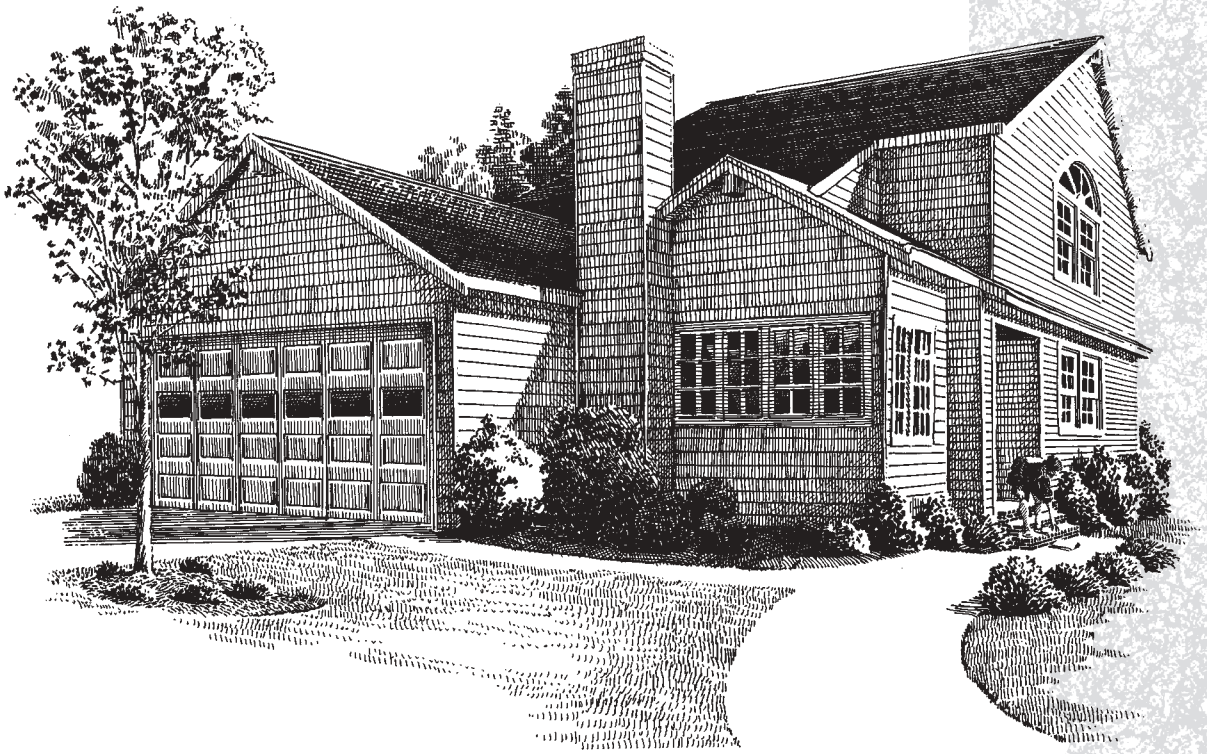


Floor Cable Installation Guide

A publication of Minnkota Power Cooperative and the associated systems

INSIDE

Electrical Thermal Storage Floor Cable Installation Requirements

A large number of installations and considerable experience (15+ years) indicates **correct installation** is the key to long-term performance and reliability. The following basic installation requirements **must be followed** 100 percent to fulfill quality heating system requirements.

System Requirements

1. Perimeter insulation, two to four inches of rigid, waterproof Styrofoam, is required on the foundation wall. Extend the insulation at least four feet down or to the footing. The edge of the concrete slab is required to have the same amount of insulation. The slab **must not** extend to the foundation or the outside wall. All exposed insulation must be covered with aluminum flashing or a thick and rigid exterior plastering system. Also acceptable is a concrete bond especially designed for protecting exterior and exposed high density rigid board insulation.

The exterior protective flashing or plaster must be installed in a way that will prevent rodents from chewing through the insulation or otherwise gaining entrance to the sand and cable under the floor.

The flashing or plaster covering over the exterior surface of the rigid board insulation must cover all rigid board surface above grade and must extend to a depth of 2½ to 3½ feet below the grade surface. *See diagram below.*

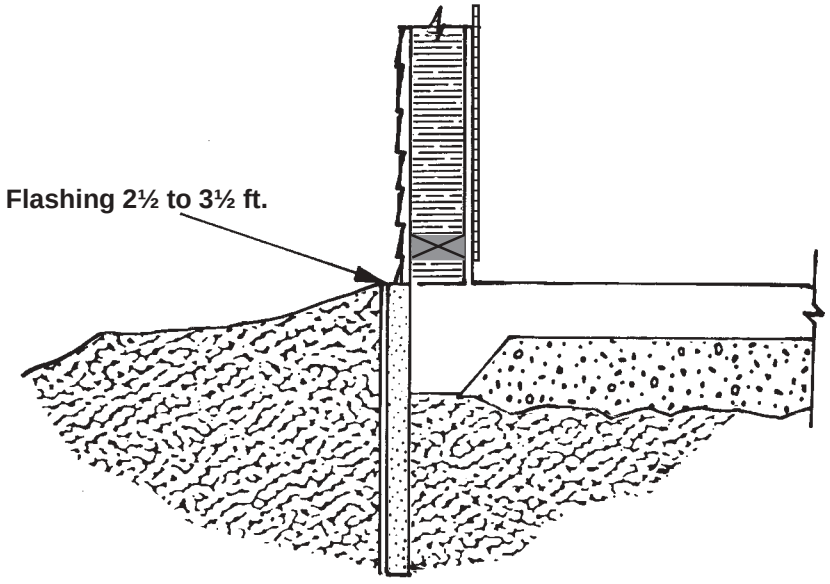
Horizontal or flat insulation under the sand is not required and, in fact, only complicates the process. The only exception might be a high water table; in this case, call your local utility for advice.

A four to six mil continuous vapor barrier between the sand and concrete is an important requirement. The vapor barrier must be specified for ground contact.

2. The slab base **must** be 10 to 12 inches of sand over undisturbed soil. This sand base **must be free of rocks, broken concrete pieces, and construction debris.** This is critical so that sharp edge debris does not damage the cable or penetrate the vapor barrier. Screened sand works best. (Pea rock or gravel is not acceptable.)

3. The sand must be leveled to the exact slab reference depth prior to cable installation.

4. Drive all leveling and forming stakes prior to cable installation. Once the cable has been installed into the sand, no further holes, disturbance of the sand base, or penetration into the sand base is allowed. No blind stakes are allowed after the cable has been installed. Sand must be thoroughly tamped and leveled to the exact slab reference depth again after cable installation to prevent settling.



5. Size the cable for the floor area or each zone according to the procedure listed on page 12, plus any additional procedures or requirements contained in the manufacturer's instructions and installation procedures. The complete roll of cable must be properly placed in the floor. **Excess cable cannot be cut off** or simply left lying in the sand. At this point prepare a rough map or sketch of the zone layout, cable spacing, in-line splices, and any other information necessary to effectively install the cable. If you have questions concerning sizing or layout, call your local electric cooperative.

6. Prepare an **accurate scale drawing** of the floor area that includes a map of the actual as-installed cable and zone areas and any in-line splices used. When completed, this scale drawing should be complete and accurate enough to facilitate future maintenance or repair work as needed.

7. Select an optimum location for the cable leads to enter the side wall at a J-box. This is a **starting point**. The cable "cold lead" and "hot-to-cold" junction must be in the sand below this starting point. This area must be carefully noted and described on the final floor layout drawing. All cables can be terminated directly at the junction box even though several cables are used for a specific installation.

8. Access to "hot-to-cold" lead splices should be made by installing a wooden frame around the leads at the base of the conduit in the concrete. Fill this wooden frame with sand and cover with a thin layer of concrete. This allows easy access should the need arise. Each standard cable roll has two 10-foot "cold leads." This represents standard hookup type wire that can be run in conduit or crossed. Examine the reel and determine where the "cold leads" end and locate the "hot-to-cold" junction. This "cold lead" should be coiled and left in the wood-framed box at the base of the conduit. The copper braiding surrounding the cable must be brought and connected to the J-box. Do not cut or tape this end. Twin cables also have splices on the end of the cable that need special attention. The manufacturer's installation instructions should be reviewed and carefully followed. **Be sure to replace any labels that are removed from the cable ends.**

9. The conduit (¾-inch or larger) carrying the "cold leads" must terminate in the sand. When several sets of leads are carried in the same conduit, they should be taped in pairs. Protect the conduit ends with proper bushings. The "hot-to-cold" junctions must be spread at least three inches, and from this point on, the heating cable must always maintain a **minimum horizontal spacing** as specified by the cable manufacturer. The minimum horizontal spacing is usually four to seven inches. *To calculate distance for proper cable spacing, use the formula below.* The spacing of the back and forth pattern is determined from heat loss calculation data and the manufacturer's data concerning watt per foot heating capacity and standard lengths for a specific type cable. It is best to leave an 18-inch space along all outside walls that have no cable because this area **is** prone to settling.

Cable Spacing Calculation Procedure

_____	x	_____	=	_____		
SLAB LENGTH - 2 FT.		**SLAB WIDTH - 2 FT.**		**TOTAL USEABLE AREA** (sq. ft.)		
_____	x	**12**	÷	_____	=	_____
TOTAL USEABLE AREA (sq. ft.)		**INCHES/FT.**		**TOTAL CABLE LENGTH** (ft.)		**SPACING IN INCHES**

Remember to subtract the square feet of area lost to pipes, footings, edge void area, etc. from the gross floor area to determine the net floor area into which cable can be installed. In some cases the amount of net floor area may be the limiting factor for the amount of cable that can be installed.

10. Typically, the cable laying task begins at the "hot-to-cold" lead junction. From this starting point, you go around the perimeter to the farthest corner. At the farthest corner, you begin a back and forth laying pattern to where you finally return to the starting point. For single conductor cable, the "cold lead" needs to continue to the starting point and up the conduit for termination. With dual conductor cable, the cable installation is complete upon returning to the starting point location. Termination of this end is not required. See diagrams on pages 8 and 9.

It is very important that the location where dual conductor cables end be shown on the scale drawing of the project.

11. The cable must be ohmmeter tested at least **four times** during the full installation cycle for continuity. It must also be insulation tested twice during installation. Continuity of the ground conductor must also be checked.

a. The cable should be insulation and continuity tested at the beginning of installation, before the cable is removed from the reel.

b. Continuity testing should be done after the cable is plowed in.

c. Continuity testing on cables with two ends must include testing of heat conductor to ground, heat conductor to heat conductor, and ground to ground.

d. Insulation and continuity testing should also be done prior to the beginning of the concrete pour.

e. Continuity testing should be done at the end of the concrete pour, prior to troweling.

For continuity testing, check the center insulated wire to the braided copper ground for opens, shorts, and continuity between both ends of the center insulated wire.

For insulation testing, use a 500 volt DC megohm meter. Measure and record the insulation resistance of each cable. This reading is taken between the center insulated wire and the copper braided ground. Minimum accepted reading is one megohm.

12. Each standard cable reel has a marking indicating the midpoint of the cable. This can be used as a bench mark to determine whether all of the cable will fit into the laying space.

13. Install the heating cable at a **depth of at least six inches below the bottom of the slab.** The actual depth, six inches or deeper, will be determined by the length of storage heating time or the maximum time electric power is to be cycled off. This must be done in a uniform method so that the selected spacing is maintained throughout the building. It is extremely important to turn the plow in such a manner to prevent cable bunch up, cable overlap, or the cable end from being too close to the perimeter run. Again, it is imperative that the heating cables never cross, twist to cause a cross, or are placed closer than three inches to each other, whether it is an adjacent run or whether it is at the point where the cable turns.

The deeper the cable, the greater the heat storage capacity.

14. The following are suggestions for controlling the quality at the turn:

a. Open a trench at the point of turn around. This will allow you to see all the cable turns and make sure they are uniform and each new run begins with correct spacing.

b. Use wooden stakes or two- to three-inch PVC pipe at the turn point and move the plow shoe as close as

possible around the stake. After progressing about four feet past the stake, pull on the cable so it is snug against the stake.

c. Ideally, this is a two-person installation project. One pulls the plow, the other holds the cable in place at the beginning or during turns and curves.

NOTE: At no time whatsoever, regardless of separation depth, shall the heating leads of the cable cross or be closer than three inches. At any point where the heating leads cross or the spacing is closer than three inches, a failure may result.

15. In the case of floor drains, lay cable in such a manner that spacing will not affect adjacent cable. Turn the plow and **loop** back and forth until the next run will be sufficient to pass the floor drain. Avoid areas under tubs and showers entirely. See diagrams on pages 8 and 9.

16. Each zone requires two thermostats: a control thermostat to sense slab temperature and a high temperature limit thermostat to monitor surface temperature of the cable. A ¾-inch rigid conduit with capped end must be prepared and installed as shown in the diagram on page 6 for the thermostat sensing unit. Notice this thermostat conduit is placed in the concrete two inches below the top surface of the concrete and at least two to three feet away from the side wall. Minimum radius for all bends must be seven inches.

17. The high-limit sensing unit **must be installed** and run adjacent to the heating cable at a point having a representative temperature of the area. For protection of the capillary tube, this should also be run in ¾-inch conduit and placed before the concrete is poured. Be sure to have a 1½- to 2-inch separation of conduit and cables.

18. Just before the continuous vapor barrier is installed and the concrete is poured, wet the sand with a fine water spray to help compact the sand and prevent the concrete from curing too rapidly. You must install a continuous vapor barrier at this time. The contractor should advise all workers of cable location and warn them against digging or drilling holes after the cables are in place. **Ask workers to report any possible damage to the cables during construction so that repairs can be made before the pour is completed.** All repairs must comply with standards established by the applicable code enforcement authorities. All wiring and installation must be performed in accordance with UL requirements, the National Electrical Code, and all local codes and specifications.

While pouring the concrete, use only flat shovels and blunt leveling equipment. Sharp end shovels and sharp spears **should not** be used within the building. Ideally, **a work foreman should have an eye on all concrete workers** to make sure they do not stab anything into the sand base hitting the cable. Run all wheeled vehicles on planks or select a concrete transporting method that doesn't cut into the sand base while pouring the concrete.

19. For all installations it is extremely important to obtain a copy of the cable or mat manufacturer's specifications, installation procedures, and requirements.

The procedures and requirements stated by the manufacturer, as well as the quality heating system requirements stated herein, must be followed and fulfilled.

All applicable codes must be fulfilled.

Electric Thermal Storage Floor Mat Installation Requirements

Heat mats are an alternative to installing cable. Site preparation, control, and installation in the sand bed are the same as for cable. Mat sizing needs to be designed for the specific layout. Sizing information must be based on the manufacturer's information and procedures.

Typical Underfloor Heating Installation

1. External grade should be up to slab level. Where this is not done (such as a loading dock), perimeter insulation thickness should be doubled from two inches to four inches.

2a. Thermostat sensing bulb in conduit for controlling slab temperature.

2b. High temperature safety cutout sensing bulb in conduit. Placed near center cable of a mat.

2c. Cold leads of heating cable in conduit.

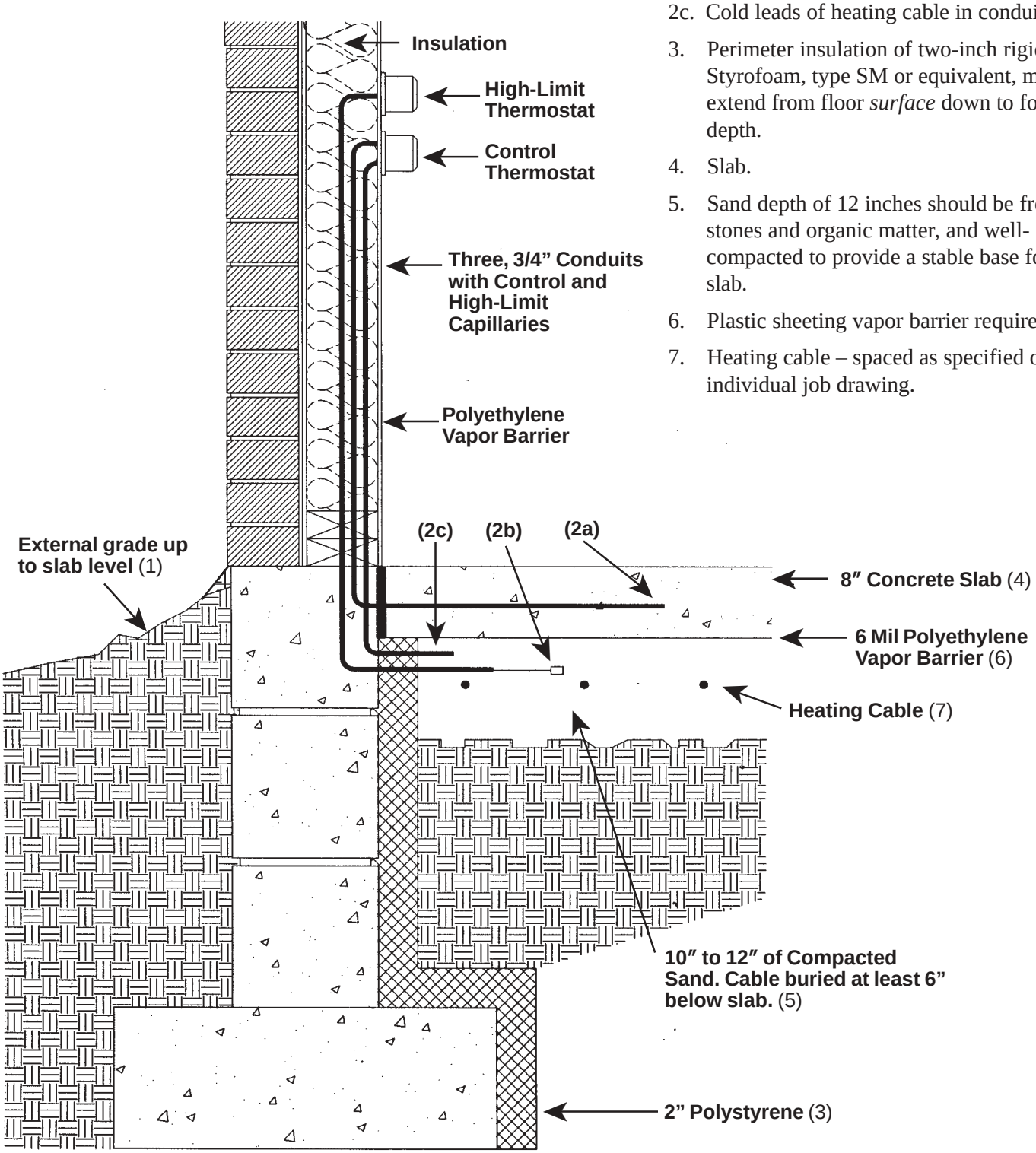
3. Perimeter insulation of two-inch rigid Styrofoam, type SM or equivalent, must extend from floor *surface* down to four-foot depth.

4. Slab.

5. Sand depth of 12 inches should be free of stones and organic matter, and well-compacted to provide a stable base for the slab.

6. Plastic sheeting vapor barrier required.

7. Heating cable – spaced as specified on individual job drawing.



Quality Heating Floor Cable Installation Diagram

Name _____
Account No. _____
Phone _____
Total Wattage _____

Scale diagram of floor cable installation
(Use separate page(s) if more space is needed)
(Indicate thermostats, high limits, junction boxes, room measurements, etc.)

Wattage/Length

Cable 1 __________ Cable 4 _____ \ _____

Cable 2 __________ Cable 5 _____ \ _____

Cable 3 __________ Cable 6 _____ \ _____

Scale: ¼ in. = x ft.

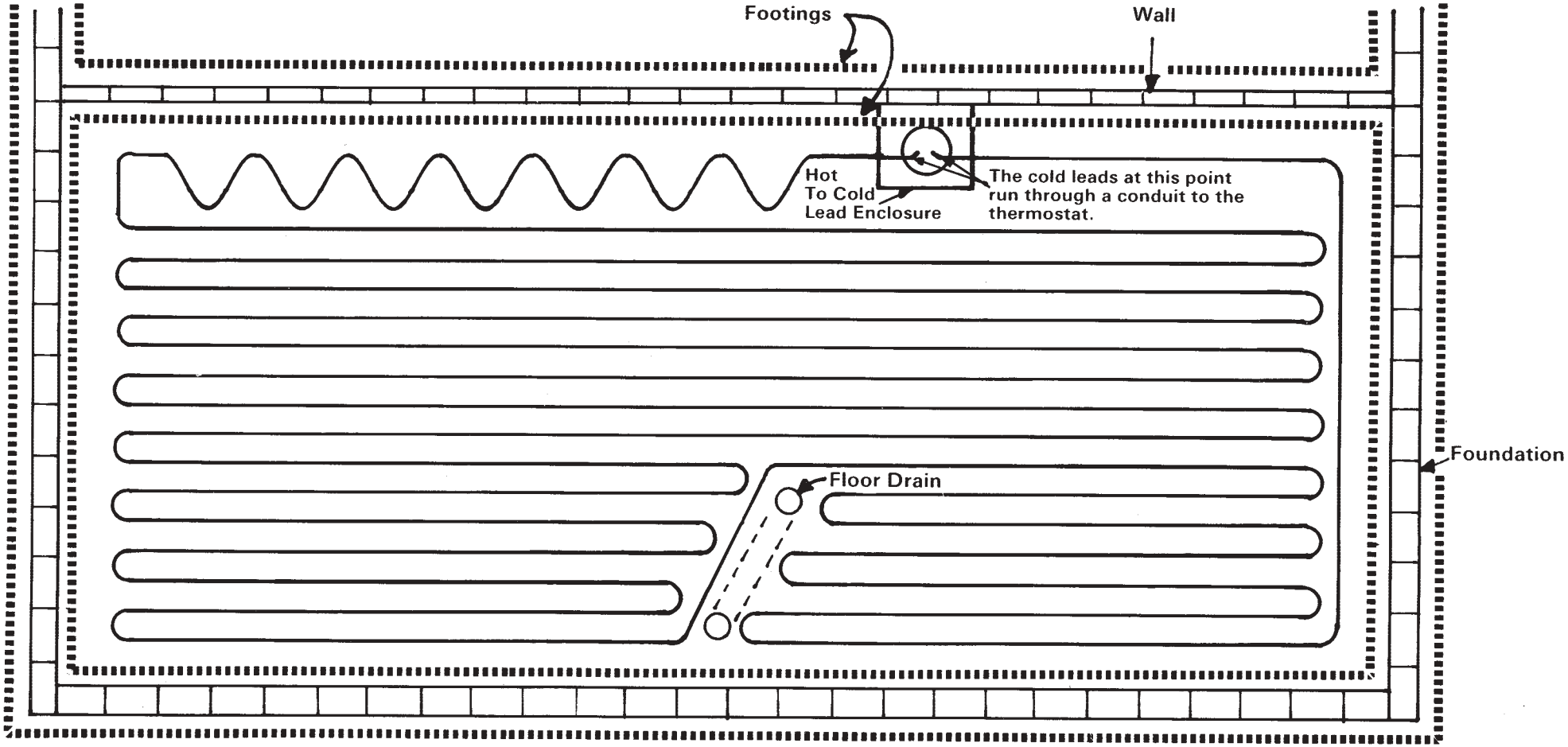
Requirements

- ✓ Vapor barrier on top of sand under slab.
- ✓ Foundation and floor edge insulation.
- ✓ Scale drawing of floor area, detailing accurately the cable configuration and other underfloor components.
- ✓ High temperature control on each thermostat.
- ✓ Must use a screened-type sand. No rocks, pea rock, or gravel.
- ✓ Sand tamped after installation.
- ✓ Cold lead splices located near conduit entrance.
- ✓ Access hole around cold lead splices for future repairs.

Typical Cable Layout

Single Conductor

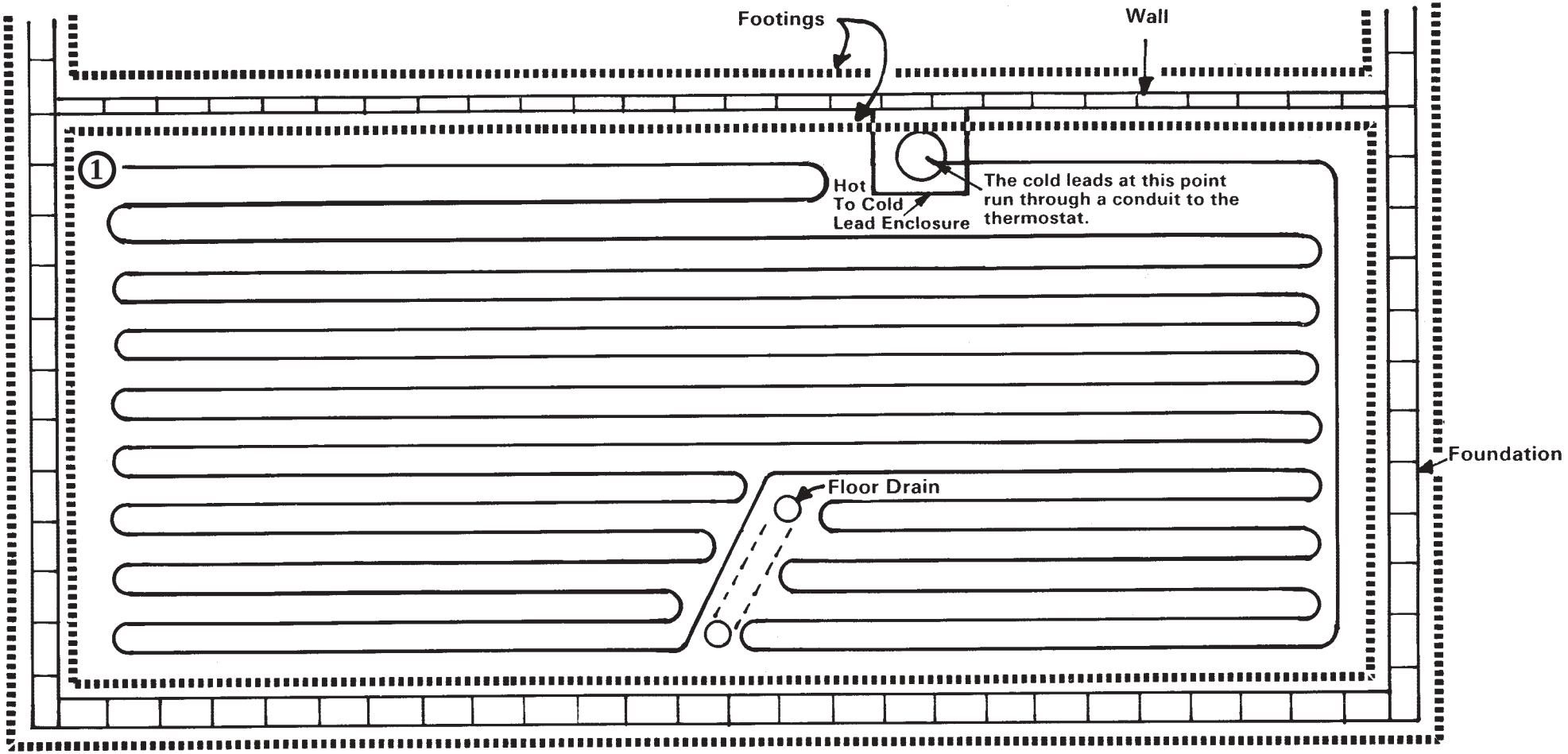
Scale ¼ in. = x ft.



Typical Cable Layout

Dual Conductor

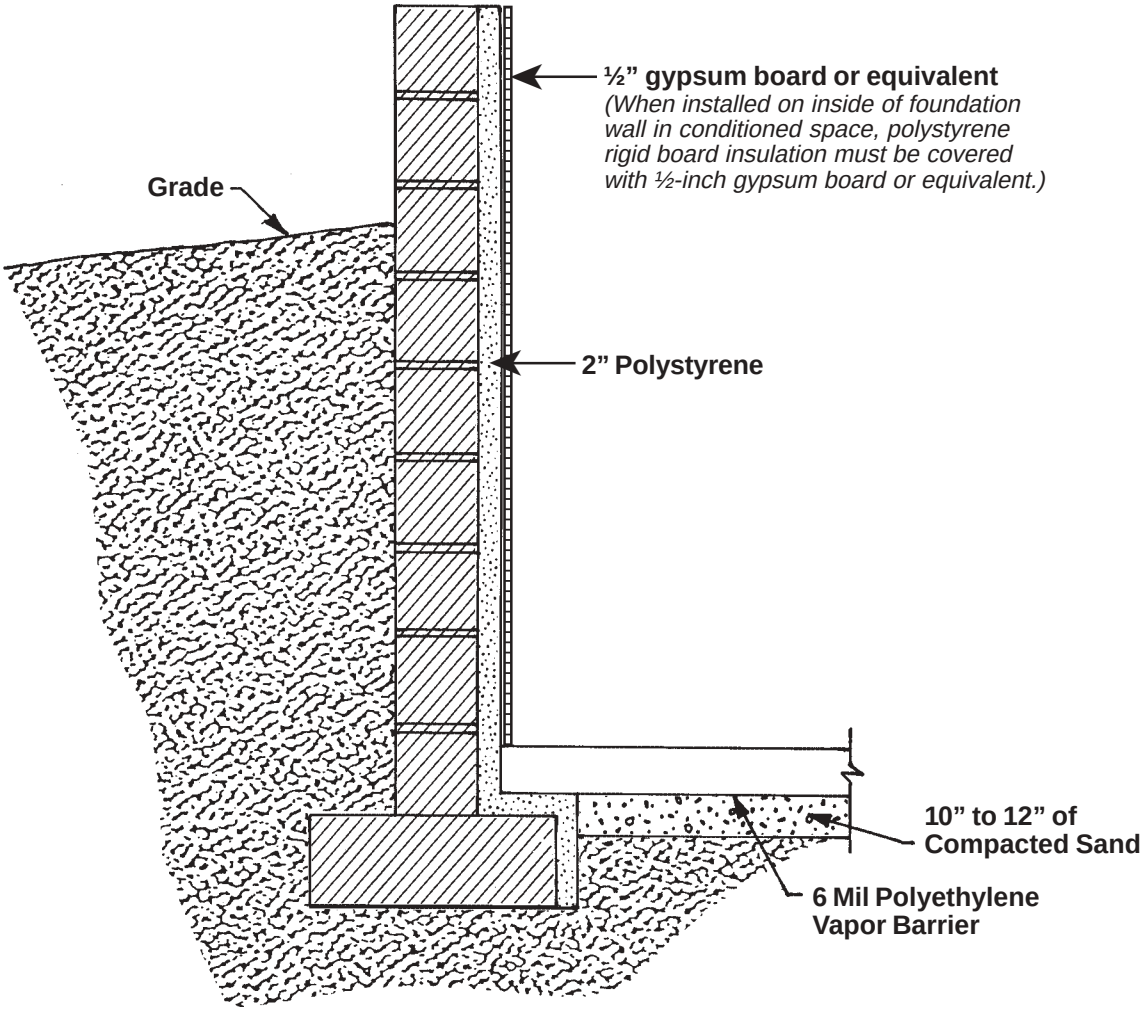
Scale ¼ in. = x ft.



① This end must be accurately marked on the scale drawing of cable layout.

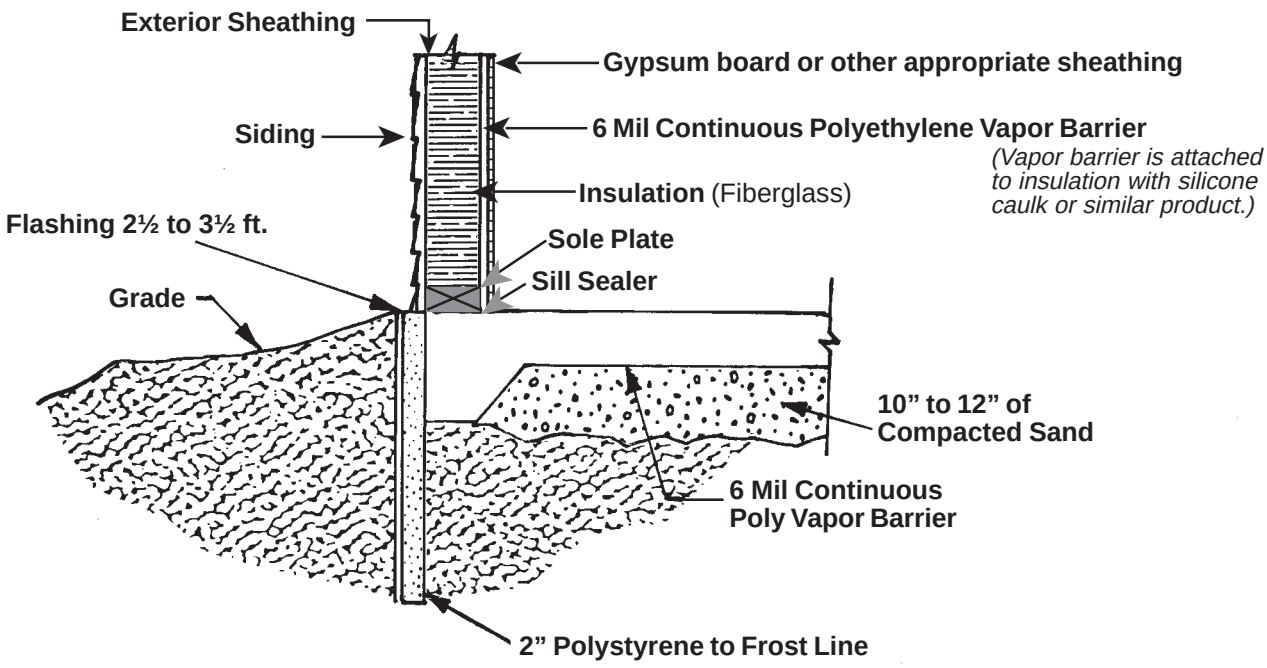
Slab Insulation Techniques

Inside Wall

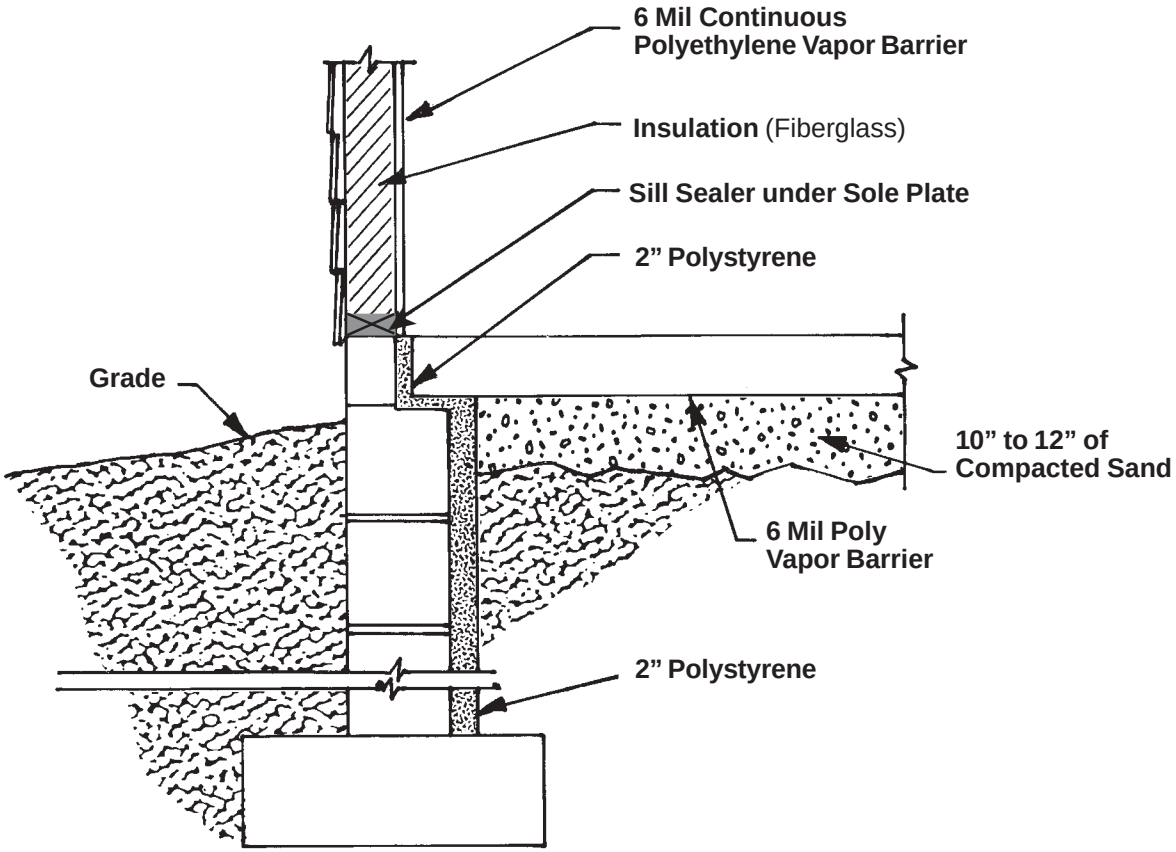


Slab Insulation Techniques

Floating Slab on Grade



Slab on Grade with Footing



Sizing Cable for the Area

There is a maximum cable capacity that can be installed in the sand base and sizing involves several components to determine the optimum cable amount and spacing. These steps represent a guide:

1. To determine a building envelope heat loss, use the standard manual J or other standard heat loss calculation procedure. Building envelope heat loss means the conduction heat loss plus the natural air leakage associated with infiltration and exfiltration leakage. It does not include ventilation make-up air heating or the heating associated with extensive or frequent door openings or other similar air loads. It is always extremely important to follow the manufacturer's cable specifications and literature with respect to choosing cable wattage, layout patterns, and installation practices. To determine the number of cables required, refer to the manufacturer's data concerning standard cable lengths and wattage.

   Example: Based on building heat loss calculation, your building needs 24 kW of heat. Convert 24 kW to watts. 24 kW x 1000 w/kW = 24,000 watts. Refer to the manufacturer's cable wattage and length guide on page 13 and find the largest wattage that will divide into 24,000 watts evenly. In this case, 24,000 watts divided by 4000 watts = 6 cables. You would need six cables that are 495 feet long.

   NOTE: This is the natural building heat loss only and must not include ventilation make-up or recovery for opening doors, etc. Supplementary heat may be required to take care of ventilation and other non-building envelope losses.

2. To determine cable spacing, measure the sand base area and reduce the length and width by two feet. Note: If there are areas such as concrete footings, special plumbing, blocked off areas, sump pump, etc., that you must go around with the cable, and this area is more than about five percent, you will need to compensate for this with less cable.

   Example: Inside measures 40 feet x 60 feet, reduce by 2 = 38 feet x 58 feet.

   - Multiply the width x length by 12 inches. Example: 38 feet x 58 feet x 12 inches = 26,448 inches.

   - Divide by length of cables required. (Six cables at 495 feet = 2,970 feet)
     26,448 inches ÷ 2,970 feet = 8.9 inch spacing.

Cable Spacing Calculation Procedure Example

40 – 2 = 38	x	**60 – 2 = 58**	=	**2,204**		
SLAB LENGTH – 2 FT.		**SLAB WIDTH – 2 FT.**		**TOTAL USEABLE AREA** (sq. ft.)		
2,204	x	**12**	÷	**2,970**	=	**8.9**
TOTAL USEABLE AREA (sq. ft.)		**INCHES/FT.**		**TOTAL CABLE LENGTH** (ft.)		**SPACING IN INCHES**

Example of one manufacturer's standard cable sizes: length and watts

Sizing Cable Guide

for use with
Dual Conductor Earth Thermal Storage Cable
8 watts/ft.

240 Volt Operation

Catalog (Dual Conductor)	Length (Feet)	Actual Wattage	Nominal Amperage
XD102	126	1000	4.2
XD152	190	1500	6.3
XD202	253	2100	8.8
XD252	303	2500	10.4
XD302	369	3000	12.5
XD352*	435	3500	15.0
XD402*	495	4000	16.7
XD502*	661	5200	20.7

* *Indicates those cables using #10AWG Cold Lead*
All other cables use #14AWG Cold Lead
All Cold Leads are 10 feet as standard

- Standard cables are designed for 240 volt operation
- For 208 volt operation, multiply nominal wattage by .75
- For 480 volt operation, series connect two 240 volt cables of equal wattage together in the field

Storage Capability at Typical Cable Spacings

Cable Spacing	Watts per square foot
6″	16
8″	12
10″	10
12″	8
14″	7
16″	6
18″	5

Operational Tips

1. During the heating season, **set the thermostat** between 50 and 65 degrees. If it appears the thermostat must be higher than 65 degrees, there is something wrong with the installation or application.
2. The circuit breakers should be turned off during the summer months.
3. At the completion of installing the cable and before the concrete is poured (not months later), **a scale diagram** must be made showing the basic cable pattern with the various circuits. This will be helpful in the future if a problem develops. Use the approved quality heating floor cable installation diagram on page 8 or 9. Also, leave ID tags on the end of the cold leads for future reference.
4. Carpeting above floor cable is not a problem if it is the correct type. First of all, keep in mind one of the primary reasons for thick, insulated, rubber back carpet on basement floors is to insulate from the cold concrete. With the use of a storage cable system the floor is warm, eliminating the need to insulate the floor. **The recommended type** of floor covering is jute back carpeting without a pad. (Refer to floor covering guide on page 15.) If a pad is used, it is important to keep the pad as thin as practical and not to exceed the recommended floor covering R-value of 3. The thermostat may be set a few degrees higher to compensate for the carpet insulation.
5. At least 60 percent of the **floor area** must be free of flat, tight-bottom surface items that could block radiated heat. Furniture, tables, and shelves that have legs as low as four inches would not be considered a problem.
6. Start heating floor systems early in the fall on lower settings. Gradually increase settings. It takes two to three days to bring slab up to a comfortable temperature level. Increasing temperature settings too rapidly will stress the heating cable and take many years of life out of the floor heating system. The warm days and cold nights in the spring and fall are usually not a problem for slab commercial/farm buildings with minimal windows or for residential basement systems. In the case of slab homes with large window solar gain, the thermostat should be turned down in the fall and spring to prevent daytime overheating.
7. **Very important: Do not** use the heating cable to **dry out** the concrete.
8. A heating cable that is in good condition and has been properly installed will never “burn out.” The normal operating temperatures are below this point. The covering(s) of the cable are such that ground soil conditions will rarely affect the insulating qualities of the insulation.

   Despite good conditions and all precautions, an occasional failure will occur. A failure can be difficult to locate because of the construction of the heating cable with its braided wraparound ground. We have equipment available to locate these faults.
9. For more information on floor cable installations, contact your power supplier.

Installation Tips

1. Cable must **not** touch:
   – Wooden grade stakes
   – Perimeter or any type insulating Styrofoam
   – Any plumbing or other pipes (PVC or metallic)
2. Cable can be in contact with sand only. Avoid clay mixed with sand.
3. Cable should not be taped to high limit pipes. High limit pipe should be one to two inches over the top of cable.

Failure to follow any of the above suggestions could lead to spot burnout or total cable burnout. All of the above conditions have been observed when repairing underfloor cables and all have caused cable overheating failures.

Slab Heating Floor Covering Guide

R - Values of Common Floor Coverings

R-Value	Floor Covering	Tufts/ Sq. In.	Depth (Inches)
0.20	Bare Floor	-	
0.21	Linoleum or Vinyl Sheet Goods	-	
0.22	Ceramic Tile	-	-
0.54	Hardwood	-	3/8
0.55	Nylon Level Loop	86	1/8
0.65	Nylon Level Loop	48	1/8
0.67	Nylon Level Loop	67	3/16
0.68	Nylon Level Loop	80	1/8
0.78	Acrylic Level Loop	80	3/16
0.93	Hardwood	-	3/4
0.95	Polyester Plush	54	1/4
1.03	Acrylic Level Loop With Foam Back	80	1/4
1.12	Nylon Plush	88	1/4
1.33	Nylon High Low Tip Sheared	55	varies
1.51	Nylon Shag	28	1
1.66	Polyester High Low Tip Sheared	54	varies
1.71	Acrylic Plush	44	1/2
1.83	Nylon Plush	80	7/8
1.90	Acrylic Plush	58	11/16
1.96	Nylon Saxony	29	9/16
2.19	Wool Plush	45	1/2
2.46	Nylon Shag	22	1 1/4

Plus Carpet Pads

R-Value	Carpet Pad	Depth (Inches)
0.62	Slab Rubber	
0.78	Waffled Sponge Rubber 48 oz.	-
1.61	Prime Urethane 2.2 lbs. Density	3/8
1.71	Coated Combined Hair and Jute 56 oz.	-
2.09	Bonded Urethane 4 lbs. Density	1/2
2.15	Prime Urethane 2.2 lbs. Density	1/2

Recommendation: Floor covering R-Values should total less than 3.

For more information, contact the energy experts at your cooperative or municipal system

COOPERATIVES

Beltrami Electric Cooperative
Bemidji, MN · (218) 444-2540

Cass County Electric Cooperative
Kindred, ND · (701) 356-4400

Cavalier Rural Electric Cooperative
Langdon, ND · (701) 256-5511

Clearwater-Polk Electric Cooperative
Bagley, MN · (218) 694-6241

Nodak Electric Cooperative
Grand Forks, ND · (701) 746-4461

North Star Electric Cooperative
Baudette, MN · (218) 634-2202

PKM Electric Cooperative
Warren, MN · (218) 745-4711

Red Lake Electric Cooperative
Red Lake Falls, MN · (218) 253-2168

Red River Valley Cooperative Power Association
Halstad, MN · (218) 456-2139

Roseau Electric Cooperative
Roseau, MN · (218) 463-1543

Wild Rice Electric Cooperative
Mahnomen, MN · (218) 935-2517

MUNICIPALS

Bagley Public Utilities
(218) 694-2300

Baudette Municipal Utilities
(218) 634-2432

Fosston Municipal Utilities
(218) 435-1737

Grafton Municipal Utilities
(701) 352-2180

Halstad Municipal Utilities
(218) 456-2128

Hawley Public Utilities
(218) 483-3331

Park River Municipal Utilities
(701) 284-6150

Roseau Municipal Utilities
(218) 463-1542

City of Stephen Utilities
(218) 478-3614

Thief River Falls Municipal Utilities
(218) 681-4145

City of Warren Water and Light
(218) 745-5343

Warroad Municipal Utilities
(218) 386-1873

– Notes –