

SnoTrac™

Skin Effect System for Snow and Ice Melting

INFORMATION GUIDE



The Heat Tracing Specialists®

Commercial Products

INFORMATION GUIDE

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SnoTrac™ System for Surface Snow and Ice Melting

Introduction . . .

SnoTrac is the most rugged and reliable snow and ice melting system available in the world today. Based on skin effect heating technology, a SnoTrac system utilizes a rugged, thick-walled ferromagnetic “heat tube” to melt snow and ice. This heat tube, imbedded directly in concrete or asphalt, utilizes a custom designed SnoTrac conductor to safely deliver energy into the system. A truly unique feature of a SnoTrac system is its ability to provide snow melting to extremely large areas with a minimal number of circuits. Over 2,000 square feet (186 square meters) can be protected from a single power point.

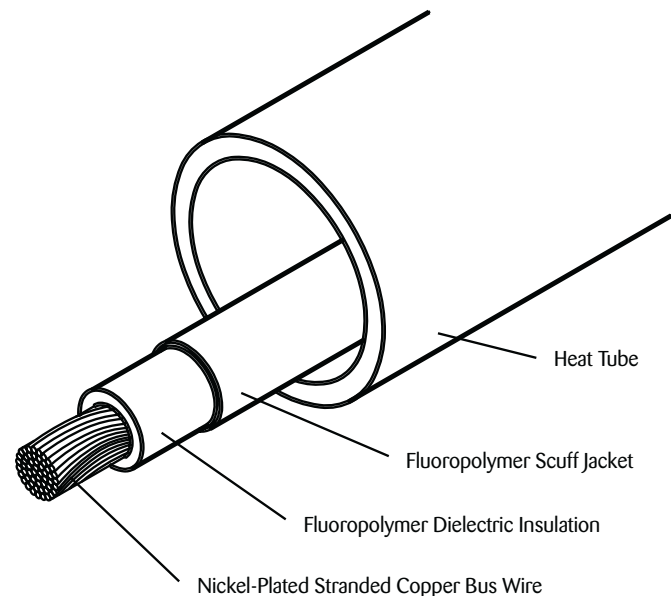
Each SnoTrac system is designed, engineered and installed per the requirements of the National Electrical Code, Articles 426 and 427, which specifically address skin effect heating systems. Additionally, to assure clients and customers of the performance and safety included with each Thermon snow and ice melting system, SnoTrac skin effect systems are Factory Mutual Research approved (File J. I. 2N6A0.AF) and Underwriters Laboratories Listed (File E163149, Project 94NK14488) specifically as snow melting and deicing equipment. Thermon obtained these approvals based on a range of design conditions encountered and have supplied approvals specific to the project in question to customers who have requested them as part of the project specification.

Reliability, expected service life and ease of maintenance are high on the list of reasons why engineers choose Thermon’s system for snow and ice melting. Other reasons include:

- Reduced number of circuits required to cover a given area as compared to resistance heating cables.
- Ability to gain access to the SnoTrac conductor should the need ever arise.
- Lower annual energy costs than hydronic snow and ice melting systems.
- Design and engineering assistance offered by Thermon.
- Rugged nature of the heat tube.
- Thermon TurnKey installation which guarantees not only the product but also the installation and performance.
- Ability to perform the installation and pour the concrete in stages.

Heating System Description . . .

The operating principle of a SnoTrac skin effect heating system is based on two phenomena called proximity effect and skin effect. The heating device is a carbon steel pipe called a heat tube through which a specially designed fluoropolymer insulated conductor has been pulled. The heat tube and insulated conductor are joined together at one end, while at the opposite end the heat tube and the conductor are connected across an AC voltage source. The impressed AC voltage will generate a current in the conductor which will return on the inside surface of the heat tube. The concentration of the return current on the inside surface of the heat tube is due to the proximity effect caused by the magnetic flux linkages originated by the currents in the insulated conductor and the return pipe. The return current penetrates into the pipe a distance termed the “skin depth.” The current that circulates in this skin depth causes the heat generated by the heat tube which is transferred to the surrounding concrete. Due to the phenomena described, there is virtually no measurable voltage on the outer surface of the heat tube, allowing the system to be grounded at both ends and at intermediate points if desired. The skin effect principle is further explained on page 3 of this guide.



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The Skin Effect Principle . . .

The current density in a conductor carrying alternating current is not uniform over the cross section of the conductor, but rather is greater near the surface, thereby displaying a phenomenon known as “skin effect.” The effective current-carrying cross section of the conductor is therefore reduced and thus its effective resistance is increased. Skin effect in a conductor is brought about by the self-induced electromotive force set up by the variations in the internal flux in a conductor and has a greater effect the higher the frequency of the alternating source.

The skin effect phenomenon is illustrated in Figures 1, 2 and 3. When an AC voltage is applied to a steel bar, as shown in Figure 1, alternating current flows on the outer surface and not through the central core.

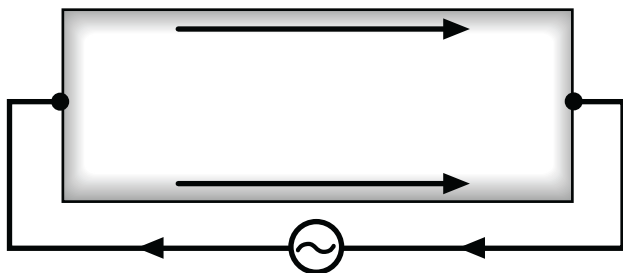


Figure 1

Figure 2 shows what happens if the steel bar is now formed into a tube. The current still flows on the outer surface of the tube (with current inside the tube still at zero).

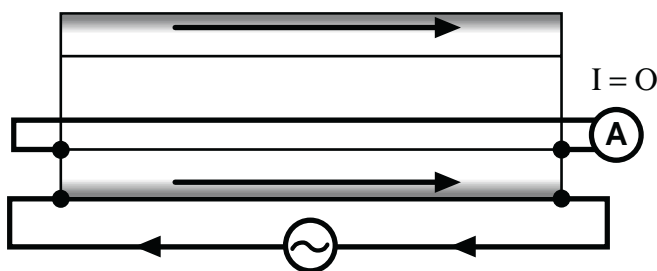
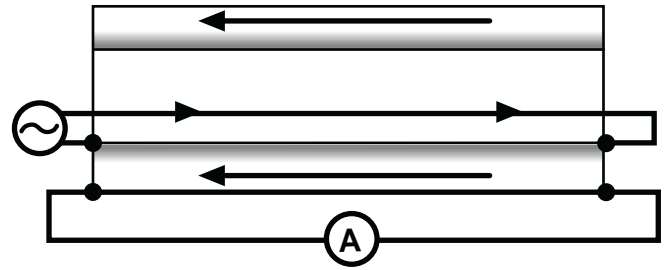


Figure 2

Figure 3 shows a voltage source connected between a central conductor contained within the tube and then subsequently to the tube itself. The alternating current in this case appears exclusively within the insulated power conductor and returns on the inner surface of the tube (no current now flows on the tube's outer surface).



$$I = 0$$

Figure 3

The connection method of Figure 3 is the basis for SnoTrac skin effect heating systems. Because the areas requiring snow and ice melting will typically have rectangular or irregular shapes, the heat tube layout must follow this shape. To accomplish this, a series of pull boxes and curved sections of heat tube (capable of continuing the skin effect phenomenon) are used. Additional power connection and end termination boxes complete the circuit while protecting the connections from moisture and exposure.

The use of carbon steel pipe as the heat tube provides excellent ferromagnetic properties, and the skin effect of schedule 40 carbon steel pipe is excellent when AC voltage of standard commercial frequency is used. It should be noted that this is not true of copper and other nonmagnetic materials unless special high frequencies are used.

Generating Heat Via the Skin Effect System . . .

Skin effect heat tracing uses the induction effect not to generate heat but to increase the effective resistance of a portion of the heating circuit by concentrating the current-carrying path to only a small portion of the conductor's cross section. It is this increased resistance of the carbon steel pipe that generates the majority of the heat for a SnoTrac system. (Some unavoidable I^2R heating occurs within the SnoTrac conductor as a result of carrying the supply current to the skin effect end termination box.)

While the electrical current (and therefore the heat) is generated on the inner surface of the heat tube, the heat generated will dissipate from the tube into the surrounding concrete to increase the surface temperature of the slab to a designed level high enough to melt snow and ice without causing damage to the slab or the system.

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Simplified Wiring Diagram . . .

The skin effect system consists of a steel tube as one conductor of an electrical AC circuit while the insulated copper conductor wire inside the steel tube is the other conductor. The induction and electromagnetic effects of the alternating AC current flow in the copper wire develops a skin effect in the inner wall of the tube which limits the penetration depth of the AC flow to an identifiable depth.

With a ferromagnetic steel tube, this effect results in a total absence of current in the outside layer of the tube; therefore, the steel tube can be grounded anywhere along its length and be secured to any reinforcing steel used in the slab without causing current drain. The reinforcing steel can also be grounded at any point. In addition, the steel tube provides mechanical and moisture protection for the inner copper conductor cable.

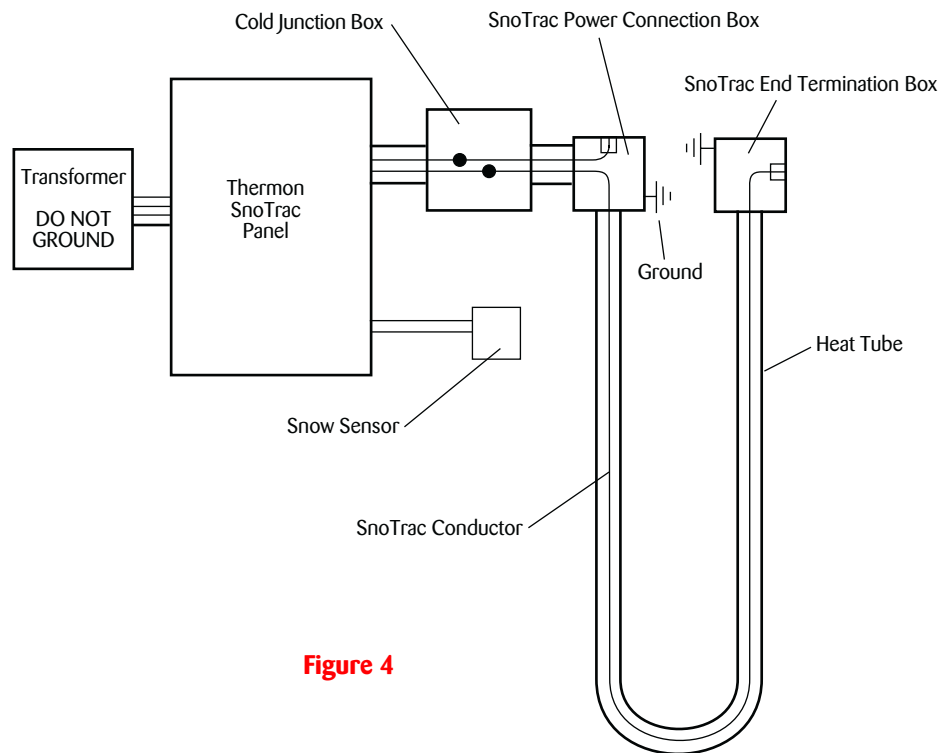


Figure 4

Included With Each SnoTrac System From Thermon . . .

Typically the scope of proposed work includes the design, fabrication and supply of a SnoTrac skin effect system for the prevention of snow and ice accumulation from surface areas protected by the system. The Thermon scope of work includes:

- Calculating the heating requirements based on the design parameters provided by the system owner or his agent. If necessary, the impact of an alternate heat requirement may be presented to facilitate the decision/selection process regarding the level of protection required.
- Selecting the heat tube size and the SnoTrac conductor.
- Verifying performance using finite element analysis.
- Designing of SnoTrac transformer and selecting the secondary voltage required to feed the heating system.
- Designing and supplying (if necessary) a current balancing load center to feed electrical power to the heating system.

- Designing and supplying ancillary equipment consisting of cold junction boxes, power connection boxes, end termination boxes and pull boxes.
- Providing engineered drawings showing heat tube routing, all box locations, electrical wiring diagrams, field connections, transformer connections and power distribution and control panel connections.
- Supplying specifications for the carbon steel heat tube, couplings and related accessories.
- Supplying specifications for installation, welding and testing of heat tube, couplings and related accessories.
- Supplying operation and maintenance manuals for the SnoTrac heating system.
- Supplying technical assistance consisting of field visits and necessary inspections.
- Commissioning, start-up and training of maintenance personnel responsible for the SnoTrac system.



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Advantages of a SnoTrac System . . .

- Installation is simple and techniques used are well known, frequently implemented procedures for the trades involved.
- All of the installation materials required, with the exception of the SnoTrac conductor, are readily available.
- The system is safe. There is no potential from the heat tube to ground. Excellent mechanical protection is provided for the SnoTrac conductor by the rugged heat tube.
- Safe to use in hazardous areas (electrically defined as Class I, Division 2).
- One circuit can provide the equivalent heat to an area six times the size of a resistance heating cable.
- Ease of maintenance. The SnoTrac conductor can be removed and inspected or replaced without disturbing the concrete structure.

Questions & Answers About SnoTrac Systems . . .

- Q** At what primary and secondary voltages does a SnoTrac system operate?
- A** A SnoTrac system can usually be designed to use standard commercially available voltages from 277 to 480 Vac as the primary feed. Secondary voltages are obtained through special transformers designed to optimize the power and layout requirements of the specific installation. These secondary voltages will customarily be 480 Vac or less.
- Q** What are the watt densities possible with a SnoTrac system?
- A** The typical watt-per-linear-foot output of a SnoTrac system is 45 to 50 watts. Many applications may only need this heat/power output and will therefore require 12-inch center-to-center heat tube spacing. Where the design requires higher thermal demands, the spacing of the heat tube is reduced.
- Q** How many power points are required to supply power to a SnoTrac system?
- A** A single SnoTrac circuit can extend 2,000 linear feet. Typical installations of SnoTrac systems have circuit lengths ranging from 800 to 1,850 feet.
- Q** Does a SnoTrac system generate Radio Frequency Interference (RFI)?
- A** SnoTrac systems are designed to operate at commercial frequencies (50/60 Hz) and do not cause RFI.

- Q** How reliable is SnoTrac?
- A** Given the basic system components (i.e., carbon steel heat tube, SnoTrac conductor, power transformer and power distribution equipment), a SnoTrac system is considered a highly reliable heat tracing system. The fact that the conductor is shielded from physical abuse by the heat tube makes SnoTrac the most durable system available.
- Q** Will a SnoTrac system operate during a period of reduced power or brownout conditions?
- A** Yes! Basically, the reduction of power would not affect the operation of the system other than possibly reducing the heat output relative to the amount of voltage drop. However, associated control functions such as transformers, contactors and sensors may not function as intended; therefore, it is not recommended that the system be operated in an under voltage condition unless it is an emergency situation.
- Q** Is a SnoTrac system compatible with cathodic protection systems?
- A** The currents generated in the heat tube do not penetrate the wall of the heat tube. The probability of stray currents is therefore eliminated allowing the heat tube and any reinforcing steel it contacts to be electrically grounded. It can be safely stated that a SnoTrac system is compatible with cathodic protection equipment since no electrical interaction exists between the two systems.
- Q** What is the general makeup of a SnoTrac conductor?
- A** SnoTrac conductors are manufactured using a nickel-plated stranded copper conductor to allow maximum flexibility during installation. The outer jacket consists of an abrasion and heat-resistant fluoropolymer covering a primary dielectric fluoropolymer insulation. The size of the conductor and the thickness of the insulation jacket is dependent upon the power/heat requirements and operating voltage of the system.
- Q** What spare parts are required for a SnoTrac system?
- A** Depending upon the power distribution equipment, the typical spare parts kit will consist of spare indicating bulbs, power fuses and spare SnoTrac conductor. Actual quantities of spare parts are recommended on a per system basis.

General Specification

Part 1 . . . General

1. Design, furnish and install a complete UL Listed and Factory Mutual Approved system of heaters and components approved specifically for snow and ice melting. Heating system must be suitable for direct burial in concrete. The heat tracing system shall conform to ANSI/IEEE Standard 515-1997 and IEEE Standard 515.1-1995 and comply with manufacturer's installation instructions in its entirety. No deviations are allowed.
2. The heating system to be utilized is described as a "skin effect heating system" and consists of ferromagnetic heat tubes, a removable single conductor 600 Vac rated skin effect conductor, load and control equipment, snow sensor and all necessary installation accessories. System parts, design technology and installation inspection shall be by the manufacturer. Use of direct buried electrical resistance heating elements are not allowed except where specifically indicated on the plans and only as described in Specification Section 16XXX.
3. Number of circuits to be determined based on system design and performance requirements (see Part 3). Heat tubes are to be spaced to provide the watts per square foot necessary to meet the system performance requirements in areas indicated on the drawings. The heat shall be generated in the skin depth of the heat tube.
4. The system shall use 480/277 Vac as the primary power supply. Circuits will be fed from dedicated transformers supplied by the skin effect manufacturer, which shall be sized to provide the power required to feed the circuits.
5. The configuration of the circuits shall balance the skin effect heat tube loading of the three-phase supply across all three phases. Should the design have an even number of circuits, the isolation transformer shall be a three-phase to two-phase type. Number of transformers required and their size shall be determined by the system designer.
6. Voltage of the skin effect circuits shall not exceed 480 Vac.

Part 2 . . . Products

1. Heat tubes shall be schedule 40 carbon steel tubing either seamless or welded equal to ASTM A-53. The heat tube size shall be as determined by the manufacturer. Inside wall surfaces shall be free from roughness, scale or other projections that can be damaging to the skin effect conductor. Sharp edges are unacceptable. Bent tubing, equal to ASTM A-53, of an equivalent diameter may be used if required by the manufacturer.
2. All couplings shall be weld couplings equal to ASTM A-53. All couplings shall be welded over 100% of the joining surface.
3. Heat tube shall be supplied by the installer.
4. Skin Effect Conductor: A bare stranded wire is extrusion jacketed with a fluoropolymer dielectric insulation. A second fluoropolymer scuff jacket is then extruded over the composite. Jacket thicknesses are 0.030 inch for the primary insulation and 0.012 inch for the scuff jacket. All jacket thicknesses given are the minimum allowable. Jacket shall be minus zero to plus ten mil extrusion tolerance. Jacket material composition shall be virgin fluoropolymer resins. The power conductor wire shall utilize stranded 50 micro-inch nickel-plated soft annealed concentric/copper wire. Gauge size and stranding configuration to be specified by the skin effect manufacturer.
5. Manufacturer shall submit, as part of the design package, results obtained from conducting the following tests for the skin effect conductor on a routine basis:
 - a. Spark Test—During manufacturing (extrusion and cooling), each foot of power cable conductor must withstand an in-line spark test of 10,000 volts minimum at a line speed of 10 ft./sec. or less. Should a fault occur, the location must be marked/noted; and upon completion of the primary jacket extrusion run, the cable shall be re-spooled and any faults located, removed and discarded.
 - b. DC Voltage Dielectric Withstand Test—Upon completion of manufacturing, all power cables must withstand a DC voltage of 10,000 applied for five minutes between the conductor and water in which the cable is immersed. Cable must be immersed for a minimum of 6 hours prior to testing. (The cable shall be initially tested at a level of three times the rated AC voltage for 15 seconds, followed by exposures in steps where each step increases the voltage by 2KV for a period of 15 seconds prior to reaching the five-minute test level.) Test failure happens when an arc or breakdown in the insulation occurs. All portions of the cable which do not pass this test will be removed and rejected.
 - c. AC Voltage Dielectric Withstand Test—A 10-foot sample from every continuous extrusion run will be immersed in water and hi-potted to 2,200 Vac. Maximum voltage will be applied for one minute. (The cable shall be initially tested at a level of two times the rated AC voltage for 10 seconds. The cable is then exposed at steps in voltage of 500 Vac for a period of 10 seconds at each level prior to reaching the one-minute test level.) Test failure is defined when an arc or breakdown in the insulation occurs.
 - d. Dimensional Measurements—Samples of extruded power cable conductor, 6 inches in length, will be taken at the beginning and end of every continuous extrusion run. Each sample is measured for dielectric and nominal diameter of wire. Results must meet requirements of the specification.
 - e. Marking and Identification—All power conductor cable reels will be tagged with production information. In addition, the scuff jacket shall be continuously printed with the manufacturer's name, dielectric type, wire gauge (AWG), wire type, voltage rating and catalog number.



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Snow and Ice Melting Skin Effect Heat Tracing

6. Pull boxes, expansion boxes and power/termination boxes shall be as required by the skin effect system manufacturer. Boxes shall be epoxy-coated and fitted with watertight lids. Boxes requiring power connection or earth grounding shall utilize copper tabs.
7. Panel: Control panel, including circuit breakers and contactor, shall be weatherproof and waterproof NEMA 4X, suitable for outdoor operation. Panel shall include all necessary terminal strips and internal wiring. Control system shall include differential current monitors for ground-fault protection.
8. Control System Components: The control system for the skin effect heating shall be designed by the manufacturer and shall consist of a Programmable Logic Controller (PLC), relay switches, contactors, meter relays or current sensing relays and ammeters for control of amperage levels in the heating circuits. Also included (and in a separate panel if advantageous to do so) is an emergency stop button and indicating lights to identify system status, including system OK, system fault, heaters ON and individual circuit lights indicating heaters are ON.

Part 3 . . . System Performance

1. Snow and ice melting system shall be designed to keep the surface clear of snow and ice when the ambient air temperature is at or above ____°F and wind speeds are at or below ____ mph.
2. System performance shall be based on a heated surface temperature of 32°F (minimum) during the snow melting process. Start-up in cold concrete shall be used for circuit breaker sizing only.
3. Manufacturer to submit finite element analysis (FEA) of a cross section of the slab area as generated on an ANSYS FEA computer-assisted design program. The intent of the design program is to verify the worst case environmental conditions under which the snow melting system will be capable of operating. The program shall show as a minimum the inch-per-hour snow melting capabilities based on three different sets of operating conditions consisting of ambient temperature, relative humidity and rate of snowfall.

Part 4 . . . Installation

1. The snow and ice melting system shall be installed by the skin effect manufacturer.
2. It is the contractor's responsibility to coordinate all the requirements of the skin effect system manufacturer with the site specific installation requirements. These requirements include, but are not limited to, the fabrication and/or procurement of all pull boxes, expansion boxes, power/termination boxes and termination components and details, adequately sized control wiring, power conductors, etc.
3. Schedule 40 carbon steel heat tube is to be laid in the topping slab prior to the installation of the reinforcing steel and

placement of concrete. Tubes are to be supported by chairs as indicated on the installation drawings. Reinforcing steel can be secured to the heat tubes with tie wire. Tubing should be located a minimum of 2 inches, but not more than 3 inches, beneath the finished slab surface. Particular attention shall be paid to expansion, construction or working joints in the concrete of structural or topping slabs. Expansion boxes shall be provided where required. Ream out the ends of each piece of heat tube. The bevel should be approximately 10°. Swab the inside of the heat tube to ensure that all cutting oil, metal filings and other debris is cleaned out. Filet weld 100% of the circumference of the coupling to prevent the possibility of concrete penetrating the inside of the heat tube.

4. Install the power/termination, expansion and pull boxes per manufacturer's instructions and layout drawings.
5. Prior to pulling the power wire conductor through the assembled heat tube, swab out the entire length from pull box to pull box to ensure that the inside of the heat tubes are free from debris and obstructions. Pulling compounds are not required. The pulling tension must not exceed 300 lbs.
6. Provide and install all power wiring required from the transformer to the circuit breaker, from the circuit breaker to the control panel, from the control panel to the heating circuit power termination boxes. Make cold lead power connections to the snow melting cable per the manufacturer's recommendations.
7. Set transformers, control panel, disconnect, etc., where indicated on the plans or described in the installation instructions.
8. Make all necessary power connections between the transformer, circuit breaker, control panel, automatic controller and heater power terminations.

Part 5 . . . Testing

1. All heat tube joints shall be visually inspected by a representative of the manufacturer to ensure that all are welded per the manufacturer's instructions.
2. Skin effect conductor shall be tested with a 2,500 Vdc megohmmeter (megger) between the conductor and the heat tube prior to making any end terminations. While a 2,500 Vdc megger test is recommended, the minimum acceptable level for testing is 500 Vdc. Cable resistance to ground shall be greater than 20 megohms regardless of the conductor length. Note: The ends of the electrical cable shall not be connected until after this test is performed.
3. Initial start-up of the snow melting system shall be done under the supervision of the manufacturer to ensure proper system operation.
4. All control and safety devices shall be operated and system operating data shall be checked against design calculations. Detailed operating instructions shall be provided by the manufacturer.



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