daily Temperature - 2B vs 7B

CHART 15



Maximum Daily Temperature - 5B vs 7B

CHART 16



Maximum Daily Temperature - 8B vs 7B