TEMPORARY HEATING IN CONSTRUCTION CONTRACTS

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ABSTRACT: It appears that in construction projects extending through winter with freezing temperatures, the cost of temporary heating is not always equitably resolved between the parties in a contract. Although existing guidelines have been initiated since 1964 by the construction industry, the bid allowances in calendar days and cost perdiem of heating, as suggested, have not been implemented. The three case studies described with varying structures and heating systems, show how heating costs are affected by changes beyond the General Contractor's control. These costs can be substantial; however, they can be minimized if owner, designer, contractor and mechanical subcontractor can co-operate.

INTRODUCTION

One of the crucial subjects that nearly always becomes a conflict or snag between parties in a construction contract is temporary heating. It appears from Appendixes I and II that this subject is somehow stacked away prior to bid time and kept in the refrigerator until its eruption in the field.

Most temporary functions during construction are taken care of by the General Contractor or his subcontractors or both, or by the assigned subcontractors. The temporary water, electricity, compressed air, offices, toilets, storage sheds, and signs are installed temporarily at the start-up of construction and dismantled at the end of construction. Generally, these temporary facilities do not cause any special conflicts between the parties. Their use may be free of charge to the General Contractor and his subcontractors at a reduced rate or at the expense of the project. However, due to their specific known costs, it does not cause concern.

Temporary heating is still a big concern to the construction industry, designers, and owners—differing from project to project, since it is dependent on weather conditions.

CONCERNS

The concerns vary for each party, and so far there appears to be no consensus on what is the best way to work those concerns out such that all parties are mutually satisfied. The purpose of identifying some of these concerns is to attempt clarification of sources of conflict.

Some of the Owner's concerns are: (1) Cost of temporary heating; (2) since the General Contractor is in charge of the project, temporary heating is in his domain and should be handled by him in the most competitive manner; (3) in order to cut the high costs of temporary heating,

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the Owner may agree and volunteer or not volunteer to give an option to the General Contractor to use the permanent heating system for temporary heating of the building during construction; and (4) the Owner wants the most competitive bid price without assuming any risks regarding temporary heating and the option to occupy the premises before completion. Some of the designer's concerns are: (1) To write a specification that conforms with the Owner's wishes; (2) to design a permanent heating system that is the most economical and compatible with existing system (if applicable), owned by the Owner; (3) to avoid gaps in the specifications so that claims do not arise as a result of temporary heating; and (4) to assure that his design is safe and workable, and does not give rise to the Owner's claims towards him. Some of the General Contractor's assumptions are: (1) To bid in the most competitive manner, assuming the most optimistic attitude on unknowns such as temporary heating; (2) to assume that there will be no delays beyond his control; (3) to assume that the design of the permanent heating system enables him to use it, when needed, if such an option is given; and (4) to assume that if delays are caused beyond his control, reasonable agreement on additional expenses can be reached with the Owner.

It seems that there is no possibility of conflict between parties; however, the fact of the matter is these concerns and assumptions between parties are only the nuclei of a time bomb.

Existing Guidelines

On December 1, 1964, the Joint Construction Industry Committee, including the Associated General Contractors, the Mechanical Contractors Association, and the American Institute of Architects—all from the Detroit Chapter—issued Bulletin #I: "Heating During Construction" (2). The bulletin divides heating into two distinct classes: (1) Cold Weather Protection; and (2) Temporary Heating. Temporary Heating is defined as heating required *after enclosing the building* (exterior walls erected and openings covered, roofing watertight—all to provide reasonable heat retention). Recommendations in this bulletin for temporary heating include: (1) Use of the permanent heating system to be provided by the heating and ventilating subcontractor, to maintain a minimum of 50° F (10° C) in entire building; (2) owner to furnish Boiler & Machinery Policy Broad Form (Insurance); (3) temporary electrical connections for temporary heating to be provided by the electrical subcontractor; (4) fuel and electrical power for temporary heating to be provided by the General Contractor (if from an existing central heating plant then by the Owner); and (5) as a basis for bidding, temporary heating shall be provided for a specified number of calendar days with a per diem unit price for adding or deducting one calendar day.

These guidelines were specifically issued in order to alleviate the "friction and confusion in the Owner-Architect-Contractor relationship" in the words of William E. Stewart, Secretary of JCIC.

Nine years later (August 1973) the Construction Specifications Institute, Inc. published a Monograph (01M513) entitled "Temporary Heat" (5). The monograph divides heating into the same two classes as did the JCIC Bulletin, and adds that temporary heating could also be used to

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allow beneficial occupancy of the building prior to its completion and acceptance.

The minimum temperature to be maintained is 40° F (4° C); however, a minimum heat is required for each activity: (1) Concrete and masonry 50° F (10° C); (2) plaster 55° F (13° C), woodwork; (3) painting up to substantial completion 70° F (21° C). Among the major recommendations in this monograph for temporary heating are:

1. The use of the permanent system must be sufficiently complete with safety controls; however, the Architect/Engineer or Owner is responsible for making the determination as to when, in his opinion, the permanent heating system is sufficiently completed to allow safe operation.
2. After temporary use of the permanent system and before acceptance by the Owner, temporary filters should be removed and replaced with permanent filters, and the system cleaned to a first class condition.
3. During use of the permanent system, the filters should be replaced to keep the system in a reasonably clean condition, and the equipment well-maintained. Special requirements are necessary for boilers and steam boilers.
4. In competitive bidding, requirements and cost allowances are to be clearly spelled out for temporary heating.
5. The General Contractor is responsible for all weather protection and temporary heating prior to use of permanent system. He also expedites the installation of the permanent system.
6. In the case of separate prime contracts, responsibilities between the parties should be spelled out.
7. Local trade union requirements such as standby labor (sheet metal workers, steamfitters, electricians, stationary engineers) can be costly if permanent system requires a combination of the aforementioned trades. It is sometimes advisable for the Owner to accept the heating system and operate it to furnish temporary heat until the building is completed.
8. A cash allowance specified by the Architect/Engineer to be included in the bid for temporary heating, and a unit price for adjustments is recommended (no. of shifts per days of operation with fuel and maintenance labor). Incentives for savings are also indicated.

The monograph prepared by the Hartford Chapter of CSI was directed to the specifier engaged in the preparation of construction contract documents.

Two years later (March 1975) the Construction Industry Council of S.E. Michigan published their recommended guidelines for cold weather protection and temporary heat (3). This publication was revised in April 1976.

As a Michigan publication, emphasis is made on maintaining construction schedules in Michigan's winter climate. Again, recommendation is given to provide an allowance for temporary heat, costs of which are substantial (1%–5% of project budget). As can be seen from the case studies 5% as published by the CIC is quite high. The allowance device is in order to provide temporary heat at the *lowest* possible cost. Some of the other major recommendations are: (1) Minimum temperatures should be established for each project as they may apply. Mechanical

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Contractor provides temporary heating and maintenance, excluding fuel, which is an allowance; (2) in the event of extensions of contract time, the Owner will pay costs of additional temporary heat beyond allowance included in base bid; (3) heat attendant, if required, will be assigned by Mechanical Contractor; and (4) if the building is enclosed, ready to retain heat, the Mechanical Contractor shall request inspection from the Architect/Engineer prior to use of the permanent heating system.

Estimating criteria are given for assessing the allowances of fuel cost based on February 1974 prices in the Metropolitan Detroit area and attendant costs from September 30, 1976 to May 31, 1978 based on the Detroit area labor costs.

In light of the aforementioned concerns and existing guidelines, let us examine some real case studies experienced by the author.

Case Studies

The purpose of the actual case studies is to demonstrate why conflicts arise (see Analysis) in the use of Temporary Heat with varying conditions of structure, electromechanical systems and their respective specifications (see Appendixes).

I. Precast-Prestressed Parking Structure (Winter 1978/79).—The project consisted of a 6-story parking structure approximately 120 lin ft × 110 ft wide × 10 ft high (37 lin m × 34 m wide × 3 m high), including one elevator bank, two staircases and a connecting tower to existing medical facilities. Due to delays, concrete topping had to be poured in winter months on the floors of the installed precast double-tee units. The facade had a 4 ft (1.2 m) high opening at each story, which was enclosed by Kelley panels, (a prefabricated metal frame to which a corrugated fiberglas sheet is fastened) so that heat could be retained. Both the floor beneath and the floor above had to be heated prior to and during curing of concrete until cast was completed. Up to November 17, the heat could be retained by tarps and insulated blankets covering the floors. In December, Kelley panels, tarps, and reinforced visqueen coverings were necessary, together with temporary 2,000,000 Btu/hr (2,110 J/h) propane heaters. The cost for cold weather protection in this case represented approximately 1% of the project budget (example 1 of Basis for Estimates). However complex, this case did not have an option to use a permanent heating system, since the Parking Structure is open. (In Renovation Work (4), the heat from the existing building is sometimes sufficient.)

II. Glass-Clad Office and Classroom Building [Winter 1979/80 and Winter 1980/81 (Appendix I)].—The project involved a 5-story building, with the 2 lower levels of classrooms approximately 260 lin ft × 102 ft × 13 ft (79 lin m × 31 m × 4 m high) average plus a large lecture hall, and the upper 3 levels of offices were approximately 210 ft × 60 ft × 13 ft (64 m × 18 m × 4 m) high average, plus 2 stair towers, one of which also had elevators. The slabs were reinforced concrete cast in situ, while the skin of the building was of glass; the majority of the lites included tempered reflective spandrels, tempered reflective insulating glass, and reflective insulating glass.

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The heating system received high temperature hot water from the Owner's existing boiler house and distributed the heat to the building through heating coils in the air handling units to ducts and through perimeter fin tube radiation. The initial base bid was energy-conservation minded and included mostly perimeter fin tube radiation to all the areas except 3 lecture halls, which were heated through coils and ducts, assuming heat from electrical light fixtures and persons to develop the required heat. During construction of the structure, modifications were made to include heating coils to the penthouse and lower level air handling units. This change was made in October, just when the permanent system was being installed to be used for winter heat. Delays in delivery of controls and heating coils, and their installation at the penthouse during freezing weather added to the costs of construction. The General Contractor had to maintain temporary heat in the building until the revised permanent heating system was installed. The inexpensive use of the permanent system was denied the General Contractor. The project was delayed partly by this and other changes to the contract, and the union strike gave its final blow to the scheduled completion date for occupancy by the University prior to the academic year. The costs for temporary heat during 2 winters, one of which was using mostly propane temporary heaters, the other using the permanent heating system, was approximately less than 1% of the project budget (example 2 of Basis for Estimates.) This case is a typical case of substantial changes made to the mechanical system (basically through hot water) directly affecting the use of the permanent heating system.

III. Chain Motel [Winter 1981/82 (Appendix II)].—This project involved a 3 story building with 226 rental units around a Holidome approximately 257 lin ft × 212 ft × 8.5 ft (78.3 lin m × 64.6 m × 2.6 m) high per floor. Attached to it was a commercial area with meeting rooms, dining facilities, lobby and lounge approximately 196 lin ft × 162 ft × 12 ft (59.7 lin m × 49.4 m × 3.7 m) in height. The facade was brick. The permanent heating system varied with gas-fired rooftop units, fan-coil units, and heated coils and ducts; the fan-coil units and heated coils were from a central hot water boiler house. The start of this project was delayed from its beginning due to lack of access to the site; the Owner had to negotiate with the City and State on this issue. Thus, the completion date of October 1981 was delayed through the winter. Also, the heating system was changed to separate the exterior rooms' heating system from the interior rooms' heating system. Winter costs such as temporary heating and other related expenses were carried by the Owner. These costs included an Owner's maintenance operator, which turned out to be the most economical way to go. Due to the diversity of the mechanical system, the gas-fired units were first operated in October and generated enough heat until the hot water system was ready. This enabled use of the permanent gas system when needed for finishing trades.

Analysis

All the cases were competitive bids that became Lump Sum contracts. Although the existing guidelines recommend to spell out an allowance in the bid and a unit cost for additional temporary heat, none of the

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aforementioned cases had such an inclusion in the Architectural Specifications (Appendixes I and II).

The Owner and possibly the Architect believe that it was best for the Owner to let the General Contractor handle this. It is perplexing to find that they seem surprised to deal with this problem during construction and sometimes end their contract in animosity.

The cases demonstrate that some of the principle reasons have to do with events beyond the General Contractor's control. Some of these events are even beyond the Owner's control, but certainly it is not always a one-party problem, especially when the General Contractor carries the burden.

Very few projects end up without changes and even though the net dollar amount of additions and deductions may be negligible, their influence on construction time may be devastating and their impact critical to Temporary Heating. These changes are the Owner's responsibility and any additional costs due to changes affecting temporary heating should be paid by the Owner. However, it is always difficult for the Architect and Owner to define what the General Contractor's allowance was for temporary heating in the base contract unless it has been spelled out. If the allowance has not been agreed upon, cost issues arise about a unit cost.

What has been analyzed is a clear cut example in which following the existing guidelines would have "smoothed" the complex relationship of the Owner, Architect, Contractor, and Subcontractor.

Changes.—Unknown conditions (e.g., soil conditions) can also affect construction schedule and may be critical to temporary heating. These conditions are beyond the General Contractor's control, and may be an honest misjudgment of the Architect/Engineer interpretation of soil borings. True, the Owner also has no control of the soil, but he chose the property with his agent (i.e., the Architect) who certainly is dealing in the Owner's best interest. This case could also be resolved smoothly if guidelines were adopted.

Strikes.—Very few large projects end without a union strike if they extend for more than a year. Both the General Contractor and the Owner are in a bind; but, if there are no *a priori* rules established as guidelines for temporary heat, a dispute will arise once more. Knowledge that an allowance and a unit cost have been established at the time of contract signature will alleviate the settlement of any dispute due to a strike. Opinions differ here, but it is generally accepted that any costs, including temporary heating, should be shared by the parties to the Contract.

Now that some reasonable way to resolve this problem has been attained, an understanding of the most economical way for any party—Owner, Architect, General Contractor, or Subcontractor—to assume the cost is to be analyzed.

Design.—A priority of the HVAC engineer is to design the most economical system for the Owner without necessarily considering the usefulness of the permanent system for temporary heating. For example, hot water from a boiler source may be considered an economical energy system for heating, and yet water can freeze in winter; thus, unless the system is protected from freezing *prior to its initial operation*, the usefulness of the permanent system for temporary heating can be ineffective

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during winter construction. This loss of heating capacity means that temporary heat has to be generated by other methods if the Owner wants construction to proceed in winter at an additional cost to him. This could have been avoided if, for example, part of the permanent system was on a gas-fired heating unit (Case III). Such a unit could be used immediately upon its installation and connection to gas generating heat in the first months of winter until the hot water heating units are ready for use in the colder months. This chain reaction of generating heat may, in terms of overall cost, be more economical to the Owner. Scheduling design so that work can start on time to use the permanent heating system in winter is also important.

Maintenance.—Another factor that is being avoided by the Owner and Architect is maintenance of the permanent heating system. One of the biggest problems is the unions' desire to "babysit" the temporary units. The Mechanical Subcontractor is obligated to maintain the permanent heating system so long as the system is his responsibility. In some states, once he turns over the system to the Owner the union has no say. The Owner can maintain the system with his operator at a small fraction of the cost of maintenance by the Mechanical Subcontractor. Shifting this responsibility to the General Contractor does not change much, because in order to maintain the system, the General Contractor has to request his Mechanical Subcontractor to do it for him. Although the Warranty starts with operation of the permanent system by the Owner, all the bugs in the system have to be corrected anyway by the Mechanical Subcontractor during this critical period. Using the Owner's operator is in the Owner's best interest, since the operator becomes acquainted with the system early enough. If the system is not satisfactory, the Owner has time to request changes from the Designer prior to occupancy.

Energy Cost.—In operating a permanent heating system, fuel costs are always involved, but this is not the only energy used. Electricity is also used to operate the pumps, fans, and controls, and sometimes this cost is underestimated, although it can be substantial, depending on the Engineer's design.

If anybody should be aware of the fuel and electricity costs, it should be the Owner and the Architect/Engineer who designed the building and specified the minimum temperatures. By spelling out the allowance in the bid documents, all parties are aware of these costs not only for temporary heating purposes but also for occupancy expenses.

Winter Construction.—The question also arises as to whether it is in the Owner's interest to build through winter. This is dependent on various considerations. Closing construction (e.g., from mid-November to mid-March) would entail additional dismantling and setup costs to be considered, and possibly a different staff to supervise construction after winter with some loss in continuity. There are naturally financial considerations that the Owner has to look at in inflationary times. Whatever the considerations are, in some cases it could also be the Owner's option to make that decision so that the General Contractor can make his assumptions accordingly when bidding.

Basis for Estimates.—Both cold weather protection and temporary heating can be substantial in costs, and yet estimates are only educated

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guesses as to real costs which are so dependent on the severity of winter months.

Cold weather protection of vertical elements like walls are easier to keep protected from the inclement weather by stripping after the concrete has cured with or without spot heating and tarp covering as dependent on outside temperatures. Flatwork concrete protection is sometimes more difficult as in the case of a supported slab for an open parking structure. It may be necessary to heat the space below and above the slab being poured, and in order to retain the heat, the openings in the facade have to be enclosed. Such openings can be covered by tarps, 10 oz (0.283 kg) fire resistant, generally available in standard sizes of 15 ft (4.6 m) × 20 ft (6 m). Insulated blankets with standard sizes of 8 ft (2.4 m) × 15 ft (4.6 m) are a better protection; their cost per square foot, however, may be 3 times as much as for tarps. Openings can be framed with lumber and sheathed with reinforced visqueen, for example, or with ready-made panels such as the steel-framed-fiberglas Kelley panels with standard sizes of 4 ft (1.2 m) × 12 ft (3.7 m). Again, in the latter, labor cost is saved, but rental cost may exceed 3 times the material cost of lumber and visqueen. Propane gas is widely used in construction; however, the selection depends on which fuel is the least expensive at a given time. The consumption of propane gas is 91,500 Btu/gal (25 MJ/L) while the one for natural gas is 100,000 Btu/cu ft (3,800 MJ/m^3); (oil #2—141,800 Btu/gal = 39 MJ/L). Another important factor in calculating the consumption of fuel is the tightness of the enclosure. For propane gas using high temperature and low CFM pressurization principle, the factor to use could vary from 2 to 8.5 depending on how air-tight the enclosure is and on the differential temperature between the outdoor temperature and the maintenance of an average indoor temperature.

Example 1 (See Case Study I).—The volume to be heated in order to pour one supported slab in a parking structure is 120 lin ft × 110 ft wide × 10 ft high × 2 floors = 264,000 cu ft (7,930 m^3).

Using a differential temperature of 45° F (7° C) from a +10° F (−12° C) outside temperature to a +55° F (13° C) average interior temperature and assuming a framing of the reinforced visqueen to cover the openings of the parking structure, a factor of 6.5 BtuH/cu ft (2.4 × 10^5 J/m^3) is used to calculate the consumption of propane gas: (1) 6.5 BtuH/cu ft × 264,000 cu ft = 1,700,000 BtuH (1,790 MJH); and (2) 1,700,000 BtuH ÷ 91,500 Btu/gal = 19 gal per hr (72 L per h). If this is used continuously for 15 days, the consumption will be 15 days × 24 hr × 19 gal/hr = 6,840 gal (propane gas) (25,700 L).

The market has standard portable units with 1,850,000, 1,000,000, 350,000, 150,000 Btu/hr that could be used, either with propane gas or natural gas.

Basically, an estimate for cold weather protection would include the cost of covering the surface being protected or the opening being enclosed or both plus the cost of heating including fuel, maintenance, rental and other incidental costs (Table 1).

Temporary heating of a building can be performed through the permanent heating system. In this case, the building is adequately enclosed with exterior walls and a watertight roof, thus retaining heat, and the permanent heating system is operable.

TABLE 1.—Temporary Heat Cost for Placing Concrete SOG and Topping on 5 Floors of Precast Slabs (81,600 SF) from December 1–13, 1978 (12 Calendar Days = 288 hr)

		Quantity	Unit	Material U.P.	Material Total	Labor U.P.	Labor Total
1.	Kelley panel enclosure at facade	5,760	SF	.25	1,440	.27	1,584
2.	10 oz. (0.283 kg) fire resistant Tarp enclosure at ends	12,320	SF	.02	246	.18	2,218
3.	Reinforced visqueen enclosure @ Line B (double beams)	1,680	SF	.07	118	.25	420
4.	Lumber framing for above	4,053	BF	.10	405		INCL
5.	Propane fuel	6,840	Gals	.38	2,599		INCL
6.	Propane unit heater 1,850,000 BTU/Hr (rental and Maintenance)	1	EA		700		528
7.	Electrical hook-up for unit heater	1	EA		500		INCL
8.	Escalation of concrete for roof	165	Cyds	11.00	1,815		INCL
	SUBTOTAL 1				7,823		4,750
	INSURANCES & TAXES				314		2,375
	SUBTOTAL 2				8,137		7,125
	OVERHEAD EXPENSES				406		712
	SUBTOTAL 3				8,543		7,837
	TOTAL COST EXAMPLE 1					16,380	

Cost of Temporary Heat per million BTUH =

$$\frac{16{,}380.00}{6{,}840 \times 91.500}$$

= approximately $26.00/1 x 10^6 BTUH

NOTE: 1 sf = 0.093 m^2, 1 bf = 0.002 m^3, 1 gal = 3.79 L, 1 cyd = 0.765 m^3, 1 BTUH = 1.055 x KJH

One method used to calculate the fuel or energy consumption is called the Degree Day Method. The description of procedures for this method is detailed in the ASHRAE Systems Handbook (1). In short, a *daily mean temperature* is computed as half the total of the daily maximum and minimum temperatures. The difference between the daily mean temperature and 65° F (18° C) is the number of *degree days* for that day. These statistics are available from the U.S. Weather Bureau for each location used for gathering such information on a long-term basis. The nearest location to the project involved should be used. Adding up all the degree days during the winter season gives us the total degree days for that season. For example, in Southeastern Michigan for the season of 1980–1981, data taken at Detroit City Airport gave 78 degree days for the month of September 1980, 523 degree days for October, 798 for November, 1,184 for

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December, 1,369 degree days for January 1981. Detroit has an average yearly total of 6,232 degree days, extending from September–June.

An equation is used to calculate the probable energy consumption for a certain period, based on the degree days and using a corrective factor for heating effect versus degree days (1): Energy consumption = (Btu/hr × degree days × 24 × correction factor)/(temperature differential × heating system efficiency × fuel value).

The correction factor is derived from Fig. 1 (Ref. 1), and it is dependent on the number of degree days. The heating system efficiency is 1.0 for electricity, 0.55 for fossil fuels, and 0.65 for fossil fuels with energy conservation features. The fuel value is 100,000 Btu/hr (100 MJ/h) for natural gas, 144,000 Btu/gal (40 MJ/L) for heating oil, and 1.0 for high

TABLE 2.—Temporary Heat Cost Using the Installed Permanent Heating System for the Complete Enclosed Building from December 15, 1980 to January 26, 1981 (42 Calendar Days = 1,008 hr)

	Quantity	Unit	Material		Labor	
			U.P.	Total	U.P.	Total
1. Payment to Owner for use of existing boiler steam (High Temperature Hot Water)	1356×10^6	BTUH	3.80	5,153		INCL.
2. Use of electricity to run installed permanent equipment (32.7 HP)	25,200	KWH	0.05	1,260		INCL.
3. Emergency calls from existing 24 Hr. boiler room staff				INCL.		INCL.
4. Expansion Tank	1	EA	650	650		INCL.
5. Install temporary isolation valves	6	EA	150	900		INCL.
6. Temporary filters, motor lube and cleanup	6	TIMES	100	600	75	450
7. Duct modifications to distribute hot air to locations required and temp. controls	1	EA		INCL.	200	200
SUBTOTAL 1				8,563		650
INSURANCES & TAXES				343		325
SUBTOTAL 2				8,906		975
SUBCONTRACTOR'S MARK UP ON ITEMS 4 - 7				214		125
SUBTOTAL 3				9,120		1,100
OVERHEAD EXPENSES				450		110
SUBTOTAL 4				9,570		1,210

TOTAL COST EXAMPLE 2 10,780

Cost of Temporary Heat per million BTUH =

$$\frac{10,780.00}{1,356}$$

= approximately $8.00/1 x 10^6 BTUH

NOTE: 1 BTUH = 1.055 KJH, 1 HP = 0.7457 KWH temperature hot water, measured in Btu's.

Example 2 (See Case Study II).—A structure with a net heat loss of 1,745,574 Btu/hr (1,842 MJ/h) for a period totalling 1,552 degree days for a differential temperature of 61° F (16° C) using an existing boiler system with a 0.55 efficiency in which the energy transferred is high temperature hot water whose value is 1.0 will give us a probable consumption of $(1{,}745{,}574 \times 1{,}552 \times 24 \times 0.7)/(61 \times 0.55 \times 1) = 1{,}356 \times 10^6$ Btu ($1{,}430 \times 10^9$ J).

A correction factor of 0.7 was used from Fig. 1 (1). However, it should not be forgotten that apart from the fuel cost, electric costs are incurred in running fans, pumps, compressors and controls. The quantity of hp has to be factorized, since some of these loads are not continuous. A conversion to kWh is obtained by multiplying hp by the coefficient of 0.7457. This will give us the required consumption.

In addition to energy costs, there are maintenance and standby costs in which a worker is on duty checking the controls so that units susceptible to freezing do not freeze. The number of hours involved can be substantial depending on arrangements made for emergency calls and the time required for such a response. There are also special preparations that may be required to use the permanent system for temporary heat, depending on the existing design. For example, an additional expansion tank in a warm environment, isolation valves between construction zones, diversionary ducts, temporary controls if permanent controls are not available, and similar items may be required. Change of filters and clean-up of system at the end are also costs to take into consideration (see Table 2).

In their entirety, these costs may be incurred by one party or by more than one party, in which case a coordination meeting is needed ahead of the heating season to ascertain that each party is knowledgeable of his responsibilities and expenses.

Conclusions

Temporary heating is an integral part of the cost of a project. However, because of its complexity and dependence on unknown conditions beyond the reasonable control of any one party, it appears advantageous to the Owner to assume some of the risk. By team effort between the various parties (per Owner, Architect, General Contractor, Mechanical and Electrical Contractor), starting with a design that is compatible with using the permanent system for temporary heating, (e.g., case III) allowing in the bid documents for temporary heating costs, assigning the various responsibilities to each party, maintaining the system in the most economical way—the end result will be to the benefit of the Owner maintaining business-like relations between the parties.

It must be recognized that in the long run the Owner pays for everything including contingencies and mistakes. It is therefore preferable for the Owner to share in both the risks and contingencies if and when they arise rather than expect the contractor to pay for them.

The adversary relationship leads to increased costs, time, frayed nerves and arguments, and litigations, all of which can be avoided or minimized by cooperating as much as possible between the parties involved.

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(Appendixes I and II are *exact excerpts* from the Architects' specifications for Temporary Heating relative to the particular case study, which in some cases may be the reason for such controversy.)

Appendix I.—"Temporary Heat" for Case II—Glass-Clad Office & Classroom Building, Item 5.

5. Temporary Heat

5.01 The General Contractor shall protect all work against deterioration or damage due to weather or freezing until the project is turned over to Owner.

5.02 After the building is enclosed with exterior walls erected, roof deck completed and openings enclosed so as to provide reasonable heat retention, protect the building against deterioration or damage due to low or freezing temperatures at any time and maintain higher temperatures as required for the completion of the work or as otherwise required by the Technical Specifications Sections. If temporary heating equipment is used, its location and operation shall not be hazardous to the building or workmen.

5.03 The existing campus central heating system may be used for temporary heating if the building is enclosed and the new heating system is sufficiently complete, including piping, connectors, controls, pumps or other accessories and temporary wiring so that in the opinion of the Architect, it can be operated without hazard or damage. Notify the Architect in writing at least two (2) weeks before the first intended use of the central heating system for temporary heat; heating system shall be used only after Architect's approval. The Building BTU meter as specified in Division 15 shall be installed and operable. The General Contractor shall pay for all power and fuel.

5.04 Assume responsibility for damage due to dirt or abuses to the permanent heating equipment during period of temporary heating and during the progress of the building construction. The equipment shall be cleaned and all changeable filters newly replaced by the Mechanical Trade immediately prior to the building being occupied by the Owner.

5.05 If the Owner occupies a portion of the building served by a central heating system, he and the Contractor shall proportionately divide the cost of the fuel, power and attendant for permanent heating equipment operation on the basis of the part of the square footage of the total heated area under control of each as computed by the Architect.

Appendix II.—"Temporary Heat," for Case III

Temporary Heat: The Contractor shall, at his own expense, provide temporary heating as required for the proper protection and drying of all work until the completion of the project.

Appendix III.—References

1. "Description of Procedures," *American Society of Heating, Refrigerating and Air*

J. Constr. Eng. Manage., 1983, 109(4): 447-459

Conditioning Engineers 1980 Systems Handbook, Chapter 43, p. 43.8.
2. "Heating During Construction," *Bulletin #I,* Joint Construction Industry Committee, Dec. 1, 1964.
3. "Recommended Guidelines for Cold Weather Protection and Temporary Heat," *CIC 01513.1,* Construction Industry Council, Mar., 1975, and Revision, Apr., 1976.
4. Schlick, H., "Schedule and Resources of Fast Track Renovation Work," ASCE, Vol. 107, No. CO4, Dec., 1981.
5. "Temporary Heat," *Monograph 01M513,* The Construction Specifications Institute, Inc., Aug., 1973.