RAUPEX®
Snow and Ice Melt Systems

Technical Manual

Contents

1. Introduction

The objective of this Technical Manual is to provide a fundamental understanding of the features of the REHAU hydronic snow and ice melt (SIM) system. In addition, refer to the *REHAU RAUPEX® Heating & Plumbing Systems Product Catalog* which is available as a separate document. As a qualified designer with hydronic heating experience, you should, after studying these documents, be able to specify a REHAU SIM system.

We suggest that you carefully study all chapters. With practice and experience you will be able to use this Technical Manual (TM) as a convenient reference for designing, specifying or installing SIM systems.

Additional assistance and information is always available through REHAU Technical Associates, REHAU Sales Offices and the REHAU Technical Center in Leesburg, Virginia.

1.1 Description

REHAU SIM systems are hydronic systems designed to augment the removal of snow and ice by circulating a heat transfer solution (usually antifreeze and water) through RAUPEX pipe which is installed within the SIM area. With proper design and installation techniques, our SIM systems will provide long-term performance and reliability in maintaining snow- and ice-free areas. As a designer, you should be aware that it will be economically unrealistic to design a SIM system that will function for all weather conditions, in all situations. For these reasons, you should design SIM systems with the understanding that responsible oversight of system operation will be required.

Design considerations for SIM systems are considerably more complex and variable than they are for standard hydronic space heating systems. Wind velocity, slope, drainage, humidity, snow density, slab temperature at the start of melting and rate of snow or ice fall are just some of the many uncontrollable variables that affect both design and performance of SIM systems. Despite these complexities, we can have great success with SIM systems, partly because the components and pipe details are very similar to those most hydronic system designers are familiar with.

A critical component of every SIM system is the heat transfer pipe. RAUPEX is the REHAU trade name for our specially formulated cross-linked polyethylene (PEXa) pipe. It is ideally suited for SIM systems, manufactured in accordance with ASTM F877 and CSA B137.5. RAUPEX is a very durable and stable polymer that stands up well to strenuous use and various site conditions. REHAU has over 30 years of experience in manufacturing Engel PEX. RAUPEX pipe is also available with an oxygen diffusion barrier RAUPEX B, which meets the DIN 4726 standard.

REHAU also offers metric pipe, RAUTHERM (without barrier) and RAUTHERM S (with barrier).

Unless noted otherwise, when referring to the properties and technical aspects of our pipe, we will simply state RAUPEX.

Fig. 1.1
Hospital helicopter landing pad

1.2 Application

REHAU SIM systems are designed to maintain a predetermined temperature to keep surfaces snow- and ice-free under design conditions, or to melt accumulated snow and ice.

Beyond the safety benefits provided by snow- and ice-free areas, SIM systems can reduce maintenance costs (no salt or water tracked inside), reduce liability exposure and provide convenience.

As a designer, you should consider the economics of installation and operation versus maintenance cost, removal costs and lost opportunity caused by snow and ice. In many applications, with all things considered, REHAU SIM systems are a wise and economical choice. Virtually any application where snow and ice removal is necessary is a candidate for a REHAU SIM system. This may include walkways, ramps, driveways, landing pads, runways, aprons and playing fields. If you have a question about the applicability of a REHAU SIM system, please contact your nearest REHAU Sales Office.

1.3 Weather Conditions

The National Weather Service and the Climatological Atlas of Canada have very informative and detailed data for virtually every geographic location in North America. This data, particularly snow fall rate, snow fall temperature, and humidity levels, should be the starting point for design.

Every aspect of weather has a significant impact on the performance of a REHAU SIM system. With all the variables that can affect the ability of a SIM system to perform, precise calculations quickly become extremely difficult. Because of these variables, we must generalize in our design process. These generalizations (such as choosing a specific rate of snow fall) are founded on both experience and calculation.

1.3.1 Snow

Depending on the temperature of the ambient air during snow fall, snow will have different densities and therefore require different degrees of energy to melt it. The colder the air temperature, the less dense the snow that falls. There is, on average, 6 pounds per cubic foot (96 kg per cubic meter) of snow at 26ºF (-3.3ºC). Heavier (denser) snow will require more melting power from your REHAU SIM system.

Snow fall rates (from historical weather data) vary significantly from region to region and even from year to year within a given region. Weather Bureau records show that 90% of snow fall occurred between 10ºF and 35ºF (-12.2ºC and 1.7ºC). For most regions of North America, an acceptable design snow fall rate of from 1" to 4" (2.5 to 10 cm) per hour is adequate. Residential applications may allow for more design flexibility so that 1 1/2" to 2" (3.8 cm to 5 cm) per hour snow fall may be an adequate design parameter. For an emergency Medevac helicopter landing pad, a design rate of 4" (10 cm) per hour may be more prudent.

Checking your local weather data will help clarify this information and give you confidence to choose a design snow fall rate.

1.3.2 Wind

Wind velocity has a significant influence on the output of the REHAU SIM systems that you design. Wind will rapidly reduce the melting capability of your SIM system. For example, a 10 mph (16 km/h) wind may increase the SIM output requirement by 50%. A further difficulty in dealing with the wind factor is that an isolated portion of a SIM area may be subject to wind while another portion may be protected and in the sun.

Careful site evaluation is always one way to help determine wind conditions on your design site. Prevailing winds and storm winds will generally be very consistent in direction. Asking the owner of the project, checking with the local builder and verifying weather data will also help. Proper placement of control sensors, if you use them in your design (the control subject is discussed later in this TM), will help overcome wind inconsistencies across the site.

Fig. 1.2
Installation of RAUPEX SIM system on church steps

1.3.3 Operating Temperature

One obvious factor in REHAU SIM system design is the temperature at which you would like your system to operate. This will affect your design. For example, would you like your system to be able to melt at 0ºF (-17.8ºC) or is 5ºF (-15ºC) acceptable? The REHAU design process outlined in Chapter 4 on Planning and Design will cover this issue. The not-so-obvious fact about SIM system design is that we need to consider what is called pickup allowance. Even though we would like to melt at a given design temperature at the start of snow or ice fall, the SIM thermal mass may be much colder (and normally is) unless your control system is designed to maintain a specific "idle" temperature. This extra pickup requirement must be considered in determining the system output capacity and your control strategy.

1.3.4 Realization of Conditions

With all of these uncontrollable and variable weather conditions, it is impossible to design economically (or at all) for all situations. As the designer, you must make some generalizations about weather and about the situations where your designs will function. It is very important that the owner of the project and all involved contractors understand what the REHAU SIM system is designed to do. In Chapter 4, we will give you guidelines to deal with the complexities of SIM system design. You will have to rely on assumptions and averages to make your design practical. However, with our experience, REHAU can help you design very effectively and with confidence.

Fig. 1.3
SIM for garage entry

1.4 SIM Distribution

The SIM distribution area consists of RAUPEX pipe installed within a concrete slab, asphalt layer or in the base material below a concrete slab, asphalt layer, pavers or turf coverings. We call this area the thermal mass.

In your design and installation there are several ways to deal with temperature distribution and thermal mass exposure temperature concerns.

We suggest that you use the minimum fluid temperature needed to melt snow and ice at design conditions.

Generally, for most designs, we will suggest supply fluid temperatures of between 90ºF and 140ºF (32.2ºC and 60ºC) with a ΔT or temperature drop range between 20ºF to 30ºF (11ºC to 17ºC).

The high supply water temperature needed to meet the heat requirement of the thermal mass is a delicate balance. You must be very cautious about the exposure temperature to the thermal mass. Elevating the thermal mass temperature too swiftly may thermally shock it and cause damage. To reduce that possibility, maintain or elevate the supply water very slowly.

1.5 Surface Temperatures

In a typical SIM system design, a slab surface design temperature of 32ºF (0ºC) may be used for melting; however, this does not allow any room for variance in weather conditions or capacity for the heating source to meet increased demands.

To compensate for these factors, we recommend that you adhere to a design surface temperature of between 37ºF and 45ºF (2.8ºC and 7.2ºC). This design temperature will afford some protection against uncontrollable factors.

1.6 Heat Sources

There are few restrictions to the heat source you can use with a REHAU SIM system but there are three factors that you need to consider when choosing your heat source.

The heat source must be sufficient to supply the heat required for the SIM system.

The maximum temperature in the SIM system must be regulated by appropriate electronic controls which are specific to the heat source operational requirements and the SIM system characteristics. Tempering valves, mixing valves and/or heat exchangers are also used to regulate the rate of the SIM system warming. The maximum thermal mass temperature and the heat source return fluid temperature are essential for successful SIM performance.

The return water temperature from the SIM system pipe (or heat exchanger if one is installed) may be excessively low for the heat source, particularly at system startup. If the heat source cannot tolerate low return water temperatures (less than 130ºF [54.4ºC], for example), then a mixing valve, heat exchanger or mixing holding tank should be installed. Each of these can modulate the return temperature of the water going back to the heat source.

With these three factors in mind, you'll have many good choices for heat sources including cold start boilers, steam, industrial process waste heat and sequenced boiler systems.

1.7 Heating Pipe Laying Patterns

The counterflow serpentine layout pattern is very important with regard to even temperature distribution or heating across the surface. Consequences of poor temperature distribution are that in heavy load conditions the system may not be able to overcome the initial pickup load requirements, or certain isolated areas may not melt the snow or ice effectively.

1.8 Heat Transfer Fluids

REHAU SIM systems require freeze protection. You should consult the local weather data to determine design low ambient air temperature. In most cases, this will be a lower temperature than the temperature at which you are designing the SIM system to melt.

One primary method of freeze protection is simply keeping the water in the RAUPEX pipe moving. However, this method alone may not prevent freezing. Moving or not, if water is at 32ºF (0ºC) or less, and the latent heat (of fusion) is removed (change in phase without a change in temperature), it will freeze. This can occur, for example, in very cold (-20ºF [-29ºC]) and/or windy conditions. You must design for fail safe conditions (safe conditions when a component of the system, such as a circulator, fails). This means that you must use some type of antifreeze solution in every REHAU SIM system.

There are a few options available for providing antifreeze solution protection in a REHAU SIM system. The fluid that we normally recommend is propylene glycol mixed in accordance with the manufacturer's instructions. Ethylene glycol as well as brine solutions and silicon solutions may be acceptable also. Always check with REHAU to be sure the solution that you choose is compatible with RAUPEX pipe. (A partial list of approved fluids is provided in Appendix 1.) Also make sure the antifreeze solution is compatible with other system components and is acceptable for the temperatures planned in your design.

Include antifreeze maintenance in your design specifications. Inform the owner of the system that he or she will need to check the antifreeze annually in accordance with the manufacturer's recommendations. The owner, or his representative, must ensure that the antifreeze remains at design conditions (inhibitor level and system pH, for example).

Typically we will design our REHAU SIM systems to include 45% antifreeze in the solution going through the components exposed to cold weather. This includes RAUPEX pipe, but may also include distribution pipe and manifolds. To avoid filling the entire heating system with antifreeze solution, a heat exchanger is often included in the boiler piping design. Using this method only the SIM components need to be filled with antifreeze. The manufacturer of the antifreeze will indicate the amount of antifreeze needed for your design. The *RAUPEX® Hydronic Heating & Plumbing Systems Product Catalog* includes fluid capacities of each RAUPEX pipe for easy calculation of the amount of antifreeze you will need.

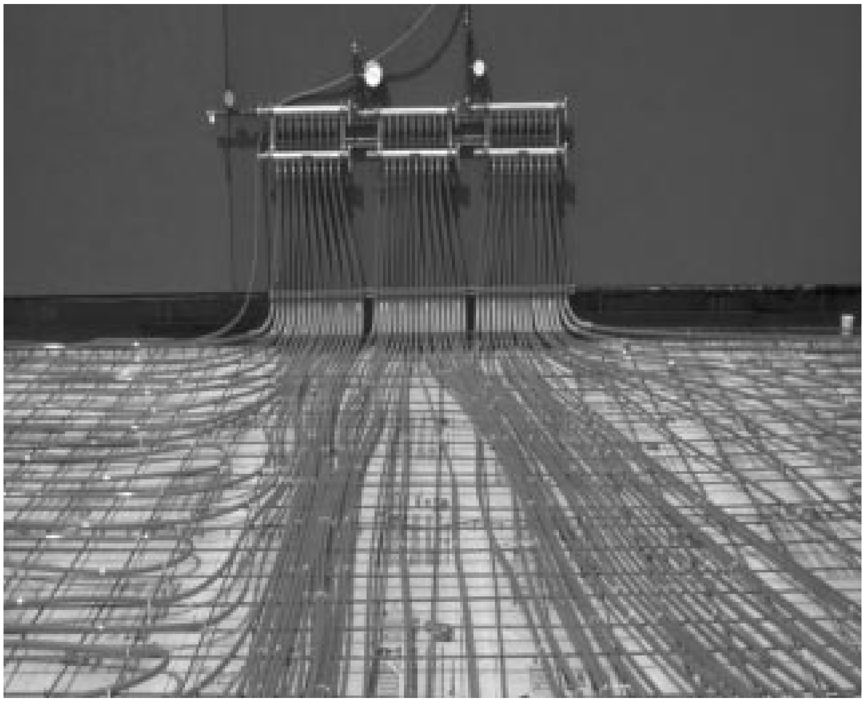

Fig. 1.4
Distribution manifolds for helicopter pad

1.9 Control Systems

You can ensure effective and cost-efficient operation by properly designing and planning the control systems for your REHAU SIM system.

The amount of energy a REHAU SIM system will consume is largely determined by the way in which it is operated. Avoidable energy loss resulting from poor system control design, lack of insulation, improper heat source operation or failure to provide system service may account for up to 20% of the annual energy consumption of your SIM system. The SIM area response time specifications may require the SIM area to maintain a minimum stand-by temperature even though no snow or ice is present. Such stand-by or idling mode requirements can account for 50% to 75% of the SIM system annual energy consumption.

As designer, you can ensure your REHAU SIM system will efficiently meet the needs of the owner. If you properly design the system, you will be able to operate the system at comparatively low water temperatures (120ºF to 160ºF [48.9ºC to 71.1ºC]) and provide melting with surface temperatures between 32ºF (0ºC) and 45ºF (7.2ºC).

1.9.1 Weather Sensing Controls

These devices, which sense both snow/ice and moisture, will normally keep the thermal mass at what is called an idle temperature (32ºF [0ºC], for example) and then, upon sensing SIM surface snow or ice, will bring the thermal mass temperature up to melting level (35ºF to 45ºF [1.7ºC to 7.2ºC]). These systems will continue to operate until all presence of moisture is gone.

A typical control device of this type will require the installer to place a sensing device within the thermal mass (this is covered in Chapter 3), and a control panel within a heated area (indoors). Location of the sensing device is very important and often several will be required for proper detection on all areas of the thermal mass. Problems associated with SIM system control can often be traced to improperly placed or dirty sensing devices.

1.9.2 On/Off Control

Many SIM systems are operated manually with an on/off switch and possibly a timer (to turn the system off). Obviously these systems involve the human factor, which is not a problem as long as the operator understands that it will require him to turn the system on during or before the start of snow/ice fall. Many installations, particularly in residences, have been successfully installed using this technique.

1.9.3 Control Wisdom

For many mechanical installers, controls can be difficult to understand. Take time to explain system operation and make sure they can explain it to the operator.

If you're designing with an on/off control, consider installing an indicator light which comes on when the system is running. It can be very helpful.

Consider sensor replacement and system upgrade. Sensor replacement will be simplified if you place sensor wires in conduit. Even with on/off systems, placement of a sensor well (covered in Chapter 3) in the SIM thermal mass will allow for future upgrades if necessary.

Explain the potential of thermally shocking the thermal mass with too quick of a startup. Concrete SIM applications are the most susceptible to thermal shock. Controls which step up the SIM fluid supply temperature based on 20ºF to 30ºF (11.1ºC to 16.7ºC) differential above the SIM fluid return temperature are recommended.

Fig. 1.5
Parking garage ramp RAUPEX B installation

Fig. 1.6
Completed parking garage ramp

Fig. 1.7
Operating SIM system for church steps

2. System Components

This chapter will give you an overview of the various components that you will use to design and specify a REHAU SIM system.

2.1 RAUPEX Pipe

The characteristics of the pipe used in REHAU SIM systems are particularly important for several reasons. The pipe must be easy to install, it must disperse heat well, and it must be durable enough for years of service. RAUPEX and RAUPEX B are produced in ISO 9001 certified manufacturing facilities (International Standards Organization). They conform to CSA B137.5 (Canadian Standards Association) and ASTM F876/F877 (American Society for Testing of Materials) for up to 160 psi (11 bar) water service and to a maximum working temperature of 200ºF (93ºC).

2.2 Pipe Material

RAUPEX pipe is extruded in cross-linked, high-density polyethylene (HDPE) with a molecular weight considerably higher than that of normal HDPE types. This material is noted for its particularly high endurance limit, impact resistance and thermal stability. RAUPEX is designed for the tough environments where SIM systems are used.

The properties of RAUPEX provide the ideal basis for optimum pipe behavior when exposed to high temperatures and pressure. Processing under extreme pressure, while simultaneously cross-linking with the aid of organic peroxides, eliminates the otherwise steep fall in long-term stress rupture found in conventional polyethylene. During the cross-linking process, the polymer chains are linked to form a three-dimensional structure. In addition to creating outstanding long-term stress rupture resistance, cross-linking also produces superior environmental stress crack resistance.

Resistance to aging is also a decisive characteristic of RAUPEX. Aging is a material change caused by the effects of temperature and oxidation. With normal pipe this will adversely affect the life of the pipe. However, with RAUPEX, aging is minimal and a superior service life is the result. REHAU counteracts these aging influences with special heat-stabilizing agents which are added during the manufacturing process.

2.2.1 Flammability

RAUPEX is a hydrocarbon and therefore burns in a manner similar to wax. Cross-linking increases the temperature at which RAUPEX will begin to liquefy to a point higher than the decomposition temperature of 752ºF (400ºC).

2.2.2 UV Resistance

Once removed from the original packaging, RAUPEX must be protected from direct sunlight if exposure time will exceed three months. Installed pipe that will be permanently out of the heated SIM thermal mass must be sheathed to protect them from direct sunlight.

2.2.3 Long-Term Performance

Tests on internal pressure endurance over many years prove that RAUPEX performs significantly better than pipe made of other polymers. RAUPEX has been subjected to more than 100,000 hours of continuous testing at 203ºF (95ºC) without deviation in the endurance characteristics. REHAU is committed to a long-term testing program. RAUPEX is listed by the PPI (Plastics Pipe Institute) at 200ºF (93.3ºC) continuous service.

2.2.4 RAUPEX Advantages

RAUPEX is distinguished among other polymer pipe because of the following superior characteristics:

2.2.5 Gas and Water Vapor Permeability

The uncontrolled diffusion of gas and vapor into closed loop hydronic systems will cause corrosion problems if not properly dealt with. RAUPEX B features an extruded RAU EVAL (REHAU ethylene vinyl alcohol) oxygen diffusion barrier that virtually eliminates oxygen permeation through the pipe wall (consistent with European DIN Standard 4726, which is the only recognized standard for determining performance for barriers).

2.2.6 Thermal Properties

RAUPEX's high-density, cross-linked molecular bridges allow it to maintain its elastic properties at temperatures beyond those of other hydronic heating pipe. Even within the viscous-elastic range of RAUPEX (-184ºF to +248ºF) (-120ºC to +120ºC), RAUPEX remains softer and more malleable than its non-cross-linked base material.

RAUPEX can be used in situations where ambient air temperature ranges from 184ºF to +248ºF (-120ºC to +120ºC).

2.2.7 Mechanical Properties

RAUPEX is tough and flexible, even with repeated bending. Because of the cross-linking process, RAUPEX is more elastic and easier to bend than pipe cross-linked electronically or by most other cross-linking methods.

2.2.8 Chemical Resistance

RAUPEX resists conventional solvents, detergents, antifreeze agents and corrosion inhibitors. Even at high temperatures, RAUPEX resists hydrous solutions of salts, acids and alkali. If you have questions regarding chemicals that might come into contact with RAUPEX that are not called out in the chemical resistance chart located in Appendix 1, call your regional REHAU Sales Office.

2.2.9 Pipe Dimensions

RAUPEX and RAUPEX B are available in 3/8", 1/2", 5/8" (B only), 3/4" and 1" (13, 16, 19, 22 and 29 mm) nominal sizes in accordance with ASTM F876/F877 and CSA B137.5. RAUTHERM and RAUTHERM S are available in 17 x 2 mm, 20 x 2 mm, 25 x 2.3 mm and 32 x 2.9 mm sizes.

2.2.10 Pipe Labeling

REHAU marks RAUPEX with all information that is required by ASTM F876/F877, ICBO and CSA B137.5. For ease of installation, we also number the pipe sequentially every 3 feet (0.9 m). For easy identification, all RAUPEX B (REHAU oxygen barrier pipe) is red in color.

2.2.11 Quality Assurance Standards

The highest standard that RAUPEX is subjected to is REHAU's own in-house testing and quality assurance, by which we continuously test and measure the quality of our pipe. REHAU production facilities are certified in accordance with ISO 9001.

2.3 REHAU EVERLOC and Compression Nut Systems

REHAU promotes two types of fitting systems for RAUPEX: EVERLOC and the compression nut system.

2.3.1 EVERLOC Fitting System

The REHAU EVERLOC fitting is ideally suited to overcoming the problem of creep associated with polymer pipe joints. Polymer pipe is constantly moving within a fitting. Traditional compression type fittings will require tightening periodically, even at temperatures and pressures associated with SIM systems.

However, the EVERLOC fitting system is the perfect way to ensure a permanent connection that does not require retightening. Our joining system employs the memory effect inherent in RAUPEX. The pipe is cold-expanded and pushed onto the brass fitting body. Because of the pipe's "memory," it will then shrink securely onto the fitting within seconds. The compression sleeve is then compressed over the pipe. The EVERLOC hand tool, required to install the EVERLOC fitting, allows for easy installation.

The EVERLOC fitting sleeve is superior to crimp fittings, split ring compression fittings and PEX ring sleeve fittings. Use our fitting with enough confidence to encapsulate it in the thermal mass or behind walls, provided this procedure meets local codes.

The EVERLOC fitting system provides the following benefits:

- Permanent connection.
- The inside diameter of the fitting does not restrict fluid flow.
- The EVERLOC fitting never leaks when installed properly!

Fig. 2.1
EVERLOC fitting

2.3.2 REHAU Compression Nut Fitting System

The compression nut system utilizes a compression fitting similar to those available on the market for soft copper pipe. The difference is the requirement of an inner support stiffener and a split compression ring required for RAUPEX. We recommend the use of these fittings only where they remain accessible.

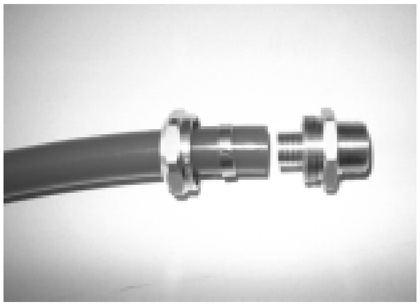

Fig. 2.2
Compression nut fitting

2.4 REHAU Heat Distribution Manifolds

There are many choices for manifolds such as copper, brass and polymer. As a designer, keep in mind that the flow capacity of the manifold should be adequate for the design, and the manifold must accept a REHAU PEX-to-copper adapter or valve fitting. REHAU has four styles of manifolds available for use with SIM systems: the HKV and HLV manifolds, the Pro-Balance Manifold™ with Gauges, which are made of brass, and copper manifolds.

2.4.1 HKV Manifolds

The HKV manifold comes as a complete assembly with 1" female threaded isolation ball valves. Each manifold comes installed on mounting brackets and is available with 2 to 12 circuits. These manifolds are acceptable for use with 3/8", 1/2", 5/8" and 3/4" pipe. Because of the flow rates normally associated with REHAU SIM systems, the HKV manifolds will apply only to smaller jobs (less than 200,000 Btuh requirement). You should check the pressure drop in the pipe size you select for the job (we describe how to do this in Chapter 4, Planning and Design) before specifying an HKV manifold.

2.4.2 Copper Manifolds

Copper manifolds are available in sections for final assembly at the site or can be specially ordered, ready to install.

Fig. 2.4
Copper manifold

Fig. 2.3
SIM distribution manifold

2.5 Installation Accessories

These accessories are used to secure or fasten the pipe prior to pouring or backfilling the thermal mass. Each component has been field tested and is designed specifically to save installation time and effectively fasten RAUPEX. The details of how and when to use each component is covered in Chapter 3, Construction Details.

2.5.1 Star Clips

Star Clips are simple and easy to use, and are available for 3/8", 1/2", 5/8" and 3/4" pipe. They have been proven to save time when attaching RAUPEX to wire mesh.

Star Clips feature a clasp at the top to hold the pipe, and a recess at the bottom for engagement onto the wire reinforcement mesh typically used in concrete. Once the clip has been installed it secures the pipe, eliminating any chance of coming off during a pour or backfilling.

Typically, you should specify that Star Clips are placed every 2' to 3' (0.6m to 0.9m) on straight runs. On bends place a clip at the start, end, and midpoint of the bend.

2.5.2 Nylon Pipe Ties

Nylon Pipe Ties are commonly used for electrical cable binding. REHAU uses nylon ties for installing RAUPEX on reinforcement bar systems and can be used for all sizes of pipe. Be very careful not to overtighten the ties when securing the pipe to the reinforcement bar. The pipe should be held loosely against the metal bar so it does not cause long-term external wear on the pipe wall caused by pipe expansion during heating cycles.

3. Construction Details

This chapter is included to give you an insight into some of the pertinent details of construction when you're designing and installing a REHAU SIM system. We have provided overview information on thermal mass types, drainage considerations and insulation. For your use in specifications, we have included many application and detail drawings with comments. If you cannot find a detail that matches your SIM situation, you should feel comfortable expanding on what we have provided here. We can also provide you with additional assistance as required.

3.1 Applicable Codes

Each state, provincial or local government will typically write, adopt or modify construction codes as defined by one of the major code organizations of either BOCA, ICBO, SBCCI or CSA. Some areas have actually written their own set of governing building codes, or adopted only portions of the code as defined by the major code organizations. While codes may be adopted and/or defined, the level of code enforcement will vary significantly from region to region. In terms of design, you should check with the local code authority where your SIM system will be installed to determine if any existing codes may regulate your design.

Mechanical codes that may be applicable to your SIM project are probably the same as the ones that will apply for most mechanical systems. Generally, the mechanical codes will be concerned with the type of material you use in the SIM system as well as joints (if any), expansion and contraction of the pipe, support of the pipe, insulation around the pipe, heat transfer fluid, valves and pressure testing. If necessary refer back to Chapter 2 regarding the components of the REHAU SIM system.

Building codes will, most likely, also apply. You should find out if there are any unique codes that apply to your SIM system.

Building codes are extensive and very important to you as the designer. For example, most will even define who qualifies for design of the project. You should speak with a local code enforcement agency and discuss your REHAU SIM project before proceeding too far. The agency can even tell you what permits will be necessary.

Fig. 3.1
Hangar door SIM construction

3.2 Thermal Mass Materials

There may be unlimited numbers of thermal mass materials that have been, or will be, used with a REHAU SIM system. These have included: concrete, various types of soils, asphalt, quarry tailings, brick and other types of pavers, sandstone and granite. The only real limitations on the type of mass that can be used are:

1. Can the mass effectively distribute the heat generated by your REHAU SIM system and be able to withstand elevated design surface temperatures?

2. Can the mass or the supporting mass with the RAUPEX protect the pipe and contain it for the life of the system?

3. Is the mass material in contact with RAUPEX compatible with RAUPEX pipe material, or when it is applied, are the agents present acceptable?

4. Is the temperature of the mass material, when applied, within tolerance limits of the RAUPEX installed?

5. Will the thermal-mechanical properties of the mass material affect RAUPEX in such a way as to damage it?

6. Will the installation technique of the mass material alter the installation of the RAUPEX pipe or damage it?

7. Many SIM thermal mass materials are very porous. You will want to determine if the surface will be washed with, come in contact with, or be subject to any materials that will leach down and harm the RAUPEX pipe.

Fig. 3.2
SIM church step installation

The thermal masses that will work best are those that have sufficient density and heat capacity (specific heat) to distribute and hold heat, and that contain minimal entrained air. While you may not be able to choose the thermal mass material, your ability to express the technical issues of the choice will be important. Many mechanical engineering handbooks will contain the necessary information should you need to review density and heat capacity data.

Many designers prefer to install RAUPEX directly under the thermal mass. This is an acceptable practice provided you follow the guidelines mentioned here and previously. Be sure that you consider the maximum pipe depth in your design work (Chapter 4, Planning and Design).

3.2.1 Concrete

Concrete is a very common REHAU SIM thermal mass. Most concrete has a specific heat capacity of around 0.20 Btu/lb-ºF (0.84 kJ/kg-ºC) and is about 144 lb/ft^3 (2306 kg/m^3). You may want to check with the installer to see if any additives will affect thermal quality of the concrete. Air entraining is very popular for exposed concrete, but not good for thermal conductivity.

When dealing with concrete thermal mass, do not assume there will be reinforcement (wire or rebar) to secure the RAUPEX. Many times, the concrete will be fiberglass reinforced. You will also want to check where any control or expansion joints will be. You must either protect RAUPEX pipe when it passes through these joints or else reroute it. If, in the case of a concrete walkway or driveway, there are many joints, it may be better to place RAUPEX under the concrete (as shown in some of the details that follow later in this chapter). Often, control joints in concrete are cut in after the cure. You will need to know if this is the case on your project and make sure the RAUPEX SIM system is protected.

3.2.2 Asphalt

Asphalt can make an excellent SIM thermal mass. It has a heat capacity of approximately 0.21 Btu/lb-ºF (0.92 kJ/kg-ºC) and is about 105 lb/ft^3 (1682 kg/m^3).

There are several details that you will need to consider when specifying a REHAU SIM system for use within asphalt. Asphalt is typically applied in a heated condition. Normally installers will heat the asphalt mix to between 250ºF and 350ºF (121ºC and 177ºC) prior to installation. A REHAU SIM system is unique and will require different installation techniques. The benefits of the resulting SIM system will have a lasting and beneficial impact that everyone can enjoy.

Fig. 3.3
Concrete installation over SIM system

3.2.3 RAUPEX in Asphalt: Installation Steps

During the installation of asphalt:

1. Require the mechanical installer of the SIM system to pressurize the RAUPEX pipe to system operating pressure (15-40 psi [100-266 kPa]) with water.

2. **Flush** water through the RAUPEX pipe and maintain a maximum return temperature of 150ºF (65ºC).

3. The asphalt installer shall be prepared to monitor the delivery temperature of the asphalt to help ensure that the asphalt temperature is at or below 240ºF (115ºC) during the installation. The petroleum-based additives that they may add to achieve this, in a workable state, are normally acceptable to RAUPEX.

Any chance of damaging the RAUPEX with hot asphalt can be avoided by simply placing the RAUPEX in a sand bed under the asphalt surface. This technique may be a wise choice particularly since, in many asphalt jobs, subsurface preparation is poor. The cracking and potholes normally present in asphalt would expose the RAUPEX if it had been installed within the asphalt.

If you suspect that the system, once installation is complete, will not be charged with antifreeze until after freezing weather sets in, be sure the flushing water is entirely removed from the RAUPEX pipe. This will most likely require forcing air through each pipe individually to ensure that all the water is gone. It is also important that the pipe installation be closed to the atmosphere as the system will “breathe” and condense the air’s water moisture. A buildup of condensation could collect sufficient water to cause freeze damage to the pipe.

3.2.4 Pavers

Brick and other similar pavers such as flagstone and sandstone are common REHAU SIM thermal mass materials. While the density and heat capacity varies for each, they are typically around 0.20 Btu/lb-ºF (0.84 kJ/kg-ºC) and are about 144 lb/ft^3 (2306 kg/m^3) for fire clay brick.

Since these types of systems are made of prefabricated units, you will need to install the REHAU SIM system in a layer underneath the pavers. As we will show you in some of the details that follow, this will entail installation of the pipe and covering with a paver base material such as sand, gravel, soil or quarry tailings (such as “crusher dust,” which is a byproduct of rock pulverizing in cement plants). Two inches (50 mm) is usually adequate; however, the pavers’ installers will normally specify the amount, type, and the degree of compaction (they will probably install the base material also). As the designer, make sure the base material is compacted well around the RAUPEX. RAUPEX will elongate during heat up, which will cause “snaking” if the pipe is not held down or “captured.”

3.2.5 Other Thermal Mass Considerations

As the designer, demand that extra effort and planning go into the subsurface under the thermal mass. The outside environment is extremely harsh and brutal on building materials. As is readily obvious, pavement cracking and damage is common in areas of North America requiring SIM systems. Proper control of the SIM system will help to prevent movement associated with frost heaving and expansion. However, even with proper site preparation and backfilling, movement can and will occur. Demanding proper site preparations and materials will help, as will proper installation planning.

SIM systems are also installed in exposed areas (systems where the underside of the thermal mass is an elevated ramp or stairway of a parking garage). These systems will not benefit from the protection of being installed in the ground, or the added thermal mass of the ground (which will help to contain heat once the thermal mass temperature is elevated). You should not assume that the heat generated by the REHAU SIM system will only transfer to the surface of the melt area. It will, in fact, transfer to all cold areas. We normally plan for 15% downward heat loss in our output and flow rate calculations. With a SIM system that is exposed on the underside, for example, this 15% will not be adequate. In fact, the downward loss (away from the melt surface) may be equal to the upward loss (or output), and if it is windy on the underside you may get more heat going toward the underside. It will be your responsibility to consider this fact. One effective way to deal with this is to insulate the underside of the exposed area. We suggest a minimum of R10 which is approximately 2" (50 mm) of rigid foam insulation.

3.3 Drainage Considerations

Proper drainage is a fundamental part of any REHAU SIM design. Here again you will need to consider all the factors that influence your design. Without proper drainage, the heat transfer problem of the SIM system will change, and the results on the melting surface may be less than acceptable.

There are two principal considerations with drainage of the REHAU SIM site. You should discuss these details with the builder, owner and site planner. They may not normally plan for some of the things you request, or they may not have even thought of the consequences of improper drainage. For instance:

1. Standing water underneath the SIM thermal mass will rob the system of heat. Water running underneath (caused by improper drainage) will rob even more heat, because a significant amount of heat can be carried away by water.
2. Once the snow and ice have melted on the surface, the melted water must be either drained off or evaporated. Normally, a combination of the two will result. Water left standing may refreeze when the system is turned off (a particular problem with on/off control systems). Water not properly drained from the edges of the SIM area may also refreeze. In some cases this refrozen water is more of a liability than it was on the melted thermal mass surface.

Despite all of this, there are steps that can be taken to properly design for drainage. Proper planning and integration of these plans with all trades is essential. Proper planning requires the following:

1. Adequate drainage under the thermal mass area. If water is moving under the fines (small diameter sand) the fines will be washed away, leaving voids. This will cause the thermal mass to move and possibly damage the RAUPEX pipe. Removal of the fines around RAUPEX, (if the pipe is installed under the thermal mass), will allow it to snake around. This movement will change your design, as the spacing may change.
2. Drainage is achieved by properly preparing the subsurface to prevent capillary action (wicking of the water from lower levels) and by digging graded trenches away from the SIM area. Capillary action can be prevented by installing larger sized stone (2" [50 mm] or larger) under the base material of the thermal mass. This may require the installer to lay down a filter cloth or other material (such as a vapor barrier) to prevent the base material from falling down in among the larger stone.
3. Mechanical compaction is normally necessary. You should consult a site planner for details on proper site preparation. The installer of the thermal mass may not necessarily have all the information needed to ensure proper site preparation and drainage.
4. Drainage away from the SIM thermal mass is accomplished by pitching the surface of the thermal mass toward a drain. If the thermal mass is pitched toward the outside (unheated) areas, the drain should be directed well away from the heated area. Don’t forget that the drain will also need to be protected against freezing.

3.4 Insulation Considerations

There are generally two schools of thought regarding the use of insulation under SIM systems. One is that you always insulate under the RAUPEX pipe to promote upward heat transfer. The other is that you do not insulate under the pipe if the pipe and thermal mass are on grade and you can use the thermal mass of the surrounding earth as a heat sink and additional thermal storage.

At REHAU we believe, largely depending on the type of control scheme selected, that both techniques have merit in particular situations. For our construction detail we will include insulation; however, the actual specification of insulation will be up to you.

There are circumstances in which you should always specify insulation: where the underside of the thermal mass is exposed to unheated air and/or wind; and where the water table is high (don't place insulation in water or allow it to soak in water) and likely to influence heat transfer. This does not replace proper drainage as previously discussed. In some cases, if you are not certain there will be proper drainage, or a high water table exists, it may be better to not use a SIM system at all. Another consideration about water is that wet insulation will have a significantly lower R value than the rated R value indicated.

When specifying insulation for use with a REHAU SIM system, make sure that it is suitable for the application and can withstand any compaction or compression that it may be subject to if it’s placed under a thermal mass. Tongue and groove insulation over a plastic vapor barrier is the best method to minimize upward ground moisture migration.

Most manufacturers will indicate where and if, their insulation is applicable to your proposed application. For example, their literature normally will indicate whether the insulation can be used below grade, such as you might specify for use with a REHAU SIM system, and whether it will stand up to the compaction and compression of your application. Do not just assume that the off-the-shelf blue board type insulation is adequate. Sprayed on urethane insulation has also been used successfully under REHAU SIM systems. Check with the urethane installers to make sure they use the proper materials and spray density to handle the job.

A final consideration about insulation:
RAUPEX that is primarily distributed to and from the SIM thermal mass should be insulated with pipe insulation suitable for buried pipe applications.

3.5 Vapor Barriers

Vapor barriers under a thermal mass are common; however, the applications seem to vary. Thermal mass installers will use them to prevent soil moisture or water from wicking up into insulation or the thermal mass. Other times a vapor barrier is used to reduce the possibility of the compacted base material from falling down into larger sub base stone underneath (as mentioned in the section on drainage).

For your REHAU SIM system design, just remember that you need the base material and the thermal mass material properly drained, with any insulation you specify free from being saturated with water. Whether you specify the vapor barrier or another specifier does, you will need to coordinate its location and understand the effect it will have on moisture in the SIM system.

3.6 Installation Applications and Details

As mentioned previously, there are virtually unlimited possibilities for applying a REHAU SIM system, but we cannot possibly discuss all of them here; what we can present are some potential applications.

The intent of this section is to familiarize you with the general techniques of what an installed REHAU SIM system will look like, what components you might specify, and how they relate to the other components of the system that you may not be specifying. These drawings and the information included are only a starting point. Your expertise and those of the installers and other designers will be needed to specifically apply each SIM system.

With the information presented previously and the examples presented here, you should get a good feel of components and technique. If you need more detail or information, we can always provide assistance.

In our details we will indicate the use of insulation. Remember, however, that insulation may not be necessary. Please review the section on insulation and vapor barriers to decide if insulation is necessary in your application.

3.7 Thermal Mass Joints

There are many instances when the thermal mass installers will place joints within the mass. These joints are either slab edge expansion and contraction joints or slab crack control joints. Frequently, as in the case of a walkway or patio, joints will be placed for aesthetics also.

You should plan to avoid passing through joints whenever possible (Fig. 3.4). Arrange RAUPEX pipe circuits around joints. When you must have pipe pass through a joint, be sure to specify protection sleeves around all RAUPEX that passes through the joint. Sleeve RAUPEX when it passes into and out of the thermal mass (Fig. 3.5).

A thermal mass will always move when heated and cooled. One advantage of a weather sensing control system is that it will help to minimize these temperature differences and therefore help to control thermal mass movement. Movement resulting from temperature differences can be approximately estimated as follows:

dl = (l) x (a) x (dt)
dl = longitudinal expansion in inches (or millimeters)
l = thermal mass length in feet (or meters)
a = coefficient of longitudinal expansion which varies for each thermal mass type in units of l/°F (l/°K).
dt = temperature difference in °F (°K).

Proper planning for this expansion (and the corresponding contraction) should be done by the engineer or designer specifying the thermal mass. These joints are particularly important because the RAUPEX pipe layout that you specify will have to plan for trying to avoid these joints. Incorrect joint installation or arrangement could damage the thermal mass and the RAUPEX pipe.

You can typically expect joints:

- at the edge of the thermal mass where it meets the building.
- around thermal mass areas larger than 430 square feet (40 square meters).
- where a ramp meets a flat surface.
- areas where the thermal mass changes from one type to another, between heated and unheated slab areas and between static heavy load-bearing slab areas and normal non-load-bearing slab areas. Some thermal mass materials, such as asphalt, will not likely have a joint within the mass but they will likely have them in other locations.

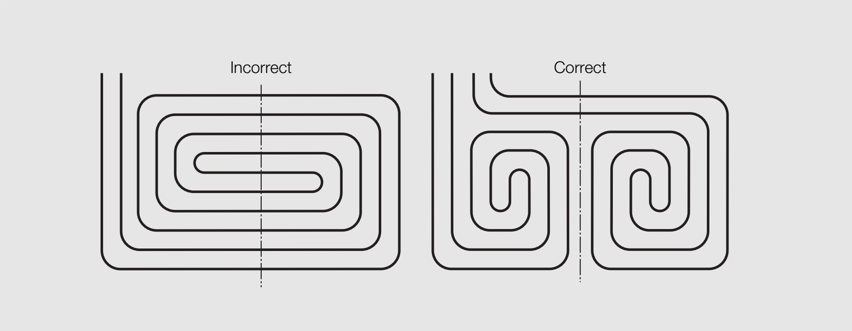

Fig. 3.4
Avoid passing through thermal mass joints whenever possible.

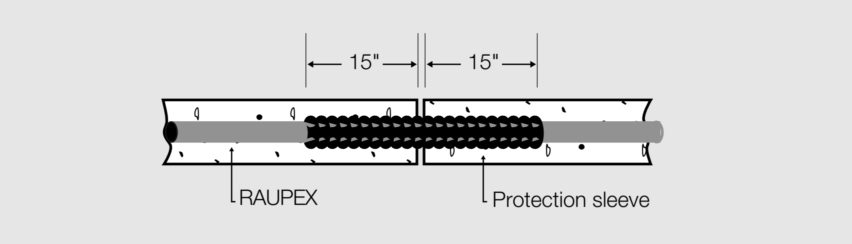

Fig. 3.5
Specify REHAU protection sleeves around all RAUPEX that passes through a joint.

4.3 Design Methodology

4.3.1 Heating Requirements

The heating requirements of your REHAU SIM design are affected by:

- The rate of snow fall/density.
- The air temperature.
- Wind speed.
- Humidity.
- Effects of convective and radiated heat transfer.
- Insulating effect of snow.

You must know three of these factors before you proceed with the design. As mentioned in previous chapters, you will determine these factors based on available weather history data for the geographic area.

Rate of Snow Fall

When snow falls on the warmed SIM surface, the snow must first be warmed to 32ºF (0ºC) and then melted. Once melted, the water from the melted snow will form a film layer over the entire area and then begin to evaporate. With this evaporation, a mass transfer from the SIM surface to the air results. Additionally, heat transfers from the film layer to the ambient air and adjacent surfaces.

Air Temperature

The temperature difference between the SIM surface and the air has to be overcome by the SIM system.

An operating surface temperature for the SIM system of 38ºF (3.3ºC) is recommended as a minimum.

Wind Speed

The wind speed dictates the heat transfer coefficient selected for the design.

Humidity

The rate snow will evaporate off of the SIM surface will depend on the wind speed and the difference in vapor pressure between the air and the melted snow. Since the SIM thermal mass surface temperature is fixed, and the vapor pressure is determined by the relative humidity and temperature of the air, then evaporation will vary with air temperature, wind speed and relative humidity.

Effects of Convective and Radiated Heat Transfer

Heat transfer by both convection and radiation will also define the amount of heat that must be generated by the SIM thermal mass. To put it simply, the amount of energy required from the SIM thermal mass will depend on the air temperature and the wind speed, when considering the loss from convection and radiation.

Insulating Effect of Snow

One should consider that snow has an insulating effect. When snow falls on the SIM surface (which in the beginning will be dry and warm), it must be heated to 32ºF (0ºC) first, and then melted. From the time that the snow is being heated up, to a time just before it is completely melted, it can actually be considered an insulator. The effect of this insulation can be considerable. With a volume of snow piled on the surface, the output requirement can be reduced significantly. It certainly will, however, take some time to melt this snow, and once it's melted, if it is still snowing, the output requirement for the SIM system will rise sharply.

4.3.2 Heating Variables

As you can see, the variables are complex. Even if you choose particular weather conditions, based on available information, you will still be basing your design on unpredictable weather conditions. It is therefore very important to review the historical weather data and base your choices accordingly. You must also insist that site conditions be optimized (such as drainage and control technology) to allow your system to function at peak efficiency. What is of overall importance is that you thoroughly discuss your design with all who are concerned with the operation of the system.

Fig. 4.2
SIM installation

4.4 The Design Process

If this is your first time through the REHAU SIM system design process, you should read this section prior to performing any calculations. Once you become familiar with and understand the general process of design, then you should be able to proceed directly to performing calculations.

The general procedure for a REHAU SIM design is a five-part process:

- **Part 1:** General design conditions summary
- **Part 2:** Calculations based on chosen design conditions
- **Part 3:** Choose output values based on calculations
- **Part 4:** Optimization of design
- **Part 5:** Design summary

4.4.1 Part 1: General Design Conditions Summary

Summarize Job Related Data

The procedure of summarizing important job related information should occur on every REHAU SIM design job and the information should be retained as a record of the factors that influenced the design and how it was performed. This information will include:

1. The owner of the project.
2. The geographical location.
3. The SIM designer's name, address and phone number.
4. The SIM system installer's name, address and phone number.
5. The SIM thermal mass installer's name, address and phone number.
6. The class of SIM design.
7. Any special design conditions.

As the designer, you should ensure that any other important information is permanently recorded in a comment area.

Weather Data

To begin your design for any class of system, acquire the SIM weather data from a reliable source. Local historical data is the best choice. You will need to determine the following information:

Thermal Mass Pickup Temperature

Add 10ºF (5.6ºC) to the normal starting temperature for determining the pickup requirement for a thermal mass that is not kept at an idling temperature (typically, an idling temperature will be around 32ºF [0ºC]).

SIM Thermal Mass Starting Temperature

The thermal mass starting temperature is the temperature of the thermal mass when the snow and ice melting system is turned on. The starting temperature of the thermal mass is dependent on the control choices that you have made. You are either designing with a control that will idle the thermal mass (typically, an idling temperature will be around 32ºF [0ºC]) or you are not designing with this type of control and expect the thermal mass will be cold at start-up. Normally, for most designs, if you do not know the cold start-up temperature, assume that it will be the design low ambient temperature with an additional -10ºF. This will help to define the pickup load, or the amount of heat required to bring the thermal mass up to the point where it will begin to melt snow and/or ice. The selection of the SIM area idling temperature or the decision to cold start the SIM process directly affects the effective response time of the SIM area.

Snow Density

Snow density varies considerably.
For most designs, in order to come to a reasonable compromise, you can assume that snow will be one of three typical densities. The snow will generally be lightweight (4 lb/ft^3 [64 kg/m^3]), average weight (6 lb/ft^3 [96 kg/m^3]), or heavy weight (10 lb/ft^3 [160 kg/m^3]). Since denser (heavier) snow will take more energy to melt per volume, this determination is important. Geographical weather data will help with the choice.

Wind Effects

Particularly for Class III, where we will keep the SIM thermal mass surface free of snow as it is falling, knowing the wind velocity is necessary. Table 4.4 is for wind speeds less than or equal to 15 mph (24 km/h). In Class I and II, where the snow will insulate the surface, wind is less of a contributing factor (until just as the surface starts to clear of snow).

Snow Fall Rate

For Class III, this is the maximum rate of snow fall in in/hr (cm/hr) you would like your SIM system to melt. For Class I and II, this will be the amount of accumulated snow you would like to melt per hour.

Design Temperature During Melting

This is air temperature you will expect to experience as you are in the melting process. The effect of wind speed and the associated chill factor is introduced through the film coefficient.

SIM Thermal Mass Data

The SIM thermal mass material that you install the RAUPEX in will have characteristics that affect both output performance and pickup load requirements. For this part of the design you will need to know:

- **SIM thermal mass characteristics** – You will need to know the conductance value and thickness of each layer of the thermal mass.

- **SIM surface area** – Two things need to be determined for SIM surface area. First, the total area where you would like melting to occur, and second, the total area that will actually contain pipe.

- **Antifreeze demand** – You will need to determine both the percentage of antifreeze required at design melting conditions (or starting temperature if you will pick up the temperature) and the lowest exposure temperature for protection against freezing. See Appendix 2 to estimate volume of antifreeze required.

4.4.2 Part 2: Load Calculation Procedure

Melting Requirement

With the class of problem and melting weather conditions, you can determine melting output requirements from Table 4.1 or 4.2. The values in the tables are in Btuh/ft^2 (W/m^2) of SIM thermal mass. When you determine total load and GPM (l/m) needed to meet this demand, you will need to calculate accordingly.

Pickup Requirement

The ability of the thermal mass to start from a “cold start” depends on the construction characteristics. The efficiency of the thermal mass, insulation design and the depth of the RAUPEX within the thermal mass will determine the amount of time that will be required to bring the SIM system up to melting capacity. In concrete slabs, for example, it takes approximately 30 Btu (8W) to raise 1 ft^3 (.0283 m^3) of concrete 1ºF (0.56ºC).

Thickness	Btuh/ft ^{2}/ºF
4"	10
5"	12.5
6"	15

Example: SIM area capacity temperature is 38ºF (3.3ºC) with a thermal mass thickness of 5" (12.5 cm) and a cold start temperature of 18ºF (-7.8ºC). Calculate the heat required to raise the slab temperature:

(12.5 Btu/ft^2) ÷ (ºF) For 5" slab

(12.5 Btu/ft^2) ÷ (ºF) x (ΔT) = Ht

ΔT = (38ºF-18ºF) = 20ºF

Ht = 250 Btuh/ft^2

Assume 85% efficient slab with edge losses = 294 Btuh/ft^2.

Melting Load, Total Requirement

Once the pickup load requirement and melting load requirement are both determined, you will need to choose the larger of the two values. This largest value, in Btuh (W), will be the heating source load requirement.

4.4.3 Part 3: SIM Load Requirement

In this step of the design process, you will be able to use Table 4.4 to determine and optimize RAUPEX spacing and mean heating water temperature (MHWT) for your design.

Choose Output Values

After determining the heat requirement use Table 4.4 to determine the required MHWT and corresponding pipe spacing.

Optimize the Design

This step will help to ensure an efficient system. When you review Table 4.4, you will notice that, in many designs, several different pipe spacings and MHWT values that will satisfy the demand requirements. To optimize the design, you should try to choose the pipe spacing that will require the lowest MHWT possible to meet the demand. Obviously, there are some trade-offs, such as the amount of pipe that will be required will increase with more tightly spaced pipe. We suggest, however, as mentioned before, that you do not compromise your design. Energy-efficient performance with optimal melting performance is what you are designing into a REHAU SIM system.

Total Pipe Requirement

With the optimal pipe spacing and MHWT chosen, you will be able to calculate the total amount of pipe required for the job. To do this you will simply need to go to Table 4.4, the pipe spacing factor, and find the multiplier to use with the pipe spacing that you have chosen. To determine the total amount of RAUPEX needed for the job, simply multiply the spacing factor by the total area that the pipe will cover (which may not be the same as the total area to be melted).

Determining GPM and Head Requirement

You will need to calculate the flow and head of the fluid required to meet your design demand. Flow is calculated by using the formula:

$$\text{GPM} = \frac{\text{Total Btu}}{(8) \times (\text{Fd}) \times (\Delta\text{T}) \times (\text{Hs})}$$

Total Btu = Heat Requirement

- 8 is a constant for U.S. customary calculations
- Fd is the fluid density
- ΔT is the temperature drop of the fluid as it passes through the SIM thermal mass
- Hs - The specific heat of the fluid at the fluid temperature that you specified

Head values are found on Tables 4.5 a-f. Base the calculation on fluid temperature, glycol percentage and pipe size.

4.4.4 Sample SIM System Project Design

Mr. Ray Howe has requested a quote for a snow and ice melt system for his driveway and walk. Mr. Howe lives in Philadephia, PA.

Obtain a set of plans of Mr. Howe's site showing elevations for drainage and a plan view of the driveway and walk. Request location of heat source for system. Determine if a Class I system will perform adequately for Mr. Howe.

From Table 4.1, find the design output for Philadelphia, PA, Class I system, 97 Btu/ft^2. From Table 4.3, you'll find the average freezing temperature to be 26.7ºF (-2.9ºC) with a wind speed of 9.7 mph (5.5 km/h). From Table 4.4, you determine that for an outside temperature of 20ºF (-6.6ºC) and a capacity requirement of 97 Btu/ft^2, a 100ºF (37.7ºC) MHWT with a 12" (30.5 cm) pipe spacing will be required.

Review of the plans shows the driveway to be 10' (3m) wide with a length of 50' (15m), totaling 500 ft^2 (46m^2). The amount of pipe required to do the driveway is determined from Table 4.4, pipe factor of 1 multiplied by the area or 500' (152m) of pipe. The length of pipe to the SIM area (tails) and extra pipe required to lay around obstructions will be added. Add 20' (6m) for tails and 5% or 25' (7.6m) for obstructions, making a total length of 545' (165m). Review of the plans shows the sidewalk to be 4' wide (1.2m) with a length of 20' (6m). Determine the pipe requirement with the same procedure used for the driveway.

Total Area = 80 ft^2
Total Pipe = (80 ft^2) (1ft/ft^2) = 80 ft
Total Pipe + Tails + Extra =
80 ft + 10 ft + 3 ft = 93 ft
Total Pipe Requirement =
545 + 93 = 638 (approx. 640 ft.)

Determine pipe size based on hydraulic requirement. Hydraulic requirement is calculated by determining total load requirement. The total area to be heated is 500 ft^2 + 80 ft^2 = 580 ft^2. Total capacity requirement is 580 ft^2 multiplied by 97 Btu/ft^2 divided by an efficiency factor. Assuming 85% efficiency of the system is a good estimate.

The calculation as follows:

$$\frac{(580\ \text{ft}^2)\ (97\ \text{Btu/ft}^2) = 66{,}188\ \text{Btu's}}{.85}$$

Knowing the total load requirement determines the total flow rate required to supply the SIM area. The formula is as follows:

GPM =

$$\frac{\text{Total Btu}}{(8)\ (\text{Fluid Density})\ (\Delta T)\ (\text{Fluid Specific Heat Fluid})}$$

Determine heat transfer fluid mixture based on freeze protection. For the Philadelphia area, a 50% glycol mixture by volume is adequate freeze protection. The properties of a 50% glycol mixture should be obtained from the glycol manufacturer. Typical values for glycol at 100ºF (37.8ºC) MHWT are as follows:

Density (lb/ft^3):	65.53
Specific heat (Btu/lbºF):	0.830

Knowing this data, calculate the flow requirement:

$$\text{GPM} = \frac{66{,}188\ \text{Btu's}}{(8)\ (65.63)\ (25^\circ\text{F})\ (.830)}$$

$$\text{GPM} = 6.08$$

Knowing the total flow rate of 6.08 GPM required, determine the number of circuits required to supply the capacity to the SIM area. With a known manifold location, the pipe circuits must be planned. To determine the allowable circuit length, one must know the total number of circuits and the pipe diameter. To determine the number of circuits, use the allowable pipe spacing to determine the number of circuits to install in the SIM area.

The plan view of the driveway and sidewalk show the manifold location at the top of the driveway. A total pipe circuit length of 640' (195m) can be planned. The total number of circuits will be 3.

Total Pipe Requirement =
640' (195m) ÷ 3 circuits = 213' (65m) per circuit
Total Flow = 6.08 GPM
Total Flow per Circuit =
6.08 GPM ÷ 3 = 2.02 GPM

Choosing a pipe diameter of 3/4" and using flow data from Table 4-5e for a flow rate of 2.10, 3/4" pipe size, the feet of head per foot of pipe is 0.03815.

Total Head Loss per Pipe Circuit =
0.03815 x 213' (65m) Circuit Length
Total Head Loss = 8.12' of Head

Table 4.1
Operating characteristics of snow melting systems

	Design Output, Btu/h - ft2		
City	**Class I System**	**Class II System**	**Class III System**
Albuquerque, NM	71	82	167
Amarillo, TX	98	143	241
Boston, MA	107	231	255
Buffalo-Niagara Falls, NY	80	192	307
Burlington, VT	90	142	244
Caribou-Limestone, ME	93	138	307
Cheyenne, WY	83	129	425
Chicago, IL	89	165	350
Colorado Springs, CO	63	63	293
Columbus, OH	52	72	253
Detroit, MI	69	140	255
Duluth, MN	114	206	374
Falmouth, MA	93	144	165
Great Falls, MT	112	138	372
Hartford, CN	115	254	260
Lincoln, NB	67	202	246
Memphis, TN	134	144	212
Minneapolis-St. Paul, MN	95	155	254
Mt. Home, ID	50	90	140
New York, NY	121	298	342
Ogden, UT	98	216	217
Oklahoma City, OK	66	81	350
Philadelphia, PA	97	229	263
Pittsburgh, PA	89	157	275
Portland, OR	86	97	111
Rapid City, SD	86	102	447
Reno, NV	98	154	155
St. Louis, MO	122	152	198
Salina, KS	85	120	228
Sault Ste. Marie, MI	78	144	213
Seattle-Tacoma, WA	92	128	133
Spokane, WA	87	127	189
Washington, D.C.	117	121	144

(Permission to use data authorized by ASHRAE)

Table 4.2
Heat output and fluid temperature for snow melting system

		t_a = 0ºF			t_a = 10ºF			t_a = 20ºF			t_a = 30ºF		
Rate of Snowfall in/h		**Wind Speed mph**			**Wind Speed mph**			**Wind Speed mph**			**Wind Speed mph**		
		5	**10**	**15**	**5**	**10**	**15**	**5**	**10**	**15**	**5**	**10**	**15**
0.08	q_o	151	205	260	127	168	209	102	128	154	75	84	94
	t_m	108	135	162	97	117	138	85	97	110	70	75	79
0.16	q_o	218	273	327	193	233	274	165	191	217	135	144	154
	t_m	142	169	198	129	149	170	117	129	142	100	105	109
0.25	q_o	292	347	401	265	305	346	235	261	287	203	212	221
	t_m	179	206	234	165	186	206	151	163	176	134	139	144

(Permission to use data authorized by ASHRAE)

4. Planning and Design

The planning and design of a SIM system involves many challenges. In this section, we have made an attempt to provide a methodology to guide the designer with a hydronics background. We supply the charts, tables, graphs and formulas. If you do not have prior experience with hydronic heating systems, please contact your local REHAU Sales Office listed on the back of this manual for assistance.

4.1 Planning

Planning requires the ability to predict the end result. In order to do an accurate and complete job, you will need to start with a current set of building plans. Discussion with the owner and/or the owner's agent will determine the expectations with regard to the performance of the SIM system.

A careful review of the site plans and weather conditions for the geographic area should be initiated. Details to review are drainage, slope, thermal mass material, proposed installation method, weather data and type of heating source.

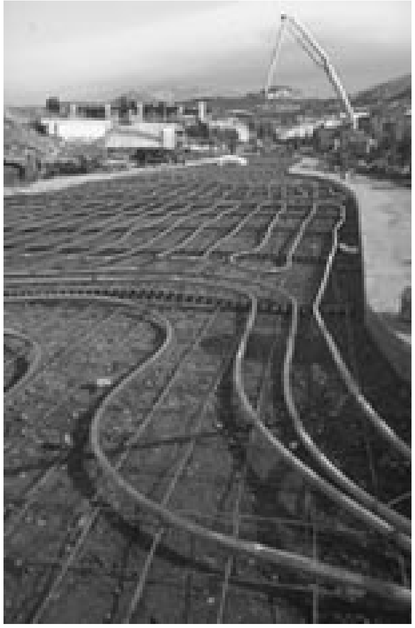

Fig. 4.1
SIM system installation beneath roadway

Once you have completed this preliminary planning, you can begin to do the actual design work. Design will take some understanding and time. There is no quick and easy method. If you are aware of rules of thumb, or standard installations, be aware that the potential for a problem could be magnified. If you follow the design steps of this chapter in accordance with your planning effort, the end result will be a conservative design.

4.2 Design

SIM designs are based on a class system as listed below. The expectations for the SIM system are established during the planning stage. The SIM requirement of the project owner will establish the class of system.

4.2.1 Class I

A Class I SIM system design is a manual turn-on system which, at full capacity for its geographic region, can handle melting up to 98% of the heaviest snow and ice load for that area. It will usually be specified for manual operation in residential usage where the owner elects to use the system at his discretion, and it may feature an automatic shut-off timer.

4.2.2 Class II

A Class II system is similar to Class I, but is usually designed for commercial purposes and can handle melting up to 100% of the heaviest snow and ice load for the area. This system is usually specified for a business that requires access during certain times of the day under all weather conditions common to the area.

4.2.3 Class III

Industrial systems where the SIM system does not allow any snow or ice accumulation for more than two hours are called Class III systems. Class III systems are designed for continuous operation for all common weather conditions for a geographic area. Ambulance ramps, parking garage ramps and helicopter pads are common examples of Class III applications.

Table 4.3
Data for determining operating characteristics of snow melting systems

					Period of Snowfall									
	Mean Air Temp. During Freezing Period ºF	Wind Speed During Freezing Period, mph	Hours of Snowfall		Required Output Btu/h - ft^2									Max Btu/ ft^2-h
					0 to 49	50 to 99	100 to 149	150 to 199	200 to 249	250 to 299	300 to 349	350 to 399	400 and up	
City			%	per Yr	Frequency Distribution of Snowfall Hours at Above Outputs, %									
Albuquerque, NM	26.2	8.5	0.6	22	62.0	25.4	7.6	4.2	-	0.8	-	-	-	259
Amarillo, TX	24.6	13.3	0.9	33	33.7	35.4	15.4	10.7	3.0	1.8	-	-	-	260
Boston, MA	24.7	14.2	4.0	145	51.5	30.0	12.3	4.3	1.2	0.6	0.1	-	-	320
Buffalo-Niagara Falls, NY	23.9	10.8	6.6	240	50.7	32.6	11.2	3.7	1.4	0.2	0.2	-	-	309
Burlington, VT	19.6	10.8	6.5	236	53.7	29.9	13.2	2.5	0.6	0.1	-	-	-	280
Caribou-Limestone, ME	16.5	10.0	8.0	290	35.0	39.7	16.0	5.7	2.0	1.0	0.5	0.1	-	378
Cheyenne, WY	21.5	15.3	3.8	138	16.5	26.2	19.4	13.1	8.6	4.7	4.2	4.7	2.6	499
Chicago, IL	21.4	11.5	3.7	134	45.8	37.4	11.4	3.1	1.4	0.6	0.2	0.1	-	368
Colorado Springs, CO	22.1	11.5	2.1	76	26.8	36.3	19.0	7.5	4.4	5.5	0.5	-	-	311
Columbus, OH	24.5	10.0	2.9	105	65.8	22.4	8.0	1.7	1.7	0.4	-	-	-	261
Detroit, MI	24.1	10.6	3.7	134	60.4	27.7	9.3	1.5	0.8	0.3	-	-	-	278
Duluth, MN	14.5	12.0	6.9	250	23.7	32.9	20.6	13.7	4.3	2.5	1.7	0.6	-	382
Falmouth, MA	25.5	12.8	2.0	73	50.0	33.9	14.2	1.6	0.3	-	-	-	-	204
Great Falls, MT	16.5	14.4	4.8	174	26.2	27.6	16.7	16.4	7.5	4.6	0.3	0.5	0.2	451
Hartford, CT	24.4	8.2	4.7	171	48.4	34.6	11.2	4.3	0.8	0.7	-	0.1	-	396
Lincoln, NB	20.8	10.1	2.5	91	32.7	26.2	20.0	13.9	5.7	1.5	-	-	-	293
Memphis, TN	27.0	11.5	0.3	11	48.4	28.3	6.7	13.3	3.3	-	-	-	-	227
Minneapolis-St. Paul, MN	16.9	11.1	5.6	203	28.4	31.4	21.7	14.1	3.5	0.6	0.3	-	-	313
Mt. Home, ID	24.9	9.5	1.1	40	74.2	21.9	3.9	-	-	-	-	-	-	143
New York, NY	24.2	11.8	2.1	76	53.1	31.8	9.4	2.2	1.5	1.7	-	0.3	-	385
Ogden, UT	24.3	9.4	4.4	160	64.6	29.2	5.8	0.3	0.1	-	-	-	-	216
Oklahoma City, OK	24.6	15.8	1.2	44	27.8	18.7	17.0	12.6	14.3	5.9	2.7	1.0	-	394
Philadelphia, PA	26.7	9.7	1.6	58	62.3	23.6	10.4	2.3	0.9	0.5	-	-	-	296
Pittsburgh, PA	24.3	11.6	5.0	182	53.6	30.8	8.4	4.6	1.9	0.7	-	-	-	282
Portland, OR	28.9	8.4	1.0	36	78.0	16.9	5.1	-	-	-	-	-	-	125
Rapid City, SD	19.3	12.9	3.2	116	29.7	29.0	16.0	8.4	6.3	3.6	1.9	2.0	3.1	581
Reno, NV	24.3	5.6	2.4	87	82.6	15.4	1.8	0.2	-	-	-	-	-	152
St. Louis, MO	25.0	11.5	0.9	33	42.9	31.4	16.7	7.1	1.9	-	-	-	-	225
Salina, KS	23.3	10.9	1.5	54	44.9	31.9	12.7	7.6	2.2	0.7	-	-	-	286
Sault Ste. Marie, MI	18.6	9.4	9.5	345	45.7	32.8	14.3	5.7	1.4	0.1	-	-	-	262
Seattle-Tacoma, WA	28.5	5.9	1.2	44	86.3	12.3	1.4	-	-	-	-	-	-	137
Spokane, WA	25.7	10.7	5.4	196	62.6	28.7	7.4	1.1	2.0	-	-	-	-	205
Washington, DC	26.8	9.6	0.9	33	59.0	29.8	10.6	0.6	-	-	-	-	-	154

(Permission to use data authorized by ASHRAE)

Table 4.4
SIM performance table ≤ 15 mph wind loads

Fluid ∆T: 25ºF			**Outside Design Temperature**			
MHWT ºF	**Pipe Spacing Inches**	**Pipe Factor ft / ft^2**	**0ºF Capacity Btu/ft^2-h**	**10ºF Capacity Btu/ft^2-h**	**20ºF Capacity Btu/ft^2-h**	**30ºF Capacity Btu/ft^2-h**
100	6	2.00	164.61	153.01	144.34	144.14
	8	1.50	151.03	140.11	131.68	130.39
	10	1.20	138.25	128.06	120.01	118.12
	12	1.00	126.94	117.47	109.88	107.75
120	6	2.00	197.52	187.01	180.41	185.32
	8	1.50	181.22	171.24	164.59	167.64
	10	1.20	165.89	156.51	150.01	151.87
	12	1.00	152.32	143.56	137.35	138.54
140	6	2.00	230.43	221.01	216.49	226.50
	8	1.50	211.42	202.37	197.50	204.89
	10	1.20	193.53	184.95	180.00	185.61
	12	1.00	177.70	169.66	164.81	169.32
160	6	2.00	263.35	255.00	252.57	267.67
	8	1.50	241.61	233.49	230.41	242.14
	10	1.20	221.16	213.40	210.00	219.36
	12	1.00	203.08	195.75	192.28	200.11
180	6	2.00	296.26	289.00	288.65	308.85
	8	1.50	271.81	264.62	263.33	279.39
	10	1.20	248.80	241.85	240.00	253.10
	12	1.00	228.46	221.85	219.75	230.89
200	6	2.00	329.17	322.99	324.72	350.03
	8	1.50	302.00	295.75	296.24	316.65
	10	1.20	276.44	270.30	269.99	286.85
	12	1.00	253.84	247.95	247.21	261.67

Table 4.5a
Flow chart - 30% Glycol (by volume) 25ºF ΔT

	Fluid Temperature								
GPM	100ºF Pipe Size Ft of Head / Ft of Pipe			120ºF Pipe Size Ft of Head / Ft of Pipe			140ºF Pipe Size Ft of Head / Ft of Pipe		
	1/2"	3/4"	1"	1/2"	3/4"	1"	1/2"	3/4"	1"
0.10	0.00080	0.00017	0.00005	0.00073	0.00015	0.00004	0.00068	0.00014	0.00004
0.20	0.00275	0.00058	0.00017	0.00251	0.00052	0.00015	0.00231	0.00048	0.00014
0.30	0.00565	0.00118	0.00035	0.00516	0.00108	0.00031	0.00476	0.00099	0.00029
0.40	0.00943	0.00197	0.00058	0.00860	0.00180	0.00052	0.00794	0.00166	0.00048
0.50	0.01402	0.00293	0.00085	0.01279	0.00267	0.00078	0.01182	0.00247	0.00072
0.60	0.01939	0.00405	0.00118	0.01770	0.00370	0.00108	0.01635	0.00341	0.00100
0.70	0.02551	0.00533	0.00155	0.02329	0.00486	0.00142	0.02152	0.00449	0.00131
0.80	0.03235	0.00676	0.00197	0.02954	0.00617	0.00180	0.02730	0.00570	0.00166
0.90	0.03990	0.00833	0.00243	0.03643	0.00760	0.00222	0.03369	0.00703	0.00205
1.00	0.04813	0.01005	0.00293	0.04396	0.00917	0.00267	0.04065	0.00848	0.00247
1.10	0.05703	0.01191	0.00347	0.05210	0.01087	0.00317	0.04818	0.01005	0.00293
1.20	0.06660	0.01390	0.00405	0.06084	0.01269	0.00370	0.05628	0.01174	0.00342
1.30	0.07680	0.01603	0.00467	0.07018	0.01464	0.00427	0.06492	0.01354	0.00394
1.40	0.08765	0.01829	0.00533	0.08010	0.01671	0.00487	0.07410	0.01545	0.00450
1.50	0.09911	0.02068	0.00603	0.09059	0.01889	0.00551	0.08382	0.01747	0.00509
1.60	0.11120	0.02320	0.00676	0.10164	0.02120	0.00618	0.09405	0.01961	0.00571
1.70	0.12389	0.02585	0.00754	0.11326	0.02362	0.00688	0.10481	0.02185	0.00636
1.80	0.13718	0.02862	0.00834	0.12542	0.02615	0.00762	0.11608	0.02419	0.00705
1.90	0.15107	0.03152	0.00919	0.13813	0.02880	0.00839	0.12785	0.02664	0.00776
2.00	0.16554	0.03453	0.01006	0.15138	0.03156	0.00919	0.14013	0.02920	0.00850
2.10	0.18059	0.03767	0.01098	0.16515	0.03443	0.01003	0.15289	0.03186	0.00928
2.20	0.19622	0.04093	0.01193	0.17946	0.03741	0.01090	0.16615	0.03462	0.01008
2.30	0.21241	0.04430	0.01291	0.19429	0.04050	0.01180	0.17989	0.03748	0.01091
2.40	0.22917	0.04779	0.01393	0.20964	0.04369	0.01273	0.19412	0.04044	0.01177
2.50	0.24649	0.05140	0.01498	0.22550	0.04700	0.01369	0.20881	0.04350	0.01266
2.60	0.26436	0.05513	0.01606	0.24186	0.05040	0.01468	0.22399	0.04665	0.01358
2.70	0.28279	0.05897	0.01718	0.25874	0.05392	0.01570	0.23963	0.04991	0.01453
2.80	0.30175	0.06292	0.01833	0.27611	0.05753	0.01676	0.25574	0.05326	0.01550
2.90	0.32126	0.06698	0.01951	0.29398	0.06126	0.01784	0.27231	0.05671	0.01651
3.00	0.34131	0.07116	0.02073	0.31235	0.06508	0.01895	0.28933	0.06025	0.01754
3.10	0.36189	0.07544	0.02198	0.33120	0.06900	0.02009	0.30682	0.06389	0.01859
3.20	0.38300	0.07984	0.02326	0.35054	0.07303	0.02126	0.32475	0.06762	0.01968
3.30	0.40464	0.08435	0.02457	0.37037	0.07715	0.02246	0.34314	0.07144	0.02079
3.40	0.42680	0.08896	0.02591	0.39068	0.08138	0.02369	0.36198	0.07536	0.02193
3.50	0.44948	0.09369	0.02729	0.41146	0.08571	0.02495	0.38125	0.07937	0.02310
3.60	0.47268	0.09852	0.02869	0.43272	0.09013	0.02624	0.40097	0.08347	0.02429
3.70	0.49639	0.10345	0.03013	0.45446	0.09465	0.02756	0.42113	0.08766	0.02551

Table 4.5b
Flow chart - 30% Glycol (by volume) - 25ºF ΔT

GPM	Fluid Temperature								
	160ºF Pipe Size Ft of Head / Ft of Pipe			180ºF Pipe Size Ft of Head / Ft of Pipe			200ºF Pipe Size Ft of Head / Ft of Pipe		
	1/2"	3/4"	1"	1/2"	3/4"	1"	1/2"	3/4"	1"
0.10	0.00063	0.00013	0.00004	0.00059	0.00012	0.00004	0.00056	0.00012	0.00003
0.20	0.00216	0.00045	0.00013	0.00203	0.00042	0.00012	0.00192	0.00040	0.00012
0.30	0.00444	0.00093	0.00027	0.00418	0.00087	0.00025	0.00396	0.00083	0.00024
0.40	0.00741	0.00155	0.00045	0.00698	0.00146	0.00042	0.00661	0.00138	0.00040
0.50	0.01103	0.00230	0.00067	0.01038	0.00217	0.00063	0.00985	0.00205	0.00060
0.60	0.01527	0.00319	0.00093	0.01437	0.00300	0.00087	0.01363	0.00284	0.00083
0.70	0.02010	0.00419	0.00122	0.01892	0.00395	0.00115	0.01795	0.00374	0.00109
0.80	0.02550	0.00532	0.00155	0.02402	0.00501	0.00146	0.02278	0.00475	0.00138
0.90	0.03146	0.00656	0.00191	0.02964	0.00618	0.00180	0.02812	0.00586	0.00171
1.00	0.03797	0.00792	0.00231	0.03578	0.00746	0.00217	0.03394	0.00707	0.00206
1.10	0.04502	0.00939	0.00273	0.04242	0.00884	0.00257	0.04025	0.00839	0.00244
1.20	0.05259	0.01096	0.00319	0.04955	0.01033	0.00301	0.04702	0.00980	0.00285
1.30	0.06067	0.01264	0.00368	0.05718	0.01191	0.00347	0.05426	0.01130	0.00329
1.40	0.06926	0.01443	0.00420	0.06528	0.01360	0.00396	0.06195	0.01290	0.00376
1.50	0.07834	0.01632	0.00475	0.07385	0.01538	0.00448	0.07010	0.01460	0.00425
1.60	0.08792	0.01832	0.00533	0.08288	0.01726	0.00503	0.07868	0.01638	0.00477
1.70	0.09798	0.02041	0.00594	0.09238	0.01924	0.00560	0.08770	0.01826	0.00531
1.80	0.10853	0.02261	0.00658	0.10232	0.02131	0.00620	0.09715	0.02022	0.00588
1.90	0.11954	0.02490	0.00725	0.11272	0.02347	0.00683	0.10702	0.02227	0.00648
2.00	0.13103	0.02729	0.00794	0.12356	0.02572	0.00749	0.11732	0.02442	0.00710
2.10	0.14298	0.02978	0.00867	0.13483	0.02807	0.00817	0.12804	0.02664	0.00775
2.20	0.15539	0.03236	0.00942	0.14654	0.03050	0.00888	0.13916	0.02896	0.00842
2.30	0.16825	0.03503	0.01020	0.15868	0.03303	0.00961	0.15070	0.03135	0.00912
2.40	0.18157	0.03780	0.01100	0.17125	0.03564	0.01037	0.16265	0.03384	0.00984
2.50	0.19533	0.04067	0.01184	0.18424	0.03834	0.01115	0.17499	0.03640	0.01059
2.60	0.20953	0.04362	0.01269	0.19765	0.04113	0.01197	0.18774	0.03905	0.01136
2.70	0.22418	0.04667	0.01358	0.21148	0.04400	0.01280	0.20088	0.04178	0.01215
2.80	0.23926	0.04980	0.01449	0.22572	0.04696	0.01366	0.21442	0.04459	0.01297
2.90	0.25478	0.05303	0.01543	0.24037	0.05001	0.01455	0.22835	0.04749	0.01381
3.00	0.27072	0.05635	0.01639	0.25543	0.05314	0.01546	0.24266	0.05046	0.01467
3.10	0.28710	0.05975	0.01738	0.27089	0.05635	0.01639	0.25736	0.05351	0.01556
3.20	0.30390	0.06324	0.01840	0.28676	0.05965	0.01735	0.27244	0.05665	0.01647
3.30	0.32112	0.06682	0.01944	0.30302	0.06303	0.01833	0.28791	0.05986	0.01740
3.40	0.33876	0.07049	0.02051	0.31968	0.06649	0.01933	0.30375	0.06315	0.01836
3.50	0.35682	0.07424	0.02160	0.33674	0.07003	0.02036	0.31997	0.06652	0.01934
3.60	0.37530	0.07808	0.02271	0.35419	0.07366	0.02142	0.33656	0.06996	0.02034
3.70	0.39419	0.08201	0.02385	0.37203	0.07736	0.02249	0.35353	0.07348	0.02136

Table 4.5c
Flow chart - 40% Glycol (by volume) - 25ºF ∆T

	Fluid Temperature								
GPM	**100ºF Pipe Size Ft of Head / Ft of Pipe**			**120ºF Pipe Size Ft of Head / Ft of Pipe**			**140ºF Pipe Size Ft of Head / Ft of Pipe**		
	1/2"	**3/4"**	**1"**	**1/2"**	**3/4"**	**1"**	**1/2"**	**3/4"**	**1"**
0.10	0.00081	0.00017	0.00005	0.00074	0.00015	0.00005	0.00068	0.00014	0.00004
0.20	0.00277	0.00058	0.00017	0.00252	0.00053	0.00015	0.00233	0.00049	0.00014
0.30	0.00569	0.00119	0.00035	0.00519	0.00108	0.00032	0.00479	0.00100	0.00029
0.40	0.00949	0.00198	0.00058	0.00866	0.00181	0.00053	0.00799	0.00167	0.00049
0.50	0.01411	0.00295	0.00086	0.01287	0.00269	0.00078	0.01189	0.00248	0.00072
0.60	0.01952	0.00408	0.00119	0.01781	0.00372	0.00108	0.01645	0.00343	0.00100
0.70	0.02568	0.00536	0.00156	0.02343	0.00489	0.00143	0.02165	0.00452	0.00132
0.80	0.03257	0.00680	0.00198	0.02973	0.00621	0.00181	0.02747	0.00573	0.00167
0.90	0.04016	0.00839	0.00245	0.03667	0.00765	0.00223	0.03389	0.00707	0.00206
1.00	0.04845	0.01012	0.00295	0.04424	0.00923	0.00269	0.04090	0.00853	0.00249
1.10	0.05742	0.01199	0.00350	0.05244	0.01094	0.00319	0.04848	0.01011	0.00295
1.20	0.06704	0.01400	0.00408	0.06123	0.01278	0.00372	0.05662	0.01181	0.00344
1.30	0.07732	0.01614	0.00471	0.07063	0.01473	0.00429	0.06532	0.01362	0.00397
1.40	0.08823	0.01842	0.00537	0.08061	0.01682	0.00490	0.07456	0.01554	0.00453
1.50	0.09978	0.02082	0.00607	0.09117	0.01902	0.00554	0.08433	0.01758	0.00512
1.60	0.11195	0.02336	0.00681	0.10230	0.02133	0.00622	0.09463	0.01973	0.00575
1.70	0.12472	0.02602	0.00759	0.11399	0.02377	0.00693	0.10546	0.02198	0.00640
1.80	0.13810	0.02881	0.00840	0.12623	0.02632	0.00767	0.11679	0.02434	0.00709
1.90	0.15208	0.03173	0.00925	0.13902	0.02899	0.00844	0.12864	0.02681	0.00781
2.00	0.16665	0.03476	0.01013	0.15235	0.03176	0.00925	0.14099	0.02938	0.00856
2.10	0.18181	0.03792	0.01105	0.16622	0.03465	0.01009	0.15383	0.03205	0.00933
2.20	0.19754	0.04120	0.01201	0.18062	0.03765	0.01097	0.16717	0.03483	0.01014
2.30	0.21385	0.04460	0.01300	0.19554	0.04076	0.01187	0.18100	0.03771	0.01098
2.40	0.23072	0.04812	0.01402	0.21099	0.04398	0.01281	0.19531	0.04069	0.01185
2.50	0.24815	0.05175	0.01508	0.22695	0.04730	0.01378	0.21010	0.04376	0.01274
2.60	0.26615	0.05550	0.01617	0.24342	0.05073	0.01477	0.22537	0.04694	0.01367
2.70	0.28469	0.05936	0.01730	0.26041	0.05426	0.01580	0.24111	0.05022	0.01462
2.80	0.30379	0.06334	0.01845	0.27789	0.05791	0.01686	0.25731	0.05359	0.01560
2.90	0.32343	0.06743	0.01965	0.29588	0.06165	0.01795	0.27399	0.05706	0.01661
3.00	0.34361	0.07164	0.02087	0.31436	0.06550	0.01907	0.29112	0.06062	0.01764
3.10	0.36433	0.07595	0.02213	0.33334	0.06945	0.02022	0.30871	0.06428	0.01871
3.20	0.38559	0.08038	0.02341	0.35281	0.07350	0.02140	0.32676	0.06803	0.01980
3.30	0.40737	0.08492	0.02474	0.37276	0.07765	0.02261	0.34526	0.07188	0.02092
3.40	0.42968	0.08956	0.02609	0.39320	0.08191	0.02385	0.36421	0.07582	0.02207
3.50	0.45252	0.09432	0.02747	0.41412	0.08626	0.02511	0.38361	0.07986	0.02324
3.60	0.47587	0.09918	0.02889	0.43552	0.09071	0.02641	0.40345	0.08398	0.02444
3.70	0.49974	0.10415	0.03033	0.45740	0.09526	0.02773	0.42374	0.08820	0.02567

Table 4.5d
Flow chart - 40% Glycol (by volume) - 25ºF ΔT

	Fluid Temperature								
GPM	160ºF Pipe Size Ft of Head / Ft of Pipe			180ºF Pipe Size Ft of Head / Ft of Pipe			200ºF Pipe Size Ft of Head / Ft of Pipe		
	1/2"	3/4"	1"	1/2"	3/4"	1"	1/2"	3/4"	1"
0.10	0.00063	0.00013	0.00004	0.00060	0.00012	0.00004	0.00056	0.00012	0.00003
0.20	0.00217	0.00045	0.00013	0.00204	0.00043	0.00012	0.00193	0.00040	0.00012
0.30	0.00447	0.00093	0.00027	0.00420	0.00088	0.00026	0.00398	0.00083	0.00024
0.40	0.00746	0.00156	0.00045	0.00701	0.00146	0.00043	0.00665	0.00139	0.00040
0.50	0.01109	0.00232	0.00068	0.01044	0.00218	0.00064	0.00990	0.00206	0.00060
0.60	0.01535	0.00320	0.00093	0.01445	0.00301	0.00088	0.01370	0.00286	0.00083
0.70	0.02021	0.00422	0.00123	0.01903	0.00397	0.00116	0.01804	0.00376	0.00110
0.80	0.02565	0.00535	0.00156	0.02415	0.00504	0.00147	0.02290	0.00477	0.00139
0.90	0.03165	0.00660	0.00192	0.02980	0.00621	0.00181	0.02827	0.00589	0.00172
1.00	0.03820	0.00796	0.00232	0.03598	0.00750	0.00218	0.03412	0.00711	0.00207
1.10	0.04528	0.00944	0.00275	0.04265	0.00889	0.00259	0.04046	0.00843	0.00245
1.20	0.05289	0.01103	0.00321	0.04983	0.01038	0.00302	0.04727	0.00985	0.00287
1.30	0.06102	0.01272	0.00370	0.05749	0.01198	0.00349	0.05455	0.01136	0.00331
1.40	0.06966	0.01452	0.00423	0.06564	0.01367	0.00398	0.06228	0.01297	0.00378
1.50	0.07880	0.01642	0.00478	0.07426	0.01547	0.00450	0.07047	0.01467	0.00427
1.60	0.08844	0.01843	0.00537	0.08334	0.01736	0.00505	0.07910	0.01647	0.00479
1.70	0.09856	0.02053	0.00598	0.09289	0.01934	0.00563	0.08816	0.01835	0.00534
1.80	0.10916	0.02274	0.00662	0.10289	0.02143	0.00624	0.09766	0.02033	0.00592
1.90	0.12025	0.02505	0.00729	0.11335	0.02360	0.00687	0.10759	0.02239	0.00652
2.00	0.13180	0.02745	0.00799	0.12425	0.02587	0.00753	0.11794	0.02454	0.00714
2.10	0.14382	0.02995	0.00872	0.13559	0.02822	0.00821	0.12872	0.02678	0.00779
2.20	0.15630	0.03255	0.00947	0.14736	0.03067	0.00893	0.13990	0.02911	0.00847
2.30	0.16924	0.03524	0.01026	0.15957	0.03321	0.00966	0.15150	0.03152	0.00917
2.40	0.18263	0.03803	0.01107	0.17221	0.03584	0.01043	0.16351	0.03402	0.00989
2.50	0.19648	0.04090	0.01190	0.18528	0.03856	0.01122	0.17592	0.03660	0.01064
2.60	0.21077	0.04388	0.01277	0.19876	0.04136	0.01203	0.18874	0.03926	0.01142
2.70	0.22550	0.04694	0.01366	0.21267	0.04425	0.01287	0.20195	0.04200	0.01221
2.80	0.24067	0.05010	0.01458	0.22699	0.04723	0.01374	0.21556	0.04483	0.01304
2.90	0.25628	0.05334	0.01552	0.24172	0.05029	0.01463	0.22956	0.04774	0.01388
3.00	0.27232	0.05668	0.01649	0.25686	0.05343	0.01554	0.24395	0.05073	0.01475
3.10	0.28879	0.06010	0.01749	0.27241	0.05667	0.01648	0.25873	0.05380	0.01564
3.20	0.30569	0.06361	0.01851	0.28836	0.05998	0.01744	0.27390	0.05695	0.01656
3.30	0.32301	0.06721	0.01955	0.30472	0.06338	0.01843	0.28945	0.06018	0.01749
3.40	0.34076	0.07090	0.02063	0.32148	0.06686	0.01944	0.30537	0.06348	0.01846
3.50	0.35893	0.07468	0.02172	0.33863	0.07042	0.02048	0.32168	0.06687	0.01944
3.60	0.37751	0.07854	0.02285	0.35618	0.07407	0.02154	0.33836	0.07033	0.02044
3.70	0.39651	0.08249	0.02399	0.37412	0.07779	0.02262	0.35542	0.07387	0.02147

Table 4.5e
Flow chart - 50% Glycol (by volume) - 25ºF ΔT

	Fluid Temperature								
GPM	**100ºF Pipe Size Ft of Head / Ft of Pipe**			**120ºF Pipe Size Ft of Head / Ft of Pipe**			**140ºF Pipe Size Ft of Head / Ft of Pipe**		
	1/2"	**3/4"**	**1"**	**1/2"**	**3/4"**	**1"**	**1/2"**	**3/4"**	**1"**
0.10	0.00081	0.00017	0.00005	0.00074	0.00016	0.00005	0.00068	0.00014	0.00004
0.20	0.00279	0.00058	0.00017	0.00254	0.00053	0.00015	0.00234	0.00049	0.00014
0.30	0.00573	0.00120	0.00035	0.00522	0.00109	0.00032	0.00482	0.00101	0.00029
0.40	0.00955	0.00200	0.00058	0.00870	0.00182	0.00053	0.00803	0.00168	0.00049
0.50	0.01420	0.00297	0.00087	0.01295	0.00270	0.00079	0.01195	0.00250	0.00073
0.60	0.01964	0.00410	0.00120	0.01791	0.00374	0.00109	0.01654	0.00345	0.00101
0.70	0.02583	0.00540	0.00157	0.02357	0.00492	0.00144	0.02177	0.00454	0.00132
0.80	0.03276	0.00684	0.00200	0.02990	0.00624	0.00182	0.02762	0.00576	0.00168
0.90	0.04041	0.00844	0.00246	0.03688	0.00770	0.00224	0.03408	0.00711	0.00207
1.00	0.04874	0.01018	0.00297	0.04450	0.00929	0.00271	0.04112	0.00858	0.00250
1.10	0.05776	0.01206	0.00352	0.05274	0.01100	0.00321	0.04874	0.01017	0.00296
1.20	0.06745	0.01408	0.00411	0.06159	0.01285	0.00375	0.05693	0.01187	0.00346
1.30	0.07779	0.01624	0.00473	0.07104	0.01482	0.00432	0.06567	0.01369	0.00399
1.40	0.08877	0.01853	0.00540	0.08108	0.01691	0.00493	0.07496	0.01563	0.00455
1.50	0.10038	0.02095	0.00611	0.09169	0.01912	0.00557	0.08479	0.01768	0.00515
1.60	0.11262	0.02350	0.00685	0.10289	0.02146	0.00625	0.09515	0.01983	0.00578
1.70	0.12548	0.02618	0.00763	0.11464	0.02391	0.00697	0.10603	0.02210	0.00644
1.80	0.13894	0.02899	0.00845	0.12696	0.02647	0.00771	0.11743	0.02447	0.00713
1.90	0.15300	0.03192	0.00930	0.13982	0.02915	0.00849	0.12934	0.02695	0.00785
2.00	0.16766	0.03497	0.01019	0.15323	0.03195	0.00931	0.14176	0.02954	0.00860
2.10	0.18291	0.03815	0.01112	0.16718	0.03485	0.01015	0.15468	0.03223	0.00938
2.20	0.19874	0.04145	0.01208	0.18166	0.03787	0.01103	0.16809	0.03502	0.01020
2.30	0.21514	0.04487	0.01308	0.19667	0.04099	0.01194	0.18199	0.03791	0.01104
2.40	0.23212	0.04841	0.01411	0.21221	0.04423	0.01288	0.19638	0.04091	0.01191
2.50	0.24966	0.05206	0.01517	0.22826	0.04757	0.01386	0.21126	0.04400	0.01281
2.60	0.26776	0.05583	0.01627	0.24483	0.05102	0.01486	0.22661	0.04720	0.01374
2.70	0.28642	0.05972	0.01740	0.26191	0.05458	0.01589	0.24243	0.05049	0.01470
2.80	0.30563	0.06372	0.01857	0.27950	0.05824	0.01696	0.25873	0.05388	0.01568
2.90	0.32539	0.06784	0.01976	0.29759	0.06201	0.01806	0.27549	0.05737	0.01670
3.00	0.34570	0.07207	0.02100	0.31618	0.06588	0.01918	0.29272	0.06095	0.01774
3.10	0.36654	0.07641	0.02226	0.33527	0.06985	0.02034	0.31041	0.06463	0.01881
3.20	0.38793	0.08087	0.02356	0.35485	0.07392	0.02152	0.32856	0.06841	0.01991
3.30	0.40984	0.08543	0.02488	0.37492	0.07810	0.02274	0.34716	0.07228	0.02103
3.40	0.43229	0.09010	0.02625	0.39548	0.08238	0.02398	0.36622	0.07624	0.02219
3.50	0.45526	0.09489	0.02764	0.41652	0.08676	0.02526	0.38572	0.08030	0.02337
3.60	0.47876	0.09978	0.02906	0.43804	0.09124	0.02656	0.40567	0.08445	0.02457
3.70	0.50278	0.10478	0.03052	0.46004	0.09581	0.02789	0.42607	0.08869	0.02581

Table 4.5f
Flow chart - 50% Glycol (by volume) - 25ºF ΔT

	Fluid Temperature								
GPM	160ºF Pipe Size Ft of Head / Ft of Pipe			180ºF Pipe Size Ft of Head / Ft of Pipe			200ºF Pipe Size Ft of Head / Ft of Pipe		
	1/2"	3/4"	1"	1/2"	3/4"	1"	1/2"	3/4"	1"
0.10	0.00064	0.00013	0.00004	0.00060	0.00013	0.00004	0.00057	0.00012	0.00003
0.20	0.00218	0.00046	0.00013	0.00205	0.00043	0.00013	0.00194	0.00041	0.00012
0.30	0.00449	0.00094	0.00027	0.00422	0.00088	0.00026	0.00400	0.00083	0.00024
0.40	0.00749	0.00156	0.00046	0.00705	0.00147	0.00043	0.00668	0.00139	0.00041
0.50	0.01115	0.00233	0.00068	0.01049	0.00219	0.00064	0.00994	0.00207	0.00060
0.60	0.01543	0.00322	0.00094	0.01452	0.00303	0.00088	0.01377	0.00287	0.00084
0.70	0.02032	0.00424	0.00124	0.01912	0.00399	0.00116	0.01813	0.00378	0.00110
0.80	0.02578	0.00538	0.00157	0.02427	0.00506	0.00147	0.02301	0.00480	0.00140
0.90	0.03181	0.00663	0.00193	0.02995	0.00624	0.00182	0.02840	0.00592	0.00172
1.00	0.03839	0.00801	0.00233	0.03615	0.00754	0.00219	0.03428	0.00714	0.00208
1.10	0.04552	0.00949	0.00276	0.04286	0.00893	0.00260	0.04065	0.00847	0.00247
1.20	0.05317	0.01108	0.00323	0.05008	0.01043	0.00304	0.04749	0.00989	0.00288
1.30	0.06134	0.01278	0.00372	0.05778	0.01204	0.00351	0.05481	0.01141	0.00332
1.40	0.07002	0.01459	0.00425	0.06596	0.01374	0.00400	0.06257	0.01303	0.00379
1.50	0.07921	0.01651	0.00481	0.07462	0.01554	0.00453	0.07080	0.01474	0.00429
1.60	0.08890	0.01852	0.00539	0.08376	0.01744	0.00508	0.07947	0.01654	0.00481
1.70	0.09907	0.02064	0.00601	0.09335	0.01944	0.00566	0.08858	0.01844	0.00537
1.80	0.10973	0.02286	0.00666	0.10340	0.02153	0.00627	0.09812	0.02042	0.00594
1.90	0.12087	0.02518	0.00733	0.11391	0.02372	0.00690	0.10810	0.02250	0.00655
2.00	0.13249	0.02759	0.00803	0.12486	0.02599	0.00756	0.11850	0.02466	0.00717
2.10	0.14457	0.03011	0.00876	0.13626	0.02836	0.00825	0.12932	0.02691	0.00783
2.20	0.15712	0.03272	0.00952	0.14809	0.03083	0.00897	0.14056	0.02925	0.00851
2.30	0.17012	0.03542	0.01031	0.16036	0.03338	0.00971	0.15222	0.03167	0.00921
2.40	0.18359	0.03822	0.01112	0.17306	0.03602	0.01048	0.16428	0.03418	0.00994
2.50	0.19750	0.04112	0.01197	0.18619	0.03875	0.01127	0.17675	0.03677	0.01069
2.60	0.21187	0.04411	0.01284	0.19975	0.04156	0.01209	0.18963	0.03944	0.01147
2.70	0.22668	0.04719	0.01373	0.21372	0.04447	0.01294	0.20290	0.04220	0.01227
2.80	0.24193	0.05036	0.01465	0.22811	0.04746	0.01381	0.21657	0.04504	0.01310
2.90	0.25762	0.05362	0.01560	0.24292	0.05054	0.01470	0.23064	0.04796	0.01395
3.00	0.27374	0.05697	0.01658	0.25814	0.05370	0.01562	0.24510	0.05097	0.01482
3.10	0.29030	0.06041	0.01758	0.27376	0.05695	0.01656	0.25995	0.05405	0.01572
3.20	0.30729	0.06395	0.01860	0.28980	0.06028	0.01753	0.27519	0.05721	0.01663
3.30	0.32470	0.06757	0.01966	0.30623	0.06369	0.01852	0.29081	0.06046	0.01758
3.40	0.34254	0.07127	0.02073	0.32307	0.06719	0.01954	0.30681	0.06378	0.01854
3.50	0.36080	0.07507	0.02184	0.34031	0.07077	0.02058	0.32320	0.06718	0.01953
3.60	0.37949	0.07895	0.02297	0.35795	0.07444	0.02164	0.33996	0.07066	0.02054
3.70	0.39859	0.08292	0.02412	0.37598	0.07818	0.02273	0.35709	0.07422	0.02157

SIM Design Sheet

Owner:	**Location:**
Designer:	**Installer:**
Class System	**Temp**
Capacity Required	**Wind**
MHWT	**SIM area**
Pipe Spacing	**% Antifreeze**
Pipe Required	
Flow Required	
Head Loss	
NOTES:	

5. Installation

The installation of a REHAU SIM system will vary considerably depending on the type of project with which you are involved. We have included this section to highlight some of the important aspects of installation that will concern both the designer and the installer. Some of the information presented here has been previously discussed and is repeated for your convenience.

5.1 Subsoil Requirements

Installers should inspect the subsoil underneath the SIM thermal mass to ensure the following conditions:

- Subsoil is clean and compacted.
- Subsoil is dry and will not allow ground water to within 3' (0.9m) of the SIM pipe.
- If the subsoil contains bedrock within 1' (0.3m) of the SIM pipe then insulation should be installed over the bedrock formation.
- Subsoil should be graded with proper aggregate sizes to minimize frost heave.

5.2 Insulation

The critical factors to be concerned with when installing insulation are:

1. Insulation is of sufficient density to withstand the compression to which it will be subjected.

2. Insulation must be capable of withstanding the moisture conditions of the site.

3. If you're using board insulation, all joints should be taped with moisture-proof insulation tape.

4. If you are planning on installing pipe with Insulation Screw Clips, a minimum of 1" (25 mm) thick insulation must be used.

5. With board insulation, the subsurface should be flat and compacted to prevent the insulation from cracking due to uneven support when it's stepped on.

5.3 RAUPEX Pipe Installation

5.3.1 Uncoiling RAUPEX

Properly uncoiled RAUPEX will lie flat with nothing required to hold it flat. You must uncoil RAUPEX by working with the memory direction of the coil.

5.3.2 Securing RAUPEX

All sizes of RAUPEX should be secured every 2' to 3' (0.6m to 0.9m) on straight runs and on the start, finish and midpoint of any turns, to hold the established laying pattern. This will ensure that the pipe remains at the desired spacing and does not float in the thermal mass in instances where you have installed the pipe against the memory.

5.3.3 Bending RAUPEX

For cold bending of RAUPEX (a bend without the aid of heat), the theoretical minimum bend radius is five times the diameter of the pipe. If you provide heat and a bending template, you can reduce this to three times the diameter. If you need to make a tighter bend (because you have closer spacing requirements), simply widen the spacing at the bend. A counterflow spiral installation technique will help to maximize bend radii.

5.3.4 Cutting RAUPEX

When cutting RAUPEX to attach to the manifold, for example, use a ratchet style or scissor style plastic pipe cutter for the job. All cuts should be perpendicular to the wall of the pipe. These clean, square cuts will ensure proper seating when attaching to the manifold and when using REHAU EVERLOC and compression nut fittings.

5.3.5 Crimped or Kinked Pipe

Should you accidentally crimp or kink RAUPEX during installation, you can return the pipe to its original shape by use of a paint stripper type heat gun. Simply straighten the crimped or kinked section by hand, apply heat by slowly moving the heat gun over the area until the pipe turns clear. Once it's clear, continue to move the heat around the pipe for about 30 seconds. Then remove the heat and let the area cool.

5.3.6 Damaged Pipe

If the wall of the pipe has been scored or cut by a sharp object, it is best to remove the damaged section and replace with a new section connecting (joining) with the EVERLOC fittings (be sure to wrap the brass fitting with a covering to protect it from a possible corrosive reaction with concrete), or remove and replace the entire pipe circuit.

5.3.7 Sleeve Material

REHAU Protective Sleeves should cover all RAUPEX that either penetrates the thermal mass, or crosses a control or expansion joint. You should install and secure the protection sleeve to ensure it does not move during the thermal mass installation. Protective Sleeves are also used to protect the PEX from ultraviolet (UV) light exposure. Allow enough Protective Sleeve to extend a minimum of 12" (30.5 cm) beyond the area you intend to protect in both directions.

5.4 Thermal Mass

The following items should be addressed:

1. You should ensure that the thermal mass structure is constructed as planned during the design process. This will include all layers above and below the pipe. You must also ensure, particularly for problems where there is a pickup load, that the depths of the material applied are the same as those used to calculate the pickup load.

2. You must ensure, during the installation of the thermal mass, that the pipe is pressurized with an attendant watching the pressure gauge for a sudden loss of pressure due to a leak in the system.

3. Watch to ensure that the pipe is protected from sharp objects during the thermal mass installation. Also ensure that the materials making up the thermal mass, such as stone, will not damage the pipe during any compaction processes that may occur after the installation of the mass.

4. When asphalt and other hot mix thermal mass materials are planned, ensure that the proper steps have been taken to protect the pipe from the extreme exposure temperatures. You can, and should, insist that the installation take place at a lower temperature (230^{0}F [110^{0}C]). You can also flush cold water through the pipe during the installation to minimize the chance of damage occurring. If you do flush water through the pipe, be aware that any water left in the pipe will be subject to freezing and should be removed, so protect it from freezing if possible.

5. Loose fill or fill with a large aggregate size will incorporate air pockets which will lead to inefficiency in the thermal mass design. Unless you properly designed for it, do not allow a thermal mass with a significant amount of air space.

5.5 Heat Transfer Fluid Requirements

The following items should be addressed:

- Check the antifreeze just after installation and document the values obtained per the manufacturer's recommendations (usually inhibitor level and freeze protection level).

- Check the antifreeze before the start of every melting season at a minimum. Do not allow water to be added to the system without rechecking the antifreeze levels.

- Charging the antifreeze with a mechanical charging pump is an efficient way to introduce the antifreeze. Once the antifreeze has been installed, be sure to circulate it thoroughly through all pipe circuits, until all air is removed and the antifreeze is completely mixed into solution.

5.6 Pressure Testing

An initial pressure test must always be performed on the SIM system to make sure the RAUPEX has not been damaged and is leak free. The initial test should be done prior to installation of the covering layers of thermal mass. You must keep the piping pressurized during the installation of this layer of thermal mass. Pressure tests are documented as part of the Warranty Site Inspection Report (WSIR).

5.6.1 Air Pressure Testing

An air test is done when it is difficult to fill the system with the heat transfer fluid due to site conditions. To perform the air test, secure the pipe to the permanent manifold (or a temporary one). Isolate all other components of the system that may be damaged by pressurization or otherwise cause a loss of pressure.

Charge the system with air between 60 and 100 psig (400 to 660 kPa gauge). Check all exposed joints and compression fittings for leaks with leak detection fluid. The pressure may drop initially (within 10 minutes) but should stabilize. Maintain this pressure until the thermal mass installation is complete. Small changes, up and down, will occur with air temperature changes and from thermal mass-generated heat.

5.6.2 Heat Transfer Fluid Pressure Testing

In order to use heat transfer fluid to pressure test the RAUPEX, it will be necessary to purge all circuits of air. With a valved manifold simply turn off all circuits and purge one at a time. With a valveless manifold, it is best to fill slowly to ensure all circuits fill at the same time. Test pressure is normally one and one-half times the working pressure.

5.7 Control Systems

For control systems that use sensors, you should ensure that all sensors are accessible for repair and replacement.

- All snow sensors, placed within the thermal mass, can be installed with wiring in conduit (minimal bends).

- During installation of control sensor wiring, all wires should be checked for continuity prior to installation of the thermal mass.

- Installers should check, particularly with snow sensors, that they are located as per the design.

- Controls will need to be checked and thoroughly tested prior to signing off the system as completed.

5.8 SIM System Commissioning

All REHAU SIM systems require a completed WSIR. Every SIM system should be thoroughly tested and evaluated prior to system sign off. If weather conditions do not permit operation, the installer can simulate weather conditions by warming and cooling the sensors. Every system owner (or his representative) should be given an overview of the features of the SIM system and instructed on its operation. The installer should plan on returning to the site during operation to ensure it is working properly.

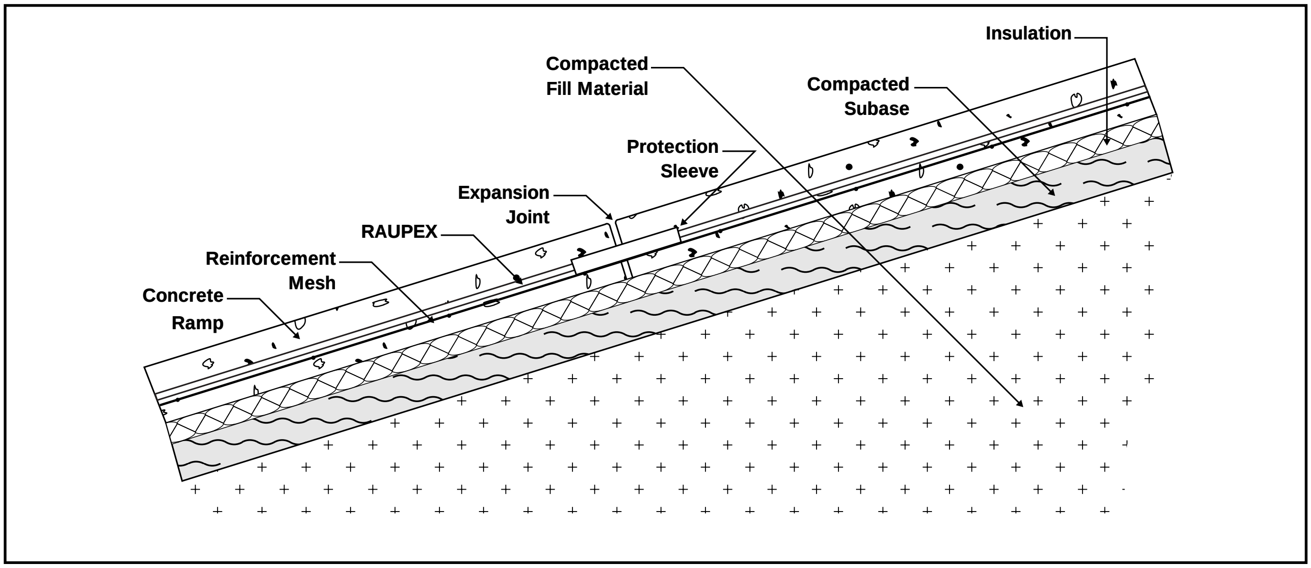

Fig. 5.1
REHAU SIM Application - Concrete ramp

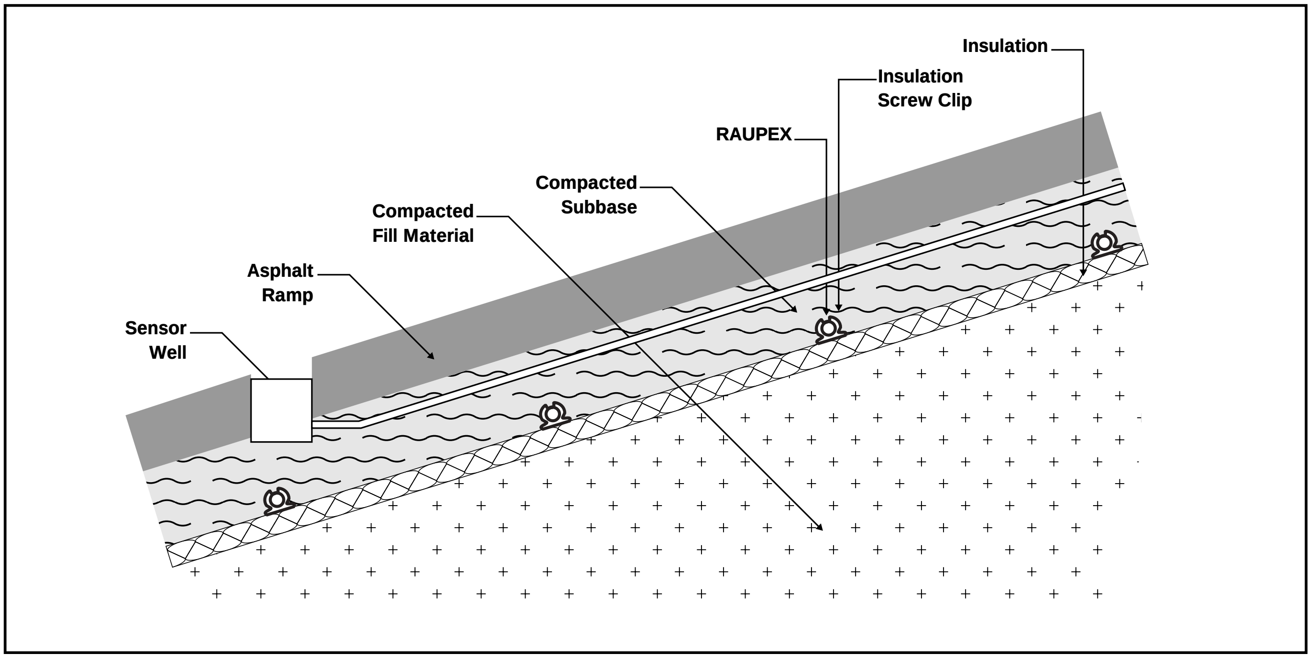

Fig. 5.2
REHAU SIM Application - Asphalt ramp

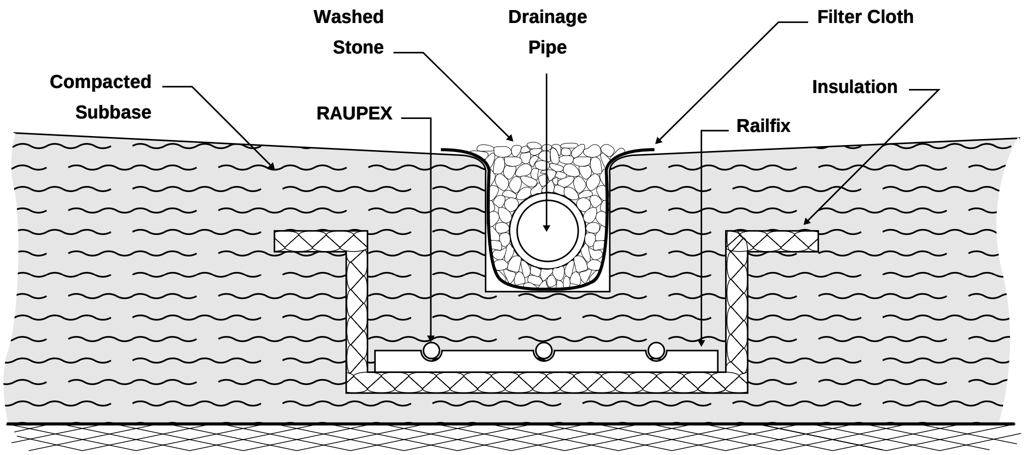

Fig. 5.3
REHAU SIM Application - Drainage pipes and tunnels

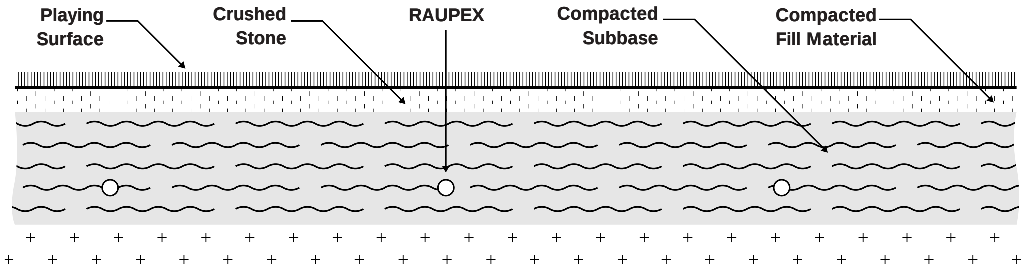

Fig. 5.4
REHAU SIM Application - Athletic playing fields

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