AHT Technical Brochure for Snow Melting & Ice Prevention

Advanced Heating Technologies Ltd

June 2007

Chapter 1

Introduction

1.1 Scope

AHT currently supplies two families of Snow-and-Ice Melting products:

- Outdoor Underground Heating Ribbons and Mats, normally at 250-500 watts/m^2. Higher outputs can be easily achieved by controlling the spacing between ribbon runs on the ground.
- Pipe and Gutter Freeze Protection / Heat Tracing Ribbons.

Both product families are based on a unique design of fully grounded heat-tracing cables (Heating element) made of amorphous metallic ribbons enclosed in a mechanically strong but flexible enclosure. The heating element is designed per IEEE 515.1 standard for underground and outdoor-exposed applications.

This manual covers AHT's first product family of Snow-and-Ice Melting products − Outdoor Underground Heating Ribbons and Mats. The manual provides general information on these products, and specifies the installation procedures for the field technician.

See AHT's manual on these products for information on AHT's Pipe and Gutter Freeze Protection / Heat Tracing Ribbons.

1.2 Manual Organization

The manual is divided into three chapters and two appendices:

Chapter 1 – Introduction
This chapter outlines the purpose and structure of this manual and gives a general outline of the AHT Snow-and-Ice Melting System.

Chapter 2 – AHT System Description and Main Characteristics
This chapter provides a general description of AHT's Outdoor Underground Heating Ribbons and Mats, describes the Heating element, which is the building block of these systems and gives the main features and specifications of the Heating Ribbons and Mats.

Chapter 3 – Installation Procedure
This chapter provides the field technician with detailed instructions on installing the AHT's Heating Ribbons and Mats, including the tools and materials required to execute the installation.

Appendix A – Outdoor-Heating Specifications
This supplement provides a table specifying the heater and outdoor surface temperatures under different weather conditions.

Appendix B –Cable Connection Diagrams
This supplement gives connection diagrams for heating cables with 1, 2 and 3 wires.

1.3 AHT System General Overview

The AHT Systems are high quality heating devices designed for melting ice and snow covering road and sidewalk surfaces, gutters and ice and snow mounted on top of roofs during dark and freezing-cold winter days (see Figure 1-1). The AHT System is based on a unique and patented amorphous metal heating technology, specifically developed to solve safety hazards caused by harsh cold weather conditions. This product has significant advantages over any other type of hydronic or electrical cables.

The main advantages are as follows:

- Greater surface contact with cold ground or ice
- Innovative design of the heating cable
- Reaching working temperature fast
- Generating heat evenly.
- Energy savings
- Less costly
- Reliable and durable.
- **Installation is extremely simple and easy.**
- **Perfectly safe against electric shock hazards.**

Figure 1-1. Typical Use of AHT Heating Systems during Cold Winter

Chapter 2

System Description

2.1 General

This chapter provides a general description of AHT's Outdoor Underground Heating Ribbons and Mats, describes the Heating element, which is the building block of these systems and gives the main features and specifications of the Heating Ribbons and Mats.

2.2 AHT Heating Element

2.2.1 Heating Element Components

The Heating element is patented and manufactured by AHT, and consists of the following components (see Figure 2-1):

- Coated amorphous ribbon
- Internal coating
- Return lead
  (one or two leads according to the application)
- Aluminum Sheath
- Grounding lead
- External coating
- Flame retardant

2.2.1.1 Coated Amorphous Ribbon

The Heating element is made of amorphous ribbons, with a nominal thickness of 20-30 µm, and various widths ranging from 7 to 25 mm. In certain applications, two parallel (side-by-side) coated amorphous ribbons are embedded in the enclosure.

2.2.1.2 Internal Coating

The internal coating consists of a double-layer (class 2) linear low-density polyethylene with a nominal thickness of 0.5-1.0 mm on each side of the metallic ribbon.

2.2.1.3 Return Lead

According to the application, the heating element may have one or two 1.5 mm^2 leads.
The conductor is made of bare copper, insolated by HDPE of width 0.41± 0.06 mm.

2.2.1.4 Aluminum Sheath

The grounding sheath is made of 50 µm aluminum foil coated with 12 µm polyester at a total thickness of 62 µm. The aluminum side faces outward and fully covers the coated amorphous ribbon and return leads.

2.2.1.5 Grounding Lead

The grounding lead is made of a 1.5 mm^2 tinned copper conductor. The conductor is in full contact with the aluminum foil.

2.2.1.6 External Jacket

The external jacket is made of a black Liner Low-Density Polyethylene (LLDPE), has a nominal thickness of 1 mm (at least 0.9 mm) and a UV additive as required by the application. For outdoor-exposed applications, an FR additive is added to the coating material.

2.2.1.7 Flame Retardant

A PE Flame Retardant concentrate is added to all applications in order to provide self-extinguishing properties. The Flame Retardant meets UL94 requirements.

Note:
Both internal coating and external jacket are characterized by:

- High melting temperature (approximately 120°C)
- Low friction coefficient
- Good abrasion resistance
- Good petroleum-jelly resistance
- Low water absorption
- Well-dispersed, highly effective UV stabilizer in sufficient amount to ensure excellent weathering resistance

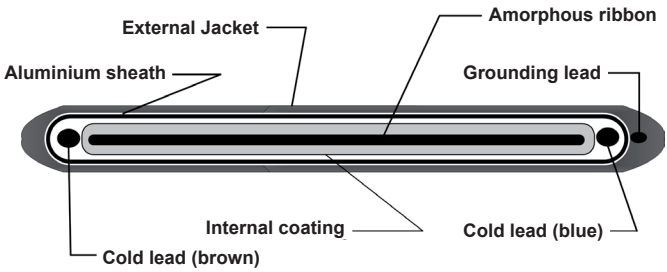


Figure 2-1. AHT Heating Cable Components

2.2.2 Heating Element Performance

The heating element possess a fixed power per meter length. Thus, using different widths of amorphous ribbons and different length of the element, one can easily set the required output

power per linear meter. The upper limit for the heating element is 62 watts per meter. This limit corresponds to 5A on a single unit. The heating element can be driven by various AC or DC power sources: 110-120, 208, 220-240, 400 and 600 Volts, as long as the current limit is met.

The heating element's upper working temperature limit is 70°C.

The two embedded electrical leads enable the connection of sequential heating elements to form long heating elements (up to 100 m long), which are fed from a voltage supply located only at one end of the cable.

2.3 AHT Heating Mat

2.3.1 Purpose and Use

The Outdoor Underground Heating Mat is designed to be laid beneath concrete, asphalt, paving stones, or gravel surfaces, and provides a safe solution against hazards caused by harsh-cold weather conditions in the following sites:

- Pedestrian crossings.
- Driveways in front of garages.
- Bus and tram stops.
- Any other place where the safe walking and entrance to buildings should be maintained

2.3.2 Heating Mat Description

The Outdoor Underground Heating Mat is composed of one or more heating elements connected in parallel. The heating elements are either straight or bent, according to site conditions, and can be supplied as a specified heating mat, or as a serpentine cable buried in the ground (see Figure 2-2).

Figure 2-2. AHT Heating mat

Each heating mat is individually connected to a voltage source through a single cold-lead cable (consisting of three leads: power, neutral and ground, and shielded if it local codes require so). The cable is routed to an electrical connection box. The power supply system must include a GFCI or RCD, and a controller that with temperature and moisture sensors.

2.3.3 Geometric Dimensions and Tolerances

The heating mats are designed so the heating element covers from 15% to 30% of the heated surface, per customized design request, or per project.

Chapter 3

Installation Procedure

3.1 General

This chapter provides the field technician with detailed instructions on installing the AHT's Heating Ribbons and Mats, including the recommended construction profiles used in the design of open courts, tools and materials required to execute the installation

3.2 Design of Open Courts – Construction Profiles

3.2.1 Under Cold Asphalt

The construction profile of the AHT heating element installed under cold asphalt should be as shown in Figure 3-1.

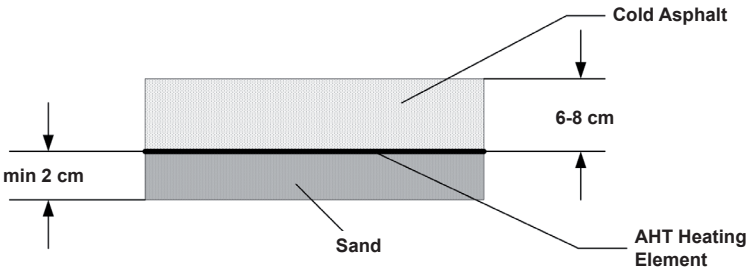


Figure 3-1. Construction Profile Under Cold Asphalt

3.2.2 Under Concrete

The construction profile of the AHT heating element installed under concrete should be as shown in Figure 3-2.

3.2.3 Under Pavement

The construction profile of the AHT heating element installed under the street pavement should be as shown in Figure 3-3.

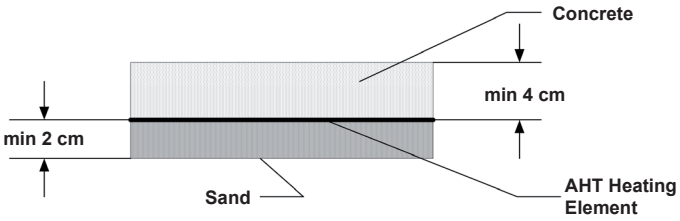


Figure 3-2. Construction Profile Under Concrete

3.2.4 Under Gravel

The construction profile of the AHT heating element installed under gravel should be as shown in Figure 3-4.

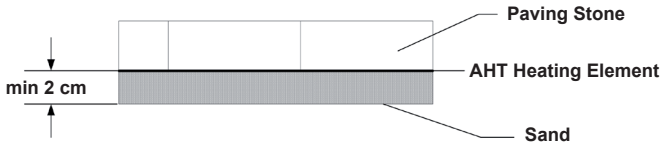


Figure 3-3. Construction Profile Under Pavement

3.3 Power Loadings

The following heat flux densities are recommended for ice and snow prevention in open areas:

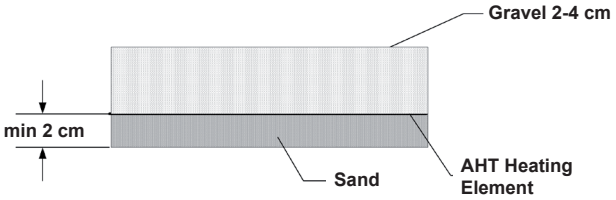


Figure 3-4. Construction Profile Under Gravel

- Parking Lots 250 – 350 W/m^2
- Driveways 250 – 300 W/m^2
- Sidewalks 250 – 300 W/m^2
- Doorsteps 300 – 375 W/m^2
- Bridges 300 – 400 W/m^2

These power restrictions depend on the weather conditions, such as ambient temperature, humidity, wind speed, snowfall rate and level of thermal insulation. The above values correspond to windless weather and typical snow melting rates between 6.35 and 12.7 mm per hour, when the corresponding air temperature ranges from -7°C to -2°C. To prevent ice and snow (melting), the covering surface temperature must be theoretically 0°C (in practice, we recommend 1-2°C). The time required to reach the melting temperature depends on the heat flux density of the heating element, the depth of the heating element below the covering surface, the thermal and physical properties of the covering surface, and the weather conditions.

AHT's specialists developed a computer program that enables to calculate the temperature distribution in the covering surface and the heating time to desired temperature. An example of such calculation is presented in Appendix 1.

3.4 Planning the Installation of the Heating Elements

When planning the installation of the AHT cables in your project, you should determine the number of assembled cables required and the number and lengths of cable sections required to form each assembled cable. Proceed as recommended below:

- Use the longest possible cable sections to minimize the number of section connections.
- If possible, use cable sections of the same length to form an assembled cable.
- Use **no more than three** cable sections per connection box.

Notes:

- Ensure that the source can support the power requirements of the required installation.
- To include a control box with a humidity and temperature sensor in your installation, consult with an AHT representative.

3.4.1 Step 1: Measuring the Project Site

Prior to installation, draw an installation plan showing the placement of the heating cable based on the power needed, and the connection boxes. Use this plan to determine the number and length of each assembled cable and the power cord required for the installation (see Figure 3-5).

3.4.2 Step 2: Determining the Required Assembled Cables

Based on the installation plan designed in Step 1, determine the number and length of each cable section, and those of the assembled cables required for the installation.

The following example shows an installation in a rectangular site of 10 m × 30 m, where the required power is 40 W/m^2.

3.4.3 Step 3: Determining the Power Requirements

Prior to installation, make sure the electrical capacity of the site can support the installation power requirements.

Use the following formula to calculate the current required for each assembled cable:

$$I = \frac{V}{R} = \frac{V}{L * \rho}$$

I – current in amps
R – resistance
L – length
V – volts
ρ – resistance per meter

Table 3-1 lists the resistance per meter for each cable model.

Cable Model	Resistance per Meter
AHT03O0707	17.8Ω
AHT03O0700	8.9Ω
AHT03O1200	5.2Ω
AHT03O2500	2.5Ω

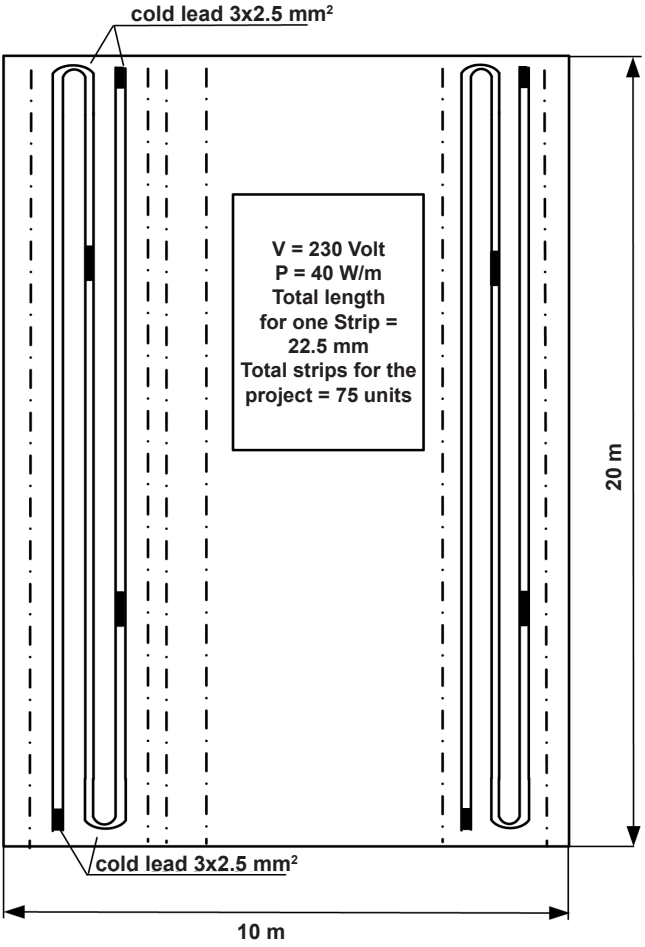


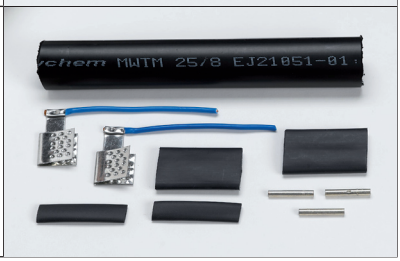
Figure 3-5. Example of an Installation Plan

3.4.4 Step 4: Determining the Number of Connection Kits Required

Use connection kits for each type of connection required in your installation. There are three types of connection kits. Table 3-2 describes and illustrates each type of connection kit.

*Table 3-2. Types of Connection Kits**

* The following illustrations refer only to the 25 mm ribbon kit.

Connection Type	Kit Type	Illustrated Kit
Connection between a cable and a power cord	Power Connection Kit	
Sealing of a cable end not connected to a power cord or another cable.	Termination Connection Kit	
Connection between two cable sections in an assembled cable	Section Connection Kit	

Each cable model has its own set of connection kits. Table 3-3 to Table 3-5 provide lists of connection kits available for each cable model, along with the contents of each kit.

Table 3-3. Connection Kits for Cable Model AHT 0302500

Kit Type	Connection Kit No.	Contents
Power Connection Kit	AHT01OckP2500	1 unit – 20 mm crimp connector with 6 cm electrical wire 3 units – copper crimp sleeves, tin plated 2.5 Ø 1 unit – 18/6 shrink tube (5 cm) 2 units – 8/2 shrink tubes (3.5 cm) 1 unit – 25/8 shrink tube (16 cm)
Section Connection Kit	AHT01OckS2500	2 units – 20 mm crimp connectors with 6 cm electrical wire 3 units – copper crimp sleeves, tin plated 2.5 Ø 2 units – 18/6 shrink tubes (5 cm) 2 units – 8/2 shrink tubes (3.5 cm) 1 unit – 25/8 shrink tube (17 cm)
Termination Connection Kit	AHT01OckT2500	1 unit – 20 mm crimp connector 1 unit – 18/6 shrink tube (6 cm) 1 unit – 8/2 shrink tube (2 cm) 1 unit – 25/8 shrink tube (10 cm)

Table 3-4. Connection Kits for Cable Model AHT 0301200/0700

Kit Type	Connection Kit No.	Contents
Power Connection Kit	AHT01OckP1200/0700	1 unit – 10 mm crimp connector with 6 cm electrical wire 3 units – copper crimp sleeves, tin plated 2.5 Ø 1 unit – 12/3 shrink tube (4 cm) 2 units – 8/2 shrink tubes (3.5 cm) 1 unit – 25/8 shrink tube (16 cm)
Section Connection Kit	AHT01OckS1200/0700	2 units – 10 mm crimp connectors with 6 cm electrical wire 3 units – copper crimp sleeves, tin plated 2.5 Ø 2 units – 12/3 shrink tubes (4 cm) 2 units – 8/2 shrink tubes (3.5 cm) 1 unit – 25/8 shrink tube (16 cm)
Termination Connection Kit	AHT01OckT1200/0700	1 unit – 10 mm crimp connector 1 unit – 12/3 shrink tube (5 cm) 1 unit – 8/2 shrink tube (2 cm) 1 unit – 25/8 shrink tube (10 cm)

Table 3-5. Connection Kits for Cable Model AHT 030707

Kit Type	Connection Kit No.	Contents
Power Connection Kit	AHT01OckP0707	2 units – 10 mm crimp connectors with 6 cm electrical wire 3 units – copper crimp sleeves, tin plated 2.5 Ø 2 units – 12/3 shrink tubes (4 cm) 2 units – 8/2 shrink tubes (3.5 cm) 1 unit – 25/8 shrink tube (16 cm)
Section Connection Kit	AHT01OckS0707	2 units – 10 mm crimp connectors with 6 cm electrical wire 1 unit – 20 mm crimp connector. 3 units – copper crimp sleeves, tin plated 2.5 Ø 2 units – 12/3 shrink tubes (4 cm) 2 units – 8/2 shrink tubes (3.5 cm) 1 unit – 18/6 shrink tube (5 cm) 1 unit – 25/8 shrink tube (17 cm)
Termination Connection Kit	AHT01OckT0707	1 unit – 20 mm crimp connector 1 unit – 18/6 shrink tube (6 cm) 1 unit – 8/2 shrink tube (2 cm) 1 unit – 25/8 shrink tube (10 cm)

3.4.5 Step 5: Determining the Amount of Resinex Sealant Required

Note:
Always wear plastic gloves while using Resinex.

Use Resinex sealant to tightly seal each assembled cable. Each Resinex kit contains sufficient sealant material for 6 to 8 connections. Purchase enough Resinex sets to complete the necessary number of connections.

Once you mix the Resinex components, you must use them within 10 minutes.

To make sure you can use the entire Resinex kit, prepare enough connections and terminations before mixing the Resinex components; then seal all the connections and terminations within 10 minutes after mixing the Resinex.

Proceed as follows to seal the shrink tubes using Resinex:

1. Put on the plastic gloves provided with the Resinex kit.
2. Empty the contents of the bottle into the can.
3. Mix the contents well with the mixing stick.
4. Pour an appropriate amount of Resinex into the shrink tube, enough to fill the tube when sealed with no excess.
5. Wait 20 minutes, and then squeeze the closed shrink tube. Make sure the sealant fills the tube, and no air is left inside.
6. Allow the Resinex to thoroughly dry − it takes from one to four hours.

3.5 Installation Tools Required

The following tools are required to perform all installations of AHT's Heating Ribbons and Mats (see Figure 3-6):

- Industrial Fan (for sealing shrink tubes) (1)
- Wire stripper (2)
- Pliers (3)
- Wire cutter (4)
- Connection crimper (5)
- Industrial-strength scissors (6)
- Crimper (7)
- Utility knife (Not shown)
- AVO meter (Not shown)
- Megger tester (Not shown)
- Black plastic cable ties (Not shown)
- Metal fixing bands (Not shown)
- Power cord (Not shown)

Figure 3-6. Required Installation Tools

3.6 Installing the Heating Elements

Note:
All installations must be performed by an electrician certified in the country where the installation takes place, and is authorized by AHT's to install its Snow-and-Ice Melting products.

3.6.1 Step 1: Getting the Cables

AHT's Snow-and-Ice Melting System cables are sold in rolls.

The cable has meter markings on the LLDPE insulation. The remaining length of the cable is marked at each meter. Use these markings to measure the cable length.

3.6.2 Step 2: Connecting the Cables

Note:
The cable sections must be connected on a dry, flat surface.

Proceed as follows to prepare the cables for connections and terminations:

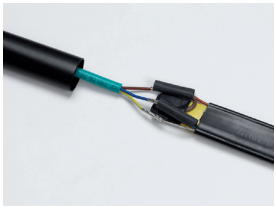
1. Use the utility knife to strip 3½ to 4 cm of insulation from both ends of each cable. Carefully cut all the way around the cable and peel off the insulation, including the aluminium layer. Do not cut the ribbon or the cable wires.

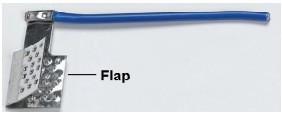
2. Open the appropriate connection kit and perform the required connection. Refer to the appropriate section for the type of connection required:
   - If you are connecting a power cord to the cable, refer to Step 3: Connecting the Power Cord (Section 3.6.3).
   - If you are connecting cable sections, refer to Step 4: Connecting Cable Sections (Section 3.6.4).
   - When terminating the cable, refer to Step 5: Terminating the Cable (Section 3.6.5).

3.6.3 Step 3: Connecting the Power Cord

Use the Power Connection Kit (see Table 3-3 to Table 3-5), and proceed as follows to connect the power cord to the cable:

1. Open the Power Connection Kit.
2. Peel off approximately 4 cm of insulation from the end of the power cord.
3. Peel off approximately 4 cm from all wires.
4. Crimp the crimp connector onto the ribbon.
5. Fold the flap onto the crimp connector.



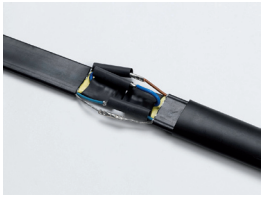


6. Place the 12/3 (or 18/6 if you are using 25 mm cable) shrink tube over the end of the ribbon, and use the fan to seal the tube.
7. Place the 25/8 shrink tube over the cable. Leave all wires exposed.
8. Twist together the crimp wire and the brown wire from the cable and insert the twisted portion of the wires into one of the copper crimp sleeves.
9. Place an 8/2 shrink tube over the brown cable and crimp wires.
10. Insert the brown wire from the power cord into the other end of the copper crimp sleeve covering the brown wire from the cable and the crimp wire and crimp the sleeve closed.
11. Slide the 8/2 shrink tube over the sleeve, and use the fan to seal the tube.
12. Insert the blue wire from the cable into another copper crimp sleeve.
13. Place an 8/2 shrink tube over the blue cable wire.
14. Insert the blue wire from the power cord into the other end of the copper crimp sleeve.
15. Slide the 8/2 shrink tube over the sleeve, and use the fan to seal the tube.
16. Insert the grounding wire from the cable and the yellow wire from the power cord into the ends of the third copper crimp sleeve. It is not necessary to cover these wires with a shrink tube.

17. Slide the 25/8 shrink tube over the entire connection area, and use the fan to seal the power cord end of the tube.
18. Use Resinex to seal the other end of the 25/8 shrink tube. Refer to the instructions for using the Resinex sealant provided in Section 3.4.5.

3.6.4 Step 4: Connecting Cable Sections

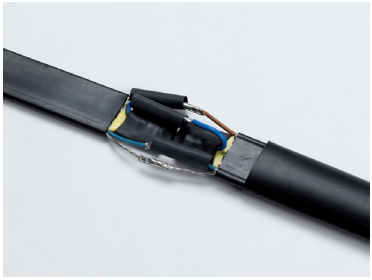
Use the Section Connection Kit (see Table 3-3 to Table 3-5), and proceed as follows to connect the two cable sections in an assembled cable:



1. Open the Section Connection Kit.
2. Peel off approximately 4 cm from all the wires.
3. Cut a small piece of the ribbon on each cable, to make it shorter than the wires.
4. Crimp a crimp connector onto each ribbon and fold the flap onto each crimp connector.
5. Place the 12/3 (or 18/6 if you are using 25 mm cable) shrink tube over the end of each ribbon, and use the fan to seal the tube.
6. Slide the 25/8 shrink tube onto one of the cables, leaving the ribbon and wires exposed.

Note:
The procedure for connecting the wires between the two cables differs according to the number of wires (2 or 3) in the assembled cable. In case of 3 wire cables, the wire connection procedure depends on the specific wires to be connected. Table 3-6 provides wire connection instructions for the various types of section connections. Make sure you perform the connections as instructed.

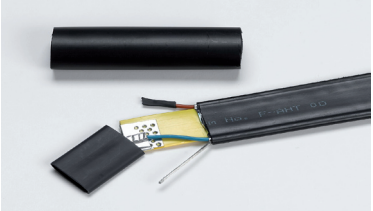
Table 3-6. Wire Connection Instructions

Type A Connection	Type B Connection
	
• Two Cables in Assembled Cable • Three Cables in Assembled Cable — Connection Adjacent to Termination	• Three Cables in Assembled cable — Connection Adjacent to Power Cord

Type A Connection	Type B Connection
1. Insert the blue wire from one cable into a copper crimp sleeve. 2. Place one of the 8/2 shrink tubes over the blue cable wire. 3. Insert the blue wire from the other cable into the other end of the copper crimp sleeve. 4. Slide the 8/2 shrink tube over the sleeve, and use the fan to seal the tube. 5. Repeat this procedure for the brown cable wires and the crimp wires. 6. Repeat this procedure with the grounding wires. 7. Slide the 25/8 shrink tube over the entire connection area, and use the fan to seal one end of tube. 8. Use Resinex to seal the other end of the 25/8 shrink tube. Refer to the instructions for using the Resinex sealant provided in Section 3.4.5. **Note:** Shrink tubes are not required for grounding wires.	1. Twist together the crimp wire and the brown wire from one cable, and insert the twisted portion of the wires into a copper crimp sleeve. 2. Place one of the 8/2 shrink tubes over the twisted wire pair. 3. Twist together the crimp wire and the brown wire from the other cable, and insert the twisted portion of the wires into the other end of the copper crimp sleeve. 4. Slide the 8/2 shrink tube over the sleeve, and use the fan to seal the tube. 5. Insert the blue wire from one cable into a copper crimp sleeve. 6. Place one of the 8/2 shrink tubes over the blue cable wire. 7. Insert the blue wire from the other cable into the other end of the copper crimp sleeve. 8. Slide the 8/2 shrink tube over the sleeve, and use the fan to seal the tube. 9. Repeat this procedure with the grounding wires. **Note:** Shrink tubes are not required for ground wires.

3.6.5 Step 5: Terminating the Cable

Use the Termination Connection Kit (see Table 3-3 to Table 3-5) to seal each cable end. Proceed as follows:



1. Open the Termination Connection Kit.
2. Take out the crimp connector and place it on the ribbon.

3. Peel off the blue wire that protruding from the cable.
4. Crimp the blue wire inside the crimp connector, and fold over the connector to secure the wire.
5. Place the 12/3 (or 18/6 if you are using 25 mm cable) shrink tube over the end of the ribbon, and use the fan to seal the tube. (If you are using cable model AHT 0300707, place the 12/3 shrink tube over one ribbon, and then place the 18/6 shrink tube over the entire cable).
6. Cut the brown wire protruding from the cable short, enough to fit inside the 8/2 shrink tube.
7. Place the shrink tube over the brown wire, and use the fan to seal the tube.

8. Cut off the silver grounding wire protruding from the cable so that it can be places flush with the end of the insulation.
9. Place the 25/8 shrink tube over the cable end so it covers all wires, and use the fan to seal the end of the 25/8 shrink tube opposite the cable.
10. Use Resinex to seal the end of the shrink tube that is flushed with the cable. Refer to the instructions for using the Resinex sealant provided in Section 3.4.5.

3.6.6 Step 6: Checking Connectivity

After completing all necessary connections, check the connectivity of each cable assembly as follows:

1. Use a Megger Tester to make sure that leakage is within the range permitted by the applicable law. At one end of the cable, touch ground with one Megger Tester probe, and, at the other end of the cable, touch the lead with the other probe.
2. Use the AVO meter to test the total power.

3.6.7 Step 7: Laying Out the Assembled Cables

Lay out the assembled cables as follows:

1. Verify the ground surface is flat and smooth with no sharp stones.
2. Lay the heating elements on the ground according to the construction profile (see Section 3.2).

Note:
Use a U-shaped hook for anchoring the cable where needed. Do not pierce the cable with any fastener (such as nails, screws, rivets, etc.).

3. Pull the cold wires out off the surface towards the connection box, according to the installation plans.
4. Make sure the connection box is installed according to local codes, and as close as possible to the installation area.
5. Install the thermostat according to the manufacturer's instructions.
   The recommended thermostat is O.J Electronics, model ETO-3550, with a ground sensor for detecting temperature and moisture, or ETOG-5, or any thermostat with the same specifications.

Advanced Heating Technologies Ltd

Appendix A – Outdoor Heating Specifications

4. Appendix A – Cable Connection Diagrams

This appendix provides a table specifying the heater and outdoor surface temperatures under different weather conditions.

Appendix 1							
Outdoor heating (ice prevention)							
Asphalt							
	In. temp	**Amb. temp**	**Heat flux**	**Wind rate**	**Heater temp**	**Surface temp**	**Heating time**
Thickness	Ti, ^{O}C	Ta, ^{O}C	q, (W/m^2)	v, (m/s)	Th, ^{O}C	Ts, ^{O}C	t (h)
0.07	-5	-10	200	0	11	0	4
	-8	-10	200	0	11.3	0.5	5.3
	-8	-10	200	2	15	0	8.2
	-8	-10	400	0	19.5	0.2	3
	-8	-10	400	2	23.4	0.3	4
	-8	-10	400	4.5	29	0.3	6
	-8	-15	400	0	20.5	0.1	3.3
	-8	-15	400	4.5	34.6	0.2	10
0.1	-5	-10	200	0	16	0	7
	-8	-10	200	0	15.5	0.2	8.7
	-8	-10	200	2	21	0.1	14
	-8	-10	400	0	27.2	0.2	5
	-8	-10	400	4.5	41.6	0.5	11
	-8	-15	400	4.5	48.7	0	17.9
	-12	-15	400	4.5	49.8	0.4	20.2
Concrete							
0.07	-5	-10	200	0	6.3	0.7	1.3
	-8	-10	200	0	6.3	0.8	2
	-8	-10	200	2	7.4	0	2.5
	-8	-10	400	0	10.9	0.6	1
	-8	-10	400	2	12.5	0.4	1.3
	-8	-10	400	4.5	14.8	0.1	1.8
	-8	-15	400	4.5	17.6	0	3

Appendix B

Connection Cable Diagrams

5. Appendix B – Cable Connection Diagrams

This appendix provides connection diagrams for heating cables with 1, 2 and 3 wires.

5.1 1-Single Cable Heater

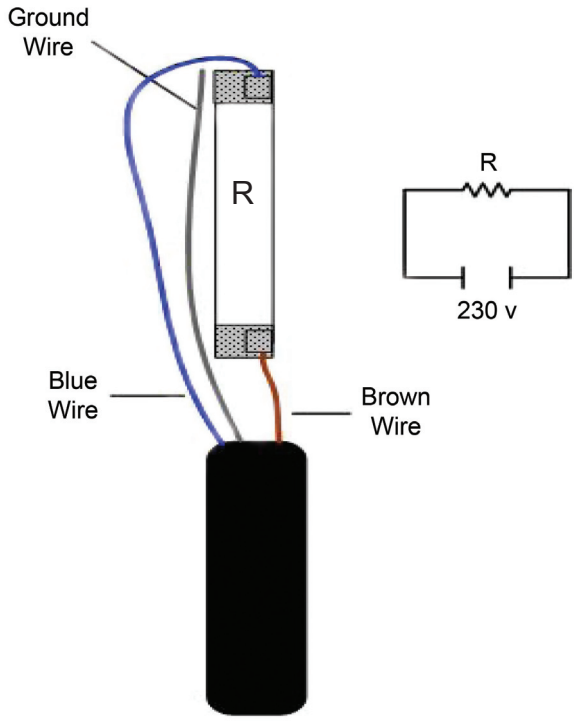


Figure 5-1. Connection Diagram for 1-Single Cable Heater

5.2 2-Double Cable Heater

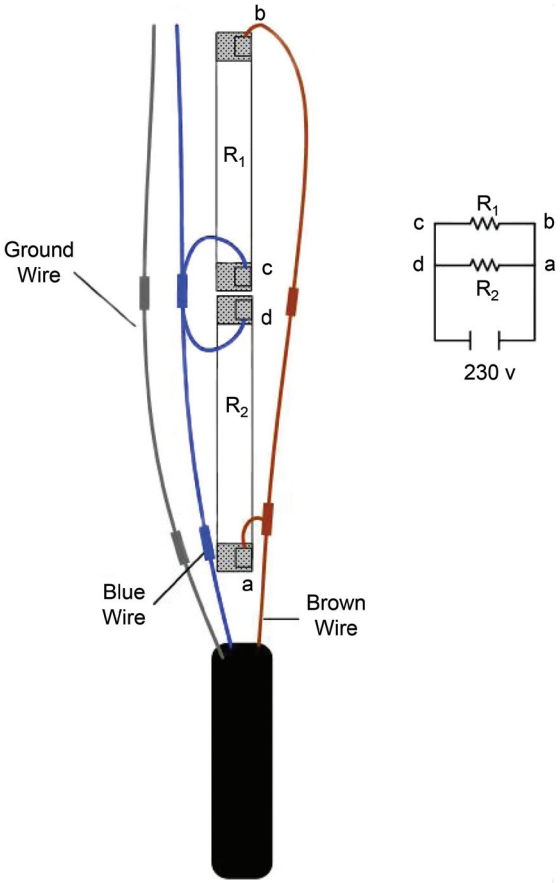


Figure 5-2. Connection Diagram for 2-Double Cable Heater

5.3 3-Triple Cable Heater

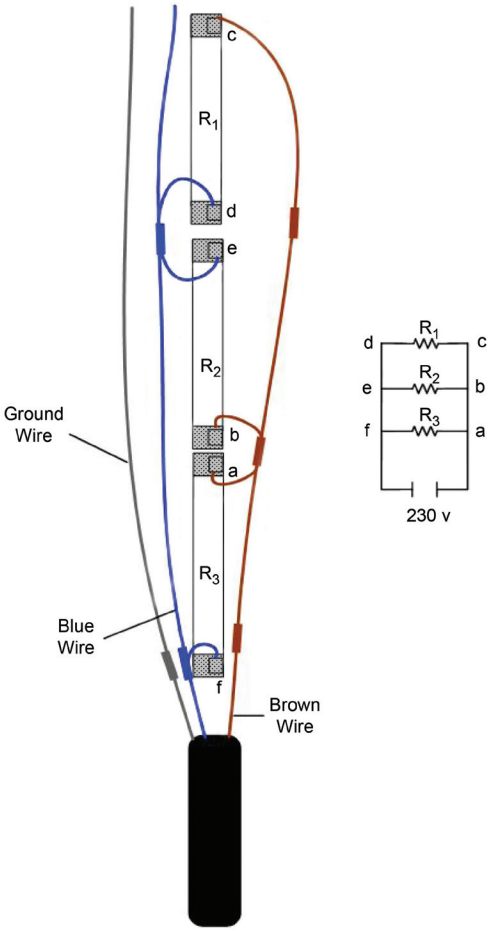


Figure 5-3. Connection Diagram for 3-Triple Cable Heater

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