Kingspan
Environmental

Kingspan Solar
Complete Solar Thermal Solutions

Commercial | Industrial | Institutional

contents

Please visit:
www.kingspansolarmanual.com

This document is not for use as a design tool, it is for guidance only and designs should be reviewed by our technical team. All solar thermal systems should be fully designed by a competent engineer. Kingspan Group plc or any of its companies do not take responsibility for any systems designed using the following details. We recommend that you review your design with us.

All descriptions and specifications of products and procedures in this manual are current at the time of printing. However, Kingspan Environmental is continually involved in product testing and improvement, and specifications and procedures are subject to change. We reserve the right to amend specifications and procedures without prior notice.

Regulations and Standards
The solar thermal system should be installed in compliance with current building regulations, all local standards and health & safety regulations. These regulations are statutory documents and take priority over all recommendations within this document. For installation and operating procedures, please refer to the Installation and Operating manuals provided with the product.

For system design assistance, please contact our technical support team: (410) 799 6600.

kingspan group

Kingspan Environmental is part of Kingspan Group, global leaders in sustainable building products for energy and water efficiency. With manufacturing and distribution operations worldwide, Kingspan is recognized throughout the construction industry for innovation, design, quality, technical expertise and service.

Kingspan Environmental offer an array of products and services that provide renewable energy, water management and environmental solutions. Our Solar thermal package solutions, wind turbines and rainwater harvesting systems have been used on prestigious buildings across North America with great success.

25+ years knowledge and experience to support your business

14million Thermomax tubes installed worldwide

10 offices across North America

1,000+ employees in our North American businesses

40+ countries in which we operate

no.1 design team

Kingspan Solar offer a complete solar thermal solutions for commercial, industrial, institutional and residential applications. Our Thermomax technology is the original and best evacuated tube collector on the market for over 25 years. We pride ourselves on not only our worldclass product, but on the design, engineering, and technical service we provide our customers every time.

The Cliff House Resort & Spa,
OGUNQUIT, ME

kingspan environmental

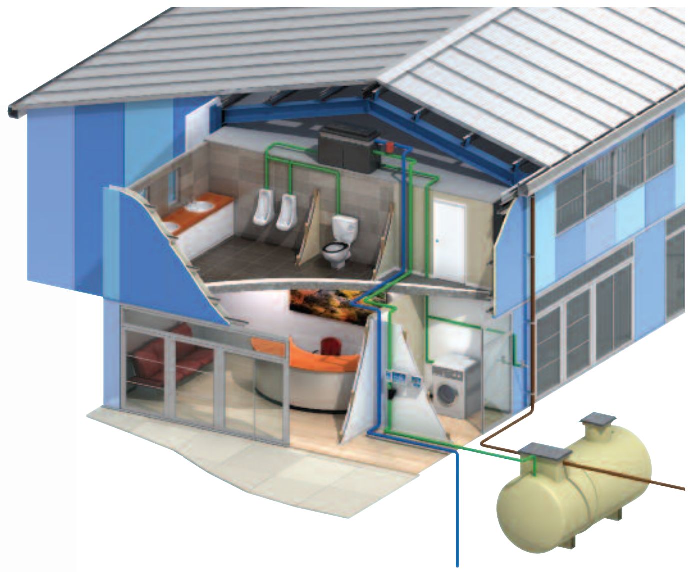
KingspanWind

Combining patented, high performance technology with long-standing expertise in the sector and delivering the very best in innovation, customer services and results, KingspanWind KW3 and KW6 turbines are the world's No.1 robust small scale wind turbines available on the market today.

A unique blade and hinge design allows KingspanWind turbines to regulate their rotational speed, thereby maximising output.

As the wind gets stronger the blades pitch and cone, protecting the turbine and allowing continual operation – ensuring the turbines have no requirement to brake themselves in high winds.

A result of 30 years of research and development, with installations in over 60 countries varying from rural domestic installations across Europe to remote islands and off-shore oil platforms, KingspanWind offers unrivalled wind power solutions the world over.



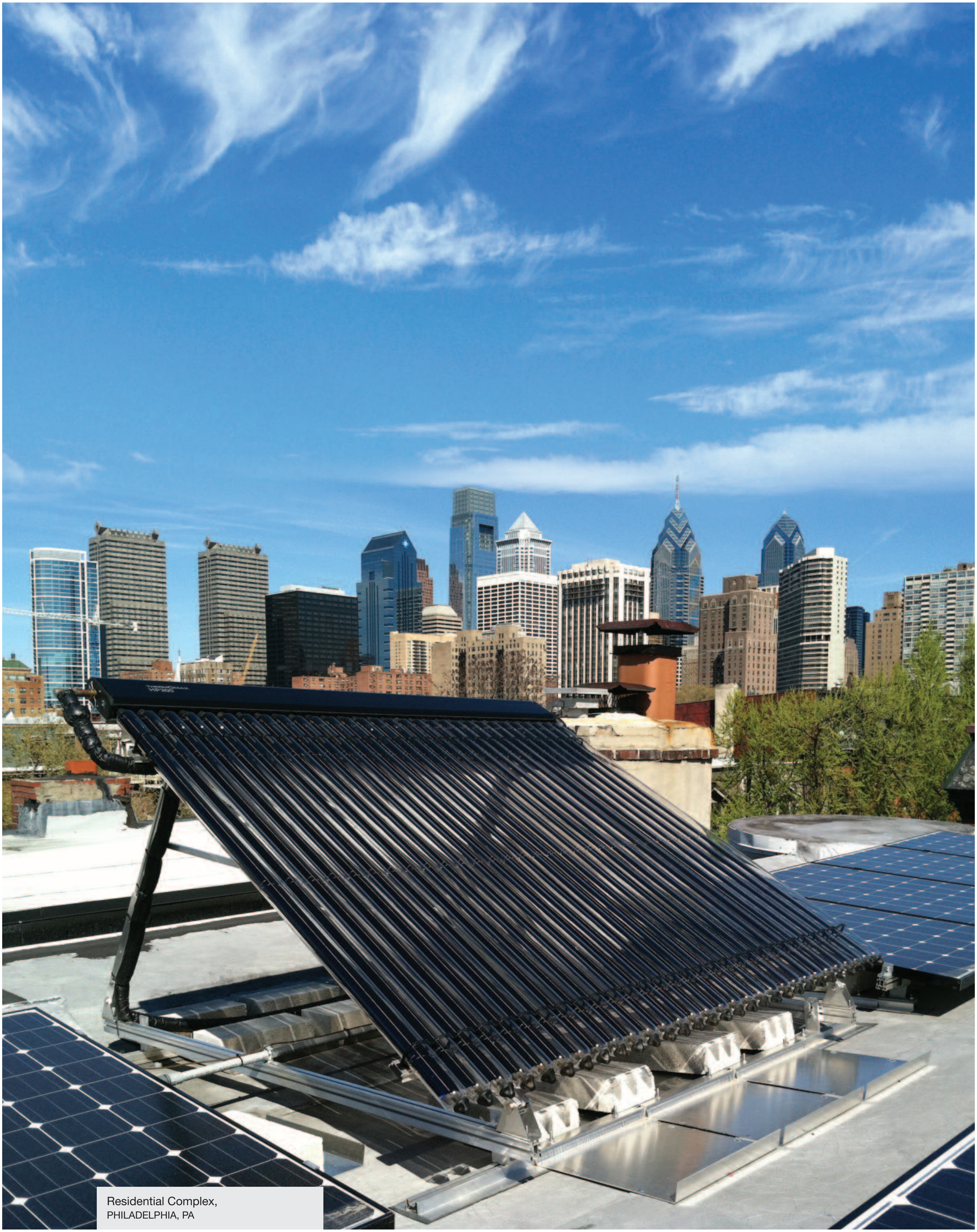
KingspanWater

KingspanWater is an experienced designer, manufacturer and provider of rainwater harvesting systems with an extensive track record in developing packaged products and bespoke systems.

Factors such as ease of use, rapid installation and use of quality materials and components are the hallmarks of the KingspanWater range – the same values associated with all Kingspan products.

KingspanWater systems are installed across a broad and increasingly complex range of commercial construction projects, with rainwater being put to use in a diverse range of applications far beyond washing or toilet flushing.

KingspanWater has become the premier choice for developers and construction professionals aiming to deliver sustainable water to buildings across the international construction industry.



Residential Complex,
PHILADELPHIA, PA

introduction

solar radiation
across north america

Solar radiation is a general term for the electromagnetic radiation emitted by the sun.

It can be captured and converted into useful forms of energy, such as heat, using solar thermal collectors. The technical feasibility and economical operation at a specific location depends on the available solar radiation.

The United States lie in the middle latitudes and receive more solar energy in the summer not only because days are longer, but also because the sun is nearly overhead. The sun's rays are far more slanted during the shorter days of the winter months. Figure 1 shows the annual average direct normal solar radiation for the United States*.

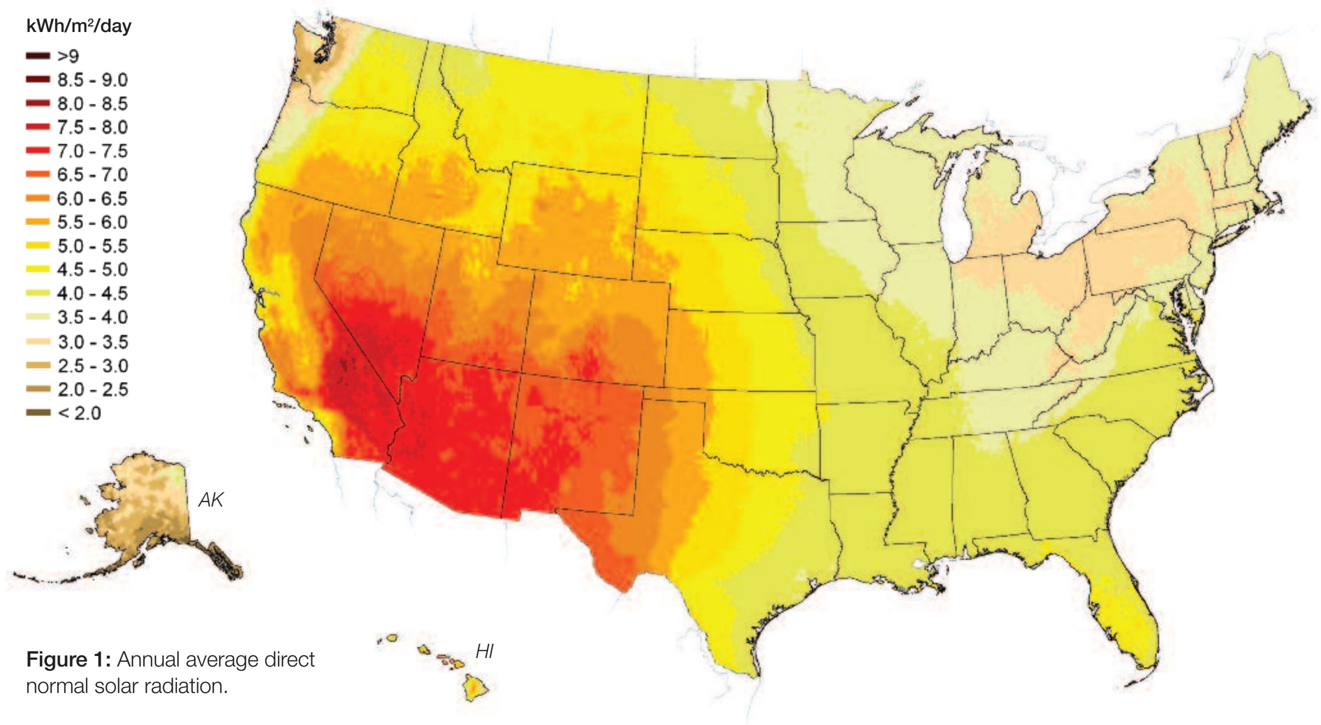


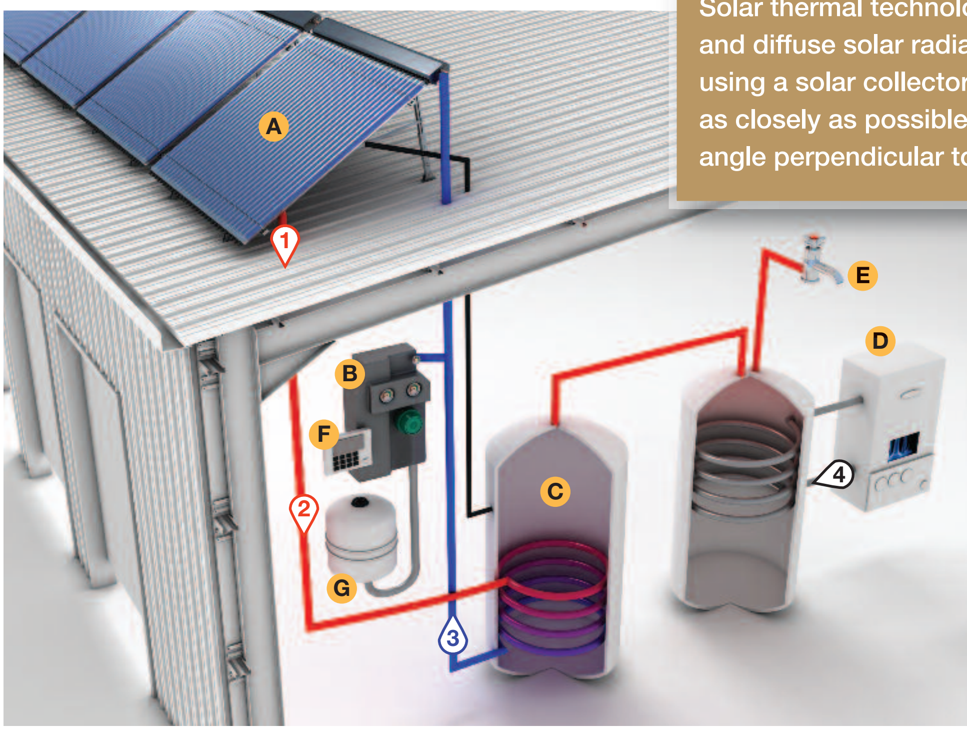
Figure 1: Annual average direct normal solar radiation.

*Data for Hawaii and the 48 contiguous states is a 10km, satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998 to 2005. Data for Alaska is a 40km dataset produced by the Climatological Solar Radiation Model (NREL, 2003). This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy. February 2009.

NREL

how it works
solar thermal system

Solar thermal technology transforms direct and diffuse solar radiation into useful heat using a solar collector, which should face as closely as possible to the south at an angle perpendicular to the sun.



- **A** **Solar collector** - the efficiency and quality of the collector determines the performance of the whole system.
- **B** Pump station
- **C** Hot water storage tank
- **D** Back-up heat source
- **E** Hot water distribution system
- **F** Solar controller
- **G** Expansion tank

All components work together to heat water from sunlight:

1. Sunlight hits the solar collector and heats thermal transfer liquid passing through it.
2. A pump circulates the heated thermal transfer liquid from the solar collector to the water tank coil, where its heat transfers to water within the tank.
3. The pump returns the cooled thermal transfer liquid to the solar collector for reheating.
4. When needed, a back-up heat source, such as a boiler, on-demand water heater, or electrical immersion element, boosts the tank water to the desired temperature before it is distributed to its end use.

The differential temperature controller monitors and regulates the circulation rate of the thermal transfer liquid, based on weather and hot water demand. The expansion tank regulates system pressure as the thermal transfer liquid expands and contracts.

business case
why solar thermal energy?

> **“A domestic solar hot water system can provide up to 80% of hot water needs FREE.”**
>
> *Source: U.S. Department of Energy.*

The Sun - an unlimited energy resource

Every year the sun provides over 8000 times as much energy as we consume worldwide. In North America, a well designed solar thermal system can provide up to 80% of a buildings needs annually.

This is why solar thermal systems are one of the most cost-effective and environmentally-friendly renewable energy solutions available – reducing fuel bills and greenhouse gas emissions.

Solar thermal energy enjoys many economic and environmental advantages over other forms of energy currently used, including:

Reduce your energy bills

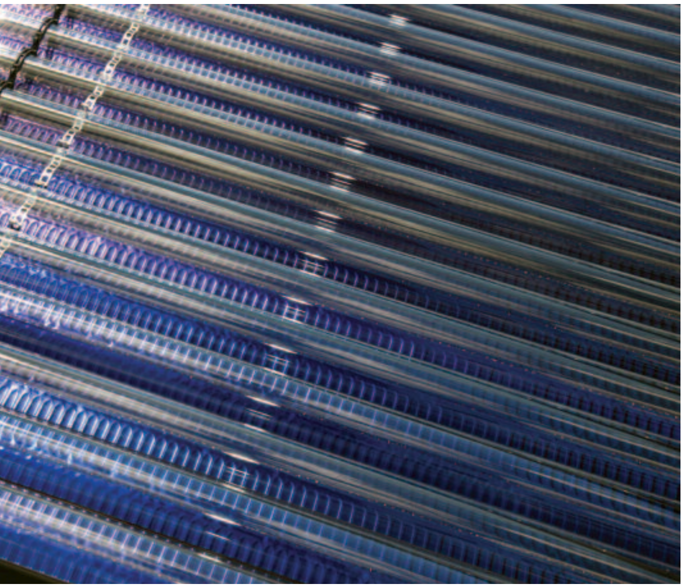
- Cost effective: economical, mitigates future energy shortages and price increases.
- Immediate and permanent savings.
- Enjoy **FREE** hot water all year round.
- Fastest payback and lowest energy cost over the lifetime of the system compared to other renewable energy technologies.

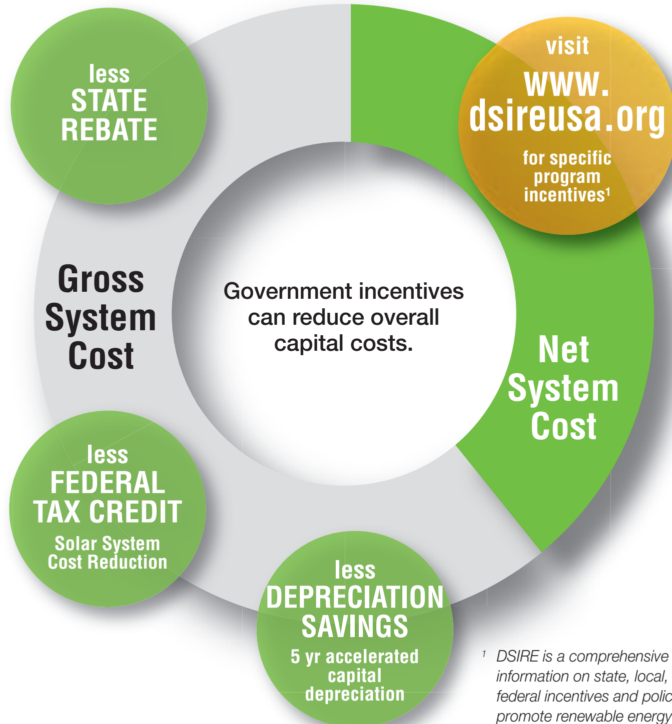
Superior system performance

- Provides up to 96% solar energy absorption with 5% emmissivity
- Generates heat energy even on overcast and cloudy days.
- High performance, tailored solutions for hot water, central / space heating, cooling and pool applications across a wide range of building sectors.
- Solar thermal systems are up to 30% more efficient than photovoltaics.
- Safe, reliable, durable and time-tested with a design life of over 30 years.
- Rapid installation and low maintenance.

Market-based incentives

- Tax credits for renewable energies - deductions range from $0.30-1.80 per square foot.
- Generous federal, state and utility incentives.
- A solar hot water system can be cash flow positive from day one.
- A domestic solar hot water system can last in excess of 25 years and pay for itself many times over.





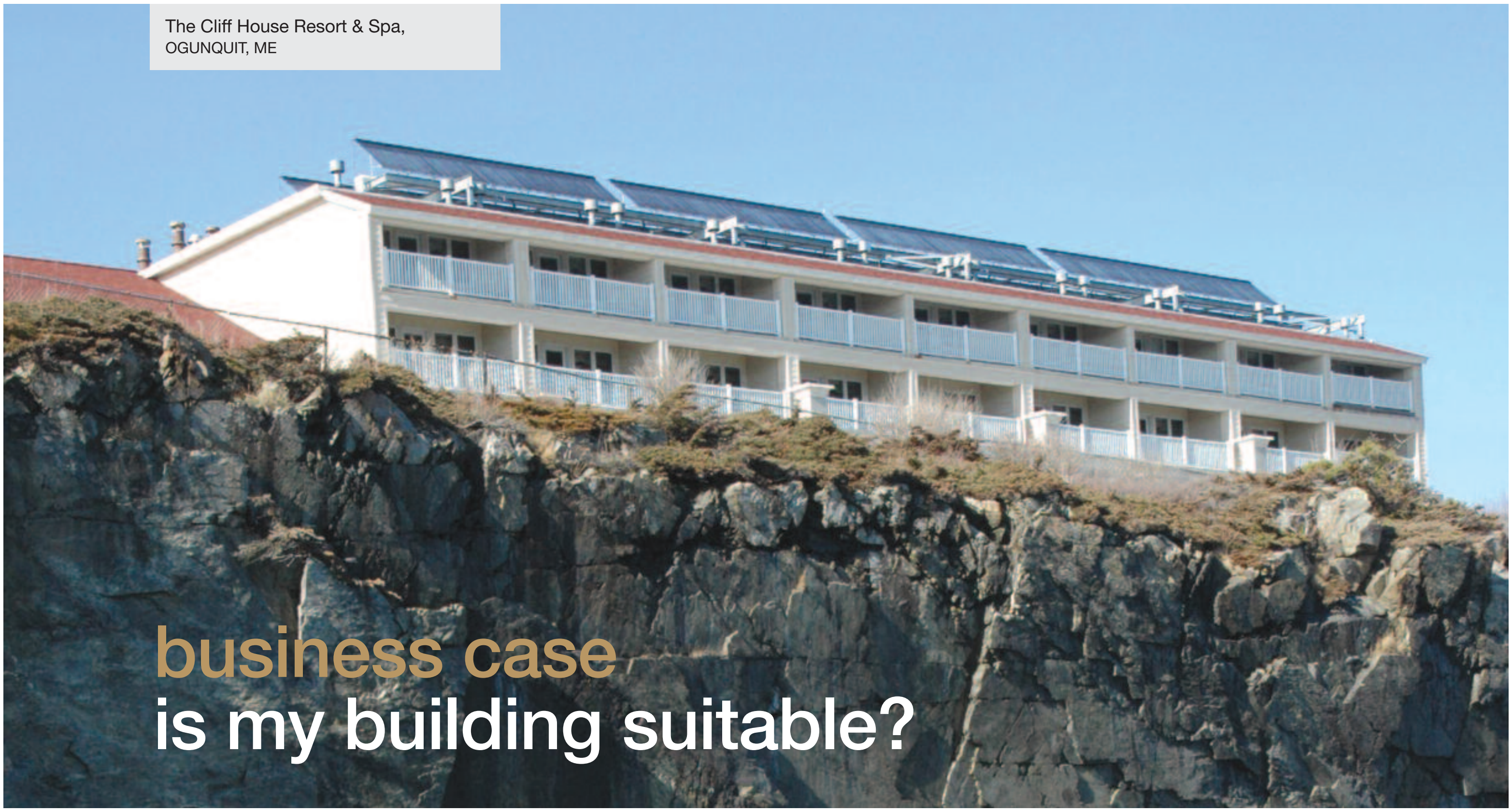
[1] *DSIRE is a comprehensive source of information on state, local, utility and federal incentives and policies that promote renewable energy and energy efficiency. Established in 1995 and funded by the U.S. Department of Energy, DSIRE is an ongoing project of the N.C. Solar Center and the Interstate Renewable Energy Council. www.dsireusa.org*

Environmentally friendly

- Non-toxic systems.
- **Non-polluting:** solar hot water generation produces no greenhouse gas emissions.
- **Non-consumptive:** the suns radiation is a limitless resource.
- Going 'green' for commercial projects has now become a PR advantage.
- Can contribute up to 10 points within LEED® Credits.

Accessibility and security

- **Security:** the price of solar energy does not fluctuate.
- **Instant distribution:** there are no expensive transportation costs for solar energy because the sun shines everywhere.



The Cliff House Resort & Spa,
OGUNQUIT, ME

business case
is my building suitable?

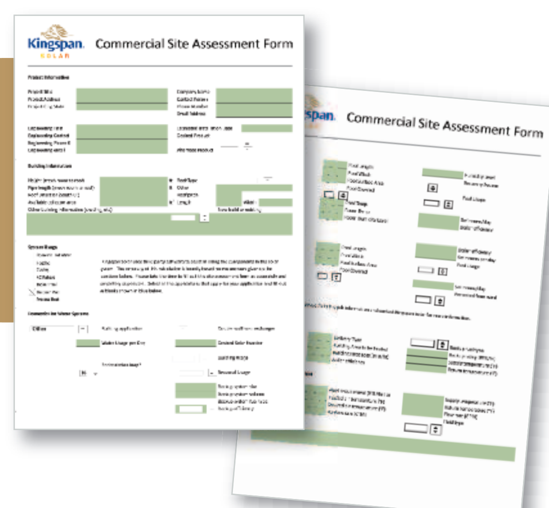
When considering a solar thermal system for your building, there are key factors that need to be considered.

As each project has individual requirements, Kingspan will develop a bespoke package, taking into account:

- Location / insolation level
- Orientation
- Limiting factors, e.g. shading
- Roof pitch / slope
- Roof area
- Hot water, heating and/or cooling demand

Kingspan Solar Technical Service

The checklist opposite provides an example of a typical site assessment. To assist you further, Kingspan Environmental offers a simple site assessment form (right) that, once completed, allows our technical team to size, design, and estimate savings on your project.



Site Assessment Checklist

Project Information

Project title:	Company name:
Project address:	Contact person:
Project city, state:	Phone:
	Email:

Engineering firm:	Estimated installation date:
Engineering contact:	Desired product:
Engineering phone:	Alternate product:
Engineering email:	

Building Information

Height (mech room to roof):	ft	Roof type:	
Pipe length (mech room to roof):	ft	Other:	
Roof direction (South 0°):		Roof pitch:	
Available collector area:	ft^2	Length:	Width:
Other building information (shading, etc):		New build or existing:	

System Usage

Domestic hot water ☐	AC reheat ☐	Outdoor pool ☐
Heating ☐	Indoor pool ☐	Process heat ☐
Cooling ☐		

Domestic Hot Water Systems

Building application:	Desired solar fraction:	Backup system size:
Water usage/day:	Building usage:	Backup system volume:
Recirculation loop? Y/N:	Seasonal usage:	Backup system fuel type:
Double wall heat exchanger:		Backup efficiency:

Indoor Pool

Pool length:	Pool covered:	Pool usage:
Pool width:	Humidity level:	Swimmers/day:
Pool surface area:	Recovery system:	Boiler efficiency:

Outdoor Pool

Pool length:	Pool covered:	Boiler efficiency:
Pool width:	Pool usage:	Protected from wind:
Pool surface area:	Swimmers/day:	

Cooling

Contact Kingspan Environmental for further information.

Space Heating

Delivery type:		Boiler efficiency:		Supply temperature:	°F
Building area to be heated:	ft^2	Backup fuel type:		Return temperature:	°F
Building heat loss:	BTU/hr	Backup rating:	BTU/hr		

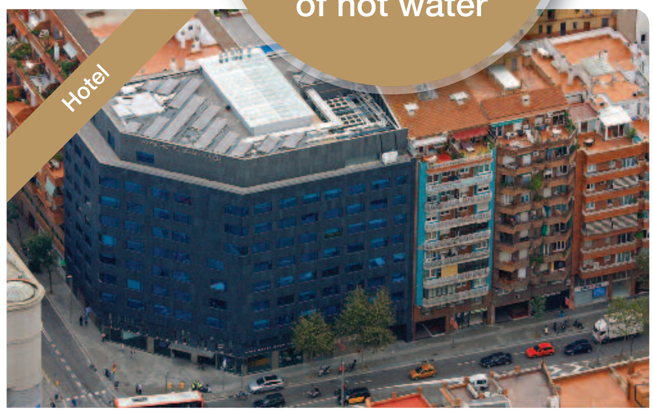
AC Reheat or Process Heat

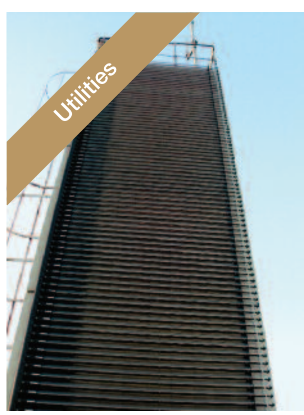
Heat requirement:	BTU/hr	Air flow rate:	CFM	Flow rate:	GPM
Cooled air temperature:	°F	Supply temperature:	°F	Fluid type:	
Desired air temperature:	°F	Return temperature:	°F		

business case
market sector applications

- **Leisure** – Hotels, camping grounds, health clubs, spas, and water parks.
- **Medical Facilities** – Hospitals, clinics and retirement homes.
- **Education** – Schools, colleges, universities, and campus accommodation.
- **Residential** – Apartment complexes.
- **Process and Manufacturing** – Drying, industrial cooking, pasteurization, and chemical manufacturing.
- **Office.**
- **Sports Facilities.**
- **Swimming Pools and Water Parks.**
- **Military.**

Commercial, industrial, and agricultural businesses using a high volume of hot water





Home and small businesses:

- Dish and laundry washing.
- Swimming pools.
- Baths and showers.
- Space and radiant floor heating.

engineering,
service and support

At Kingspan Solar we aim not just to manufacture and supply high quality solar thermal systems, but provide engineering, support and service that is second to none throughout your project – offering the ultimate, single-source solar solution.

- Project design concept
- Energy assessment and system specification
- Cost and payback proposal
- Proposal review and approval
- Installation training
- Commissioning support

Kingspan Solar Service

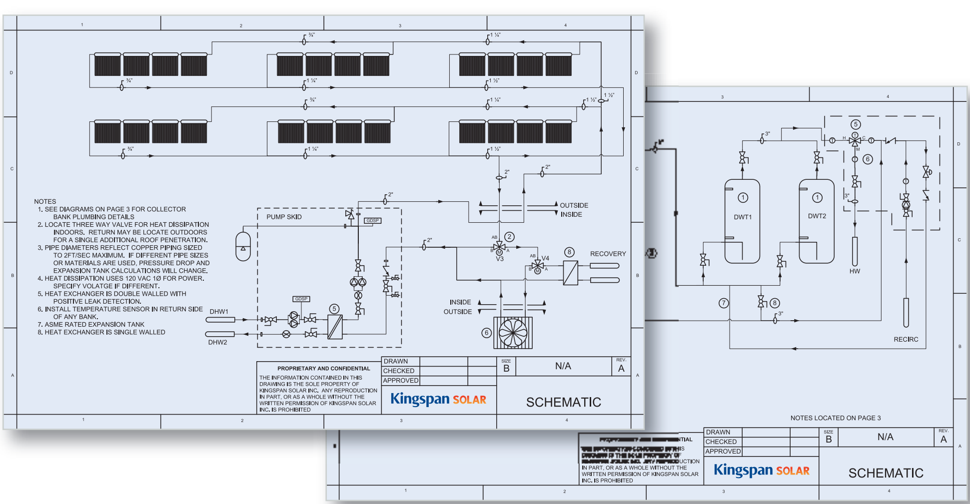
Full-Service Engineering

Kingspan Solar boasts an in-house engineering service department that advises and supports designers, engineers and installation contractors in the areas of renewables specification, design, product application and integration, code compliance and site-work installation practices.

At Kingspan Solar, we offer our customers over 25 years of solar thermal expertise and experience to supply technical designs and cost effective solutions on all projects. We can provide project specific Auto CAD schematics and roof layouts along with individual reports produced for each project.

We can work with you to advise and recommend solar thermal solutions for your project, from the design concept stage through to installation. We offer a fast, project specific, tender bid and specification service. We use T*SOL, the world renowned solar simulation software, for system sizing.

Call **410-799-6600**, to speak with one of our team, or go online to submit an inquiry at **www.kingspansolar.com**, and we'll respond to your inquiry with tailored solutions.



Example schematics as supplied by the Kingspan Solar Design Team

Mike Shellito Indoor Pool,
ROSEVILLE, CA

Customer Service

Our dedicated team provides focused customer service including delivery scheduling and installer support, ensuring a seamless, well co-ordinated customer experience.

To ensure high levels of satisfaction, we conduct customer surveys to gather important feedback that help us keep a pulse on the marketplace.

Site Service Support

Our technical team provides off- and on-site installation training and support in order to guide our installers to deliver products that fulfill customers' requirements and expectations. Our team of fully qualified engineers provide system checks and start-up support, ensuring installations are fully operational and working from day of completion.

We offer a site inspection service throughout the installation process as well as advice on operation and maintenance.

Warranty

The 20 year warranty on Thermomax evacuated tubes reinforces our confidence in the quality and longevity of the product. Flat plates come with a 10 year warranty. Please refer to our terms and conditions in the section "Specification and Performance Data", page 106.

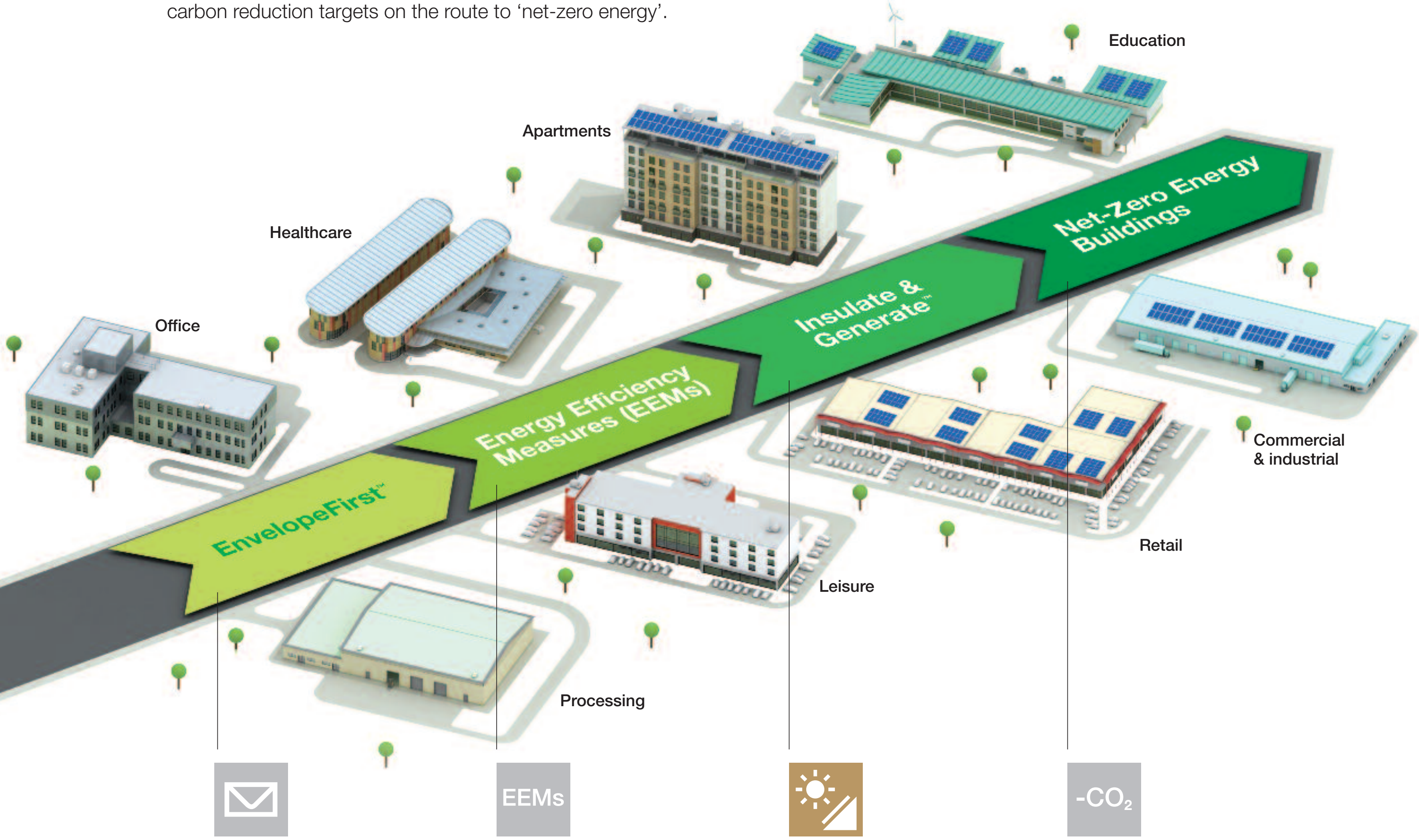
committed to
green buildings

The new frontier of building design is known as ‘net-zero energy’. The U.S. Department of Energy aims to achieve marketable net-zero energy buildings by 2025.

Attaining this goal requires that buildings be energy efficient and include a means of producing energy from renewable resources.

The Route to Net-Zero Energy Buildings

Kingspan solar thermal systems offer outstanding performance and durability, providing a valuable contribution to a buildings overall energy efficiency and carbon reduction targets on the route to ‘net-zero energy’.



EnvelopeFirst™

Highly insulated building envelope.

Energy Efficiency Measures (EEMs)

Building services and controls.

Insulate & Generate

EnvelopeFirst™ + integrated renewable technologies, e.g., Kingspan Solar.

Net-Zero Energy Buildings

Optimized energy efficient buildings that are energy neutral over the course of a year.

Designing Green Buildings

LEED®

Developed by the US Green Building Council (USGBC), the Leadership in Energy and Environmental Design (LEED®) certification scheme provides building owners and operators with a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions.

Kingspan is committed to supporting green rating systems such as LEED®. Specification of effective products and systems is key to achieving these certifications. With this in mind, Kingspan Solar provides a LEED® credits guide to assist the building team on how solar thermal systems contribute to overall building performance and ratings criteria.

Within LEED®, Kingspan's solar thermal systems are eligible under *Credit 1: Optimize Energy Performance* in the *'Energy and Atmosphere'* category.

Federal Buildings

Hot water demand

At least 30% of hot water demand in new or renovated federal buildings must come from solar hot water heating. Existing buildings with minor renovations must incorporate the most energy-efficient designs, equipment and controls.

Reduction of fossil fuel generated energy

Starting in 2010, new or renovated agency building designs must reduce fossil fuel-generated energy consumption by 55% compared to a 2003 baseline. In 2030 building designs must further reduce the fossil-fuel generated energy consumption by 100% compared to a 2003 baseline.

For further information regarding renewables in Federal Buildings, please visit:
http://www1.eere.energy.gov/femp/regulations/eisa.html

committed to green buildings

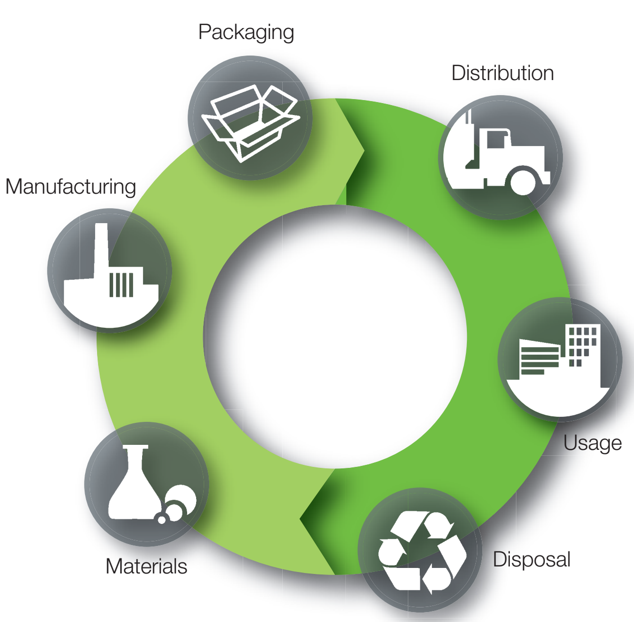
Our Commitment to Sustainability

Kingspan's primary contribution to meeting our global environmental challenges is to design, develop and supply new systems and solutions in a highly responsible and efficient manner.

Kingspan has set ambitious targets for reducing the effects of our operations and products on the environment. We have invested in life cycle assessment and are committed to establishing ISO 14000 Environmental Management System standard at all five manufacturing locations across North America. We continue to further our engineering research and development programs to maximize the life cycle performance and end of life procedures of every product we manufacture.

Through its employees, Kingspan instills an environmental awareness and responsibility that is reflected in the concept, design, development and production of all its products and services.

Kingspan promotes the use of construction techniques that respect the environment in terms of manufacturing, transportation, site installation, waste and end-of-life.



> **"Energy efficiency and environmental sustainability are at the forefront of our thinking."**
>
> *Gene M. Murtagh, Chief Executive, Kingspan Group.*

We believe these construction methods are better integrated, more efficient, faster and safer. Kingspan always selects materials and systems to minimize the overall ecological impact of buildings.

Vision

"To be a global leader in sustainable business and establish a leading position in providing sustainable, renewable and affordable best practice solutions for the construction sector."

Sustainability Policy

Striving for sustainability in all our business products and operations is our corporate and personal responsibility. Kingspan Solar aims to adopt and apply best practice sustainability principles by ensuring environmental, social and economic parameters are considered in an integrated way in product and service delivery. To this end, Kingspan Solar will:

- Incorporate the ethos of sustainability into the vision and values of the organization.
- Continually improve operational performance through the setting of long-term objectives and targets related to sustainability and review progress regularly.
- Comply or exceed applicable legal and policy requirements related to the environmental and social aspects of the organization.
- Optimize energy and raw material usage and prevent or minimize pollution and environmental damage.
- Communicate and actively promote awareness and acceptance of this policy to everyone working for, or on behalf of, the organization (including employees, shareholders, suppliers/sub-contractors and customers).
- Ensure employees are given adequate training in sustainability issues and are fully involved in helping deliver the Sustainability Vision & Policy.

case studies

Cliff House Resort & Spa

"System payback less than 6 years."

Location	Ogunquit, ME
Application	Domestic hot water and space heating
Client	Cliff House Resort & Spa
Installer	Nelson & Small Energy Conservation Products, Inc.
Product	70 Thermomax Heat Pipe collectors
Payback	< 6 years

Committed to sustainability and preserving the environment, the 5 star Cliff House Resort & Spa has installed one of Maine's largest solar thermal systems. The installation uses 2,100 tubes on 70 collectors.

This solar installation will save an estimated 11,000 gallons of propane annually and reduce greenhouse gas emissions by more than 140,000 lbs. per year.

Solar energy will be used to provide heat and hot water for the Resort's Spa building, which includes 32 guest rooms and 10 treatment rooms. The Resort estimates it will reduce fossil fuel consumption in this building by 30%. A grant from the U.S. Department of Agriculture, as well as federal tax credits, helped offset project costs and reduce payback to less than six years.

Kingspan Support

Kingspan Solar not only supplied the collectors, but designed, specified and supplied all the components, programmed the controls and commissioned the entire system prior to handover, providing the ultimate solar thermal solution.

case studies

Mike Shellito Indoor Pool

"100% reliable."

The City of Roseville California decided to build a new indoor pool complex in 2009. They wanted a building that minimized the use of fossil fuels - this was achieved using 90 Thermomax Heat Pipe Collectors.

The energy collected by the solar system can be used in several different areas. In summer, the energy is used for the domestic hot water and to heat the pool. For dehumidification, the roof of the pool is opened and outside air is allowed to enter to maintain the humidity level at the required levels. During winter, the dehumidification is achieved by letting fresh air into the pool area after it has been heated by the Thermomax collectors. Additionally, energy from the collectors is still used to heat the hot water for the showers.

"The unique design of Thermomax tubes make them amongst the most effective on the market… the perfect renewable energy source for innovative developments, such as this."
Stephen Witek, Project Engineer.

"The panels have worked spectacularly well from the beginning and regardless of weather, the system remains 100% reliable. It is a real talking point within the community."
Tim Rath, Facilities Manager.

Location	Roseville, CA
Application	Domestic hot water, space heating, dehumidification
Client	City of Roseville California
Product	90 Thermomax Heat Pipe collectors
Production	900,000 BTUs per hour peak output

Location	Toronto, ON, Canada
Application	Solar cooling, domestic hot water and heating
Client	Shouldice Hospital
Installer	Glenbarra Energy Management Corporation
Product	131 Thermomax Heat Pipe collectors
Savings	56% total energy load per annum

Shouldice Hospital

"Saves 56% of total energy load."

Shouldice Hospital in Toronto, Ontario has installed one of the premier solar thermal systems in the world. The complete system provides heating, cooling and domestic hot water for use in the hospital.

Kingspan Thermomax Heat Pipe collectors were selected for this system due to their superior performance at the high temperatures required.

The hot water collected is pumped to either the absorption chiller system, the domestic hot water tanks or the building's heating system. A chiller is used to convert the hot water into cool air. For the chiller to operate at peak efficiency, the temperature of the fluid from the collectors must be up to 200°F. This is simply too high for most other solar thermal collectors to reach efficiently.

The solar thermal system provides Shouldice Hospital with annual energy savings of:

- 36% (306,295,104 BTU) Cooling;
- 44% (136,407,859 BTU) Heating; and
- 91% (536,690,050 BTU) Domestic hot water.

These substantial savings equate to an impressive 56% of the total annual energy load.

Kingspan Support

Providing an all round, single-source solar solution, Kingspan Solar worked closely with the client to design and supply a tailored system that was integrated and installed seamlessly into Shouldice's existing heating and cooling system.

case studies

Location	Kingsville, TX
Application	Domestic hot water for the halls of residence
Client	Texas A&M University
Product	66 Thermomax Heat Pipe collectors
Production	960,000,000 BTU per annum

Texas A&M University

"Produces 960,000,000 BTU per year."

The Mesquite Village West Residence Hall is a completely new 98,000 ft² building, serving as home to the University's new Honors College and providing housing for approximately 300 students in suite-style apartments.

The state-of-the-art solar water heating installation is the first of its kind on the Texas A&M Kingsville campus and provides practical, meaningful results to its residents and to the campus community.

Commissioned in July of 2011, the system uses 66 evacuated tube solar thermal collectors to heat three 1000 gallon domestic hot water storage tanks to nearly 190°F. The solar collectors are installed in three separate arrays on the south-facing and west-facing roof tops and will generate enough hot water to produce as much as 80% of the four-story facility's domestic hot water demand.

At the time of commissioning, the Kingsville campus solar water heating installation was one of the largest evacuated tube solar thermal systems in Texas.

Washington and Lee University

"Produces 400,000 BTU per hour"

The largest solar thermal system in Virginia at the time of installation, generates approximately 50% of the heating load for Washington & Lee University's undergraduate library.

The heat generated by the system is used to preheat incoming outside air in the colder months. During the warmer months, the generated heat is utilzed to reheat air that has been cooled down for dehumidification, known as AC reheat.

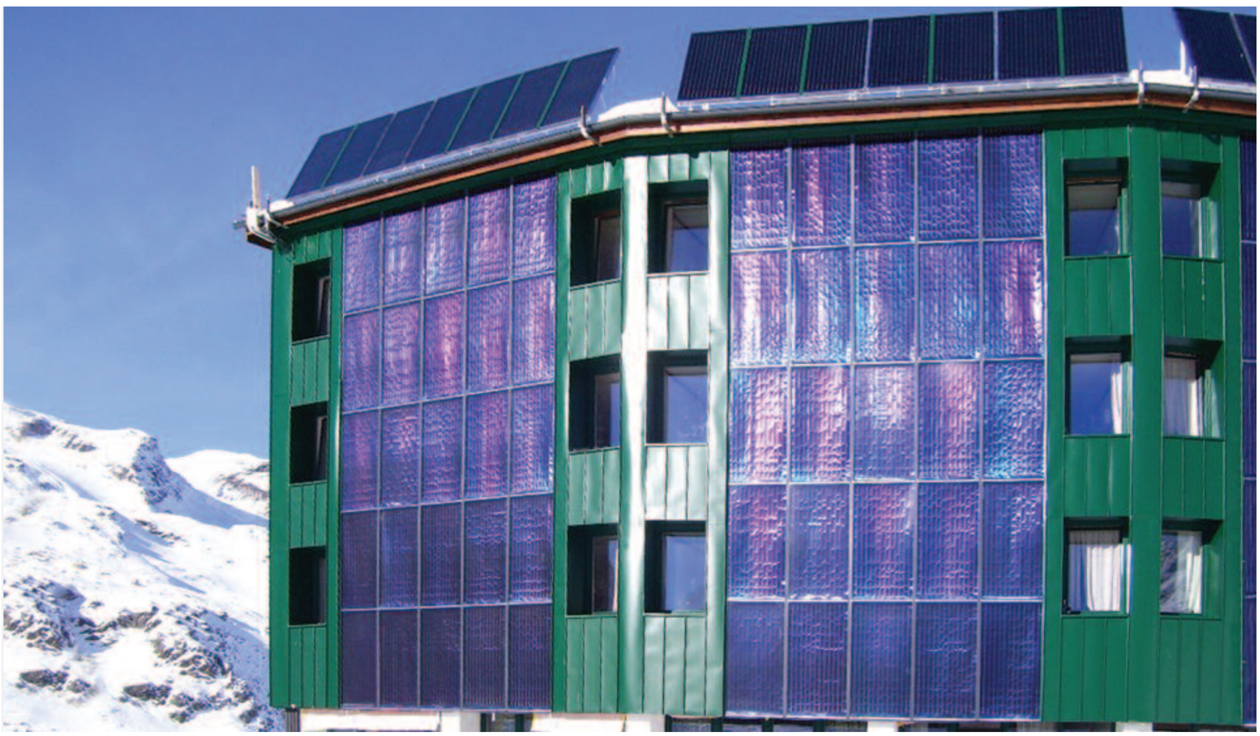
AC reheat is when the air is cooled below the desired temperature to bring the humidity down to a set point and then the air must be heated to bring it up to the desired temperature for the room. This is common in areas that have a lot of air changes per hour, such as hospitals, laboratories, or areas with a high volume of people, for example, airports.

The solar thermal system on Leyburn Library is comprised of 1,200 evacuated tubes for a total of over 1,800 ft^2 of gross collector area and a maximum output of approximately 400,000 BTU/hr.

Location	Lexington, VA
Application	Domestic hot water, space heating, dehumidification
Installer	New Grid Energy
Product	40 Thermomax Heat Pipe collectors
Production	400,000 BTU/hr

case studies

Hotel Rudolfshütte



"Saves $13,000 per year."

Location	Salzburg, Austrian Alps
Application	Domestic hot water and space heating
Client	Berghotel Rudolfshütte GmbH
Product	145 Flat Plate collectors
Savings	$13,000 per annum

Located in the Austrian Alps at an altitude of 7,595ft, the Rudolfshütte resort has installed a total of 145 (20ft^2 absorber area each) south facing flat plate solar collectors.

A mixture of 112 vertical façade-mounted panels and 33 'A' frame panels located on the roof of the building provide energy to the domestic hot water tank and also contribute to space heating via a total of 4,760 gallons buffer tank storage capacity.

Incorporated into the building façade, the vertical panels create not only a unique architectural feature to the building, but also provide space heating requirements due to the lower angle of the sun in the winter months when space heating demand is at its highest.

The solar contribution to the hotel's energy demand peaks at 1,000,000 BTU per day in the summer months and reaches an annual output of approximately 500,000,000 BTU. This equates to yearly cost savings of 37% and greenhouse gas reductions of 75,888.47 kg per year.

Hale's Ales Brewery & Pub

"Saves $15,000 per year."

Location	Seattle, WA
Application	Brewing processes, space heating, and domestic hot water
Client	Hales's Ales
Installer	Net Zero Impact LLC
Product	16 Thermomax Heat Pipe collectors
Savings	$15,000 per annum

Located in Seattle's Fremont neighborhood, Hale's Ales are brewers of traditional hand-crafted beers, whose 17,000 ft² premises house both the brewery and the Hale's Pub.

By replacing the inefficient gas-fuelled steam boiler system with a high-efficiency system featuring 480 Thermomax solar tubes, Hale's expects to save approximately $15,000 per year on natural gas costs. The new solar-thermal investment is one of several sustainable initiatives Hale's Ales has implemented.

"We've spent 27 years serving the community with the very best hand-crafted beers possible and making our operations greener is just another way of giving back to our community."

Mike Hale, founder and President, Hale's Ales.

The system will supply up to 2,000 gallons of solar-heated water per day for various brewing processes, radiant heating for the building and use by the adjoining pub.

case
studies

George Washington University, Foggy Bottom Campus

“Cash flow positive from day 1.”

This is a flagship installation, one of the largest in the country, in the heart of DC on one of the most prestigious colleges in the whole of the US.

GWU received the system for no upfront or capital cost, and will continue to receive solar hot water from Skyline at a rate that is a fixed percentage lower than their Washington Gas utility rate, meaning their savings are guaranteed and they achieve project payback on day one.

“We are excited to bring solar thermal systems to GWU’s residence halls and have the largest solar thermal system in D.C. These systems will help us explore how to expand future use of this technology.”.”

Alicia O’Neil, Senior Associate Vice President of Operations, GWU.

Location	Washington DC
Application	Pre-heating hot water for two large dorms
Client	George Washington University
Solar Developer	Skyline Innovations
Product	90 Thermomax Heat Pipe collectors

New Hampshire Veterans Home

"Saves 8,400 therms of natural gas."

The Tilton Veterans Home is a long-term care facility with approximately 250 residents and 400 employees.

The daily hot water demand has been calculated at 3,000 gallons per day. The complete solar assembly consists of two separate systems, each system contains 24 No. 30 tube roof mounted 'A' frame evacuated tube collectors.

The system is designed with a solar pre-heat tank, with a storage capacity of 2,750 gallons, that feeds a reheat tank of 3,000 gallons. The system is design to pre-heat the water to the reheat tank and therefore reduce the natural gas consumption on the site. The solar water pre-heat system provides 50% of the yearly domestic hot water needs for the facility, including the demands of the kitchen, but excluding the commercial laundry facility.

Location	Tilton, NH
Application	Domestic hot water
Client	New Hampshire Veterans Home
Product	48 Thermomax Heat Pipe collectors
Savings	8,400 therms of natural gas per annum

Hotel Julia,
MADRID, SPAIN

The Royal Danish Academy of Fine Arts School of Architecture,
COPENHAGEN, DENMARK

product range

solar thermal systems
product overview

Kingspan offers a range of solar thermal solutions to suit every application.

Thermomax Evacuated Tube Collector

The Kingspan Thermomax Heat Pipe collector is the most efficient, longest lasting heat pipe type solar collector on the market today. Made in Europe since 1982, Thermomax has withstood the test of time.

Each collector consists of a highly insulated manifold and a series of evacuated tubes. The vacuum inside each tube provides perfect insulation, protecting the system from outside influences, such as cold and windy weather or high humidity.

The dry connection between manifold and tube means Thermomax heat pipe systems are perfect for commercial installations – the tubes can be inserted only when the building is complete and the system is ready to use.

- Highly efficient – super fast heat transfer
- Temperature limitation safety device
- Ease of installation and maintenance
- ‘Plug and play’ design

Varisol Evacuated Tube Collector

World leading evacuated tubes and a new click-fit design, combine to make the world’s first modular solar thermal collector.

Varisol technology provides a modern and adaptable alternative to traditional rigid manifold systems. Its precise sizing and modular flexibility means it can be sized to the exact requirements of the end user, so they only use and pay for what is needed for ultimate results.

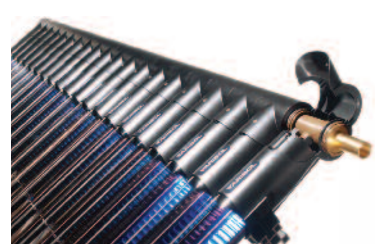
It is completely expandable so customers can grow their solar systems as their needs change.

Installation couldn’t be easier

Insert Varisol tube...

rotate down...

click into position.



Flat Plate Collector

Kingspan also offers a range of durable and very efficient flat plate collectors to meet the needs of a wide range of applications from small residential systems to large scale commercial installations. Four panel options are available to meet the needs of your specific application.

Robust, durable and high performance, these flat plate panels deliver excellent levels of efficiency combined with flexibility in installation.

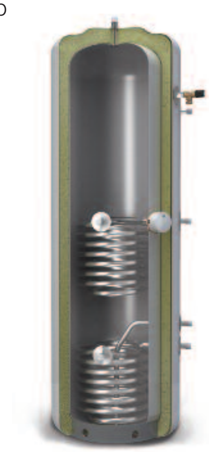
The panels are aluminium cased, low iron tempered glass units containing copper risers with copper absorption plate, TiNOx coated absorbers, ultrasonically welded to give a full covering of copper within the units.

System Components

Kingspan also supplies a range of components in order to provide complete solar thermal solutions, including:

Pump Stations

Pump Stations contain a circulating pump that circulates the heat transfer fluid through the solar loop (see page 54).



Tanks

In a solar system, the tank is almost as important to the collection of energy as the collector. Kingspan Tribune tanks are designed specifically for solar systems to maximize their output.

Expansion Tanks

In closed loop systems, an expansion tank is required to compensate for fluid expansion and contraction.

- Different sizes available.
- ASME and non-ASME rated tanks available.

Solar Controllers

Differential Temperature Controllers are required to activate circulating pumps and motorized valves and monitor system performance. They can record data from all sensors in the solar thermal system.

- Kingspan offers a wide range of controllers for different system types and requirements.
- Many different accessories available including LAN module, data logger and BACnet module.

Propylene Glycol

Kingspan Solar recommends Tyfocor Propylene Glycol, a high temperature glycol formulated specifically for solar thermal systems.

thermomax heat pipe solar collectors

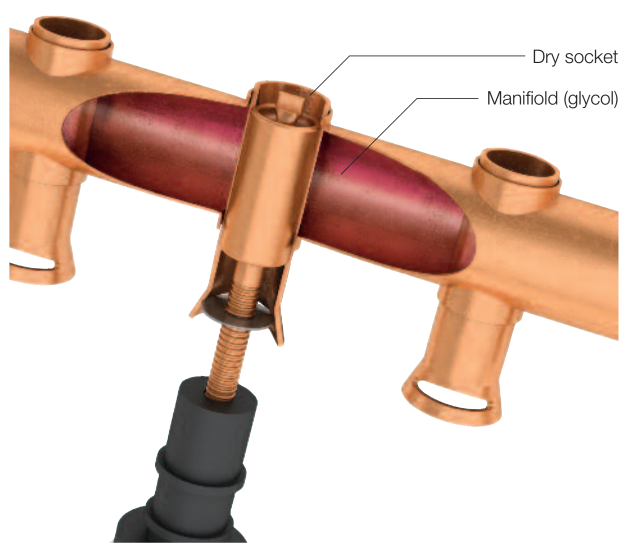
Figure 2: How a Heat Pipe works.

How it Works

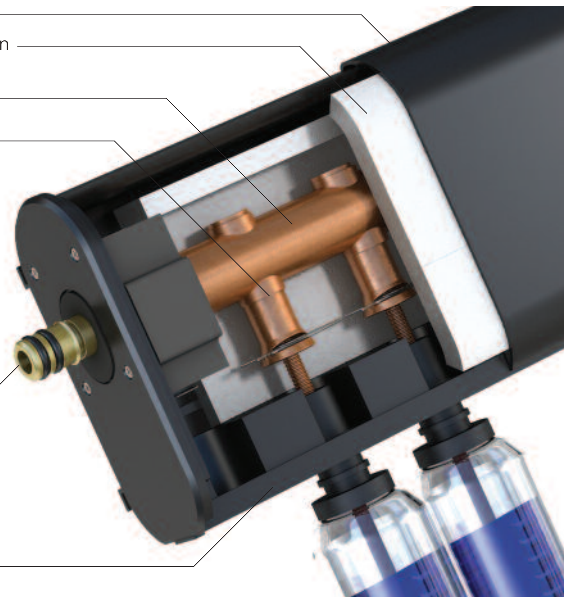
An absorber plate is located inside a glass tube where a vacuum is pulled to keep the losses to the environment as low as possible. 99.999999% of the air is removed from inside the glass enclosure during the manufacture of the tubes to mimimize heat loss. The heat pipe is the method of heat transfer from inside the tube to the manifold, where a water glycol mixture flows past the condenser heat at the top of the heat pipe and pulls the energy away.

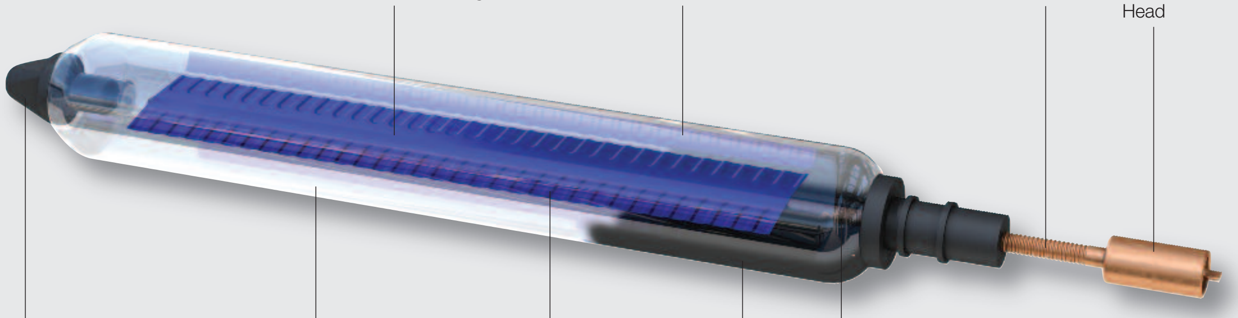
On the back of the copper absorber plate is welded a small copper tube. This tube is sealed at the bottom and, before it is sealed at the top, a small amount of fluid is added to the tube and a vacuum pulled inside the tube. The vacuum inside the heat pipe causes the water to boil at 85°F instead of its usual 212°F. The absorber plate collects energy from the sun and becomes hot, causing the water in the heat pipe to boil. The steam naturally rises up to the top of the heat pipe and into the condenser head which is located inside the manifold. Glycol flowing past the condenser head causes the water to condense, heating the glycol and causing the water to run back down to the bottom of the heat pipe allowing the process to continue when significant light is available (Figure 2).

The heat pipe is a very efficient method of transferring the energy from the tubes to the glycol in the manifold. Each tube plugs into a dry socket in the manifold where the glycol runs past it. This allows for individual tubes to be removed from the system without having to drain the glycol. The system can also be commissioned, flushed and filled prior to inserting the tubes into the collectors, an important point for large systems that need to be commissioned before a building is occupied. When the time comes, simply insert the tubes into the system and it is ready to produce hot water.



The manifold itself is formed from heavy duty aluminum extrusions on the front and back. Inside is the condenser manifold where the heat transfer occurs between the condenser and the glycol flowing past. To install the tubes simply open the manifold cover, line the tubes up with the manifold, and press them into place. When finished, close the manifold cover and this will retain the tubes in position. The manifold is the only area of the system that becomes hot and is not protected by a vacuum, so it is protected with high tech melamine foam insulation. This insulation has a very high R-value and is stable at the high temperatures the collector can achieve.





The image above shows the other key components of the Thermomax heat pipe tube. The getter is a layer of barium that is deposited on the inside of the tube after the vacuum is drawn. This protects the vacuum over time from any air molecules that may make their way through the glass.

If the vacuum is lost in one of the tubes, the getter will turn white to indicate this. The TiNOx coating used on the tubes is designed to absorb 96% of the sun's energy that strikes it while emitting only 4% back to the environment. This is currently the best available coating for solar collectors.

product range

thermomax heat pipe
solar collectors

The Thermomax Heat Pipe has a feature that makes it unique when compared to any other evacuated tube on the market today:

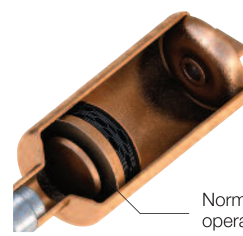
Thermostatic Control

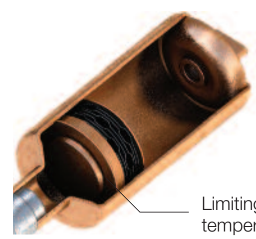
When the hot water storage reaches its maximum temperature, the solar pump stops and additional heat will not be removed from the collector. This will cause the tubes to become very hot. To protect the glycol in the manifold, Thermomax tubes have a patented thermostatic control device. This activates automatically in the condenser head and prevents the temperature in the manifold from becoming hot enough to damage the glycol.

When the temperature rises to 275°F, a stack of bimetallic disks flexes, closing a valve that will not allow additional steam from the heat pipe to enter the condenser head.

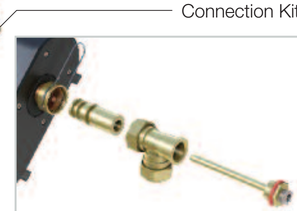
The temperature in the manifold may rise above the 275°F point, but it will be kept below the 350°F breakdown point of the glycol in most cases. When flow is restored to the collectors and the temperature falls below 250°F, the disks snap back and the valve reopens restoring the system to normal operation. A lower temperature version is also available.

Stagnation is any time when the solar pump cannot circulate the glycol fluid. The thermostatic control does not prevent this but is designed to control the system temperature and pressure. Solar installations should always be designed to minimize stagnation occurrence.





System Components



The connections at the end of the manifold use a redundant double o-ring seal to allow for expansion and contraction, if multiple manifolds are connected in series. The connection kit provides the adaptors necessary to adapt this to ¾" copper pipe at the end of collector banks. Connecting multiple collectors is easy with the interconnection kit. One end of the manifold simply slides into the other and the interconnection kit provides the hardware to properly align these end fittings.

Mounting Hardware (Frames)

Kingspan offers a selection of frames to hold the collector at the proper angle. All Kingspan frames are made from extruded aluminum supports and stainless steel hardware for the ultimate durability. Frames are supplied partially assembled with all clips in the correct locations and legs bolted together, facilitating fast and accurate installation.

Mounting the frame to the roof is another area that requires particular attention. The mount will depend on the type of roof and exactly how the collectors are to be mounted.

Kingspan Solar offers a wide variety of mounting hardware and provides the experience to select the correct system for the application. From asphalt shingle, to tile, to EPDM, we can help you choose the correct mounting hardware for the application.

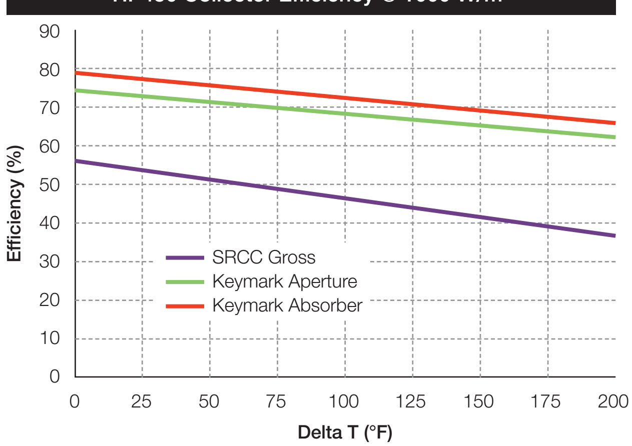
Certified Efficiencies

	SRCC Gross	Keymark Aperture	Keymark Absorber
η_0	0.556	0.750	0.794
a_1	1.78	1.18	1.25
a_2	0.0016	0.010	0.010

SRCC Output Predictions (mBTU/day) (20/30 Tube)

	Clear	Mildly Cloudy	Cloudy
A (-9ºF)	32.5 / 48.6	24.6 / 36.7	16.7 / 24.9
B (9ºF)	30.6 / 45.8	22.7 / 33.9	14.8 / 22.1
C (36ºF)	27.8 / 41.5	19.9 / 29.7	12.0 / 18.0
D (90ºF)	22.7 / 33.9	14.9 / 22.3	7.3 / 10.9
E (144ºF)	17.6 / 26.2	10.3 / 15.4	3.4 / 5.1

HP450 Collector Efficiency @ 1000 W/m²



Key Parameters

	20 Tube	30 Tube
Aperture Area	23.68 ft²	35.51 ft²
Width of Manifold	55.8"	83.8"
Length (Tube and Manifold)	76.85"	
Depth	3.66"	
Gross Area	29.95 ft²	44.97 ft²
Fluid Volume (in Manifold)	0.29 gallons	0.45 gallons
Inlet and Outlet Dimensions	0.75"	
Weight (Empty)	106 lbs	158 lbs
Recommended Inclination	20-70º	
Rated Flow rate	0.71 gpm	1.06 gpm
Minimum Flow rate	0.30 gpm	0.45 gpm
Maximum Flow rate	1.32 gpm	2.11 gpm
Maximum Operating Pressure	116 psi	
Stagnation Temperature	362ºF	
Heat Transfer Fluid	Propylene Glycol Mixture	
Absorber	Copper	
Coating	Selective Coating	
Absorbance	95%	
Emissivity	5%	
Mounting Hardware (Frame and Clips)	Stainless Steel, Aluminum, EPDM	
Glass	Low Iron – Transm. 0.92	
Vacuum	Lower than 10^{-6} bar	
Temperature Limitation	275ºF	275ºF
SRCC Certification	10001723	10001721
Solar Keymark Certification	011-7S1793 R	011-7S1793 R
Hail Impact Test	Yes	Yes

varisol
award winning solar collectors

The revolutionary new design of Varisol offers a modern and flexible alternative to the rigid manifold system.

Additional Benefits

Delivering all the benefits of Kingspan Solar's market-leading evacuated tubes, Varisol offers the combination of total flexibility, high quality and proven performance.

The evacuated tubes are pre-assembled with the Varisol connector for ease of installation and collector sizes of up to 150 tubes. The technology is suitable for both domestic and commercial applications and is completely expandable enabling customers to grow their solar thermal systems as their requirements change.

Precision sizing means customers only need to pay for exactly what they need. For installers they are quick and easy to install and distributors benefit from improved stock control with no manifolds to stock or invest capital in. They are also environmentally friendly, using 100% recyclable polymer material.

Varisol has lowered its carbon footprint by eliminating the need for brazing and welding as well as energy intensive materials, such as copper and aluminium. The system is also more lightweight and requires less packing and boxes, therefore minimising the impact of transport.

Technical Information	
Dimensions (Each Tube)	41.3" x 2.8" x 2.8"
Weight (Each Tube)	5 lbs
Volume (Each Tube)	0.05 gallons
Pipe Connections	$^{3}/_{4}$" compression
Max Operating Pressure	90 psi
Min Slope	0°
Max Slope	90°

A copper pocket is over-moulded into the polymer header to house the condenser and ensure a dry connection of the tubes.

"Quick and easy to install, Varisol allows individual tubes to be simply clicked together to create solar collectors of varying sizes."

Kingspan Environmental

Retirement Home,
ITALIAN ALPS

The direct flow evacuated tube collector can be installed on a pitched or horizontal surface, and the tube can be rotated 25° to compensate for installations that deviate from south. As this collector is a fully pumped unit there is no minimum angle of inclination for the collector.

“This versatile product provides the perfect solution when the ideal position on the building is not available.”

Certified Efficiencies

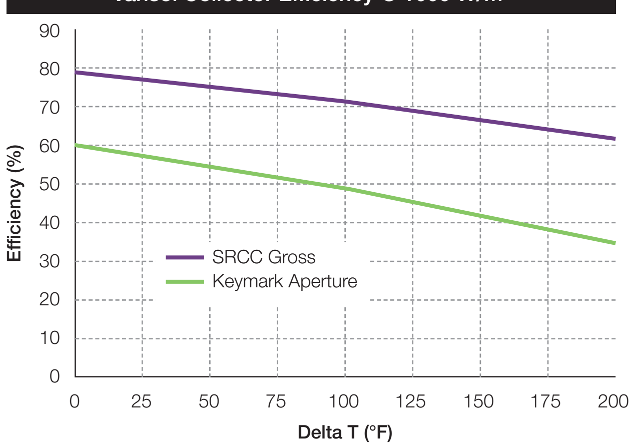
	SRCC Gross	Keymark Aperture
η_0	0.599	0.783
a_1	1.749	1.061
a_2	0.0044	0.023

SRCC Output Predictions (mBTU/day) (20/30* Tube)

	Clear	Mildly Cloudy	Cloudy
A (-9°F)	34.5 / 51.8	26.1 / 39.1	17.7 / 26.6
B (9°F)	32.7 / 49.1	24.3 / 36.5	15.9 / 23.9
C (36°F)	29.8 / 44.7	21.3 / 32.0	13.0 / 18.5
D (90°F)	24.3 / 36.5	16.0 / 24.0	7.9 / 11.9
E (144°F)	18.3 / 27.5	10.7 / 16.1	3.4 / 5.1

**30 tube data is extrapolated based on 20 tube rating.*

Varisol Collector Efficiency @ 1000 W/m²



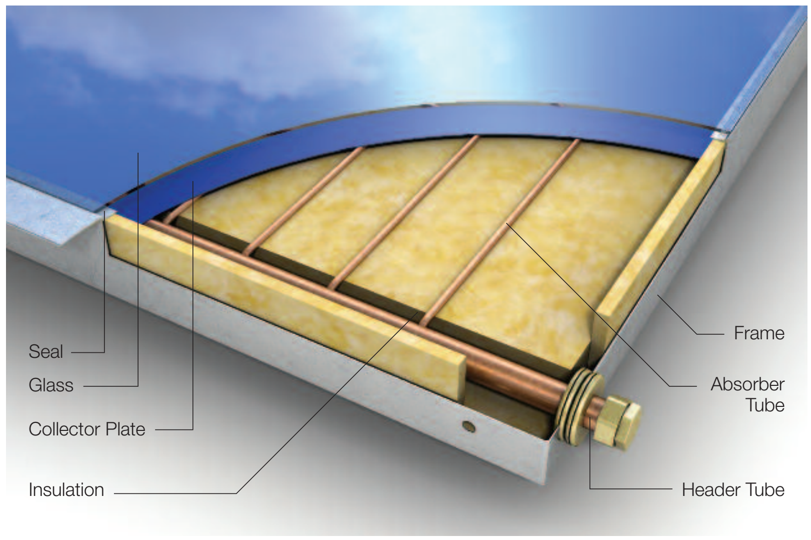
Key Parameters

	20 Tube	30 Tube
Overall Dimensions	76.8” l x 55.8” w x 27.9” h	76.8” l x 83.7” w x 27.9”
Aperture Area	22.60 ft²	33.90 ft²
Depth	3.66”	
Gross Area	29.79 ft²	44.69 ft²
Fluid Volume	1.0 gallons	1.5 gallons
Inlet and Outlet Dimensions	0.75”	
Weight (Empty)	97 lbs	145.5 lbs
Mounting		
Recommended Inclination	0-90°	
Performance Data		
Efficiency	Based on aperture	
Eta 0	0.783	
a^1 (W/m²K)	1.061	
a^2 (W/m²K²)	0.023	
Solar Keymark Licence No.	011-7S1238F	
Operating Data		
Flow rate		
Minimum Flow rate	0.30 gpm	0.50 gpm
Maximum Flow rate	1.32 gpm	2.11 gpm
Maximum Operating Pressure	87 psi	
Stagnation Temperature	464.7°F	
Heat Transfer Fluid	Water / Glycol	
Absorber	Copper	
Coating	Selective Coating	
Absorbance	95%	
Emissivity	5%	
Mounting Hardware (Frame and Clips)	Stainless Steel, Aluminum, EPDM	
Glass	Low Iron – Transm. 0.92	
Vacuum	Lower than 10^{-6} bar	

flat plate
solar collectors

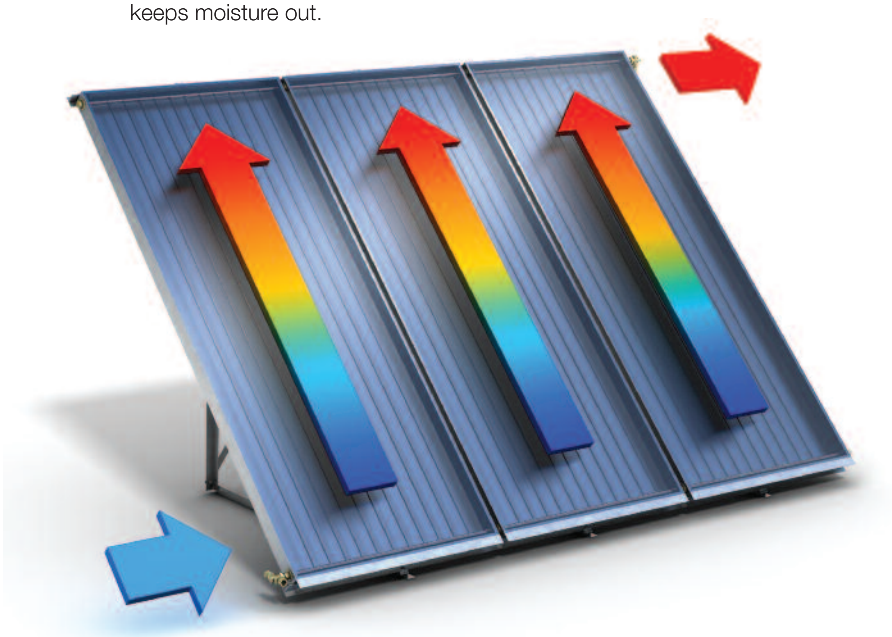
How it Works

Flat plates are a very simple method for capturing the energy form the sun and turning it into hot water. A copper plate is coated with a special coating that absorbs as much of the sun's radiation as possible. On the back of this plate are a series of tubes that are welded directly to the back of the plate. Glycol flows from a manifold on one end of the collector to another manifold at the other end. As it passes through the tubes on the back of the plate, it is heated by the energy that the plate has absorbed from the sun.



To keep as much energy in as possible, the collector plate is surrounded on five sides by insulation. This insulation prevents the loss of energy from the hot plate to the surrounding environment. On the front side of the panel is a plate of glass that the sun shines through. The glass also provides insulation for the collector plate from the cold environment outside. A frame around the outside holds everything together and keeps moisture out.

Both ends of the manifolds have union fittings that allow for a connection kit to be attached, or another panel. For arrays of multiple collectors, one collector simply screws into the next and seals with a flat washer. A plug is screwed into one end of each of the manifolds and the connection kit added to connect up an array of collectors.



"Kingspan offers two sizes of flat plate in both vertical and horizontal orientations.

This allows for optimal placement of the panels on the roof and significant flexibility in the output of the system."

Key Features

There are many flat plate products on the market today, differing significantly in terms of design, construction quality, performance and size. Kingspan flat plate collectors offer high efficiency, combined with robust design and construction, providing solar thermal systems that are designed to last and perform for many years.

Key differences between Kingspan flat plate collectors and others on the market.

- Single Piece Stainless Steel Frame: Many other collectors will use aluminum extrusions that are joined in the corners, rather than a single piece frame. By making the frame out of a single piece of steel and welding the joint, there will be less moisture that can enter the collector during operation. The back is secured and sealed to this frame. Stainless steel will provide the ultimate protection against corrosion during the life of the collectors.

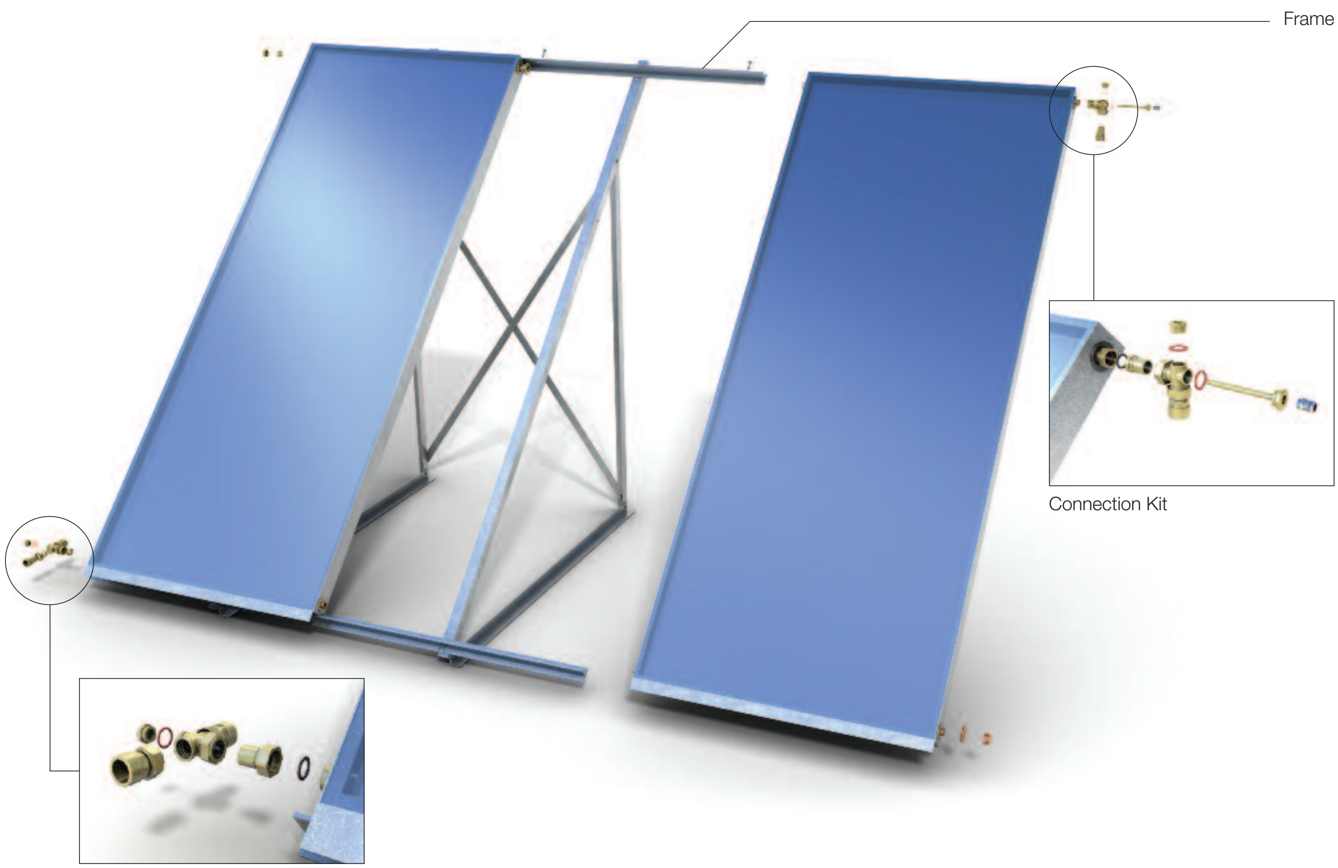
- Insulation: Kingspan's Flat Panels use a proven mineral fibre insulation that can withstand temperatures up to 1,500°F, ensuring no degradation of the insulant and securing the longevity of the collectors.

- TiNOx Coating: As with Thermomax evacuated tubes, Kingspan flat plates use the best coating on the market today; TiNOx. TiNOx is a proprietary coating that absorbs 96% of the sun's radiation, while emitting only 4%. Many other coatings used on flat plate collectors, such as black chrome or selective black paint will absorb closer to 90% of the sun's radiation. This difference makes a large contribution to the high output of Kingspan collectors.

- Glass Attachment: Kingspan Solar flat plate collectors have glass that is attached at the factory using a special sealant / glue to make sure there is never any leakage at this key joint. The cost and difficulty of shipping such a large sheet of glass means that if a glass panel does break on a collector it is cheaper to change the whole panel rather than attempt replacement. Many other panels use an EPDM seal that is placed at the factor, but designed to be removed to allow for glass replacement. The factory made seal on Kingspan collectors is 100% inspected to insure that there will be no leakage at this junction.

flat plate
solar collectors

System Components



The connection kits attach to the ends of the collector banks by using the union nuts on each of the collectors. Included with the connection kit is a sensor well for the temperature sensor that measures the collector's temperature for the controller. The other end includes an air vent and additional ports are available if more hardware needs to attach.

Mounting Hardware (Frames)

Kingspan offers a selection of frames to hold the collector at the proper angle. All Kingspan frames are made from extruded aluminum supports and stainless steel hardware for the ultimate durability. Frames are supplied partially assembled with all hardware in the correct locations and legs bolted together, facilitating fast and accurate installation.

Mounting the frame to the roof is another area that requires particular attention. The mounting hardware will depend on the type of roof and exactly how the collectors are being mounted. Kingspan Solar offers a wide variety of mounts and provides the experience to select the correct system for the application. From asphalt shingle, to tile, to EPDM, we can help you make the right decision.

Flat Plate Specification	FP200V	FP200H	FP240V	FP240H
Length	79 1/2”	40 1/8”	96 1/4”	40 1/8”
Width	38 3/4”	78 1/8”	38 3/4”	94 7/8”
Height	3 1/8”	3 1/8”	3 1/8”	3 1/8”
Gross Area	21.4 ft^2	21.7 ft^2	26 ft^2	26.4 ft^2
Absorber Area	20.1 ft^2	20.1 ft^2	24.4 ft^2	24.4 ft^2
Fluid Volume	0.26 gal	0.42 gal	0.29 gal	0.53 gal
Weight	75 lbs	77 lbs	91 lbs	93 lbs
Flow Rate	0.3 GPM / panel	0.3 GPM / panel	0.4 GPM / panel	0.4 GPM / panel
SRCC Certification	2011060A	2011060A	2011060B	2011060B
Keymark Certification	11-7S1548 F	11-7S1548 F	11-7S1549 F	11-7S1549 F
Inclination	20° – 80°			
Maximum Pressure	87 psi			
Heat Transfer Fluid	Propylene Glycol			
Absorber Material	Copper			
Absorber Coating	TiNOx			
Absorbance	96%			
Emissivity	4%			
Mounting Hardware Material	Stainless Steel			
Piping Material	Copper			
Insulation Material	Rock Wool			
Stagnation Temp.	390°F			

Certified Efficiencies

	SRCC Gross	Keymark Aperture
η_0	0.740	0.797
a_1	3.7926	4.21
a_2	0.00356	0.0035

SRCC Output Predictions (mBTU/day) (200/240)

	Clear	Mildly Cloudy	Cloudy
A (-9°F)	30.7 / 36.2	23.2 / 27.7	15.8 / 19.0
B (9°F)	27.9 / 32.9	20.4 / 24.2	13.0 / 15.5
C (36°F)	23.7 / 28.1	16.4 / 19.5	9.1 / 10.9
D (90°F)	16.3 / 19.2	9.4 / 11.3	3.0 / 3.7
E (144°F)	9.9 / 11.8	3.8 / 4.7	0.0 / 0.0

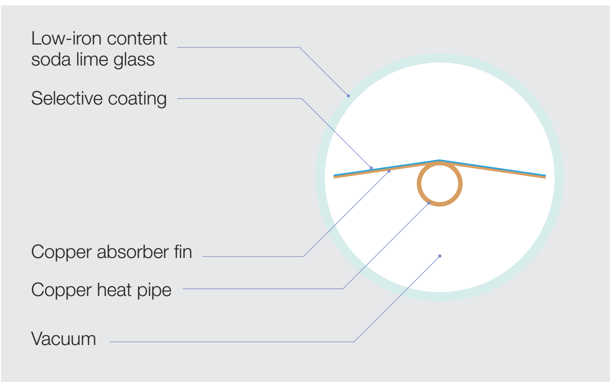
unique features of kingspan thermomax tubes

Tube Design

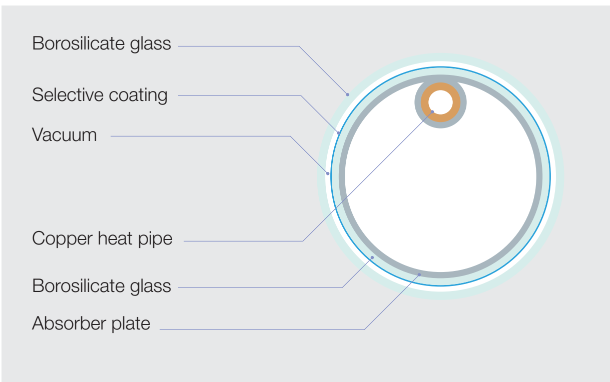
Thermomax 'Fin-in-tube' Design

In a Thermomax evacuated tube system, a copper absorber plate is welded to a heat pipe tube and sealed inside a single wall glass tube to collect the sun's energy. Most other evacuated tubes are a Sydney design in which two glass tubes are formed into a vacuum flask with the selective coating surface on the inner glass tube and the absorber plate and hydraulic fittings are housed inside the cavity of an open ended flask.

Thermomax Heat Pipe Tube Cross Section



Sydney Tube Cross Section



Thermomax sealed glass tubes protect all components inside a controlled environment where outside conditions cannot affect heat production and heat transfer. Moisture will not build up around the tube's components and they will not corrode.

The Alps,
ITALY

Benefits of Thermomax Tubes

There are three core objectives -

- Performance
- Longevity
- Consistency

These main objectives are fulfilled through the following:

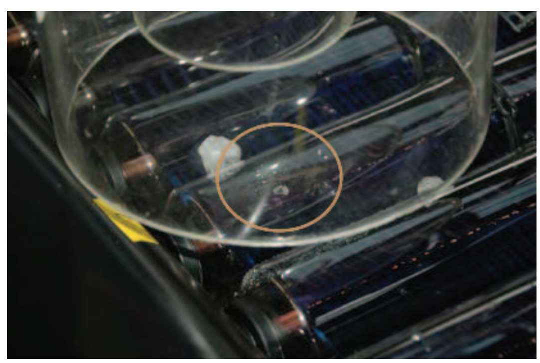
High Quality Glass

Outside air will seek to penetrate and compromise the insulation properties of a vacuum – quality glass can prevent this from happening.

Thermomax tubes are constructed of low-iron content soda lime glass. We generally think of glass as being completely transparent, but glass actually absorbs some of the light passing through it, typically allowing only 94% of light to assist the heating process. Low-iron content soda lime glass has one of the highest transmission characteristics of any high-strength glass on the market today.

The Hail Impact Test

Thermomax evacuated tubes are one of the few tubes from the major solar thermal manufacturers to have passed this European trial that is covered under EN 12975-2 specification.



Shot impact point.

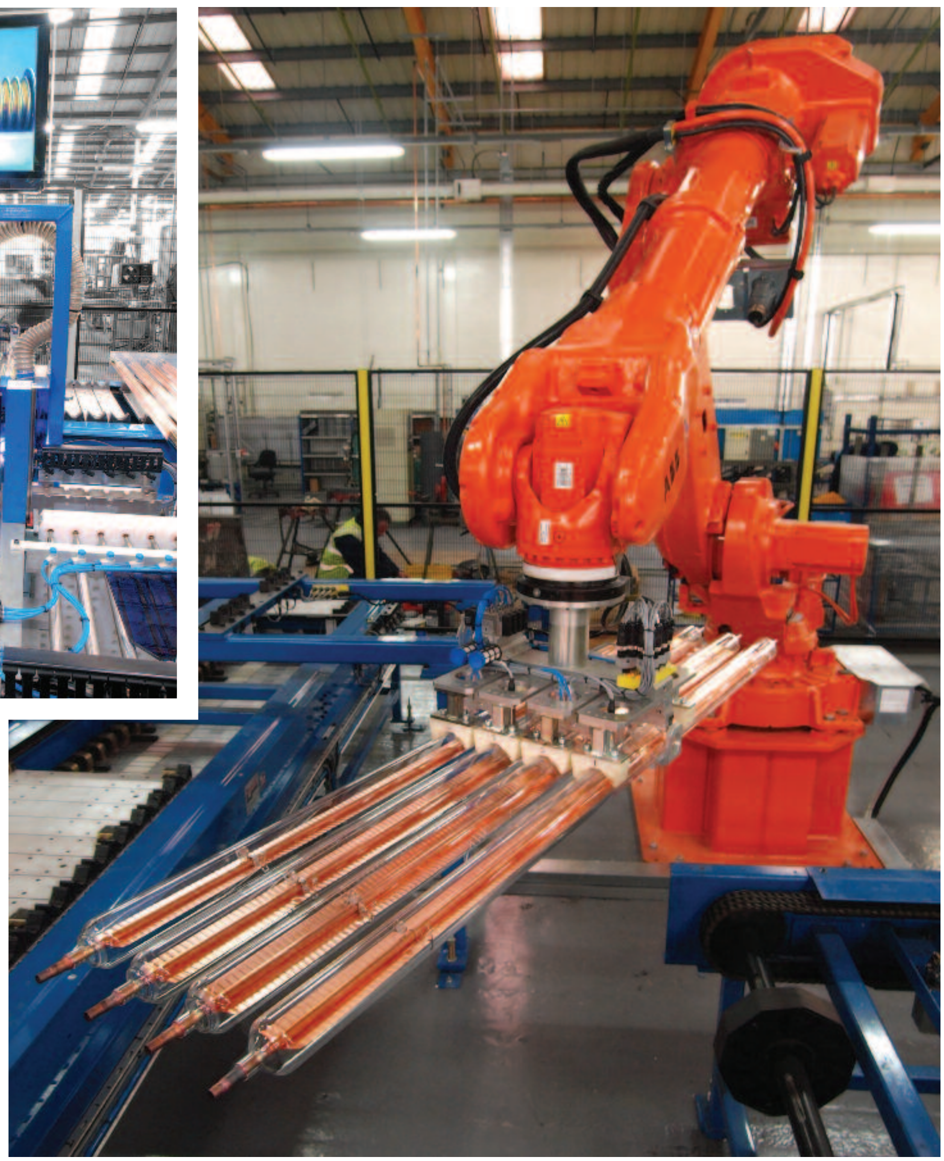
The test involves firing a one inch ice ball at 50 mph, five times at the same point on the tube (Figure 1). Kingspan tested borosilicate glass to quantify the performance difference as compared to soda lime glass.

product range

unique features of kingspan thermomax tubes

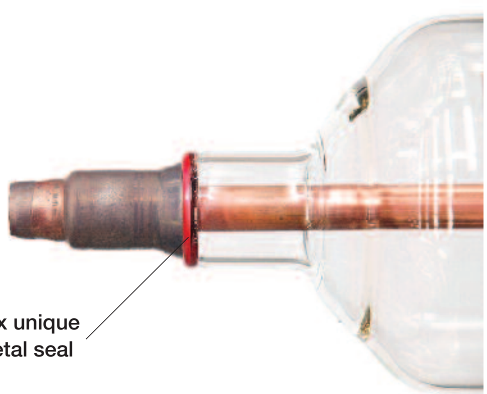
State-of-the-art Manufacturing

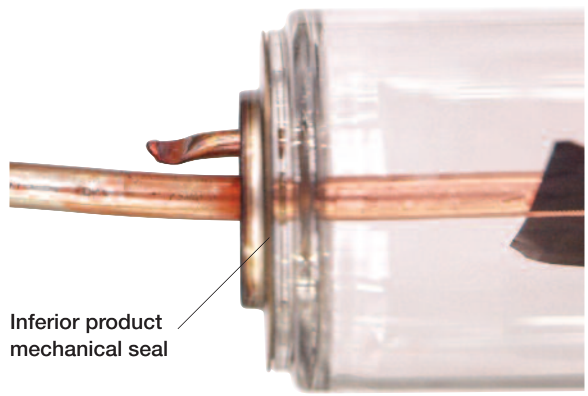
Thermomax tubes are manufactured using European sourced parts in a state-of-the-art facility in Northern Ireland. The evacuated tube manufacturing process is fully automated, removing the potential for human error and providing consistently high levels of production quality.



Unique Glass to Metal Seal

The seal between the glass and the heat pipe where the pipe emerges from the neck of the tube is critical to maintaining the vacuum and its insulation properties. The tubes feature a patented hermetic seal that fuses metal and glass together. The two materials are bonded so the seal remains intact under all operating conditions.





Superior Vacuum

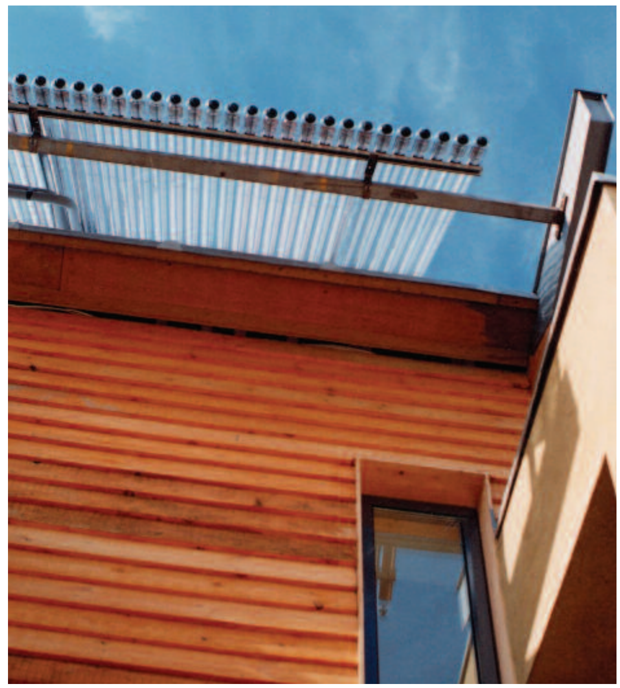
The vacuum and its insulation properties are the most important elements of an evacuated tube. The vacuum is drawn to $1x10^{-6}$ mbar, signifying that 99.9999999% of the air is removed from the tube. It is extremely difficult to remove this much air from any space in a commercial production environment without using state-of-the-art manufacturing techniques.

"Kingspan Thermomax tubes maintain their vacuum, continuing to perform for over 30 years."

All evacuated tubes use a barium getter to attract and collect outgassed air or stray molecules that can infiltrate the evacuated tube and degrade the vacuum. Thermomax tubes provide the largest getter surface area in the industry, maintaining their vacuum and continuing to perform for over 30 years in many cases. It is not surprising that Thermomax tubes contain one of the best vacuum levels on the market.

evacuated tube comparisons

Thermomax evacuated tubes last longer and perform better than any other evacuated tube on the market.



In the following section, competitor's tubes have been photographed and compared to the Thermomax tube to demonstrate the key differences in quality and production.

The two types of evacuated tubes are:

- Fin-in-tube or single wall tubes – as discussed earlier, Thermomax is a 'Fin-in-Tube' type design which has the heat pipe sealed inside a single wall glass tube; and
- Sydney Tube or double wall tubes – where two glass tubes are formed into a vacuum.

This section aims to give an overview of the differences in both types of tubes and outline of the main differences between Thermomax and other tubes on the market.

System comparison: Thermomax Heat Pipe vs. fin-in-tube copy

High Quality Heat Pipe Seal

Thermomax Tube

✓

Heat pipe sealed with spin closing and TIG weld. Double protection with 100% automated inspection.

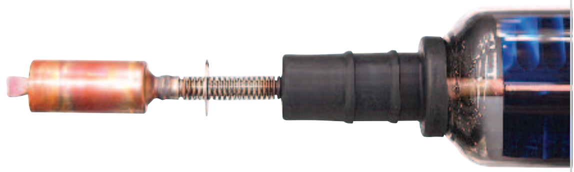
Inferior Copy

✗

Heat pipe sealed with a plug.

Flexible Neck

Thermomax Tube



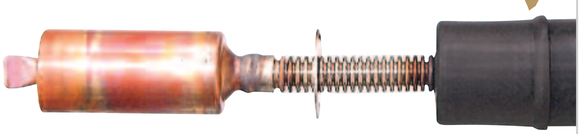
High quality flexible stainless steel neck (relieves stress on the glass to metal seal with high quality, UV stable EPDM rubber flange.

Inferior Copy

Stiff neck technology stresses the glass / metal seal.

Temperature Limitation Device

Thermomax Tube



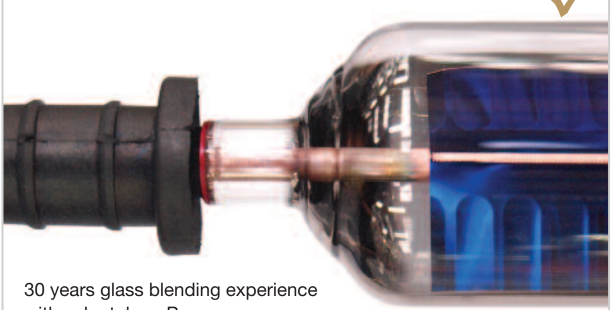
Unique patented and 'patent pending' temperature limiting technology used within the Thermomax condensers.

Inferior Copy

Empty heads – no mechanical temperature limitation.

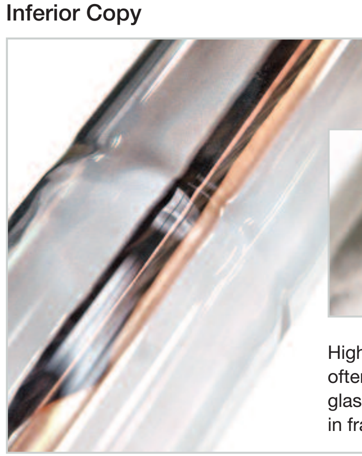
Quality Glass Welding & Blends

Thermomax Tube



30 years glass blending experience with solar tubes. Processes perfected and fully automated.

Inferior Copy



Highly visible glass blend lines often with air bubbles in the glass blends which can result in fractures after installation.

product range

evacuated tube
comparisons

System comparison: Thermomax Heat Pipe vs. fin-in-tube copy

High Quality Protective End Bumper

Thermomax Tube

✓

High quality EPDM rubber end protector on the tube.

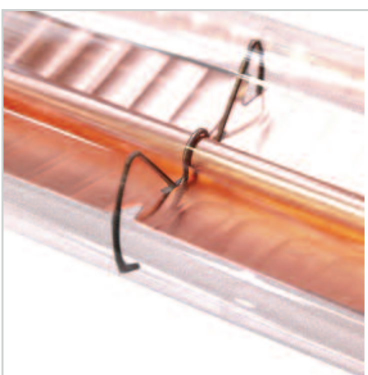
Inferior Copy

✗

Low cost option – no end protection.

Single Pipe

Thermomax Tube



✓

Heat pipe is a single hermetically sealed copper pipe within the vacuum space.

Inferior Copy

✗

Mechanical/soldered join within the vacuum space.

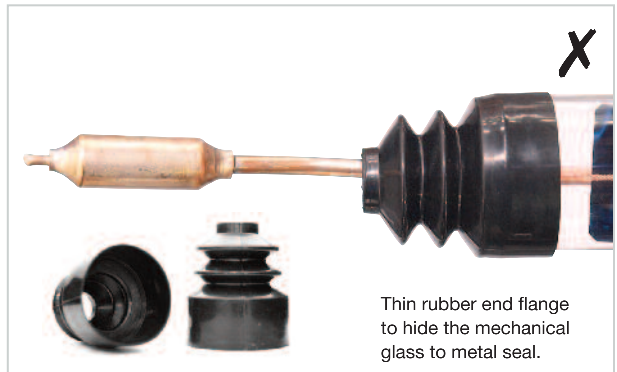
product range

High Quality Rubber Flange

Thermomax Tube

High quality rigid EPDM rubber flange. Insulates and protects the glass to metal seal.

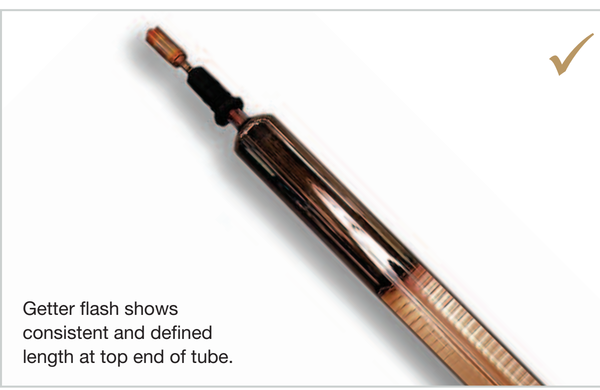
Inferior Copy



Thin rubber end flange to hide the mechanical glass to metal seal.

Larger Getter Area, More Robust Vacuum

Thermomax Tube



Getter flash shows consistent and defined length at top end of tube.

Inferior Copy

Getter flash has undefined length at centre of tube.

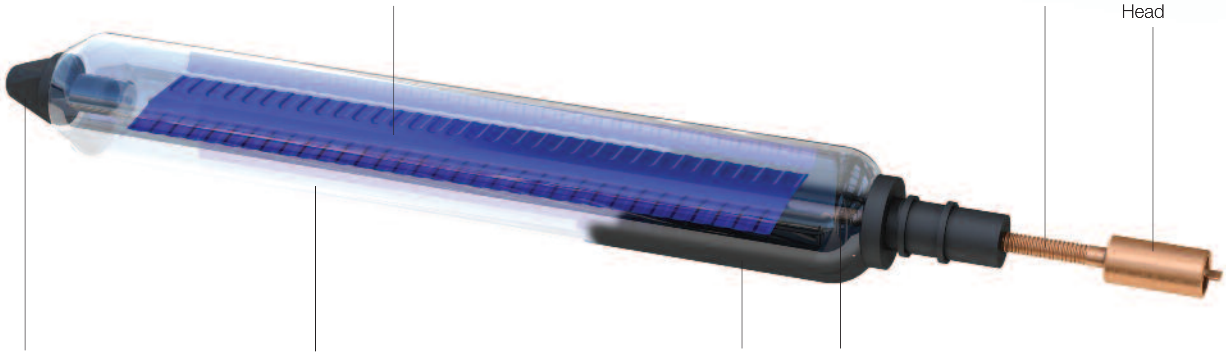
evacuated tube
comparisons

System comparison: Thermomax Heat Pipe vs. single wall / fin-in-tube

Thermomax Tube

Tube Diameter 2 5/8"

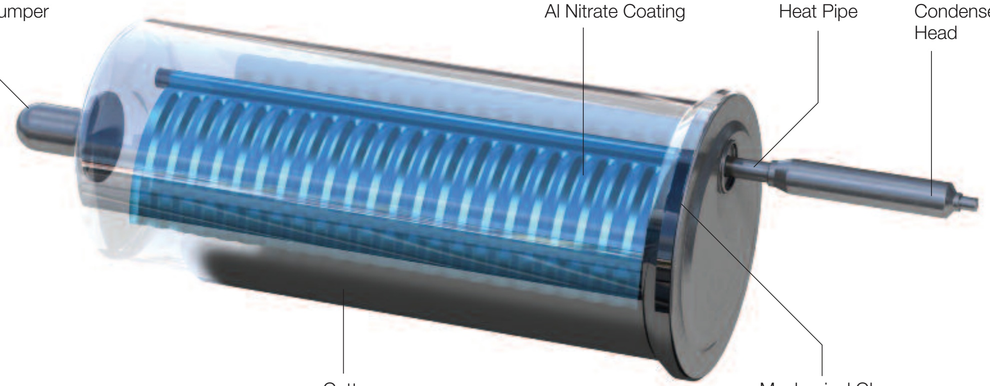
✓



Single-walled Tube

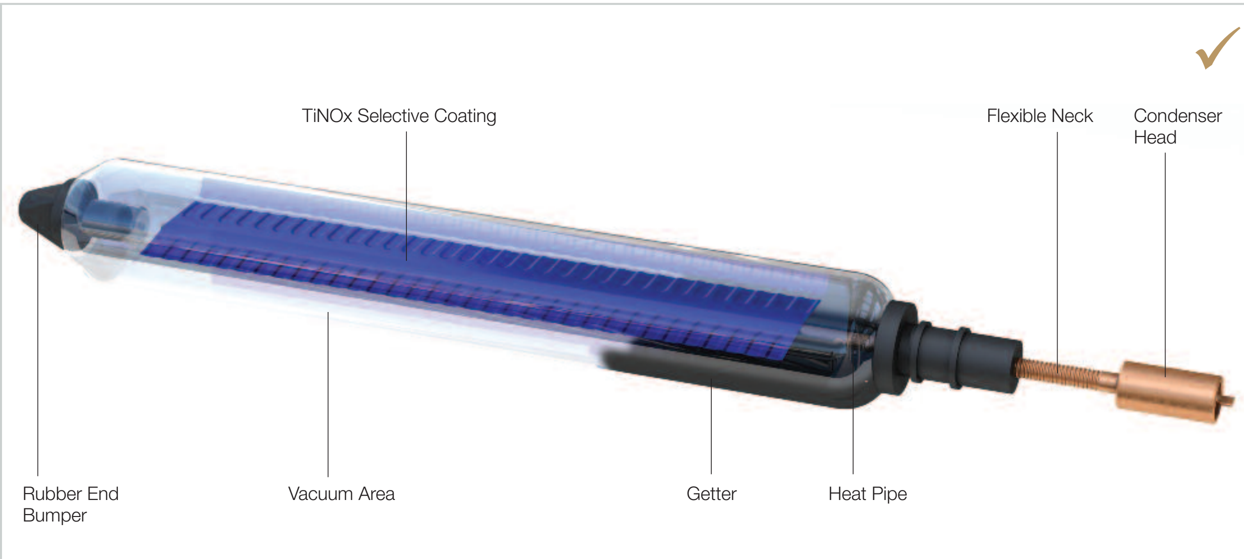
Tube Diameter 4"

✗

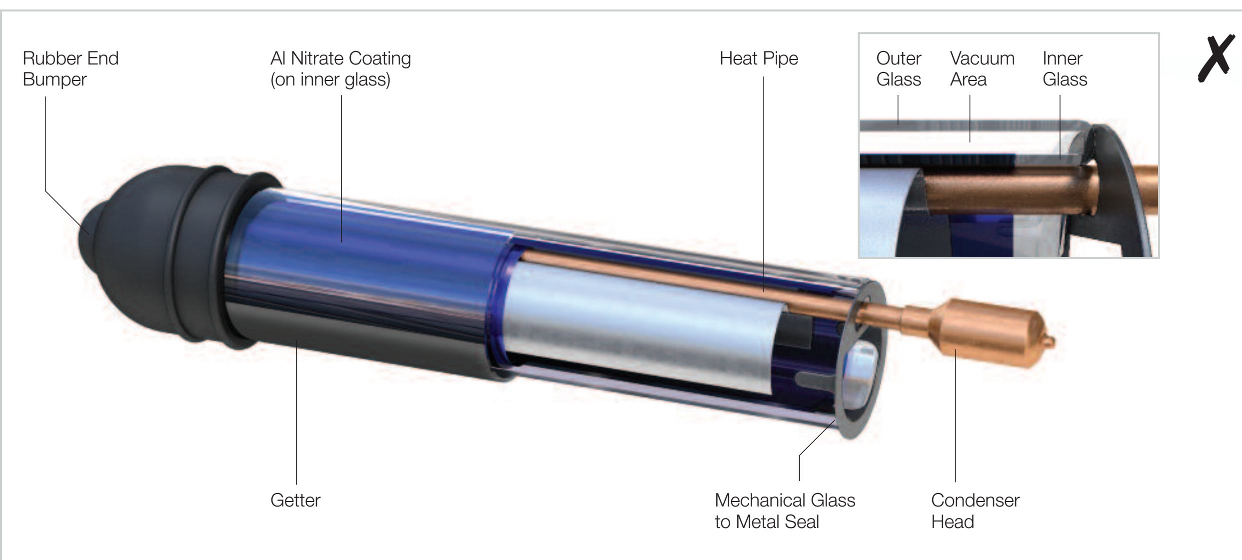


System comparison: Thermomax Heat Pipe vs. Sydney / double-wall tube

Thermomax Tube



Sydney Tube



kingspan
pump stations

All solar thermal applications require a pump system to move fluid through the collectors.

Kingspan Solar recommends the use of closed loop glycol systems and offers a series of pump stations suited for use in these systems.

Systems will differ in the number of collectors in them, the length of piping and the type of heat exchanger used. All of these parameters will affect the choice of the proper pump station for the system. Kingspan Solar's offering includes a wide variety to handle from small systems with only a few collectors to very large systems that require a custom design.

In a closed loop system, there are a large number of components required to satisfy the maintenance and safety requirements of the system. The pump station is a collection of these components in one small preassembled package. One main difference between the various offerings is if a heat exchanger is offered in the pump station. This will depend on if the heat exchanger is included in the tank or not. The various offerings Kingspan Solar has have been categorized based on if they include the heat exchanger or not.

All heat exchangers in the pump stations are double walled with positive leak detection. Most codes will require these for solar systems to separate the water and glycol mixture, even though the glycol mixture is termed 'non-toxic'.

The controls are another thing that are closely tied with the pump stations. The controls are required to activate the pumps when there is energy to be harvested from the solar collectors. The various different pump stations will require the solar controllers to be programmed differently depending on how the system is hooked up, etc. Kingspan Solar offers the specialty controls that go with the pump stations and provides a program for the particular system selected. This ensures that the overall solar system will function as intended.

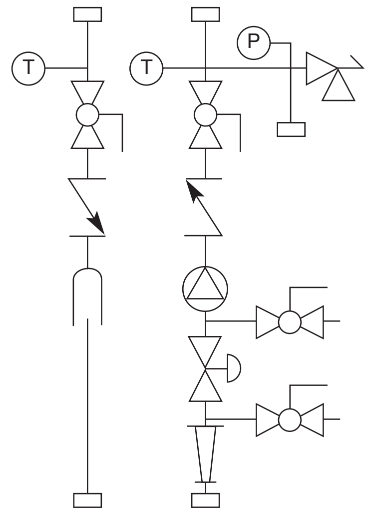


Figure 2: Typical pump station without heat exchanger.

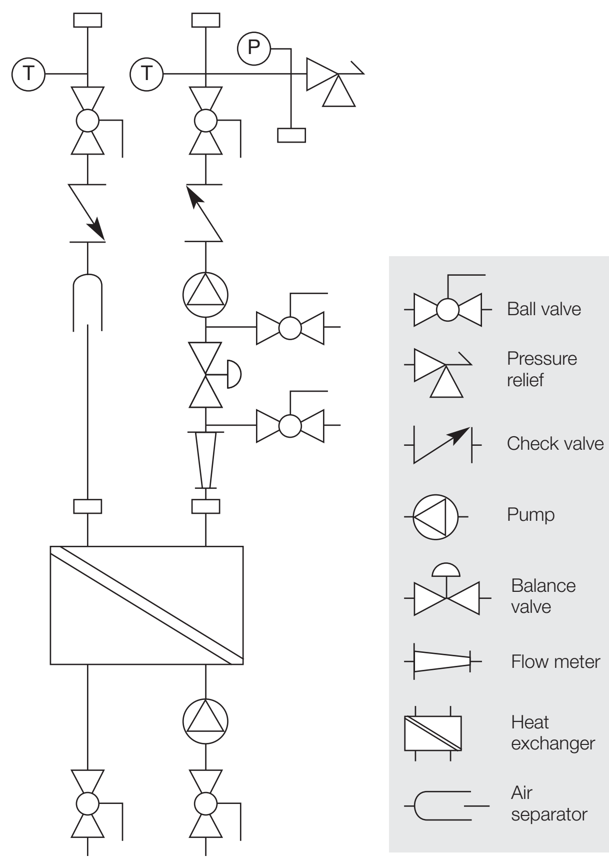
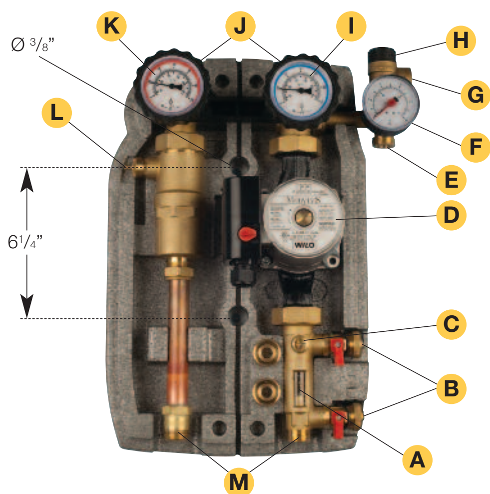


Figure 3: Typical pump station with built-in heat exchanger.

Small Pump Stations

The pump stations offered by Kingspan for small systems with internal heat exchangers are an excellent way of gathering the components required for a closed loop system in one small, simple package. Three different sizes are offered, depending on the number of collectors in the system. These stations feature three speed pumps for controlling the flow through the system and a balance valve for even finer control.



- **A** Flow meter
- **B** Flush / fill ports
- **C** Balance valve
- **D** Wilo solar circulator
- **E** Expansion tank connection
- **F** Pressure gauge
- **G** Pressure relief valve discharge
- **H** Pressure relief valve
- **I** Supply temperature / check & ball valve
- **J** 3/4" BSPP collector connections
- **K** Flow temperature / check & ball valve
- **L** Air trap bleed
- **M** 3/4" BSPP tank connections

Figure 4: Small pump station.

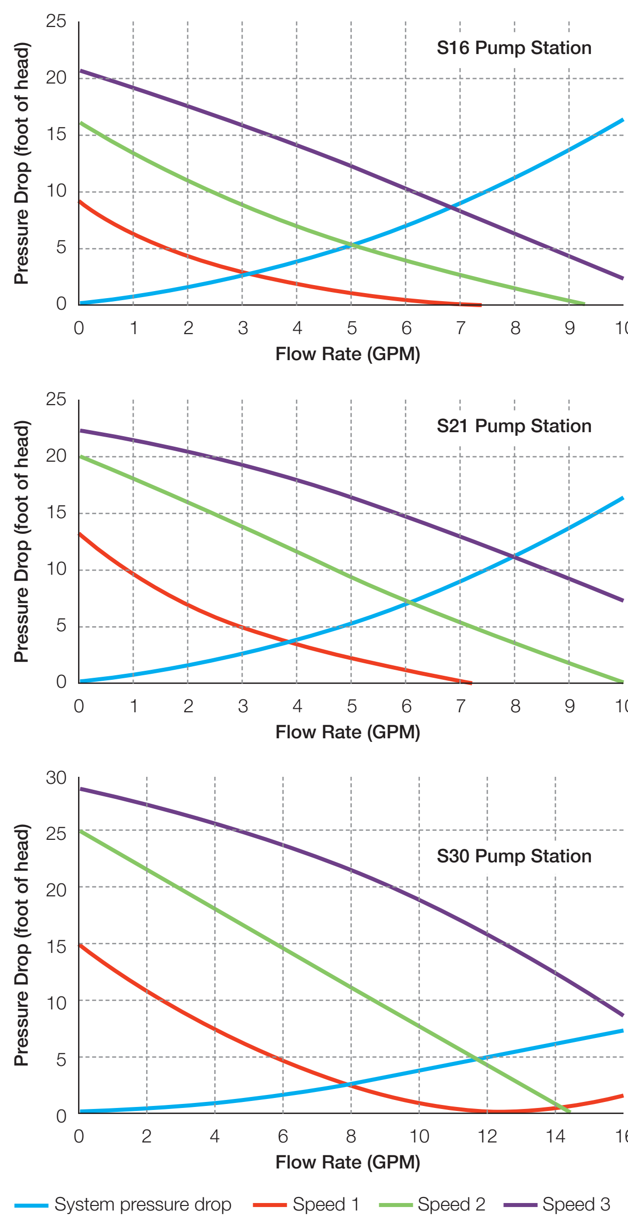


Figure 5: Small pump station pump curve comparisons.

Table 1 (right) and Table 2 (overleaf) represent the maximum of collectors in a system. There are other considerations that may limit the exact number of collectors that may be used. Please contact Kingspan Solar for more information before choosing a pump station based on these numbers.

Table 1: Maximum Number of Collectors in a System

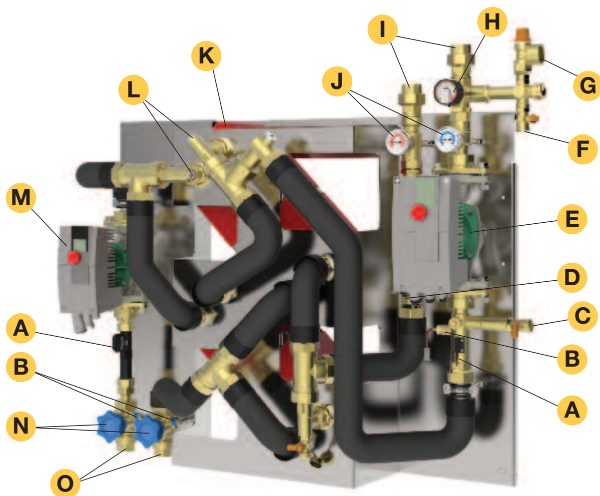
	S16	S21	S30
4 collector banks	4	8	20
5 collector banks	-	5	15
FP240	15	20	40

kingspan
pump stations

Pump Stations with Heat Exchangers

Kingspan Solar also has a selection of systems with built in heat exchangers for systems where there is no heat exchanger in the tank. All heat exchangers are double walled with positive leak detection. In addition to the heat exchanger, a pump for the potable water is included. This pump is either stainless steel, or bronze in order to resist corrosion in water. The solar controller will activate both pumps independently as the temperatures reach the set points. The XL unit contains flow meters on both loops for heat measurement as well, where as the smaller units do not have this option.

The XL unit is different from the smaller pump stations in that it uses variable speed pumps instead of three speed pumps. This means that all points below the line are achievable operating points. In addition, the flow meters on both the solar and secondary sides are built into the pump station.



- **A** Flow meter
- **B** Temperature sensors
- **C** Fill port
- **D** Pressure transducer
- **E** Primary pump
- **F** Expansion tank connection
- **G** Pressure relief
- **H** Pressure gauge
- **I** Solar loop connections
- **J** Temperature gauges
- **K** Heat exchangers
- **L** Air vents
- **M** Secondary pump
- **N** Isolation valves
- **O** Secondary loop connections

Figure 6: XL unit – pump station with heat exchangers.

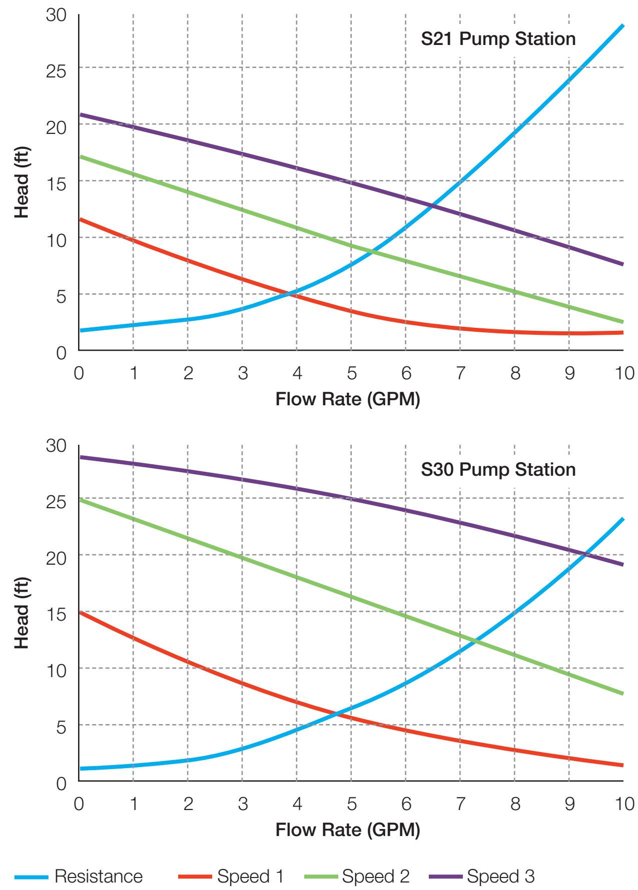


Figure 7: Pump stations with heat exchanger pump curve comparisons.

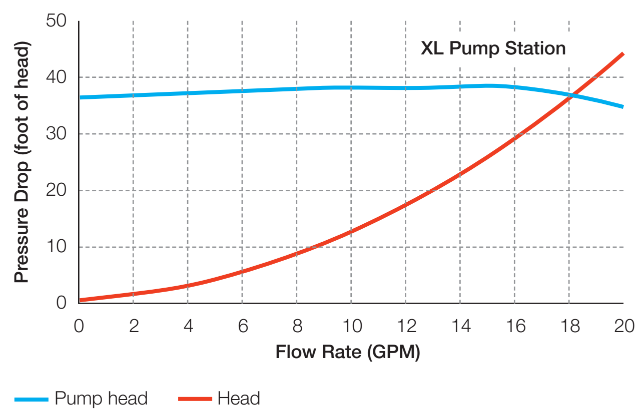


Figure 8: XL pump station with heat exchanger performance.

Table 2: Maximum Number of Collectors in a System

	S21	S30	XL
4 collector banks	8	12	24
5 collector banks	5	10	20
FP240	16	24	40

Larger Systems

Kingspan has a wide range of pump skids for larger projects as well. The larger stations are built on skids with electrical enclosures and all of the necessary components in place. These units range from semi custom, all the way to full custom pump skids, depending on the job and number of collectors.

All of these skids include all instrumentation required to monitor the performance of the system and verify that it is working properly. The controller included with these systems comes preprogrammed for the particular system and all documentation is included for the installation.

Smaller Pump Skids

The smaller pump skids utilize up to three pumps in parallel to achieve the desired flow rates. These pump stations are available either with or without a heat exchanger. All pumps used on these systems are variable speed to optimize the electrical and thermal efficiency of the specific system.

Full Custom Pump Skids

For larger systems, Kingspan offers a full custom pump skids design service to fit your needs. These units can include simplex or duplex pumps, fixed or variable speed pumps in any configuration to meet your needs. If your project requires a custom pump skid, please contact Kingspan for design and specification assistance.

Bristol Lido Outdoor Pool,
BRISTOL, UK

system technical considerations

sizing guidelines

Solar thermal systems offer many applications where they can be used to offset the energy usage of a building. The most common usage for this energy is for heating the domestic hot water.

When using solar thermal for a particular application, there are many things to consider in designing the system. This section provides information on what is required for a solar thermal system and how Kingspan sizes based on information about the building. This section is for guidance only and designs should be reviewed by our technical team. All solar thermal systems should be fully designed by a competent engineer. Kingspan Group plc or any of its companies do not take responsibility for any systems designed using the following information.

Uses for Solar Thermal Energy

There are many processes that require heat energy. The most common usage of solar thermal collectors is to heat domestic hot water. This is a simple application that requires minimal disruption to the existing systems in the building and excellent payback in most applications.

The energy created from the solar collectors can also be used to heat buildings, pools or for AC reheat.

Most commercial buildings will use water or glycol for transport of energy throughout the building for the heating system and this is another application that is good to tap into with solar thermal collectors.

Pools require large amounts of heat energy in order to offset the losses from evaporation and solar collectors can provide a large portion of this energy that is required.

AC reheat is used when the air is over cooled to remove the humidity and then heated by a separate coil to bring the air back up to the desired temperature. This is a great application for solar because the demand is usually the highest when the sun is out and shining.

In addition, many industrial processes use large amounts of heat. The solar thermal system can provide a good portion of the overall energy needs for these processes. Breweries are a great example where a lot of energy is needed to heat the beer to the desired temperature during the brewing process.

Solar Performance

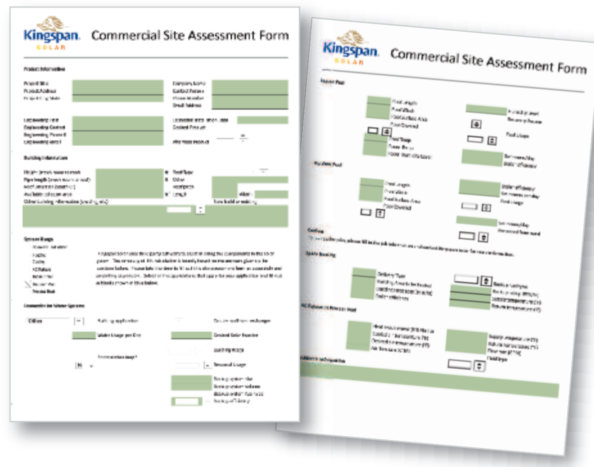
We are all used to fossil fuels providing energy in our lives. They provide the same energy regardless of the conditions outside; a gallon of propane provides 92,000 BTUs on a cloudy and sunny day. Fossil fuels represent concentrated energy that was provided by the sun millions of years ago.

"A Kingspan solar thermal system can be very effective in replacing fossil fuel usage for up to 30 years with very little maintenance or replacement parts necessary."

The sun produces an abundance of energy, but it is spread out and requires much more collection area to provide equivalent energy to fossil fuels. A 30 tube collector will provide about as much energy on its peak day as a gallon of propane. However, unlike a gallon of propane the collector will continue to provide energy as long it is exposed to sunlight instead of ending up as carbon dioxide and water.

Solar systems can be utilized to offset a large portion of the fossil fuels that we currently use, but they require a different method of sizing than traditional fossil fuel systems. With lower output than a boiler, they require additional storage for a given building size. The collector array may take up the entire roof of a building. If everything is designed and sized correctly, the solar system can be very effective in replacing fossil fuel usage for up to 30 years with very little maintenance or replacement parts necessary.

Kingspan Environmental



Kingspan Environmental has a simple site assessment form that, once completed, allows our technical team to size, design, and estimate savings on each project.

Domestic Hot Water Systems

Domestic hot water systems are probably the most common use for solar thermal energy (Figure 9). They are typically sized to provide up to 80% of the overall hot water demand for the structure and the balance is made up by a backup hot water heater.

The solar collectors are typically mounted on the roof of the building and plumbed to a heat exchanger that is either immersed in the tank, or an external plate type. When the sun shines on the collectors, the solar pump activates and runs glycol through the collector manifolds. The solar collectors will raise the temperature of the glycol by around to 30°F per pass through the collector and this energy is transferred to the water in the tank via a heat exchanger.

The key information required for sizing these systems is how much water is used on a daily basis, when it is used and how much the solar collectors will produce. Determining the hot water usage is the key factor in the design. The output of the collectors is simulated in software using historical weather data from the location that the collectors are going to be installed, along with calculations based on the usage pattern of the building. These are critical factors in determining the number of solar collectors and the size of the tanks. Information in this section can be used to approximate the number of collectors and tank size in the system, but the software will provide a far more accurate calculation of what is needed. Kingspan Solar will be happy to run these solar reports for your project with a completed site assessment form.

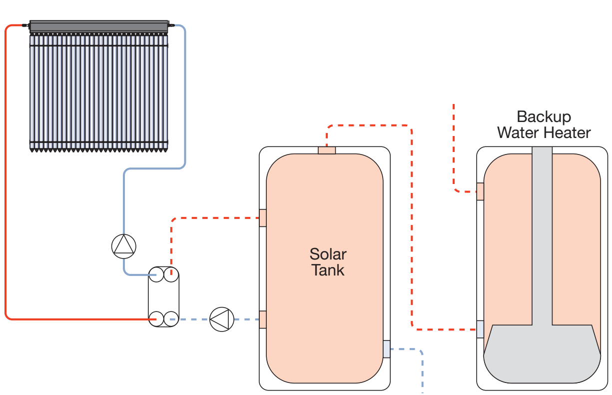


Figure 9: Typical domestic hot water system

Determining Hot Water Demand

Solar hot water systems are sized very differently from traditional water heaters. A traditional water heater will look at the maximum possible demand of the building and then size the tank and burner so that this demand can always be met. The only consideration for this is how many taps there are and how much they can flow. A solar hot water heater will look at the overall demand for the building and base the size of the solar collectors and tanks on this.

The solar system will be sized to meet a portion of the hot water for the structure, but not all of the demand. Typically this will be between 20% and 80% of the yearly demand for the structure. There are several reasons for this:

1. There are more sun hours in the summer than in the winter. Sizing a system to meet the winter demand will mean that it is much too large in the summer.
2. The weather affects the output of the solar system. Often, the storage will be large enough to allow solar energy to be carried over from a sunny day to a cloudy day, but several successive cloudy days will deplete the solar storage and require a backup system.
3. Energy produced above what can be used in the building must be dissipated. This prevents the overheating of the system and will ensure a long life for all components. Any energy that must be dissipated will not contribute to the payback of the system.

Guinness Brewery,
DUBLIN, IRELAND

sizing guidelines

"Kingspan will assist in the design, sizing and specification of all commercial solar thermal systems."

Because the solar system will not provide all of the hot water, a backup system is required. The backup system should be sized normally because the minimum contribution of a solar system is zero and the backup system must insure that all demand is met under all circumstances. The backup system will not run as often as it would if the solar system were not there, but during some periods may have to run at full capacity.

There are two ways to determine the demand from a structure; measurement and estimation. Measuring is the best way to ensure that the solar system is sized properly. Most buildings will not have a measurement system for the hot water, so one will have to be added. The simplest way to measure hot water demand is using an ultrasonic flow meter. This meter simply attaches to the outside of the cold water pipe going into the water heater and will log how much water enters the water heater. The hot water delivery temperature and cold water temperature complete the data needed to measure the hot water energy for the building.

To calculate the daily energy usage in BTUs, Equation 1 should be used:

Equation 1:

$$Energy = Gallons\ of\ Hot\ Water \times (T_{OUT} - T_{IN}) \times 8.33$$

Where:

T_{OUT}: is the delivery water temperature, and
T_{IN}: is the cold water temperature

Estimating will provide a good baseline for how many collectors are required for a given structure and is the only method for structures that haven't been built. This can be a difficult thing to do; if you have an office building, how much hot water are people going to use there? How many times per day do people wash their hands? Are there showers provided and if so, how often are they used? ASHRAE has made some recommendations summarized in Table 3 as to the usage for various applications. There are further considerations for properly sizing a hot water system and more thought should be given prior to finalizing the system size, but these numbers give a reasonable starting point.

Some additional things need to be taken into consideration before these numbers become accurate. For instance if a particular hotel has an occupancy rate of 50%, then the numbers have to be adjusted for this. One thing that the hotel and motel numbers assume is that the laundry is done in house. These numbers will drop significantly if the sheets and towels are laundered outside. Likewise, the full meal restaurants are assumed to use reusable plates and cups and not disposable, as the latter does not require a dishwasher. It never hurts to ask a lot of questions to try and determine if there is anything that may cause the hot water load to be higher or lower than what is shown in Table 3.

Once the hot water load is known, there are a few more parameters that need to be known before the solar system can be designed. These are listed on the Kingspan Solar Site Assessment Form and should be filled in as best as possible in order to accurately size the system.

Table 3: ASHRAE Guidelines for Multifamily Commercial Projects – Hot Water Usage Per Day	
Men's Dormitories	13.1 gal / student
Woman's Dormitories	12.3 gal / student
Motels (number of units)	
20 or less	20.0 gal / unit
60	14.0 gal / unit
100 or more	10.0 gal / unit
Nursing Homes	18.4 gal / bed
Office Buildings	1.0 gal / person
Food Service Establishments	
Full Meal Restaurants and Cafeterias	2.4 gal / meal
Drive-ins, grilles, luncheonettes, sandwich and snack shops	0.7 gal / meal
Apartment Houses (number of units)	
20 or less	42 gal / apartment
60	40 gal / apartment
75	38 gal / apartment
100	37 gal / apartment
200 or more	35 gal / apartment
Elementary Schools	0.6 gal / student
Junior and Senior High Schools	1.8 gal / student
Hotels (number of rooms)	
Less than 150	17.8 gal / room
150 – 299	22.8 gal / room
300 - 500	30.3 gal / room
Greater than 500	28.5 gal / room
Laundromats	2 gal / pound / hour

- **Ground water temperature:** Important for sizing both the solar collectors and the tanks. This will vary with season with the highest temperature coming around August and the lowest in February or March.
- **Shading:** Also greatly affects the output of the collectors. Any time the collectors are in a shadow, they will not produce energy. This should be considered early on in the project, as not all locations are a good fit for solar systems. The sun's path varies greatly depending on the time of year, so a device called a solar pathfinder should be used to check if the shading is an issue and when it occurs. Figure 10, right, shows the sun's path at different times during the year.
- **Panel orientation:** For optimal performance, the collectors should face due south. Slight deviations from south will not affect performance much; in fact they can be orientated within 45° of south and still have about the same performance.
- **Building recirculation loop:** Most commercial hot water systems will have a recirculation loop on them to provide instant hot water at the taps throughout the building. This is a major source of energy loss from the hot water system. It is important to know the length, insulation and operating hours of the recirculation loop for aiding in sizing the system. The solar system has to be oversized in order to help provide this energy.
- **System operating temperature:** Commercial systems generally operate at temperatures of 140°F to protect against legionella bacteria growth in the tank. Some systems for laundry or dish service will operate at higher temperatures than this. The higher the temperature, the more solar collectors will be needed to provide the energy for the system.

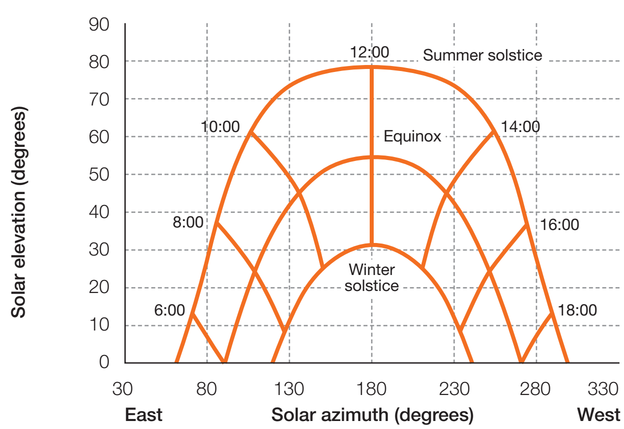
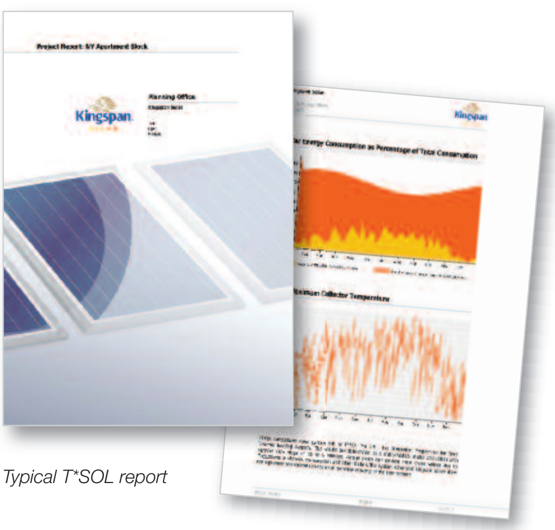


Figure 10: Sun position chart illustrating how the sun moves across the sky throughout the year

sizing guidelines

Collector Sizing

All systems should be designed using computer software to predict the overall system performance. The computer software used by Kingspan, T*SOL, is third party software that utilizes weather data from over 100 locations in North America, collected every hour for a typical year at that location. The software also takes into consideration the load patterns and tank sizes to accurately size these parts of the system. Collector performance is predicted using data taken from the Solar Keymark ratings that are used in Europe. The overall report produces a good picture of how a system is going to perform during a typical year.



*Typical T*SOL report*

Kingspan provides a site assessment form that asks the questions we need in order to properly run a T*SOL simulation. Once this form is filled out, Kingspan will return a completed system design and report within 48 hours.

Another consideration when sizing the system is how much roof area is available to take the solar collectors. The collectors cannot be placed directly behind one another, or they will shade each other and reduce the output of the system. Often, the limiting factor of how many solar collectors a building can take is not the demand, but rather how much space is available on the roof.

System Integration

There are two basic ways of connecting the solar portion of the system to the hot water system of the building; preheat the water going into the fossil fueled portion of the system, or utilize a direct fired water heater's tank for the solar as well. Both systems involve minimal disturbance to the overall system that is used in the building. If the system is being retrofitted, then there will be minimal changes to the system that is already in the building. Figures 11 and 12 show the basic configuration of these two systems.

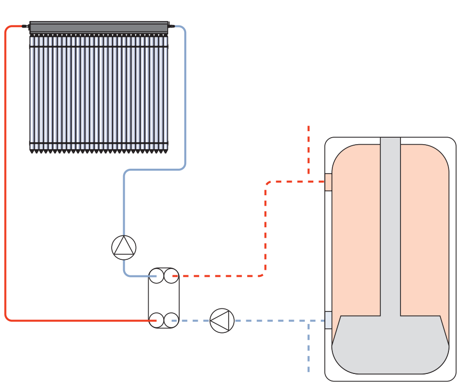


Figure 11: Single direct fired tank system

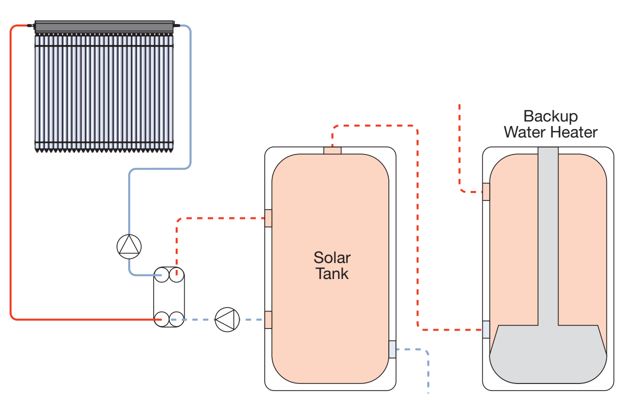


Figure 12: Preheat solar tank

Tank Sizing

As with the collectors, the sizing of the tank is greatly aided by using computer software to confirm the final size of the tank is correct. The first step in sizing the tank is to determine the usage pattern for the building. For instance, an apartment building will have a peak in the morning when everyone takes a shower, have low or no usage during the day while they are at work and then have another peak in the evenings when everyone comes home. An office building may have constant usage during the day, but no usage in the morning and night when there is no one in the building. These different scenarios will affect the size of the tank.

The solar storage must provide ample energy storage for the solar energy to be stored on clear days and utilized on cloudy days. The size of the tank must be based on the average solar collection, but take into account the peaks; extremely hot and sunny days where the system will outperform the average by a factor of two or greater and very cold and cloudy days where the system output may be nothing at all. The tank is the battery for these systems and provides for the direct storage of energy that is collected from the sun.

The basic rule of thumb for commercial solar hot water systems is that you want 30 – 80 gallons of storage per collector. By not having enough storage, the tank will quickly reach its maximum temperature on sunny days and by having too much the storage will never get to a high enough temperature to cause the back up system to shut down entirely. Also, increasing storage volume increases the cost of the tanks, so it is desirable to keep the volume to a minimum. The optimal tank volume will be determined by the T*SOL software during the simulation.

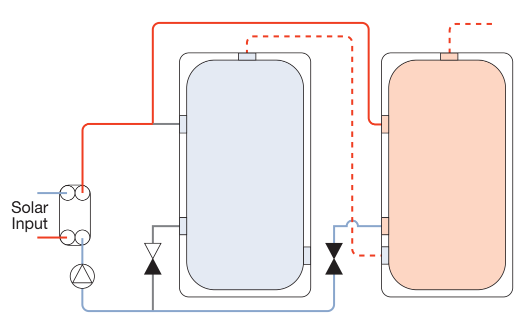


Figure 13: First tank charging

Using Multiple Tanks

The tank storage volume takes into consideration how the solar system will perform on very sunny summer days. The system will not produce as much energy in the winter months, nor will it produce as much if it is partly cloudy. This means that the water temperature in the solar tanks will be less on these days. There will still be an overall energy savings, since the water being fed into the backup system will be warmer than the water coming out of the ground (a British Thermal Unit is defined as the energy to raise one pound of water 1°F; it doesn't matter what temperature it is at). However, the largest energy savings are realized when the backup system does activate at all.

The way to do this is to utilize multiple tanks in an array with two or three way valves to divert the solar energy into one of the tanks at a time. It works like this:

1. The solar controller detects a low temperature in Tank 1. Valve 1 is opened to allow all the solar energy to flow into the first tank. Since this is one half the overall volume, the tanks heats up twice as quickly as compared to one tank with the total volume (Figure 13).
2. When the temperature sensor detects Tank 1 has reached its maximum, then Valve 1 closes and Valve 2 opens, diverting all the solar energy into Tank 2 (Figure 14).
3. If there is a hot water draw and the temperature in Tank 1 falls below the maximum, then Valve 1 opens and Valve 2 closes, allowing Tank 1 to heat up again (Figure 13).

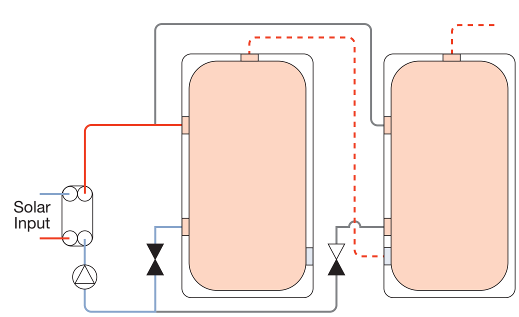


Figure 14: Second tank charging

system technical considerations

sizing guidelines

Since Tank 1 is right next to the backup tank, the backup system will not come on unless the temperature in Tank 1 drops below the set point. This is a simple way to allow the system to utilize the most energy possible and keep the backup system from firing at all. The more tanks, the more effective this system overall, but it will add to the cost and complexity of the system. A good middle ground is three tanks arranged like this in the system, although for some larger systems four or even five will produce much better results.

New Hampshire Veterans Home
TILTON, NH

It is best if a system is designed with a solar fraction above 50% has multiple tanks. For systems in the 20-50% range (this will vary due to other factors in the design), a single tank is sufficient to achieve good solar performance.

Heat Exchangers

A heat exchanger is required in these systems because the glycol and potable water need to be separated from each other. See page 80 on System Components for more information on sizing. The collectors produce about 10,000 BTU/hr maximum output under ideal conditions and the heat exchangers should be sized with this number in mind.

Another consideration is that in some areas local codes require a double-walled heat exchanger between the glycol and the potable water. The heat exchangers can either be external or immersed in the tank.

Recirculation Loops

Most commercial buildings will have a recirculation loop that circulates hot water throughout the building and makes sure that the water coming out of a faucet at any point in the building is hot when it is opened. This is a major hot water energy loss for the hot water system. In fact, a recent study[1] placed this loss at average 31% in of the overall system losses in 30 buildings that were studied; the same as the boiler efficiency losses.

Figure 15 shows how the recirculation loop can be plumbed into the solar system so that it uses the solar energy in the tanks to offset this loss. What happens in this system is that it will tend to equalize the temperature in the solar tanks to the return temperature of the recirculation loop if the solar tanks are at a lower temperature than the recirculation return. It also equalizes the temperature in the solar tanks over the night if multiple tanks are used as described above. This will reduce the overall efficiency of the solar system and cause for extra fossil fuels to be burned to heat the solar tanks.

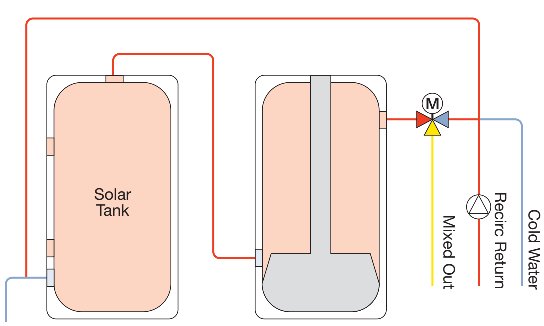


Figure 15: Solar tank in of recirculation loop

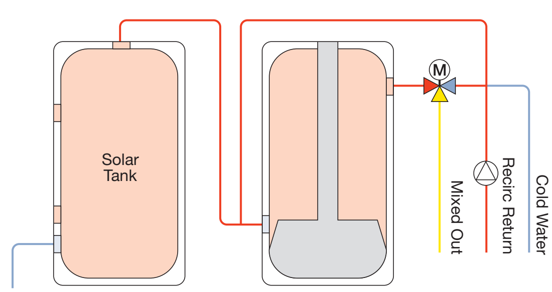


Figure 16: Solar tank out of recirculation loop.

Direct Flow System, Apartment Building,
ARNSTADT, GERMANY

There are a few options for alleviating this issue. First, you can use the fossil fuel backup system to provide the energy for the recirculation loop (see Figure 16). This is a good idea if your solar fraction is limited by roof or tank space to less than 50% of the overall load. The solar will now just focus on the water usage part of the load and not the recirculation losses (if water is drawn into the backup tank from the solar tanks and is hot, then it will contribute to the recirculation losses; however at night there won't be much draw and the backup system will have to make up these losses). Another option is to return the recirculation loop to just behind the first tank. This will only utilize the first and hottest tank for offsetting the recirculation losses from the system and is good for systems that have some extra capacity.

If the solar fraction is high enough (50%+) and the recirculation losses are taken into account while sizing the system, then the solar will contribute more energy to the recirculation loop than the backup system and it will be worthwhile to take the occasional losses from having to heat the solar tank.

Recirculation losses are difficult to calculate. A recent study[1] determined they were between 7% and 65% of the overall energy required to heat hot water. Newer buildings address these losses with more attention to the system design and better insulated pipes; however these losses can still be quite high, in particular in buildings with low usage and long recirculation loop runs (large office buildings are a good example).

It is best to use the same ultrasonic flow meter on the recirculation line to obtain the flow and temperature sensors to determine the temperature drop in the loop. The equation for finding the losses is:

$$\frac{BTU}{hr} \text{ Loss} = 8.33 \times \text{GPM Flow} \times 60 \times \Delta T$$

Where delta T is the difference in temperature between the inlet and the outlet.

Thermostatic Mixing Valves

All solar hot water systems require a thermostatic mixing valve. This valve mixes hot and cold water together to create output water that is the same temperature, regardless of the tank temperature (which must be above the set point of the valve). Solar thermal systems present an interesting challenge to thermostatic valves. The input temperature can be much higher and swing much larger than what a typical valve would see. Before installing the solar system, the current valve should be checked to make certain that it is compatible with the temperatures that solar can achieve. The valve should not be susceptible to creep, or the slow increase of temperature over time within the recirculation loop. Clearly with tank temperatures in excess of 160°F, this presents a safety hazard, as the water can scald almost instantly.

[1] *http://www.aceee.org/files/pdf/conferences/hwf/2010/3C_Charlotte_Bonneville.pdf*

sizing guidelines

Stagnation and Heat Dissipation

Solar collectors will produce energy as long as the sun is shining on them. This becomes an issue when the demand has been met and the tanks have reached their maximum temperature. The design of the tanks and the T&P valve limit the maximum temperature the water can be stored at.

When the maximum temperature is reached, the only option is to turn off the solar pumps so that the energy collected no longer raises the temperature of the tanks. This situation is called stagnation, where the energy is not being removed from the solar collectors. In order to reach an equilibrium, where as much energy is lost as is being collected, the collectors become very hot. This is more of an issue with evacuated tubes where the vacuum insulation protects from most heat loss in the system. The peak temperatures in the Thermomax Heat Pipe manifold can be as high as 350°F during periods of stagnation. Kingspan flat plate collectors can reach temperatures of 300°F or greater.

Several methods are used to protect the system from the high temperatures caused by stagnation. First, the pressure of the glycol loop should be low enough that steam will form in the manifolds and protect most of the glycol in the system from damage. This is called 'steam back' and the extra volume is designed to be taken up by the expansion tank.

The evacuated tubes are also designed to withstand periods of stagnation. All systems will stagnate at some point in their lives; because demand is met; system maintenance; or because of a power outage. This will not affect system performance, although long periods where the system goes into stagnation every day will have an impact.

Education Facility,
DENMARK

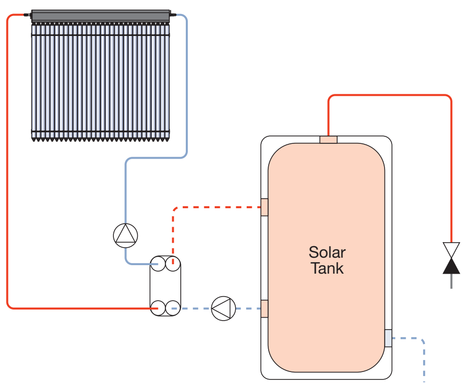


Figure 17: Water bleed heat dump

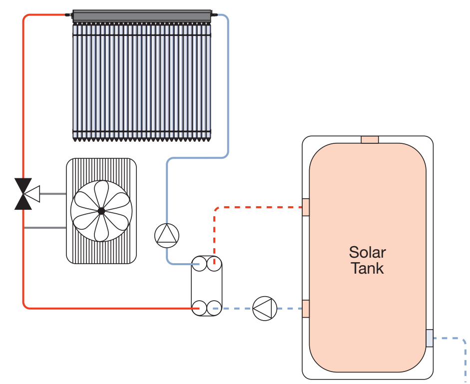


Figure 18: Diverted solar loop dissipater

This is why it is crucial to design systems properly. Adding more collectors and increasing the solar fraction makes the system more susceptible to stagnation where there are long periods of sunlight. Extra energy that is collected does not count to the payback on the system. An error by which the system is oversized by 30%, may create serious stagnation issues. Therefore it is always best to undersize systems and underestimate the number of collectors.

These systems will last longer, have fewer maintenance issues, cost less to begin with and be more efficient.

There are several ways to combat overheating:

1. design the system and size it correctly, thus avoiding need for dissipation in many applications;
2. open a spill valve from at the top of the tank and allow hot water to spill out when the tank reaches its maximum temperature (Figure 17);
3. divert flow from the collectors through a wet or dry cooler to cool the flow from the collectors once the tank has reached temperature (Figure 18); and
4. utilize an existing facility to dump heat, such as an oversized cooling tower, a section of snow melt tubing in concrete, an AC reheat system or a pool.

Allowing the collectors to stagnate for an extended period of time will cause issues with the system in the long term. This is true of both flat plates and evacuated tube systems.

Any heat dissipation system will add cost and complexity to the system. The best way to eliminate the need for a heat dissipation unit is to design the system properly so that it avoids stagnation conditions.

Some systems, however require heat dissipation even though they may be undersized:

1. systems with seasonal use, such as a resort that closes down during the off season; and
2. systems with changes in usage throughout the week, such as a school or office building, where they are not used, or underutilized on weekends.

Any system that has a usage pattern where the demand changes for whatever reason must consider the lowest demand when sizing the solar system. If the lowest demand is zero, then a heat dissipater will be required.

Heat dissipation devices should be sized at 10,000 BTU/hr/collector at 180°F incoming water temperature. This will ensure that the system will never go into stagnation when the demand has been met.

Kingspan offers a full line of components for heat dissipation and will assist in selecting the correct components for each individual project.

sizing guidelines

Swimming Pool,
GAIARINE, ITALY

Swimming Pools

Swimming pools are a great use for solar thermal energy. The collectors can be used to heat just the pool, or it can act as an additional energy sink for systems for hot water or heating. Their low temperature provides for some of the most efficient systems possible.

Pools use an incredible amount of energy, much more than most people would think. Indoor pools and outdoor pools are very different in how the energy is lost and gained.

Sizing Pool Systems

Pool systems are sized at a maximum of 50% solar fraction. A system sized at an annual solar fraction of 50% will produce 100% of the pool load on a sunny day in the summer. Pool systems do not typically have any external storage, but rather use the water in the pool for energy storage. This means that during the day the pool may rise in temperature several degrees above the set point and then cool off at night. It is important to make certain that this rise in temperature is agreed with the pool owner, since pool temperatures are generally strictly controlled.

If the temperature cannot vary above a limit in a pool, then a system utilizing storage tanks can be used. At this point, the system is designed much like a heating system with how the storage interacts with the heating demand.

A heat exchanger suitable for pools is required for all pool systems. The chlorinated water cannot be run through the solar system in any circumstance. For fresh water pools, a stainless steel heat exchanger must be used and for salt water pools, a titanium heat exchanger is required.

Since the flow rate of the water from the pool through the existing boiler system is typically much higher than the solar flow rate, the heat exchanger will generally be a shell and tube type rather than a plate type. Please refer to ‘Sizing System Components’, page 78, for more information on sizing the heat exchangers.

Process Heat

Process heat refers to any application that requires heat in the form of hot water. Examples of this are in processing milk, brewing beer, food products and other industrial processes. These systems vary significantly, depending on application, demand, existing infrastructure, temperature of the application, and when the energy is used. Kingspan Solar can assist with the design of these systems on a project specific basis and advise what system specification is required to achieve optimum operation.

Heating Systems

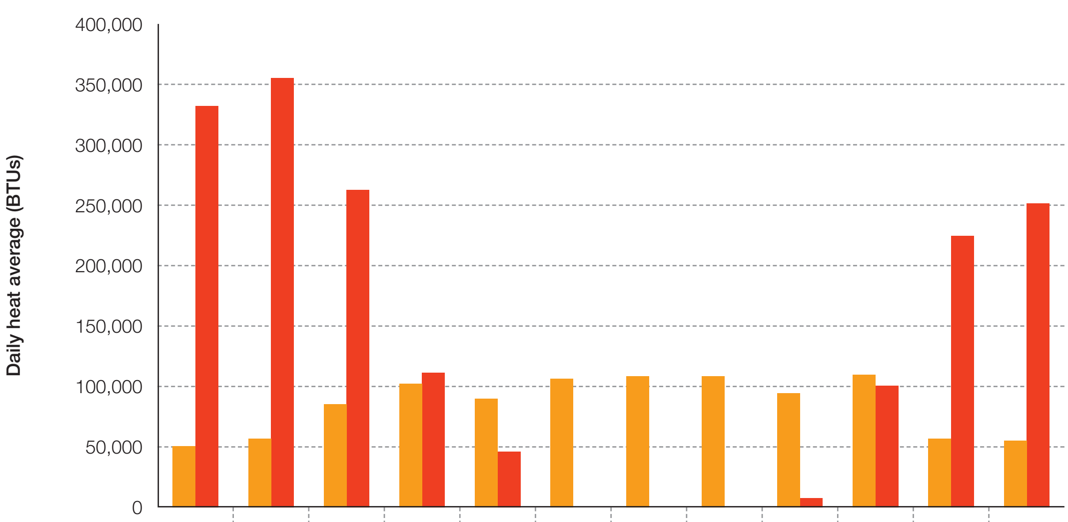
Heating systems are another use for solar thermal energy. Kingspan Thermomax evacuated tubes are an excellent fit for heating systems because of their high efficiency in cold conditions. Heating systems can refer to systems that are either used for traditional space heating or AC reheat, where the air coming in to the building is cooled below the desired temperature and then heated by a separate system back up to the desired temperature. Figure 19 shows the contribution from a well designed heating system. The overall energy provided in a system such as this is around 25% of the load.

For further information on solar thermal systems for heating applications, please contact Kingspan Solar.

Conclusions

There are many applications where solar thermal systems can be utilized to save money. Kingspan Solar can advise, design and size these systems specifically for a particular application. It is better to have the system a little undersized so that all the energy it produces can be used instead of having excess energy. The design of solar systems is different from systems that use fossil fuels as energy and this must be taken into account in the design. A well designed solar system will provide years of performance and savings.

> **"A well designed solar system will provide years of performance and savings."**



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Active solar daily av.	51,343	57,157	65,202	103,432	90,559	106,951	109,930	110,259	95,392	110,558	56,235	55,574
Building heat load daily av.	334,523	357,080	263,544	111,532	46,512	(79,952)	(136,818)	(106,287)	7,247	102,705	225,664	253,296

Figure 19: Typical heating system performance

collector layout,
and its effect on the system

Commercial building applications, requiring many roof-mounted collectors, must be carefully configured so energy generation is maximized and the system fits the roof space available.

Choosing how many collectors are in a bank will affect the choice for piping as well as the pump for the system. This section examines the choices that must be made when laying out collectors on the roof and how these choices impact the overall performance of the system.

GWU, Foggy Bottom Campus,
WASHINGTON DC

Inset: St. James's Hospital,
DUBLIN, IRELAND

Collector Angle

The majority of commercial applications will be installed on flat roofs, so the chosen collector frame will have to hold the collectors at the correct angle for optimum energy collection and production. The angle affects when the production will be the highest. Sunlight shining straight on to the collector will produce the highest output.

For northern regions, collectors that are orientated at 0.7 times the latitude of the installation will produce the most overall energy during the year; however the energy is heavily biased to the summer time when the sun is the highest in the sky.

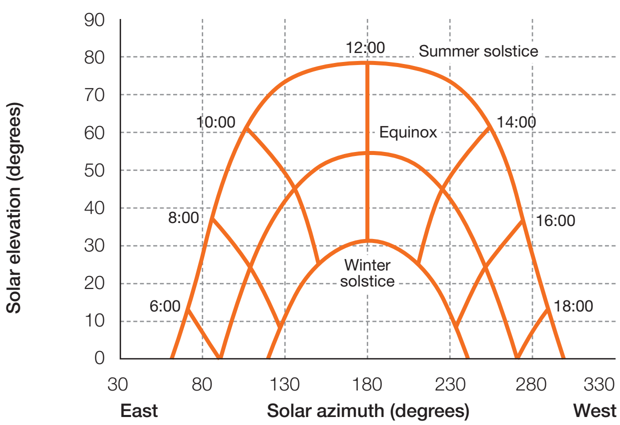


Figure 20: Sun position chart illustrating how the sun moves across the sky throughout the year

To balance the production more evenly throughout the year, the collectors should be set at the latitude of the installation. The time of year when the energy is most required should be examined. For example, if a school dormitory that is heavily occupied during the school year is to have a solar system added, then it should be tilted to the steepest angle possible to bias the production away from the summer months when it is not needed.

The solar fraction will also help determine the angle of the collectors. As the solar fraction increases above 50%, the panels should be tilted steeper to even out the summer and winter production. Typically, a solar fraction of 50% will indicate that some days during the summer will produce more energy than the system can store, however this will vary some by location. For example, Denver receives very even sunlight throughout the year, so at solar fractions above about 60% the panels should be tipped more. But, Seattle produces a lot more in the summer than the winter, so at 40% solar fraction the panels should be tilted more. The production cannot be exactly leveled by collector angle alone; even at 90° (horizontal) the production will be more in the summer than the winter due to the length of the days.

Note: All collectors have restrictions on the angles at which they can be installed. Please refer to individual data sheets for further information.

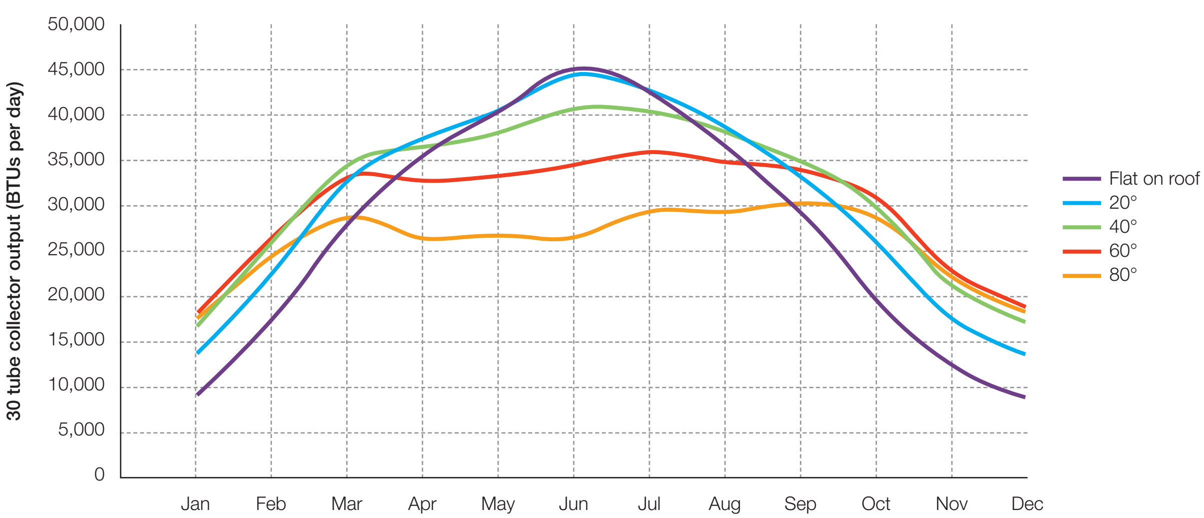


Figure 21: Average collector output for different angles

collector layout, and its effect on the system

Setting Flow Rates

All solar thermal collectors can operate at a variety of flow rates, depending on the application. The flow rate will affect the pressure drop of the collectors and also change the temperature increase across the bank. Generally a low flow rate is desired because it minimizes the pressure drop through the system resulting in smaller pipes and less energy to run the pump. The flow rate selected needs to take the heat exchanger into account to ensure sufficient heat transfer from the solar system to the tank.

The temperature increase across the collectors is driven by the level of radiation, the angle of the sun and the outdoor temperature. Once the energy output of the collector is known, the increase in temperature can be computed using the following equation:

$$\Delta T = \frac{\frac{BTU}{hr}\,Output}{GPM \times 8.33 \times 60 \times C}$$

Where GPM is the flow rate through the collector, or bank, 8.33 and 60 are constants to change the units (from gallons to pounds and minutes to hours) and C is the heat capacity of the fluid being used.

Example 1:

The calculated output of a collector is 8,000 BTU/hr. The system is running 42% glycol at 1 GPM through a single collector. What is the increase in temperature? The C of glycol at 100°F is 0.893.

$$\Delta T = \frac{8{,}000}{1 \times 8.33 \times 60 \times 0.893} = 17.92°F$$

Table 4: Temperature Increase versus Flow Rate (°F)

	Collector Output (BTU/hr)				
Flow Rate (GPM/Collector)	10,000	8,000	6,000	4,000	2,000
0.25	73.4	60.4	45.4	30.3	15.2
0.5	38.3	30.7	23.0	15.4	7.7
0.75	25.6	20.5	15.4	10.3	5.2
1.00	19.3	15.4	11.6	7.7	3.9
1.25	15.4	12.7	9.3	6.2	3.1
1.50	12.9	10.3	7.7	5.2	2.6

Table 4 shows the estimated temperature increase for normal operating flow rates. The same numbers can be used for banks of collectors if the flow rate is on a per collector basis. For example, if a bank of 3 collectors has a flow rate of 3 GPM, the flow rate per collector would be 1 GPM, so look in the 1 GPM column to find the estimated temperature increase for that bank.

The flow rate for the system should be selected carefully. Flow rates that are too small will cause a large increase in temperature across a bank of collectors, reducing efficiency and potentially creating temperatures above where the system is designed to operate. Flow rates that are too high will cause the pump to shut on and off frequently causing undue wear and tear on the pump. Ideally systems should use a controller that measures the temperature increase and adjusts the pump flow rate accordingly. Systems should be designed so that the temperature rating of the components is not exceeded. The limiting factor here is usually the pump which is usually rated to 220°F.

Generally systems with a lower solar fraction and larger storage will be able to utilize lower flow rates in the system. Systems that have high solar fractions, smaller storage, or those for heating, cooling, or high temperature industrial applications will need higher flow rates.

Pressure Drop

Kingspan solar thermal collectors are designed to connect to each other to form banks with the use of an 'interconnection kit'. One end of the collector plugs directly into the other end making a neat connection between the collectors.

Flat plate collectors connect to one another in parallel, where as evacuated tube collectors connect in series. This changes the pressure drop in a bank of collectors drastically (Figures 22 and 23). Evacuated tubes will increase in pressure drop as more are added where as flat plate collectors will have similar drops in pressure as more collectors are added to the bank.

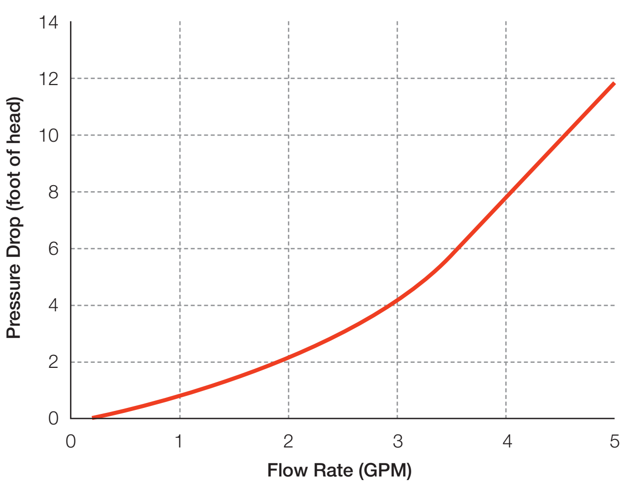


Figure 22: Pressure drop in heat pipe collector

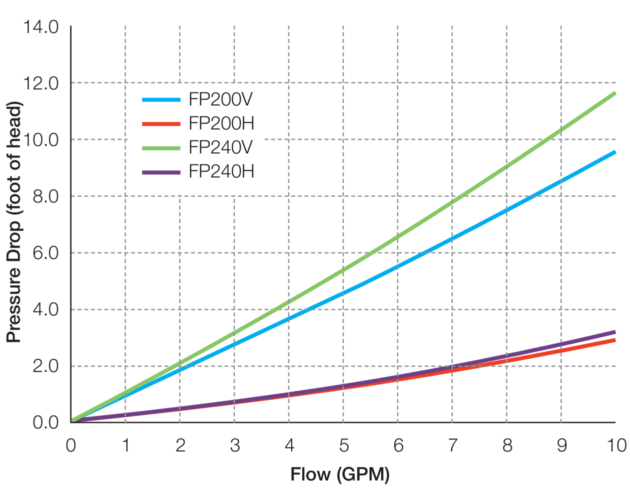


Figure 23: Pressure drop in flat plate collectors

There are many factors to consider how many collectors can be connected in series before they have to be arranged in parrallel banks. For evacuated tubes this is manily dependant on the pressure drop for the overall system to size the pump, but there is a constraint that a single bank of collectors cannot exceed 4 GPM flow because of flow velocities in the copper manifold. Flat plates can have more connected together because they are connected in parallel rather in series, but consideration must be given to how evenly the flow will distribute through the collectors in parallel. As the banks get larger, the flow will become more uneven in the individual collectors within a bank.

With heat pipe collectors, the maximum number in series for most applications is five. Depending on other components in the system, this may be reduced to four. For flat plate collectors, 8 vertical or 5 horizontal collectors may be connected in series.

Calculating the pressure drop for the entire system is a more difficult task. The piping, heat exchangers, valves, elbows and tees all make a difference in the pressure drop for the entire system. This value is required for sizing the pump. Kingspan Solar can assist in the correct sizing of the pump, as well as the piping in the system to make sure the pump is sized accurately.

Balancing

The system flow will tend to go to the banks with the lowest pressure drops in them, so a method of balancing the collectors is needed. There are two methods of doing this:

Reverse Return (Tichelmann)

A reverse return or 'Tichelmann' system is a system where the flow for any bank of collectors goes through the same length of piping regardless of where it is located on the roof. Figure 24 (overleaf) illustrates how this concept works. The first collector connected to the return will be the last collector connected to the flow. Both flow and return pipe work will run next to each other in the array to insure that both lengths are equal. The pipe diameter must be the same length throughout the array so that the pressure drop is always the same for the supply pipe and return pipe.

collector layout,
and its effect on the system

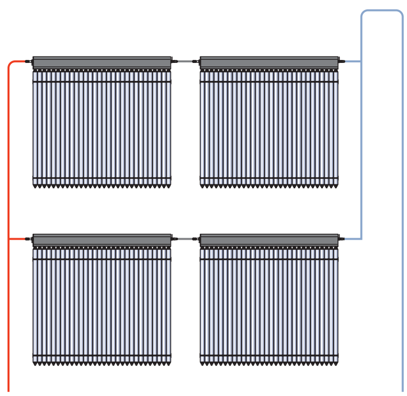


Figure 24: Reverse return system

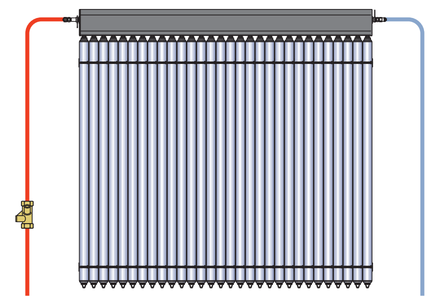


Figure 25: System with balancing valve.

The advantage of this type of pipe system is that there is no need for extra components to balance the system; in theory it is naturally balanced. The disadvantage is that the largest diameter of pipe must be used throughout the system, increasing cost. The pipe run is generally longer as it must meander past all collectors, but often these systems need balancing valves because small differences in the system will not allow it to be perfectly balanced. Additionally, all collector banks must contain the same number of collectors, or the system will not be balanced. Reverse return works well for small systems where the collectors are tightly arranged on the roof.

Balance Valves

Another way to balance the system is to use a small balance valve on each collector bank. Often times, these valves will contain a flow meter to simplify balancing as well. The balance valve is used on the inlet of each collector bank and should be positioned as far away from the collector as possible. The valves and their internal components are not rated for steam conditions that can occur if the collector stagnates. The valves are adjusted when the system is commissioned and under normal circumstances do not need to be adjusted again.

Using balance valves allows collectors to be in banks with different numbers of collectors and the pipe diameter to be optimized for the flow rate going through it at any point in the system. Balance valves do add an additional component to each collector bank, but allow for quick and easy adjustability in the system.

Collector Spacing

For systems with multiple rows of collectors, the banks must be spaced sufficiently far apart so that they will not shade each other. The general rule of thumb is that there should be no shading from one bank to the next on the winter solstice at noon. This will be the lowest that the sun will get in the sky and will not prevent all shading between banks (the sun is at zero degrees when it sets all year), but will leave the collectors largely exposed during the critical times of day throughout the year.

The spacing depends on how low the sun gets in the sky on 21 December, which depends on the latitude of the installation. The further north you go, the lower in the sky the sun will be. It is also dependant on which frame is used to support the collector. Table 5, pages 76-77, summarizes the recommended spacing for the various Kingspan frames.

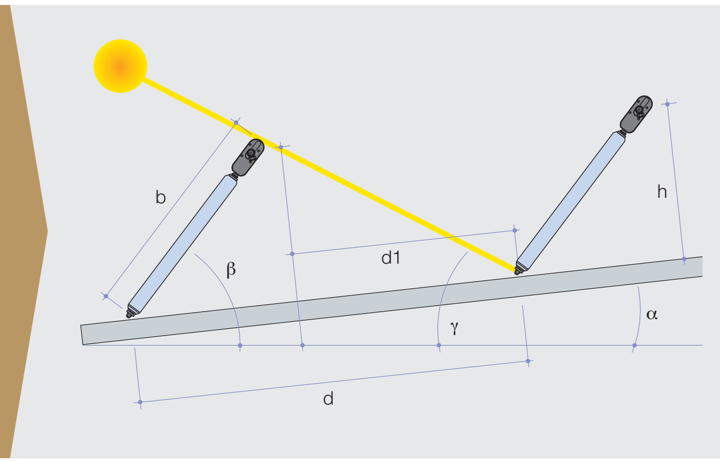
Kingspan Environmental

To calculate this by hand, the following equation can be used:

$$b \times \cos(\beta - \alpha) + \frac{b \times \sin(\beta - \alpha)}{\tan(\gamma - \alpha)}$$

Where:

b = height of solar collector (81.25”)
β = collector angle
α = roof slope
γ = minimum sun angle



Shutoff Valves on Collector Banks

In large systems, it is desirable to have shutoff valves located on both ends of the collector bank. These valves allow a single bank to be removed from operation so that maintenance can be conducted on it. If this is desired, then there must be a pressure relief valve designed to protect the collectors included between the shutoff valves and each collector bank. Without this, the collectors can continue to produce heat and cause the pressure in the isolated section to rise with the temperature. This is no different than including such a relief valve on a boiler. Note that this should be only a pressure relief valve and not a temperature and pressure relief valve pressure, as this could discharge glycol during normal operation, or stagnation of the collectors.

The Pentagon,
WASHINGTON DC

The ball valves should be selected so that they are as high temperature resistant as possible and be located as far away from the manifold in the piping as possible. This will protect them from steam ingestion from stagnation.

Conclusions

The arrangement of the collectors on a roof depends on many factors. The arrangement must be determined in order to size other system components, such as pumps and heat exchangers. By varying the flow rate through the system, the temperature increase across the collectors can be controlled. Different systems will utilize different flow rates, depending on the purpose and solar fraction of the system.

Pressure drop through the system is important when sizing pumps and piping. The system must be balanced to make sure the flow through each collector bank is equal (depending on the number of collectors) and is at the value which is designed. Also, if the banks are to have isolation valves, a pressure relief valve is required for safety. These are all important considerations when designing a solar system.

collector layout,
and its effect on the system

Table 5: Collector Spacing

20° Frame Spacing / 20 Frame Angle

Latitude	Lowest Sun Angle	Roof Slope (/12) 0	1	2	3	4	5	6	7	8	10	12	20
25	41.5	108	97	88	82	78	76	76	76	76	76	76	76
30	36.5	114	101	91	83	78	76	76	76	76	76	76	76
35	31.5	122	105	93	85	78	76	76	76	76	76	76	76
40	26.5	132	111	97	86	79	76	76	76	76	76	76	76
45	21.5	147	120	101	88	79	76	76	76	76	76	76	76
50	16.5	170	131	107	91	80	76	76	76	76	76	76	76
55	11.5	213	149	115	94	80	76	76	76	76	76	76	76

30° Frame Spacing / 30 Frame Angle

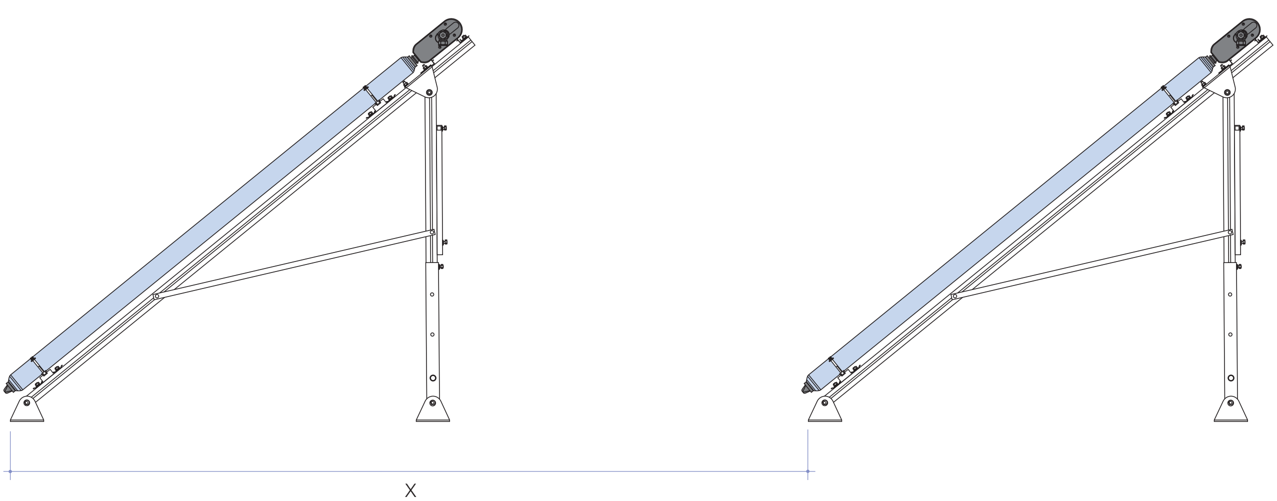
Latitude	Lowest Sun Angle	Roof Slope (/12) 0	1	2	3	4	5	6	7	8	10	12	20
25	41.5	116	103	93	86	80	75	72	70	70	70	70	70
30	36.5	125	110	98	89	82	77	73	70	70	70	70	70
35	31.5	137	118	103	92	84	78	73	70	70	70	70	70
40	26.5	152	127	110	96	87	79	74	70	70	70	70	70
45	21.5	173	140	118	102	90	81	75	70	70	70	70	70
50	16.5	207	159	129	108	94	83	76	70	70	70	70	70
55	11.5	269	189	145	117	99	86	77	70	70	70	70	70

39° Frame Spacing / 39 Frame Angle

Latitude	Lowest Sun Angle	Roof Slope (/12) 0	1	2	3	4	5	6	7	8	10	12	20
25	41.5	121	107	96	87	80	74	70	67	65	63	63	63
30	36.5	132	115	102	91	83	77	72	68	66	63	63	63
35	31.5	146	125	109	97	87	80	74	70	67	63	63	63
40	26.5	166	138	118	103	92	83	76	71	67	63	63	63
45	21.5	193	156	130	111	97	87	79	73	68	63	63	63
50	16.5	235	180	145	121	104	91	82	75	69	63	63	63
55	11.5	314	219	168	135	113	97	85	77	71	63	63	63

45° Frame Spacing / 45 Frame Angle													
Latitude	Lowest Sun Angle	Roof Slope (/12)											
		0	1	2	3	4	5	6	7	8	10	12	20
25	41.5	122	108	96	86	78	72	68	64	62	59	57	58
30	36.5	135	117	103	92	83	76	70	66	63	59	57	58
35	31.5	151	129	112	98	88	80	73	69	65	60	57	58
40	26.5	173	144	122	106	94	84	77	71	67	61	57	57
45	21.5	203	164	136	116	101	89	81	74	69	61	57	57
50	16.5	251	192	154	128	109	95	85	77	71	62	57	57
55	11.5	339	237	181	145	120	103	90	81	73	63	57	57

51° Frame Spacing / 51 Frame Angle													
Latitude	Lowest Sun Angle	Roof Slope (/12)											
		0	1	2	3	4	5	6	7	8	10	12	20
25	41.5	122	107	95	85	76	70	65	61	58	54	52	53
30	36.5	136	118	103	91	82	74	68	63	60	55	52	52
35	31.5	154	131	113	99	88	79	72	67	62	56	53	51
40	26.5	178	148	125	108	95	85	76	70	65	58	54	51
45	21.5	211	170	141	119	103	91	81	74	68	60	55	51
50	16.5	264	202	162	134	114	99	87	78	71	62	56	51
55	11.5	361	252	192	153	127	108	94	83	75	64	57	51



sizing
system components

This section covers sizing and selection of pumps, piping, tanks, expansion tanks, heat exchangers, and heat dissipaters. All these components must be sized correctly in order for the system to perform as designed.

Kingspan Solar supplies complete solar thermal packages, covering all necessary components, with a solution for every size of commercial application

Please refer to the manufacturer's instructions for the individual components to ensure that they are going to withstand the temperatures that solar thermal systems can reach. This section provides information to help determine the appropriate components. Kingspan Solar will assist in selection of the correct components for each project.

Pumps

Pumps are one of the key components within a solar thermal system. There are many different manufacturers and sizes of pumps offering products that are appropriate for use in a solar thermal system. The main requirement is that the maximum temperature rating of the pump is at least 220°F. Closed-loop glycol systems create a pressure drop due to the fluid being circulated through the system. The higher the flow through the system, the higher the pressure drop will be.

The pump's flow will decrease as the pressure losses in a system increase. Figure 26 shows the pump curves for a three speed solar pump plotted against the characteristic curve for a solar thermal system. Where the two lines cross shows how much flow the system will receive at each of the three pump speeds for the pump. The low speed will flow about 7GPM through the system, the middle 11GPM through the system and the high 12GPM. Information on choosing the correct flow rate for the system can be found under Collector Layout and its Effect on the System, page 74.

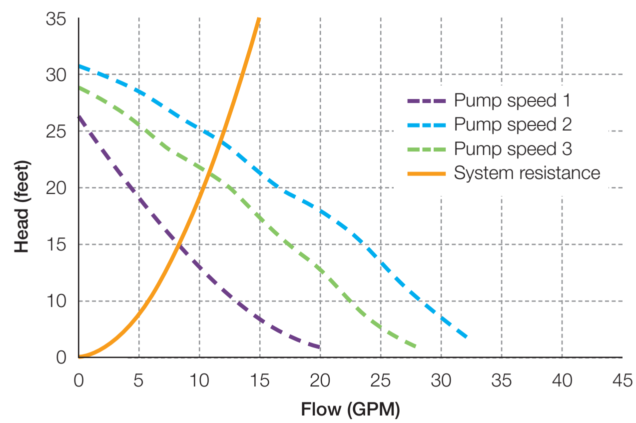


Figure 26: Example system and pump curves.

The key point here is that there is a single system flow rate per speed of the pump that can be achieved for a given system. Too low a system flow rate will result in a very high increase in temperature across the collectors and a corresponding loss in performance, where as too high a flow rate can cause erosion wear in the piping. The flow rate can be brought down using the balance valves on the collector banks if necessary, but this will consume additional electricity to run the system.

A variable speed pump can change the speed of the pump and run anywhere under the line; for instance if the pump is set to the highest speed, it can achieve any flow rate below the green line. The way it does this is by decreasing the pressure created by pump by slowing the shaft speed.

Selecting the correct electrical characteristics for a pump is covered in the Controls and Monitoring section, page 91.

Piping and Insulation

Piping is a very important part to the overall system. The type of piping selected will determine what the pressure drop in the system is. Typically, there are four types of piping available for solar thermal systems:

- copper;
- ductile iron;
- stainless steel; and
- flexible stainless steel.

Galvanized pipe must not be used as the glycol will attack the galvanized surface, causing it to chip away and clog the system.

Plastic piping is also not acceptable for use in the solar array. Stagnation temperatures are high enough to cause the piping to melt. PEX tubing is rated to 240°F continuous service, but the fittings are only rated to 220°F service.

All piping systems must take thermal expansion into consideration. As the piping expands and contracts, it will place stress on the joints. This must be compensated with in the pipe work. Make certain enough expansion compensation is included in the system for the extremes of operation. Flexible stainless steel piping does not need to have expansion compensation because the piping takes this up by itself.

Copper Piping

Copper is traditionally the most common pipe found in solar systems. Copper pipe is readily available and easy to install for people who are trained in sweating pipe. Type L or K copper pipe should be used in solar systems.

One important consideration when using copper pipe is that the flow velocity must be kept very low to prevent erosion in the piping. According to the Copper Piping Manufacturer's Association, flow velocities should not exceed 8 ft/sec for cold water, 5 ft/sec for temperatures below 140°F and 2 – 3 ft/sec for temperatures above 140°F.

Ductile Iron Piping

Ductile iron pipe is generally used on larger solar systems. The difficultly of tapping the ends of each pipe and then insuring that it seals make it more expensive than copper on smaller systems, even though the piping is much cheaper. The flow velocity should be kept below 6 ft/sec so that the pressure drop within the pipe is minimal. The pipe is much heavier than copper and requires additional supports to support the weight of the piping.

Attaching ductile iron pipe is either by tapping the ends of the pipe, or by using Victaulic type fittings. Figure 27 shows a piping system with Victaulic fittings. Generally tapping is used for smaller pipe diameters and fittings for diameters above 2". Note that expansion compensation in these pipes is very important.

Figure 27: Pump system with Victaulic fittings

Glycol has a pH of 9.0 or greater which will significantly reduce the chance of any corrosion in the piping. Since a glycol system is a closed loop system, there is no additional oxygen that is introduced into the system. This is normally a concern for systems with iron in them.

sizing
system components

Stainless Steel Piping

Once considered too expensive for many systems, stainless steel piping is becoming more common. Stainless piping is a resilient choice for piping in systems as its corrosion rate is minimal even when the glycol becomes acidic. Stainless steel piping is joined either by compression fittings for smaller diameters or welded together for larger diameters. Both of these joining methods produce joints that are robust against leaking. Stainless steel piping should not be mixed with ductile iron piping in a system without consulting an engineer about how to correctly separate the two materials.

Stainless piping is desirable because of its high tensile strengths, meaning less weight and material per foot of piping, ease of installation and keeping costs down. The flow velocity can also be up to 50 ft/sec without causing abrasive wear in the system; however 8 ft/sec is the recommended maximum for keeping the pressure drop in the piping low.

Flexible Stainless Steel Piping

Flexible stainless steel piping combines many of the best attributes of the available piping along with ease of installation. The corrosion resistance of the flexible piping is excellent, and the walls are even thinner meaning less overall weight and cost for the pipe. The piping comes in rolls of 100 feet in length with high temperature insulation already applied to the piping. The connections are through patented brass fittings that use a metal to metal seal to insure no leakage throughout the life of the system. Piping can be cut with a standard copper piping cutter. Since the pipe is flexible, there is no need for expansion compensation in the system.

Kingspan Solar carries a line of stainless steel pipe and fittings from ½” to 2” in diameter that is able to handle from 1 to 70 GPM flow. A wide assortment of couplings, tees and adaptor fittings is available to make the system installation as simple as possible. The piping is very light and can be attached to the collector frames for support.

The main advantage for using flexible stainless steel is the reduction in installation time. The pipe is very easy to cut and because it is flexible everything doesn’t need to be perfectly aligned in order for it to fit. The fittings are very easy to use and insure a robust seal so there is little chance of leakage from a joint. The pipe comes from the factory preinsulated which eliminates having to add any additional insulation. The runs are 100’ in length removing the need for joints at eight or ten foot intervals and the associated potential for leaks.

The main disadvantage is that the piping has a higher pressure drop than any other pipe because of its corrugations. If this is designed into the system, it is not a problem. However, the pump size will generally be larger than with a system that uses smooth pipe.

Piping Insulation

All solar piping runs must be insulated. When selecting an insulation material, the temperature it can withstand is critical. Insulation should be able to withstand 300°F or higher and for short periods, it should be able to withstand 350°F or more.

Fiberglass will have the best temperature characteristics (1,500°F+). Fiberglass insulation should have an Aluminum jacket around it to keep the moisture out. Fiberglass pipe insulation has a lower insulation value when compared to the alternates, so often thicker insulation is required on piping than with some of the alternatives. For durability and the ability to withstand all conditions, fiberglass is excellent. For ¾” to 1 ½” piping, 1 ½” of fiberglass insulation is recommended and for 2” and larger pipe, 2” of insulation is recommended.

Various types of closed cell foam are available that will meet the temperature requirements of a solar system. Foam insulation has excellent insulation values and is easy to install on piping. Because of the higher R-value of closed cell foam insulation, the thickness required is less. For ¾” to 1 ½” piping, ¾” thickness is recommended and for 2” and larger piping, 1” is recommended.

Jack in the Box,
EL PASO, TX

Hotel Biafore,
SAN GIOVANNI IN FIORE, ITALY

sizing
system components

Tanks

There is a significant amount of storage that is required and the tanks must be able to handle higher temperatures than in typical hot water systems. Tanks above 120 gallons must have an ASME pressure vessel rating if it is pressurized system.

The tank chosen for the system can be either pressurized or non pressurized depending on the application. A non pressurized tank will have a solid shell and then a rubber lining to prevent leakage from the tank. Heat exchangers will be provided either immersed in the tank, or the water in the tank will be pumped through external heat exchangers; the water in the tank is used for energy storage only and is not part of the hot water system in the building.

In general, Kingspan Solar recommends that pressurized tanks be considered first, but if they are deemed unsuitable (e.g. access constraints) then non pressurized tanks can be an option. Non pressurized tanks are limited in the temperature water can be stored at (usually about 150°F), requiring them to be larger. The heat exchangers in a non pressurized tank must be carefully designed as to give the maximum effect in increasing the temperature of the water. Because of this heat exchange, the efficiency of the system will be less with non pressurized tanks. Non pressurized tanks must be monitored for the proper water level within the tank, water will evaporate and the water level within the tank will decrease over time. When this happens, the tank must be manually refilled. Non pressurized tanks can collapse flat, allowing them to fit through tight spaces. For projects where a tank must be maneuvered down through tight hallways to make it to the mechanical room, a non pressurized tank is often the only choice.

For pressurized tanks there are several options available for materials and linings within the tank. These are to combat corrosion which will occur over time of the material in the tank. It is desirable in solar thermal systems to allow the temperature within the tank to increase to be significantly higher than the 120°F that the water is delivered to the faucets at because this will reduce the total volume needed for storage. The water will then be mixed down to the correct delivery temperature by a thermostatic mixing valve.
A discussion of the various materials that are available for tanks follows.

Texas A&M University,
KINGSVILLE, TX

Duplex Stainless Steel: Of all the options for a tank material, Duplex stainless steel is the best choice. It has a very high tensile strength, meaning a reduced weight of the tank and less material in comparison with the other options. Like 316 Stainless Steel, it does not require a coating as it is resistant to most corrosion but, unlike 316, it is not susceptible to pitting corrosion. Tanks made from Duplex will last a very long time at the elevated solar temperatures.

Kingspan Tribune tanks are made from Duplex, but are only available up to 119 gallons. For commercial applications, Kingspan Solar recommends PVI 'AquaPLEX' storage tanks that are available in capacities up to 4,000 gallons.

Stainless Steel Tanks: Stainless steel tanks usually refer to 316 or 316L Stainless Steel. They have no coating in the tank because stainless will not rust in most applications with water. 316 Stainless has a relatively low tensile strength and therefore the tank wall is quite thick. Check local codes to make certain these tanks may be used for storing potable water.

In most applications, 316 Stainless tanks are suitable for solar thermal systems because of their low corrosion rate at elevated temperatures. In some areas, the chloride levels in the water will cause a type of corrosion called pitting that is greatly increased at higher storage temperatures. It is recommended that a water sample be taken at the location of the installation and the chloride levels be measured and the compared with the manufacturer's specifications to ensure that this type of stainless is suitable for the location and conditions of the particular installation.

Ceramic or Glass Lined: These are the most common tanks found in the US. The coating is designed to prevent contact between the water and the steel from which the tank's inner vessel is made. These tanks generally have an anode which is a piece of material that is more reactive than the steel the tank is manufactured from and will be eaten away by the corrosion first. The anode reduces, but does not eliminate the corrosion of the steel tank vessel.

The higher the temperature of the stored water within the tank, the higher the corrosion rate of the steel will be. Higher temperature tanks generally have larger anode rods, but these will need to be maintained over time to help reduce the corrosion of the inner tank vessel. These tanks are generally acceptable for storing water at 120°F, but at higher temperatures the corrosion rate can become quite high and are therefore not recommended by Kingspan for large commercial applications involving solar arrays. If these tanks are used on a system, check with the manufacturer for the maximum allowable storage temperature and do not exceed this value.

Cement Lined Tanks: Cement lined tanks have a continuous layer of cement that is spread over the steel vessel surface.

Unlike ceramic or glass lined tanks, this layer is not designed to prevent water from coming into contact with the steel surface, but rather prevent it from moving away from the surface once it is there. The water becomes saturated at the surface of the steel and is held there by the cement, thus not allowing any further corrosion of the surface.

Cement lined tanks are a good fit for solar thermal systems because there is no increase in the corrosion rate with elevated temperatures. Check with the manufacturer for their exact recommendations, but there is generally no issue with storing water at 180°F. The disadvantage of cement lined tanks is they are very heavy as compared with other choices.

Nickel Coated Tanks: Very similar to the ceramic and glass lined tanks, nickel coated tanks have a coating to prevent the water in coming into contact with the steel of the vessel. The nickel coating is deposited through a process that leaves no gaps or scratches to allow the water to make contact with the steel. Nickel coated tanks are a good option for solar thermal systems because the coating covers everything, there is no corrosion of the inner vessel and they can take the higher temperatures. It is recommended to check with the manufacturer and make certain that these types of tanks can take elevated temperatures for long periods of time.

sizing
system components

Expansion Tanks

A solar expansion tank must perform two roles: first, it must make up for the expansion and contraction of the glycol in the solar loop due to changes in volume with temperature and it must also be able to take the fluid volume from the manifold during stagnation conditions. When the collectors stagnate, the fluid will boil in the manifold, forcing out the fluid into the expansion tank.

Table 6: Pressure vs Boiling Point

Pressure (psig)	Boiling Point (°F)
0	212
2.5	220
6.1	230
10.3	240
15.1	250
20.7	260
27.2	270
34.5	280
42.8	290
52.3	300

The pressure settings are very important for the solar loop and the expansion tank. The expansion tank must be set to 5 – 7 psi lower than the solar loop pressure. This will provide sufficient fluid in the expansion tank to back fill the system when the loop temperature is cooler than when it is filled.
The pressure the solar loop is set to will affect the boiling point of the glycol in the collectors. It is important to know where this point is so that the pump is not turned on while the collectors are stagnating, thus forcing steam into the return lines.
Table 3 above, gives the boiling point of water versus the pressure.

The temperature at which the fluid in the collectors boils should be less than the maximum temperature the glycol can take, or 350°F. In order to make certain ample time has been given for the glycol to leave the manifold, Kingspan recommends a boiling temperature of 260°F, which corresponds to a pressure of 21 psi in the collectors. In most circumstances, the collectors will be situated above the pump and where the system pressure is being measured.
This means that for every 2.3 vertical feet, the pressure in the collectors will be 1 psi lower than what is measured at the pressure gauge next to the pump. To determine the pressure for the system, use the following equation:

$$P_S = P_C + 0.434 \times h$$

Where:

P_S – System Charge Pressure (psi)

P_C – Desired pressure at the collectors (psi)

h – Collector height above the pressure gage (feet) (note that if the pump is above the collectors, h will be negative and the charge pressure will be less than the desired pressure in the collectors).

Then to determine the charge pressure of the expansion tank prior to attaching it to the system,

$$P_E = P_S - 7\ psi$$

Where:

P_E – Expansion tank pre charge pressure (psi)

It is important that the expansion tank pressure be set prior to filling the system with glycol because after it is filled, it is impossible to know the charge pressure without draining down the system.

Figure 28 shows the change with system pressure versus temperature. For this system the cold charge pressure (at 70°F) was 40 psi. As the temperature increases or decreases from this point, the system pressure varies only slightly from the initial pressure. When the fluid boils at 270°F, there is a sharp increase in pressure, due to the fluid being pushed from the manifolds into the expansion tank. The pressure then continues to increase slightly with temperature.

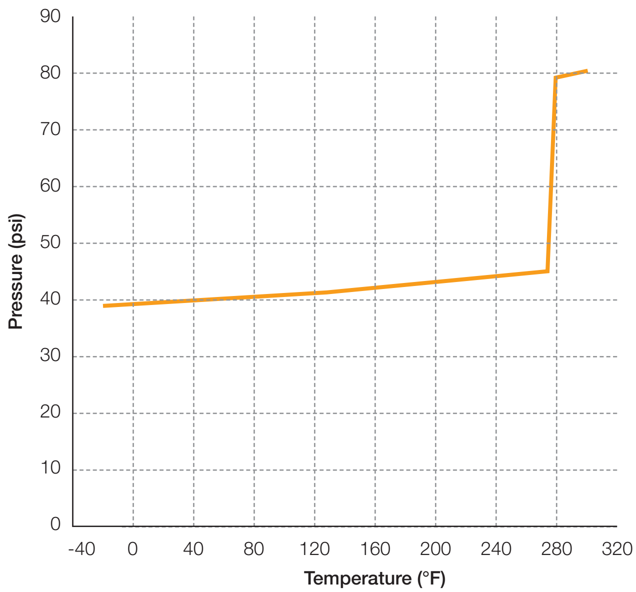


Figure 28: System pressure vs. temperature.

It is important that the value at which the pressure relief valve for the solar loop is set for is higher than the pressure that is achieved when the system stagnates. If it is not, then the valve will discharge fluid and the system will need to be refilled with glycol to operate properly again. This is an important part of how the expansion tank is to be sized.

The following is the basic equation for sizing the expansion tank for the system:

$$V_N = \frac{(\beta V_A + V_V + V_D)(P_e - 14.7)}{P_e - P_0}$$

Where:

V_N – Minimum expansion tank volume

β – Expansion ratio of fluid (0.085 for 42% Tyfocor)

V_A – Total system volume (collector volume plus pipe volume plus heat exchanger volume)

V_V – Volume of the liquid in the expansion tank at cold charge pressure (about 15% the volume of the tank)

V_D – Manifold volume (0.45 gallons for 30 tube collector and 0.3 gal for 20 tubes)

P_e – Activation pressure for the pressure relief valve minus 10%

P_0 – Cold charge pressure + 14.7 psi (to convert from gauge pressure to absolute)

Table 7: Collector Volumes

	Heat Pipe	Flat Plate
20 Tube	0.45	–
30 Tube	0.3	–
Collector	–	0.29

This gives the total volume for the expansion tank, not the acceptance volume. The acceptance volume can be obtained by the $\beta V_A + V_V + V_D$ portion of the equation. Table 7 shows the collector volume for the different Kingspan Thermomax collectors.

Heat Exchangers, Pressure Relief Valves and Heat Dissipaters

The peak output of the system is the key criteria for sizing these components. Table 8 shows the peak output of the various Kingspan collectors. For heat exchangers and heat dissipaters, the decrease in temperature across the component will also be required. Refer to the Collector Banks section, page 74, for calculating the expected increase in temperature across the collector banks and therefore the designed decrease in temperature across the load.
All components should also be designed to take temperatures in excess of 240°F.

Table 8: Peak output of collectors

Collector	Peak Output (BTU/hr)
Heat Pipe	10,000
Flat Plate	6,200

Kingspan Solar offers a selection of these components for various sized systems. Please contact us for more information.

building structural considerations

Before adding solar collectors to any structure, it should be assessed by a professional engineer to make sure the structure is able to support the additional forces the collector imparts on the building.

Kingspan Solar can advise on the different structural options and recommend professional engineers familiar with our collectors.

Most buildings can take the load of additional solar collectors, but the cost and difficulty of adding the necessary structural improvements can sometimes increase the system cost significantly. It is therefore very important to consider the structural implications in the planning stages of a design.

Wind Loads

By far the most significant load the collector imparts on the structure is that which is caused by the wind. There are very different wind requirements throughout the country, ranging from about 80mph in some areas up to over 130mph in certain hurricane zones. Based on engineering work that has been done on previous jobs, the wind load ranges from 120 pounds per foot to over 900 pounds per foot. With this significant range, it is important to have the wind load for the collectors engineered for each job.

Factors Affecting Wind Load

An engineering study conducted for the actual location of the building the collectors are to be mounted on must be conducted. The topics that are discussed here are some of the things that a professional engineer will assess when looking at the particular application. This list is presented for reference only and is not considered complete, nor a substitute to an engineering assessment.

"In order to reduce the cost of the system as much as possible, and to prevent the chance of structural failure, the collector loads should be engineered on a job by job basis."

National Taiwan University Hospital Yun-Lin Branch
HU-WEI REGION, TAIWAN (ROC)

Wind Exposure Categories

The location is classified as being in one of three wind zone categories based on the obstructions around the building. Category B is when the objects around the building are closely spaced and disrupt the wind from blowing directly on the collectors. This can give a significant reduction in the wind forces acting on the collector. Category D is for buildings that are located around water or other flat surfaces that will not block the wind from directly hitting the collectors. All other buildings fall into Category C. Hurricane zones have their own regulations that are not listed here and the wind load in these zones is usually higher than the listed categories and local codes will take precedent.

Occupancy Classification

Certain buildings have tighter or looser restrictions based on how they are used. Category I buildings are buildings that present a very low risk to humans in the event of failure, such as agricultural buildings and storage buildings. These have a reduction in their wind load requirements. Category III buildings represent buildings that have a large number of people in one area, such as schools and universities where a failure could lead to injuries of many people. Category IV buildings are deemed essential in an emergency, such as hospitals, police stations, power plants and air traffic control towers. Both Categories III and IV have higher wind loads they must be designed to handle. Category II is for all buildings that do not fall into one of the other categories.

Mean Roof Height

As the building becomes taller, the wind forces become higher. Buildings that are low to the ground (under 15 feet), or ground mount collector arrays may see a significant reduction in the wind loads.

Topographical Features

Buildings located on top of a hill or escarpment may see increased wind pressure due to the amplification provided by flowing over the hill.

Location on Roof

Collectors located on the edges of a roof may see higher wind loads than those that are located towards the center of the roof. This is mainly for collectors mounted flush to the roof, but in some circumstances may extend to angled frames.

Kingspan Solar has conducted engineering studies through a structural engineering firm that calculate the forces on the attachment points for wind loads ranging from 85 – 120 MPH.

The reports also certify that the frame and mounting hardware are sufficient to withstand the worst case conditions for this set of assumptions. Copies with an engineering stamp in all 50 states are available for our range of roof kits.

In order to reduce the cost of the system as much as possible, and to prevent the chance of structural failure, the collector loads should be engineered on a job by job basis.

It is impossible to provide for a single document that would cover all possible cases without making the worst case assumptions in every case. This would lead to a wind loads that are significantly higher than most cases would dictate. Kingspan Solar can provide a list of engineering firms that assist with this calculation.

Snow Loads

The snow load is another structural consideration for the collectors. According to the building code, at angles up to 45° the collectors can have snow build up on them. Since it is also possible for the snow to build up beneath the collectors, the snow that builds up on the collector must be added to this. In areas where the snow load is 40 pounds per square foot, this can add a significant amount of load to the roof and when combined with the downward wind force makes the downward load even higher. In most cases the wind loads are going to be significantly higher than the snow loads on the collectors.

True Davidson Acres Retirement Home
TORONTO, CANADA

Another consideration in the structural analysis is how deep the snow will pile in the winter. For areas where the snow is quite deep, it is advisable to elevate the collectors above the snow level to help keep them free from snow build up and the subsequent decrease in performance that accompanies this. Sometimes it is possible to use the added structural components for the solar system to accomplish this.

building structural considerations

Attaching Collectors to the Structure

There are three basic methods of attaching the collectors to the roof of a building; ballasting, roof penetrations and a grille. Each of these methods has their own distinct advantages and disadvantages. There is not one method that works for all buildings because of the significant differences in roof design from building to building. The discussion below lists the advantages and disadvantages of each method.

Ballasting Collectors

Ballasting is an attractive option because it does not require any roof penetrations. Ballasting must overcome the two main forces that act on the collector; the lifting force caused from wind acting from behind the collector and the force that wants to slide the collector across the roof. The ballast weight must be carefully engineered for all projects. What happens is as the collector lifts, the normal force holding it down is reduced, reducing the friction force that prevents the collector from sliding (μN; where μ is the coefficient of friction for the two materials and N is the normal force; the difference between the lifting load at the given wind speed and the weight of the ballast). The weight must be sufficient to prevent the lifting and sliding of the collectors at the given wind speed.

The second major consideration for ballasting is the structural design of the roof. Many roofs are simply not strong enough to take the ballast load and the subsequent wind loads.
The weight of the ballast plus the weight of the collector plus the downward wind load plus the snow load is the total downward load that the collector can exert on the roof.
For example, with 90mph winds with the collectors orientated at 45° and a 30 psf snow load the total downward load may be (depending on engineering) 3,296 lbs per collector (153lbs downward wind, 92 lbs snow, 529 lbs ballast, 50 lbs collector weight per foot). This equated to 69 psf and the roof still needs to be able to take the snow load, for a total of 99 psf on the roof. Note that there will never be an upward force acting on the roof. This example assumes that the collectors are fully exposed to the wind.

Ballasting is a good option if the collectors are shielded from the wind on top of a building. This will allow the engineer to significantly reduce the ballast loads on the collectors. If the collectors can be butted up against a penthouse, or other mechanical equipment on the top of the building this will allow for significantly lower loads to be required per foot.
An important consideration is how many collectors can be shielded in this manner early on in the design, as this may determine the maximum number of collectors in the array.

Figure 29: Collector system ballasted with concrete blocks

Figure 30: Here the collectors have been attached to the roof with standoffs that are individually sealed. Each collector has four attachment points

Distributed Penetrations

Distributed penetrations are when the roof is penetrated for each foot in order to attach the collectors to the roof structure. This has the advantage of not having to add the extra weight of ballast to the roof, but each penetration must be attached and sealed properly. On a large array of collectors, this can be a very high number of penetrations and a single penetration that leaks can cause the manufacturer to void the warranty on the roof. The penetrations must be designed with a roofer who can sign off that the warranty will still be in effect after they are made. Many commercial roofs can carry a ten to twenty year warranty and the solar system must not void this warranty.

Taking our previous example, the maximum downward force of the collector is now 1,180 pounds and the maximum upward force is 2,116 pounds. This equates to 55 psf downward (snow load plus downward wind load) and 44 psf upwards per collector. Note that the magnitude of the forces is the same as in the previous example, but the direction is split between downward and upward forces.

Once again, the roof structure must be taken into account. The roof design would have to be such that it can take the extra loads of the collectors and many roofs are not designed with the extra margin taken into consideration. It is up to the structural engineer to determine if the roof in question can take these forces. Once again, an examination by a professional structural engineer may allow the force exerted by the collector on the roof to be reduced because of the location of the building and the collectors.

Grille

A grille is a structure built on top of the roof that attaches to the columns of the building and supports the collectors. They will often be made out of structural steel and have large spans as to minimize roof penetrations. It offers the ability to minimize the number of roof penetration because not all columns need to be used for the structure.

The forces the collectors exert on the grille are the same as with the distributed penetrations. An engineer will need to determine the design of the grille system based on column location and the desired span. For buildings that are directly exposed to the wind, the grille is often the only option that will allow collectors to be mounted to the roof. Usually buildings are designed with enough extra strength in the columns to allow the grillage to be attached and take the load of the collectors.

Combination Systems

It is possible to come up with different ways to connect the collectors to the roof, other than what is described above, or it is also possible to combine different options shown above. An example is a ballasted system that uses a limited number of roof penetrations to reduce the ballast weight. Again, a considerable amount of engineering work can go in to figuring how to allow the building to take the additional weight of the collectors. These possibilities open up a lot of doors as to what is possible for attaching the solar system.

Figure 31: A grille type structure

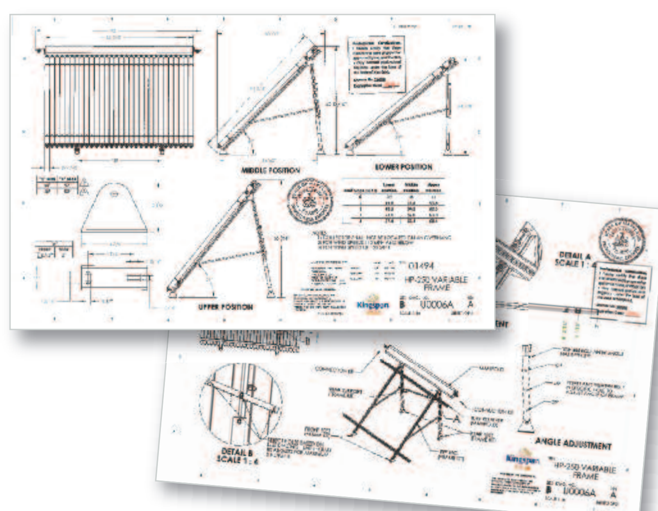
Figure 32: System utilizing a grille with minimal roof penetrations to attach to the grille of the building – the weight of the system reduces the number of penetrations required

building structural considerations

GWU, Foggy Bottom Campus,
WASHINGTON DC

Conclusions

The attachment of a solar system to the roof of the structure is an important consideration early on in the project.
Each building presents its own set of design challenges and considerations that must be overcome to insure the structural safety of the solar system. Several different options are available and each has its advantages and disadvantages for mounting collectors. Careful consideration by a professional structural engineer will usually allow one of these options to be used in the mounting of the solar system. For commercial applications, how the system is to be mounted should be considered early in the design, as it can significantly affect the overall scope and cost of the project. Please contact Kingspan Solar for assistance with your structural design.



Kingspan Solar can supply stamped structural engineer drawings for every state in the US and also recommend structural engineers familiar with our product portfolio if necessary.

controls and monitoring

solar thermal system
controls, electrical components and monitoring

Solar thermal system controls are an integral part to the entire system and how it performs. There are several different options for solar thermal controllers that will provide the necessary functions for controlling the solar system, monitoring its production and reporting any problems with the system.

Kingspan Solar offers a complete controls solution for solar thermal systems.

Controlling a Solar System

The basic algorithm for controlling a solar system is very simple. A sensor is placed in the collector bank and another in the bottom of the tank. When the difference in temperature between the sensors exceeds a set point, typically about 16°F, a relay in the controller will close and activate the solar pump. The difference in temperature shows there is meaningful energy to be collected. The pump will run until this temperature difference falls below a threshold, usually about 8°F, meaning there is no longer energy to collect.

Additionally, there are other points to monitor in the system. The controller examines the temperature in the tank and ensures that the maximum temperature is never exceeded. The temperature in the solar loop is also monitored and the controller will shut down the solar pump if the temperature becomes so high that it may damage components in the solar loop.

More complicated systems can utilize additional functions in the controller. A system that uses two tanks will utilize a function in the controller that switches a valve between the tanks when a temperature set point is reached so that the solar energy is diverted to the correct tank. More than two tanks will simply utilize more inputs and outputs on the controller. Systems with additional pumps can utilize additional temperature sensors for activating the pumps.

Because the controller has a large number of inputs and monitors the temperatures in key locations within the system, it is also often used for data recording. This usually means that the temperatures and flow rates measured by the controller are recorded on a memory card at regular time intervals. This data can then be recalled and processed to see how the solar system has been performing and provide an estimate of the system savings.

One option that is becoming more and more utilized is speed control on the solar pump. This involves varying the speed of the pump depending on the rise in temperature that the collectors are producing. The pump will run faster when the sun is intense and slower when there is less sunlight. This reduces the energy consumed by running the pump, as well as short cycling of the pump whereby it turns on and off quickly because there isn't much solar radiation. Some controllers offer variable speed (0 – 10V) outputs instead of straight relays to connect to an inverter and vary the speed of the pump.

Solar Controllers

Solar controllers are devices that are manufactured specifically to control solar systems. The controllers will differ in the number and type of inputs, number and type of outputs, if they have monitoring capability and Internet connectivity. Table 9 opposite compares the capabilities of two common controllers for commercial systems.

Berghotel Rudolfshütte GmbH,
SALZBURG, AUSTRIA

Table 9: Solar Controller Summary

	Kingspan SC300	MX
Temperature Inputs	5 (6)*	12
Flow Meter Inputs	1	3
Direct Sensor Inputs	0	4
Pyranometer Input	0	1
Solid State Relay (Triac) Outputs	2	13
Eletro-mechanical Relay Outputs	1	1
0 – 10V Outputs	0	4
Input / Output Voltage	120VAC	120/240VAC
Maximum Tanks	3	5
Data Logging	Yes	Yes
Optional Internet Connection	No	Yes
SSR Output Max Current	2.0A	1.0A
EM Relay Max Current	3.47A	4.0A
Unit Max Current	5.47A	6.3A

* One of the temperature inputs is convertible to flow meter

Solar controllers are a convenient and inexpensive way for controlling commercial solar systems.

They come preprogrammed with many of the common systems already in them and are easy to connect to the overall system. The units provide excellent data logging capabilities and this data can be accessed over the Internet. Where it is possible, Kingspan Solar includes a program on a memory card that is customized to your exact system to insure that all parameters are programmed properly in the controls.

solar thermal system
controls, electrical components and monitoring

Building Management Systems (BMS)

Most modern buildings will have a Building Management System that can examine inputs from sensors, make calculations and then turn on relays based on the sensor inputs. These systems are desirable because usually they will have data logging and are designed to be robust in a mechanical room environment. The program is also flexible so that the exact system can be programmed into the unit. Multiple sensors in the collector arrays can be used for redundancy so that if one fails, the system will continue to run. The information is also available to be monitored by the maintenance staff on a regular basis so they can see that the system is running properly.

On a site visit, the BMS system should be checked to make certain that the number of inputs and outputs are available in the current system. On most systems, additional modules can be purchased to expand the capabilities of the system if there is insufficient space available. Kingspan can supply the basic algorithms for controlling the system, but the system will have to be programmed by a professional. Usually the building owner will know who maintains and programs their system and will be able to provide this information.

Performance Monitoring

The performance of a solar thermal system is based on how many BTUs of energy that the system is providing to the load (hot water, space heating, etc.). A BTU (British Thermal Unit) is the energy required to raise one pound of water by 1°F.
The power of the system is calculated in BTUs/hour. This is how much water the system can raise in temperature per hour. This means that if we know how much water is being heated and by how much, we can calculate how much energy the solar system is producing. Figure 33 shows a solar system and how it would be set up for monitoring. A meter is used on the return side to measure the flow rate in gallons per minute of the system. Two temperature sensors, one on each side of the load are used to measure the difference in temperature. Once this information is known, Equation 1 can be used to determine how many BTUs per hour the system is producing:

Equation 1:

$$\text{Power} = \text{Flow Rate (GPM)} \times 8.33 \text{ pounds per gallon} \times 60\text{min per hour} \times (T1 - T2)$$

The power output of the system will change as the sun sweeps across the sky, or is hidden by clouds. What you will get is a varying output from the system versus the time of day. To translate this into BTUs, Equation 2 is used:

Equation 2:

$$\text{Energy} = \int_{t1}^{t2} \text{Power} = \int_{t1}^{t2} \text{flow}(t) \times 8.33 \times (T1(t) - T2(t))\, dt$$

This looks very complicated, but it really isn't. What it is saying is that the temperatures and flow rates vary with time depending on the conditions outside. If you take and add up all the power numbers in BTUs per hour and multiply them by how long the system operated at this output level, you will get the total BTUs the system produced over the day.

Kingspan Environmental

Wabasca Water World & Fitness Center,
WABASCA, AB

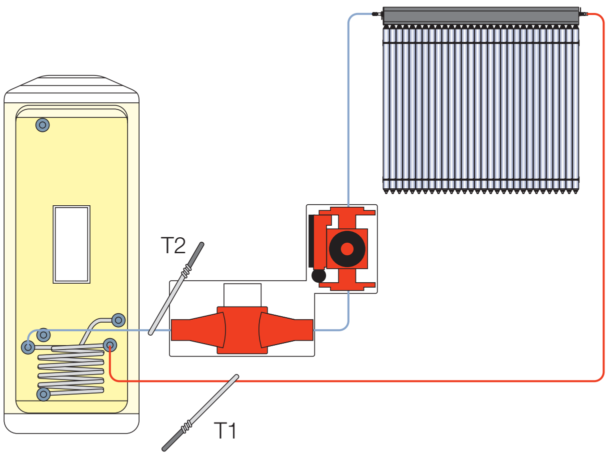


Figure 33: Location of performance monitoring equipment.

Most of the time you will have data from a system that will log the flows and temperatures every minute or so throughout the day.

This data can be imported into Excel and will look like this:

	A	B	C	D	E	F
1	Time	Flow	T1	T2	Power	Energy
2	12:00	10.5	160	125	183,677	3,061
3	12:01	10.4	150	122	145,541	2,425
4	12:02	10.4	140	120	103,958	1,732

Column E shows the power production in BTUs per hour; if the system operated in this condition for an hour, this is how much energy would be produced. Since each row represents one minute of time, the energy collected during this time is 1/60 of the power or how many BTUs are collected each minute. In this example the power is decreasing as if the sun went behind a cloud.

Equations 3 and 4 show how the power and energy were calculated as they would be typed in Excel in Row 1:

Equation 3:

*Power = 8.33 * 60 * (C2 – D2) * B2*

Equation 4:

Energy = E2/60

By adding the energy, you can calculate how much fossil fuel was displaced; in the example above the energy produced in the 4 minute period was 8,084 BTUs. The table below gives the conversion of common measurements of various fuels and how many BTUs each contains:

Unit	BTUs
Therm	100,000
Gallon of Propane	92,000
Gallon of #2 Fuel Oil	135,000
Cubic foot of natural gas	1,020
Kilowatt Hour (kWh)	3,412

Note that the efficiency of the system must also be taken into account with the overall savings; if the boiler is 90% efficient, divide the savings by 0.9 for the actual amount saved.

solar thermal system
controls, electrical components and monitoring

Pumps

Fixed Speed Control

Pumps are a very important part of a solar system. The sizing of pumps is covered in the components sizing section, but here we look at the electrical side of the pumps. The motors on pumps are rated terms of the voltage, phase and horsepower and it is very important to understand the meaning of these terms when choosing a pump for a particular job.

Most of the time the motor for a particular pump can be specified with several different voltages and phases. A site visit to the building should examine the voltages that are available and ensure that there is enough extra power on a circuit to handle an additional pump or pumps. The first thing to examine is what voltages are available. On small systems, 120V will typically be used because it is readily available and most small pumps are rated for this condition. Larger systems will use either 240V or 480V because they are more efficient at turning the pumps.

The voltage also helps determine the number of phases that are available. 120V circuits in the North America are automatically single phase. 240V circuits can be either single phase (technically split phase), or three phase where as 480V systems are more than likely three phase.

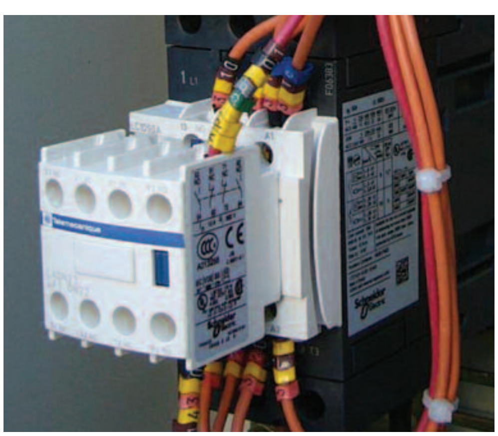


Figure 34: Contactor.

Determining the number of phases present is very important because it will dictate the motor that is chosen on the pump and the design of the motor contactors used in the electrical system.

The next thing that must be examined is the power rating on the pump. The relays in all controllers have a maximum current that they may provide to the motor and operate at a particular voltage. The standard solar controllers, for instance, are able to handle motors that draw up to about 2 Amps at 115V. Most BMS systems will have 24VAC as an output and will require a magnetic starter, Figure 29, where as PLCs can be customized with several different voltage outputs, but their current output is quite small and will need to be run through a magnetic starter as well.

A magnetic starter is similar to a relay, but intended for higher currents and they have overload protection on them to stop the motor if it exceeds its capacity. They are switched on via a small current that runs through a magnetic coil and pulls an armature to another position to switch on a much higher current through the contacts closed by the armature. Figure 35 shows a cutaway of a relay exposing the components within. The spring switches the magnetic starter off when the current is switched off to the coil.

The magnetic starter can also operate at two different voltages; the coil can be switched by 24VDC and the contacts can connect 240VAC. The correct motor starters should be chosen based on the horsepower and voltage of the motor and the available switching voltage from the controller.

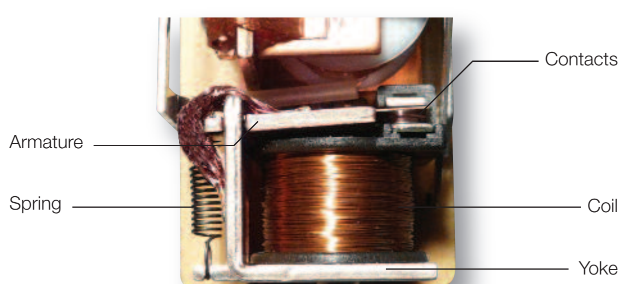


Figure 35: Magnetic starter.

The following table can be used to compute the current rating of the motor.

Motor Horsepower	115 V Single Phase	230 V Split phase	230V 3-phase	460V 3-phase
1/6	4.4	2.2	–	–
1/4	5.8	2.9	–	–
1/3	7.2	3.6	–	–
1/2	9.8	4.9	2.2	1.1
3/4	13.8	6.9	3.2	1.6
1	16	8.0	4.2	2.1
1 ½	20	10	6.0	3.0
2	24	12	6.8	3.4
3	34	17	9.6	4.8
5	56	28	15.2	7.6

Note that these are peak currents and may vary by motor. Consult the literature provided by the pump manufacturer to verify these values.

Variable Speed Control

It is desirable in solar systems to vary the motor speed depending on the amount of energy the solar system is collecting. This will help ensure the maximum output from the system and reduce the energy used to run the pumps within the system. A desired increase in temperature across the solar collector is set and the pump speed is varied to maintain this value. This is all handled in the controller.

Figure 36: Variable Frequency Drive (VFD).

For larger systems, a Variable Frequency Drive (VFD) is required. A VFD is a device that connects between the power supply and the pump and varies the frequency of the current going to the pump motor to achieve different speeds.
The speed of an AC motor is dependent on frequency of the power being fed to it; in the US, this is always 60 Hz.
The inverter can change this frequency and thus the rotational speed of the pump. A pump motor must be VFD duty rated in order to be used with a VFD.

The VFD needs an input from an outside control as to how fast it should spin the motor. This is usually a 0-10VDC, or 4-12mA signal. Some solar controllers can supply this output (see Table 9, page 93). Most BMS will have the option for an analog output and PLCs can be configured for this if specified in advance. There is a program in the inverter that will translate the signal from the controller into the motor speed that will need to be programmed, along with the motor parameters.

Often times the VFD is skipped in solar systems because of its additional expense and the difficulty of programming it. On large systems, the unit can pay for itself within a few years with the electricity saved and also provide an increase in the solar production. These systems generally last longer because the motor and pump aren't being driven as hard as a fixed speed set up and they are also not being switched on and off as frequently.

solar thermal system
controls, electrical components and monitoring

Valves

Motorized valves are also common components on solar thermal systems. They are used to divert flow from one place to another and are actuated by the controls when a certain set of conditions is met. Valves will commonly be either two way or three way valves.

A two way valve is a simple switch; in one position it will allow flow through and in the other it blocks it. Two way valves are usually used in pairs where one valve will open and another close to divert flow from one portion of the system to another. This is used commonly when shifting flow between tanks.

Three way valves are another common type of valve in solar systems. They consist of an inlet and two outlets where the flow will be diverted to depending on the position of the valve. One outlet is considered the normally open position of the valve where flow will be diverted when no power is applied to the valve and the other is the normally closed position where flow will be diverted when the valve is activated. Valves can be power open, spring return (as described above) or power open / power close where energy is required to change the state of the valve in either direction.

Figure 37: Motorized 3 Port Valve.

Valves will have voltage and current ratings on them as well. For smaller valves, they will not draw much current and can be connected to the controller directly. Larger valves will require a relay to operate properly. To switch the valve form one position to another, a small motor and gears are used.

Galderma R&D SNC,
SOPHIA ANTIPOLIS, BIOT, FRANCE

specification & performance data

thermomax heat pipe collectors specification

Part 1 – General

1.1 Related Documents

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Divisions 1 Specification Sections, apply to this section.

1.2 Summary

This section includes the evacuated tube solar collector.

1.3 References

A. SRCC OG-100 "Operating Guidelines for Certifying Solar Collectors"

B. SRCC TM1 "SDHW System and Component Test Protocols"

C. SRCC RM-1 "Methodology for Determining the Thermal Performance Ratings for Solar Collectors"

D. ASHRAE 93-2010 "Methods of Testing to Determine the Thermal Performance of Solar Collectors"

E. DIN EN 12975-1: 2006 "Thermal Solar Systems and Components – Solar Collectors – Part 1: General Requirements"

F. DIN EN 12975-2: 2006 "Thermal Solar Systems and Components – Solar Collectors – Part 2: Test Methods"

1.4 Submittals

A. Product Data: Include certification to SRCC OG-100, Solar Keymark EN 12975 Approval, DIN EN 12975-2: 2006 Impact Resistance Test Certification, Efficiency curves according to DIN EN 12975 and SRCC OG-100.

B. Collector Drawings: Include drawings showing collector dimensions, mounting bracket details and a stamped drawing showing that the collector can withstand winds up to 120 mph in the state the installation will take place. For installations with multiple collectors, a drawing detailing the sizes of the different banks shall also be included.

C. Installation Manual: A complete and comprehensive installation manual shall be included showing the manufacturer's recommended installation method.

D. Maintenance Data: Include the requirements for the solar working fluid and maintenance.

1.5 Regulatory Requirements

A. The collector shall be SRCC OG-100 certified.

B. The collector shall be certified to EN 12975

C. The collector shall meet the criteria for EN 12975-2: 2006 Impact Test (this is an optional test)

1.6 Warranty

A. Evacuated tubes shall be covered by a non-prorated 20 year manufacturer's warranty that will include loss of vacuum due to approved conditions.

B. Manifolds, frames and connection kits shall be covered by a 10 year non-prorated manufacturer's warranty.

Part 2 – Products

2.1 Manufacturers

A. Available Manufacturers: Manufacturer shall be a company specializing in manufacturing the products specified in this section with minimum twenty years experience. The solar collector shall be manufactured by a company that has achieved certification to the ISO 9001 Quality Management System.

B. The solar collector shall be SRCC OG-100 certified, DIN EN 12975 certified and listed as being energy star compliant.

C. Manufacturers: Kingspan Solar is the basis of design. Acceptable manufacturers shall be subject to compliance with the requirements.

2.2 Construction

A. Solar collectors shall be manufactured by Kingspan Solar model number HP-450 and shall be a fin in tube, dry connection heat pipe system.

B. The collector dimensions shall be 78” X 84” X 3 $^{3}/_{4}$”. The manifold shall be made from aluminum, EPDM rubber and have a copper header pipe. The manifold shall be insulated with melamine foam.

C. The evacuated tubes shall be made with lead free soda lime glass with transmission of at least 92% and will be 65mm (2 $^{5}/_{8}$”) in diameter.

D. The coating on the absorber plate shall be TiNOx with absorption of at least 96% and emission less than 4%.

E. The seal between the glass and the metal must be a fused hermetic seal.

F. A device within the heat pipe shall close at 275°F to limit the maximum temperature in the condenser head.

G. Heat pipes shall contain distilled water as the heat transfer fluid and have a bottom that is spun and welded during manufacture in order to provide protection against freezing.

H. The frames which the collector mounts to shall be made from extruded aluminum and include all of the necessary fittings to mount the collector to the frame. The fittings shall be placed in the correct locations at the factory to minimize the installation time of the frame. All clips and bolts shall be manufactured from stainless steel.

2.3 Performance

A. The efficiency of the collector, as defined by the SRCC on the gross area of the collector shall meet, or exceed the following conditions: Optical Efficiency at least 0.560, a_1 heat loss no more than -1.8 W/m^2°C, a_2 heat loss no more than -0.002 W/m^2°C^2.

B. The efficiency of the collector, as defined by the Solar Keymark EN 12975 on the aperture area of the collector shall meet, or exceed the following conditions: Optical Efficiency at least 0.75, a_1 heat loss no more than 1.18 W/m^2°C, a_2 heat loss no more than 0.010 W/m^2°C^2.

C. Collector output in the SRCC Class C category shall not drop more than 57% between sunny and cloudy days and for Class D shall not drop more than 68% between sunny and cloudy days.

Part 3 – Execution

3.1 Installation

Solar collectors shall be installed according to the manufacturer’s specifications.

3.2 Start-Up

Start up on the unit will be performed by factory trained and authorized personnel. A copy of the startup report will be provided to the owner.

thermomax heat pipe collectors
certification and ratings

CERTIFIED SOLAR COLLECTOR

SUPPLIER:
Kingspan Solar Inc.
7510 Montevideo Road
Jessup, MD 20794 USA
www.kingspansolar.com

BRAND:	Thermomax
MODEL:	HP450-30
COLLECTOR TYPE:	Tubular
CERTIFICATION #:	10001725
Original Certification:	August 10, 2012
Expiration Date:	May 31, 2024

The solar collector listed below has been evaluated by the Solar Rating & Certification Corporation™ (SRCC™) in accordance with SRCC OG-100, Operating Guidelines and Minimum Standards for Certifying Solar Collectors, and has been certified by the SRCC. This award of certification is subject to all terms and conditions of the Program Agreement and the documents incorporated therein by reference.

COLLECTOR THERMAL PERFORMANCE RATING							
Kilowatt-hours (thermal) Per Panel Per Day				Thousands of BTU Per Panel Per Day			
Climate -> Category (Ti-Ta)	High Radiation (6.3 kWh/m².day)	Medium Radiation (4.7 kWh/m².day)	Low Radiation (3.1 kWh/m².day)	Climate -> Category (Ti-Ta)	High Radiation (2000 Btu/ft².day)	Medium Radiation (1500 Btu/ft².day)	Low Radiation (1000 Btu/ft².day)
A (-5 °C)	14.2	10.8	7.3	A (-9 °F)	48.6	36.7	24.9
B (5 °C)	13.4	9.9	6.5	B (9 °F)	45.8	33.9	22.1
C (20 °C)	12.2	8.7	5.3	C (36 °F)	41.5	29.7	18.0
D (50 °C)	9.9	6.5	3.2	D (90 °F)	33.9	22.3	10.9
E (80 °C)	7.7	4.5	1.5	E (144 °F)	26.2	15.4	5.1

A- Pool Heating (Warm Climate) **B**- Pool Heating (Cool Climate) **C**- Water Heating (Warm Climate)
D- Space & Water Heating (Cool Climate) **E**- Commercial Hot Water & Cooling

COLLECTOR SPECIFICATIONS					
Gross Area:	4.178 m²	44.97 ft²	**Dry Weight:**	80 kg	176 lb
Net Aperture Area:	3.299 m²	35.51 ft²	**Fluid Capacity:**	1.7 liter	0.4 gal
Absorber Area:	3.037 m²	32.69 ft²	**Test Pressure:**	1103 kPa	160 psi

TECHNICAL INFORMATION				**Tested in accordance with:** Standard 100			
ISO Efficiency Equation [NOTE: Based on gross area and (P)=Ti-Ta]							
SI UNITS:	η= (0.560)	(-1.77810)*(P)/G	(-0.00180)*(P)²/G	**Y Intercept:**	0.560	**Slope:**	-1.877 W/m².°C
IP UNITS:	η= (0.560)	(-0.31338)*(P)/G	(-0.00018)*(P)²/G	**Y Intercept:**	0.560	**Slope:**	-0.331 Btu/hr.ft².°F

Incident Angle Modifier								Longitudinal Incident Angle Modifier at 50°:		0.98
θ	10	20	30	40	50	60	70	**Test Fluid:**	Water	
Kτα	0.99	1.00	1.00	0.99	0.98	0.97	0.93	**Test Mass Flow Rate:**	0.054 kg/(s m²)	39.807 lb/(hr ft²)

REMARKS:

Jim Huggins
Technical Director

SRCC OG-100 CERTIFIED

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TÜVRheinland®
DIN CERTCO

Summary of EN 12975 Test Results, annex to Solar KEYMARK Certificate Kurzfassung EN 12975 Test Ergebnisse, Anlage zum Solar KEYMARK-Zertifikat Synthèse des résultas d'essais selon EN 12975, annexe au certificat Solar KEYMARK	**Registration No.** Registernummer Numéro d'enregistrement	011-7S1793 R
	Date / Datum / Date	06.12.2011

Company / Firma / Société	Kingspan Renewables Ltd.	**Country**/Land/Pays	United Kingdom
Street / Straße / Rue	180 Gilford Road, Portadown Co. Armagh, Northern Ireland	**Website**	www.kingspansolar.com
Postal Code, Place / PLZ, Ort / Code postal, Place	BT63 5LF United Kingdom	**E-mail**	
		Tel. / Fax	+44 (0) 28 3836-4500 / -4501

Collector Type / Kollektorbauart / type de capteur: Evacuated tube / Vakuumröhrenkollektor / Capteur à tube sous vide

To be roof integrated / im Dach eingegliedert zu sein / pour etre intégré dans le toit: Yes / ja / oui

Product name Produktbezeichnung Modèle	**Aperture area** Aperturfläche Superficie d'entrée	**Gross length** Länge(Außenmaß) Longueuhors tout	**Gross width** Breite (Außenmaß) largeur hors tout	**Gross height** Höhe (Außenmaß) epaisseur hors tout	**Gross area** Bruttofläche Superficie hors-tout	**Power output per collector unit** Leistung je Kollektormodul Puissance fournie par le capteur {note 1} G = 1000 W/m² Tm-Ta : 0 K	10 K	30 K	50 K	70 K
	[m²]	[mm]	[mm]	[mm]	[m²]	[W]	[W]	[W]	[W]	[W]
Thermomax HP400 20	2.13	1 952	1 418	93	2.77	1 598	1 570	1 504	1 421	-
Thermomax HP450 20	2.13	1 952	1 418	93	2.77	1 598	1 570	1 504	1 421	1 322
Thermomax HP400 30	3.20	1 952	2 127	93	4.15	2 400	2 359	2 259	2 135	-
Thermomax HP450 30	3.20	1 952	2 127	93	4.15	2 400	2 359	2 259	2 135	1 987

Collector efficiency parameters related to aperture area Kollektorleistungsparameter bezogen auf die Aperturfläche Paramètres de performances thermiques rapportées à la superficie d'entrée {note 1}	η_{0a}	0.750	-
	a_{1a}	1.18	W/(m²K)
	a_{2a}	0.010	W/(m²K²)
Stagnation temperature / Stagnationstemperatur / Temperature de stagnation {note 2}	t_{stg}	167	°C
Effective thermal capacity / Effektive Wärmekapazität / Capacité thermique effective	$c_{eff} = C/A_a$	4.4	kJ/(m²K)
Max. operation pressure / max. Betriebsdruck / pression d'opération de maximum {note 3}	p_{max}	1000	kPa

Incidence angle modifiers Kθ(θ) Einfallswinkelkorrekturfaktoren Kθ(θ) Facteur d'angle d'incidence Kθ(θ)			θT / θL	50°	10°	20°	30°	40°	60°	70°
	Kθd	0.91	Kθ(θT)	0.99	1.01	1.02	1.04	1.04	0.90	
			Kθ(θL)	0.91	1.00	0.99	0.97	0.95	0.83	
					Optional values / Angaben optional / Données optionnelles					

Testing Laboratory / Prüflaboratorium / Laboratoire d'essais	Institut für Solarenergieforschung Hameln
Website	www.isfh.de
Test report id. number / Prüberichtsnummer / numéro d'identification de rapport des essais	123-11/KD; 67-11/KQ
Date of test report / Datum des Prüfberichts / date de rapport des essais	30.11.2011; 01.12.2011
Perf. test method / Leistungstestmethode / méthode d'essai de performance	EN 12975-2 6.1.5 (indoor/innen/intérieur)

Comments of testing laboratory / Kommentare des Prüflaboratoriums / commentaires du laboratoire d'essais :

The reported power output values are calculated for normal incidence.
For the Thermomax HP 400 the condenser of the evacuated tubes has a cut-off mechanism which starts operation at about 70°C and for the Thermomax HP 450 according to the manufacturer at about 130°C.
Die angegebenen Leistungswerte gelten für senkrechte Einstrahlung.
Der Kondensator der Vakuumröhren besitzt einen Abschaltmechanismus, der für den Thermomax HP 400 bei ca. 70°C beginnt anzusprechen und für den Thermomax HP 450 laut Herstellerangaben bei ca. 130°C.

Note 1	**Test conditions** Prüfbedingungen conditions d'essais	**Fluid** Flüssigkeit Liquide	Water Wasser Eau	**Flow rate** Durchfluss Débit	0.02	kg/s per m²	Institut für Solarenergieforschung GmbH Am Ohrberg 1 D-31860 Emmerthal Tel.: 0 51 51 / 999-100 Fax: 0 51 51 / 999-500
Note 2	**Irradiance** / Bestrahlungsstärke / Irradiance **G_s=1000 W/m²** **Ambient temperature** / Umgebungstemperatur / Temperature ambiante: **t_a=30 °C**						
Note 3	**Given by manufacturer** / Herstellerangaben / donnée par le fabricant						

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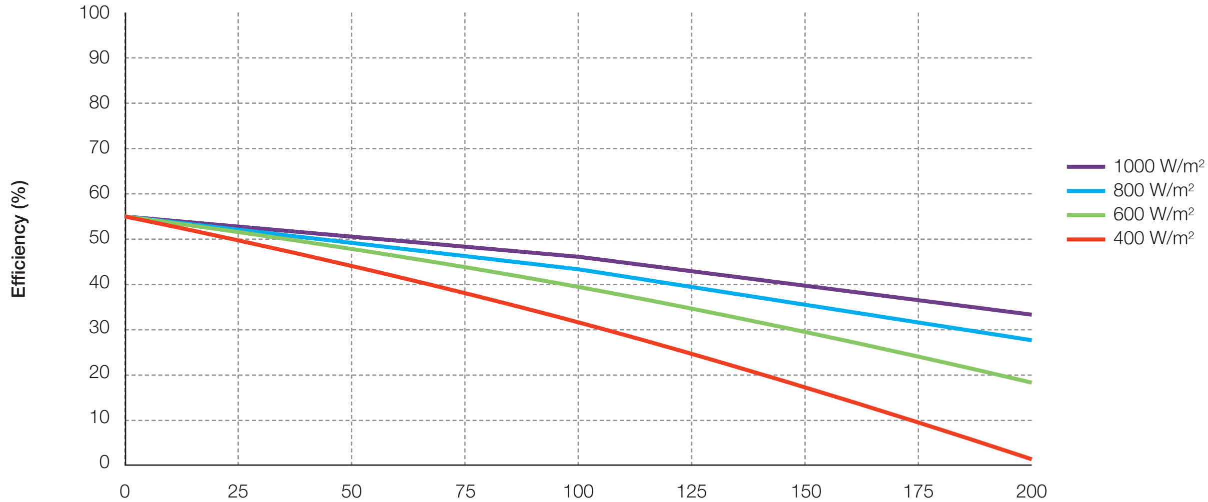
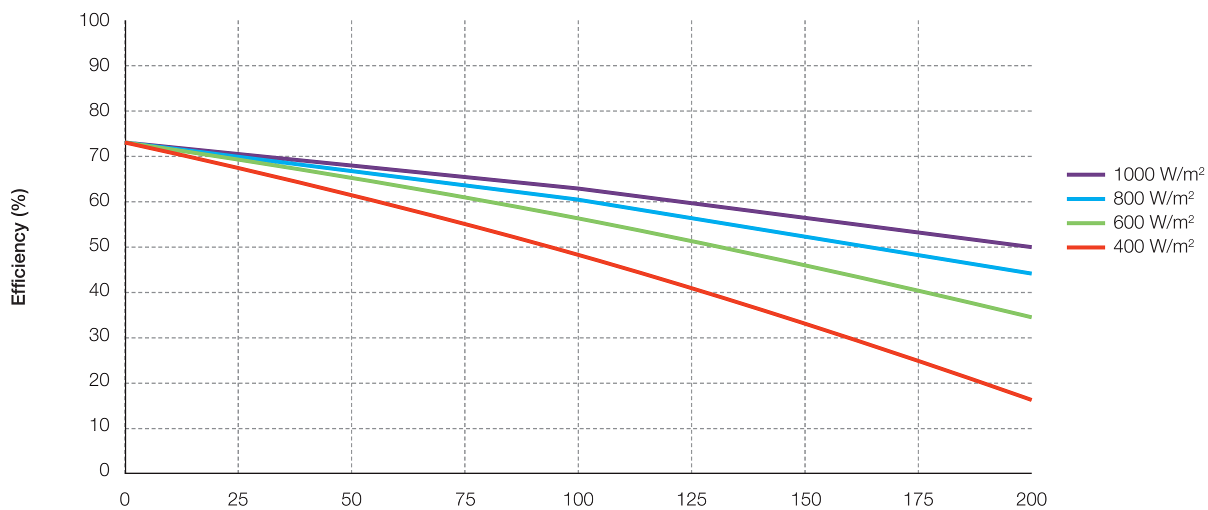
 scz, Stand/Edition: 10.07, Druck/Print: 09.12.2011

thermomax heat pipe collectors
efficiency plots

Efficiency – SRCC



Efficiency – Solar Keymark



Kingspan Environmental

thermomax heat pipe
hail impact test certification

TÜV Rheinland Immissionsschutz und Energiesysteme GmbH
Renewable Energies

Test Report

Impact resistance test in accordance with
DIN EN 12975-2:2006 using ice balls

TÜV Report No.: 21208924

Cologne, 28th of March 2008

Deutscher Akkreditierungs Rat
DAR

DAT-P-226/06-00

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The test results presented in this report only refer to the t[…]

TÜV Rheinland Immissionsschutz und Energiesysteme Gm[…]
D – 51105 Köln, Am Grauen Stein, Tel.: ++49-221/806-2477, Fax:[…]

TÜV Rheinland Immissionsschutz und Energiesysteme GmbH
Renewable Energies
Kollektoren\Thermomax\21208[…]

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TÜVRheinland®
Precisely Right.

Impact resistance test in accordance with DIN EN 12975-2:2006 using ice balls

Test conditions

Diameter of ball:	25	mm	(+/- 5%)
Mass of ball:	7.53	g	(+/- 5%)
Speed of ball:	23	m/s	(+/- 5 %)

Test procedure

Number of drops: 10

The Thermomax evacuated tube collector DF 100 was submitted in the Test Centre for Renewable Energies of the TÜV Immissionsschutz und Energiesysteme GmbH for an examination on impact resistance with ice balls according to DIN EN 12975-2:2006. The individual shots were shot from a maximum distance of 10 cm perpendicularly to the manifold box on the glass tubes. After each shot the point of impact was submitted to a visual check and the test equipment was positioned over the next tube. The maximum number of shots per tube has been two.

1.1 Test results

During the testing no major visual defects were detected, so that the collector met the pass criteria for impact resistance test with ice balls according to DIN EN 12975-2.

Cologne, 28th of March 2008

Responsible for collector qualification testing

Business Field Manager Renewable Energies

TÜV Rheinland Immissionsschutz und Energiesysteme GmbH
Renewable Energies
T:\435\2008\Solarthermie\ST-Kollektoren\Thermomax\21208924_Thermomax\Bericht\21208924_Report_Thermomax.doc

specification & performance data

thermomax heat pipe
warranty statement

Kingspan Solar Warranty Statement for Solar

Subject to the following provisions, Kingspan Solar warrants that the Goods will be free from defects in material and workmanship for a period of 20 years in relation to VACUUM TUBES and a period of 5 years for MANIFOLDS and KITS from their date of manufacture. "RESTRICTED PRODUCTS" are limited to a period of 12 months warranty.
The warranty is given by Kingspan Solar subject to the following conditions:

A. The 20 year warranty period on Vacuum Tubes is conditional on installation by a Kingspan Solar Approved Installer, and subject to the collector(s) being properly maintained according to the manufacturer's recommendations. (See Thermomax Installation Manual for further details). Otherwise a default 5 year warranty period on Vacuum Tubes applies.

B. Kingspan Solar shall be under no liability in respect of any defect in the Goods arising from any information drawing design or specification supplied by the Buyer.

C. Kingspan Solar shall be under no liability in respect of any defect arising from fair wear and tear, wilful or accidental damage, negligence, abnormal working conditions, failure to follow the Kingspan Solar's instructions, misuse or alteration or repair of the Goods without approval.

D. The above warranty does not extend to parts materials equipment not manufactured by Kingspan Renewables in respect of which the Buyer shall only be entitled to the benefit of any such warranty or guarantee as is given by the manufacturer to the Company.

E. The defect has been reported by the Buyer to Kingspan Solar within the warranty period.

F. The installation of the Goods having been carried out by fully trained and competent person(s).

G. The Goods having been subjected to neither "prolonged stagnation conditions" nor exhibiting signs of "extreme temperature exposure".

1. The Buyer shall not make any statement or representation or give any warranty to any third party in respect of any Goods other than in the terms made or given by Kingspan Solar to the Buyer nor shall the Buyer have any authority to commit Kingspan Solar to provide any service in relation to the Goods.

2. The Company's liability to the Buyer for death or injury resulting from its own or that of its employees' agents' or subcontractors' negligence and damage suffered by the Buyer as a result of any breach of the obligations implied by Section 12 of The Sale of Goods Act 1979 shall not be limited.

3. If Kingspan Solar fails to deliver the Goods for any reason other than any cause beyond the Company's reasonable control or the Buyer's fault then Kingspan Solar shall only be liable to the Buyer for and the Company's liability shall be limited to the excess (if any) of the cost to the Buyer (in the cheapest available market) of similar goods to replace those not delivered over the Price of the Goods.

4. The Buyer shall examine all delivered Goods forthwith. Any claim based on any defect in the quality or condition of the Goods or their failure to correspond with specification shall be notified to Kingspan Solar within 7 days from the delivery date or where the defect was not apparent on reasonable inspection within a reasonable time after discovery of the failure. If delivery is not refused and the Buyer does not notify Kingspan Solar the Buyer shall not be entitled to reject the Goods.

5. Kingspan Solar shall be entitled to examine any Goods, which are the subject of any claim by the Buyer, and to remove such Goods or any part thereof for testing. No tests carried out by the Buyer will be recognized by Kingspan Solar unless carried out strictly in accordance with a method previously agreed by Kingspan Solar as being suitable for the purpose.

6. Any valid claim in respect of the Goods which is based on any defect in the quality or condition of the Goods or their failure to meet specification is notified to Kingspan Solar in accordance with these Conditions. Kingspan Solar shall be entitled to repair or replace the Goods (or the part in question) free of charge or at the Company's sole discretion refund to the Buyer the Price (or a proportionate part of the Price) but Kingspan Solar shall have no further liability to the Buyer.

7. Kingspan Solar shall not be liable to the Buyer by reason of any representation (unless fraudulent) or any implied warranty condition or other term or any duty at common law (including but without limitation the negligence of Kingspan Solar its employees agents or otherwise) or under the express terms of the Contract for any loss of production loss of profits or anticipated profits loss of contracts operation time or anticipated savings loss of business or of expected further business loss of or corruption to data damage to the Buyer's reputation or goodwill damages costs or expenses payable by the Buyer to any third party or any other indirect special or consequential loss or damage or claim (whether caused by the negligence of Kingspan Solar its employees agents or otherwise) which arise out of or in connection with the supply of the Goods or their use or resale by the Buyer.

8. Without prejudice to the provisions of clauses 3, 4, 5, 6 and 7 the entire liability of the Buyer under or in connection with the Contract shall not exceed the Price of the Goods.

9. Kingspan Solar shall not be liable to the Buyer or be deemed to be in breach of the contract by reason of any delay in performing or any failure to perform any of the Company's obligations in relation to the Goods if the delay or failure was due to any cause beyond the Company's reasonable control. Without limiting the foregoing, due to causes beyond the Company's reasonable control.

10. For comprehensive details regarding "Warranties and Liability" please refer to the "CONDITIONS OF SALES" section 7.

varisol collectors
certification and ratings

CERTIFIED SOLAR COLLECTOR

SUPPLIER:
Kingspan Solar Inc.
7510 Montevideo Road
Jessup, MD 20794 USA
www.kingspansolar.com

BRAND:	Varisol
MODEL:	Varisol DF
COLLECTOR TYPE:	Tubular
CERTIFICATION #:	10001724
Original Certification:	September 06, 2012
Expiration Date:	May 31, 2024

The solar collector listed below has been evaluated by the Solar Rating & Certification Corporation™ (SRCC™) in accordance with SRCC OG-100, Operating Guidelines and Minimum Standards for Certifying Solar Collectors, and has been certified by the SRCC. This award of certification is subject to all terms and conditions of the Program Agreement and the documents incorporated therein by reference.

COLLECTOR THERMAL PERFORMANCE RATING

Kilowatt-hours (thermal) Per Panel Per Day				Thousands of Btu Per Panel Per Day			
Climate -> Category (Ti-Ta)	High Radiation (6.3 kWh/m².day)	Medium Radiation (4.7 kWh/m².day)	Low Radiation (3.1 kWh/m².day)	Climate -> Category (Ti-Ta)	High Radiation (2000 Btu/ft².day)	Medium Radiation (1500 Btu/ft².day)	Low Radiation (1000 Btu/ft².day)
A (-5 °C)	10.1	7.7	5.2	A (-9 °F)	34.5	26.1	17.7
B (5 °C)	9.6	7.1	4.6	B (9 °F)	32.7	24.3	15.9
C (20 °C)	8.7	6.3	3.8	C (36 °F)	29.8	21.3	13.0
D (50 °C)	7.1	4.7	2.3	D (90 °F)	24.3	16.0	7.9
E (80 °C)	5.4	3.1	1.0	E (144 °F)	18.3	10.7	3.4

A- Pool Heating (Warm Climate) **B-** Pool Heating (Cool Climate) **C-** Water Heating (Warm Climate)
D- Space & Water Heating (Cool Climate) **E-** Commercial Hot Water & Cooling

COLLECTOR SPECIFICATIONS					
Gross Area:	2.793 m²	30.06 ft²	**Dry Weight:**	43 kg	95 lb
Net Aperture Area:	2.083 m²	22.42 ft²	**Fluid Capacity:**	5.9 liter	1.6 gal
Absorber Area:	1.980 m²	21.31 ft²	**Test Pressure:**	896 kPa	130 psi

TECHNICAL INFORMATION		**Tested in accordance with:** ISO 9806			
ISO Efficiency Equation [NOTE: Based on gross area and (P)=Ti-Ta]					
SI UNITS:	η= 0.599 - 1.74950 *(P)/G - 0.00440 *(P)²/G	**Y Intercept:**	0.599	**Slope:**	-1.994 W/m².°C
IP UNITS:	η= 0.599 - 0.30834 *(P)/G - 0.00043 *(P)²/G	**Y Intercept:**	0.599	**Slope:**	-0.351 Btu/hr.ft².°F

Transverse Incident Angle Modifier								**Longitudinal Incident Angle Modifier at 50°:**		0.98
θ	10	20	30	40	50	60	70	**Test Fluid:**	Water	
Kτα	1.00	0.99	0.98	0.97	0.93	0.86	0.64	**Test Mass Flow Rate:**	0.0201 kg/(s m²)	14.78 lb/(hr ft²)

REMARKS:

Jim Huggins
Technical Director

www.solar-rating.org ♦ 400 High Point Drive, Suite 400 ♦ Cocoa, Florida 32926 ♦ (321) 213-6037 ♦ Fax (321) 821-0910

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flat plate collectors
specification

Part 1 – General

1.1 Related Documents

Drawings and general provisions of the Contract, including General and Supplementary Conditions and Divisions 1 Specification Sections, apply to this section.

1.2 Summary

This section includes the flat plate solar collector.

1.3 References

A. SRCC OG-100 "Operating Guidelines for Certifying Solar Collectors"

B. SRCC TM1 "SDHW System and Component Test Protocols"

C. SRCC RM-1 "Methodology for Determining the Thermal Performance Ratings for Solar Collectors"

D. ASHRAE 93-2010 "Methods of Testing to Determine the Thermal Performance of Solar Collectors"

E. DIN EN 12975-1:2006 "Thermal Solar Systems and Components – Solar Collectors – Part 1: General Requirements"

F. DIN EN 12975-2:2006 "Thermal Solar Systems and Components – Solar Collectors – Part 2: Test Methods"

1.4 Submittals

A. Product Data: Include certification to SRCC OG-100, Solar Keymark EN12975 Approval, DIN EN 12975-2:2006 Impact Resistance Test Certification, Efficiency curves according to DIN EN12975 and SRCC OG-100.

B. Collector Drawings: Include drawings showing collector dimensions, mounting bracket details and a stamped drawing showing that the collector can withstand winds up to 120 mph in the state the installation will take place. For installations with multiple collectors, a drawing detailing the sizes of the different banks shall also be included.

C. Installation Manual: A complete and comprehensive installation manual shall be included showing the manufacturer's recommended installation method.

D. Maintenance Data: Include the requirements for the solar working fluid and maintenance.

1.5 Regulatory Requirements

A. The collector shall be SRCC OG-100 certified.

B. The collector shall be certified to EN 12975.

1.6 Warranty

A. Flat plate collectors shall be covered by a non-prorated 10 year manufacturer's warranty.

B. Manifolds, frames and connection kits shall be covered by a 10 year non-prorated manufacturer's warranty.

Part 2 – Products

2.1 Manufacturers

A. Available Manufacturers: Manufacturer shall be a company specializing in manufacturing the products specified in this section with minimum twenty years' experience. The solar collector shall be manufactured by a company that has achieved certification to the ISO 9001Quality Management System.

B. The solar collector shall be SRCC OG-100 certified, DIN EN 12975 certified.

C. Manufacturers: Kingspan Solar is the basis of design. Acceptable manufacturers shall be subject to compliance with the requirements.

2.2 Construction

A. Solar collectors shall be manufactured by Kingspan Solar model number FP240 and shall be a single collector sheet harp design flat plate collector.

B. The collector dimensions shall be 79 1/2" X 38 3/4" X 3 1/8". The collector frame material shall be single piece stainless steel design.

C. The sides and back of the collector shall be insulated with rock wool insulation with a minimum thickness on the back of 1 1/2".

D. The piping and absorber plate shall be manufactured fo copper ant the two parts be ultrasonically welded to each other during manufacture.

E. The coating on the absorber plate shall be TiNOx with absorption of at least 96% and emission less than 4%.

F. The glass shall be attached to the collector frame by using adhesive at the factory.

G. The frames which the collector mounts to shall be made from extruded aluminum and include all of the necessary fittings to mount the collector to the frame. All clips and bolts shall be manufactured from stainless steel.

2.3 Performance

A. The efficiency of the collector, as defined by the SRCC on the gross area of the collector shall meet, or exceed the following conditions: Optical Efficiency at least 0.743, a1 heat loss no more than -3.8 W/m^2°C, a2 heat loss no more than -0.00358 W/m^2°C^2.

B. The efficiency of the collector, as defined by the Solar Keymark EN 12975 on the aperture area of the collector shall meet, or exceed the following conditions: Optical Efficiency at least 0.81, a1 heat loss no more than 4.25

Part 3 – Execution

3.1 Installation

Solar collectors shall be installed according to the manufacturer's specifications.

3.2 Start-Up

Start up on the unit will be performed by factory trained and authorized personnel. A copy of the startup report will be provided to the owner.

flat plate collectors
certification and ratings

SOLAR COLLECTOR CERTIFICATION AND RATING

SRCC OG-100

CERTIFIED SOLAR COLLECTOR

SUPPLIER:	**Kingspan Solar Inc.** 7510 Montevideo Road Jessup, MD 20794 USA
MODEL:	FP200
COLLECTOR TYPE:	Glazed Flat Plate
CERTIFICATION#:	2011060A

COLLECTOR THERMAL PERFORMANCE RATING

kWh Per Panel Per Day			
CATEGORY (Ti-Ta)	CLEAR DAY	MILDLY CLOUDY	CLOUDY DAY
A (-5 °C)	9.0	6.8	4.6
B (5 °C)	8.2	6.0	3.8
C (20 °C)	6.9	4.8	2.7
D (50 °C)	4.8	2.8	0.9
E (80 °C)	2.9	1.1	0.0

Thousands of BTU Per Panel Per Day			
CATEGORY (Ti-Ta)	CLEAR DAY	MILDLY CLOUDY	CLOUDY DAY
A (-9 °F)	30.7	23.2	15.8
B (9 °F)	27.9	20.4	13.0
C (36 °F)	23.7	16.4	9.1
D (90 °F)	16.3	9.4	3.0
E (144 °F)	9.9	3.8	0.0

A - Pool Heating (Warm Climate) **B** - Pool Heating (Cool Climate) **C** - Water Heating (Warm Climate) **D** - Water Heating (Cool Climate) **E** - Air Conditioning

Original Certification Date: 27-JUN-11

COLLECTOR SPECIFICATIONS

Gross Area:	1.990 m^2	21.42 ft^2	**Net Aperature Area:**	1.87 m^2	20.17 ft^2
Dry Weight:	34.0 kg	75 lb	**Fluid Capacity:**	1.0 liter	0.3 gal
Test Pressure:	1103 KPa	160 psig			

COLLECTOR MATERIALS

Frame:	Stainless Steel	**Absorber Material:**	Tube - Copper / Plate - Copper
Cover (Outer):	Tempered Glass	**Absorber Coating:**	Selective
Cover (Inner):		**Insulation Back:**	Rock Wool
		Insulation Side:	Rock Wool

TECHNICAL INFORMATION

Efficiency Equation [NOTE: Based on gross area and (P)=Ti-Ta]	Y INTERCEPT	SLOPE
SI Units: η= 0.740 -3.79260 (P)/I -0.00356 $(P)^2/I$	0.743	-4.089 W/m^2.°C
IP Units: η= 0.743 -0.66807 (P)/I -0.00035 $(P)^2/I$	0.743	-0.720 Btu/hr.ft^2.°F

Incident Angle Modifier [(S)=1/cosθ - 1, 0°< <=60°]

Model Tested: 2009050A

K&tauα = 1	-0.051 (S)	-0.111 $(S)^2$	**Test Fluid:**	Ethylene Glycol
K&tauα = 1	-0.16 (S)	Linear Fit	**Test Flow Rate:**	22.3 ml /s.m^2 0.0329 gpm/ft^2

REMARKS: Collector tested with long axis of tubes oriented north-south. IAM perpendicular to the tubes is listed above. IAM parallel to the tubes = 1.0 - 0.16(S)

SOLAR COLLECTOR CERTIFICATION AND RATING

SRCC OG-100

CERTIFIED SOLAR COLLECTOR

SUPPLIER:	**Kingspan Solar Inc.** 7510 Montevideo Road Jessup, MD 20794 USA
MODEL:	FP240
COLLECTOR TYPE:	Glazed Flat Plate
CERTIFICATION#:	2011060B

COLLECTOR THERMAL PERFORMANCE RATING

kWh Per Panel Per Day			
CATEGORY (Ti-Ta)	CLEAR DAY	MILDLY CLOUDY	CLOUDY DAY
A (-5 °C)	10.7	8.1	5.6
B (5 °C)	9.6	7.1	4.6
C (20 °C)	8.3	5.7	3.2
D (50 °C)	5.6	3.3	1.1
E (80 °C)	3.5	1.4	0.0

Thousands of BTU Per Panel Per Day			
CATEGORY (Ti-Ta)	CLEAR DAY	MILDLY CLOUDY	CLOUDY DAY
A (-9 °F)	36.3	27.7	19.0
B (9 °F)	32.9	24.2	15.5
C (36 °F)	28.1	19.5	10.9
D (90 °F)	19.2	11.3	3.7
E (144 °F)	11.8	4.7	0.0

A - Pool Heating (Warm Climate) **B** - Pool Heating (Cool Climate) **C** - Water Heating (Warm Climate)
D - Water Heating (Cool Climate) **E** - Air Conditioning

Original Certification Date: 27-JUN-11

COLLECTOR SPECIFICATIONS

Gross Area:	2.410 m²	25.94 ft²
Dry Weight:	41.0 kg	90 lb
Test Pressure:	1103 KPa	160 psig
Net Aperature Area:	2.28 m²	24.54 ft²
Fluid Capacity:	1.1 liter	0.3 gal

COLLECTOR MATERIALS

Frame:	Stainless Steel
Cover (Outer):	Tempered Glass
Cover (Inner):	
Absorber Material:	Tube - Copper / Plate - Copper
Absorber Coating:	Selective
Insulation Back:	Rock Wool
Insulation Side:	Rock Wool

TECHNICAL INFORMATION

Efficiency Equation [NOTE: Based on gross area and (P)=Ti-Ta]	Y INTERCEPT	SLOPE
SI Units: $\eta = 0.743 \; -3.80070 \, (P)/I \; -0.00358 \, (P)^2/I$	0.747	-4.089 W/m².°C
IP Units: $\eta = 0.743 \; -0.66949 \, (P)/I \; -0.00035 \, (P)^2/I$	0.747	-0.722 Btu/hr.ft².°F

Incident Angle Modifier [(S)=1/cosθ - 1, 0°< <=60°]

Model Tested: 2009050A

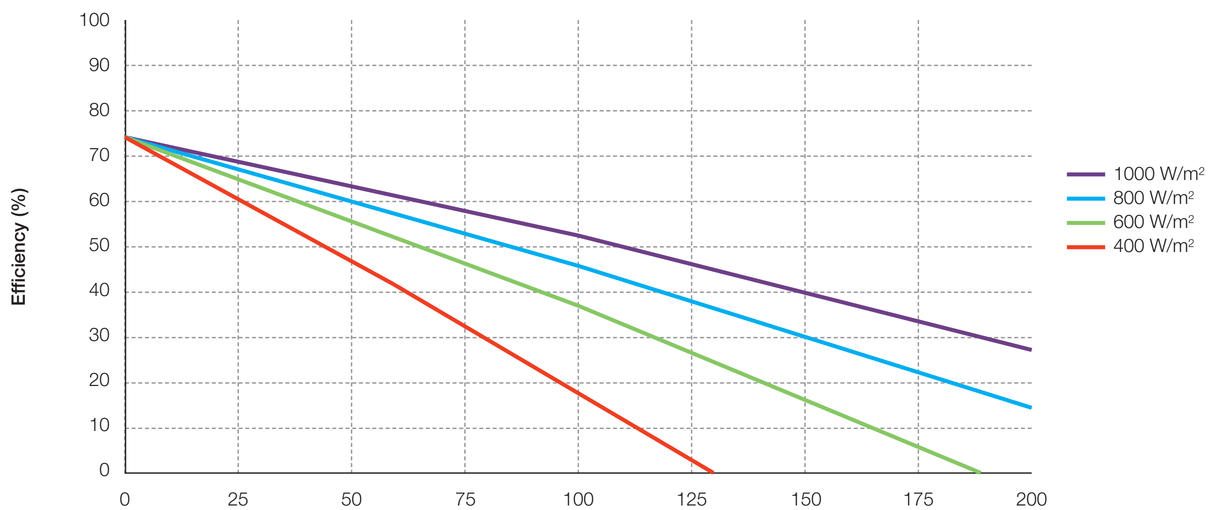
$K\&tau\alpha = 1$	-0.051 (S)	-0.111 $(S)^2$
$K\&tau\alpha = 1$	-0.16 (S)	Linear Fit

Test Fluid:	Ethylene Glycol
Test Flow Rate:	22.3 ml /s.m² 0.0329 gpm/ft²

REMARKS: Collector tested with long axis of tubes oriented north-south. IAM perpendicular to the tubes is listed above. IAM parallel to the tubes = 1.0 - 0.16(S)

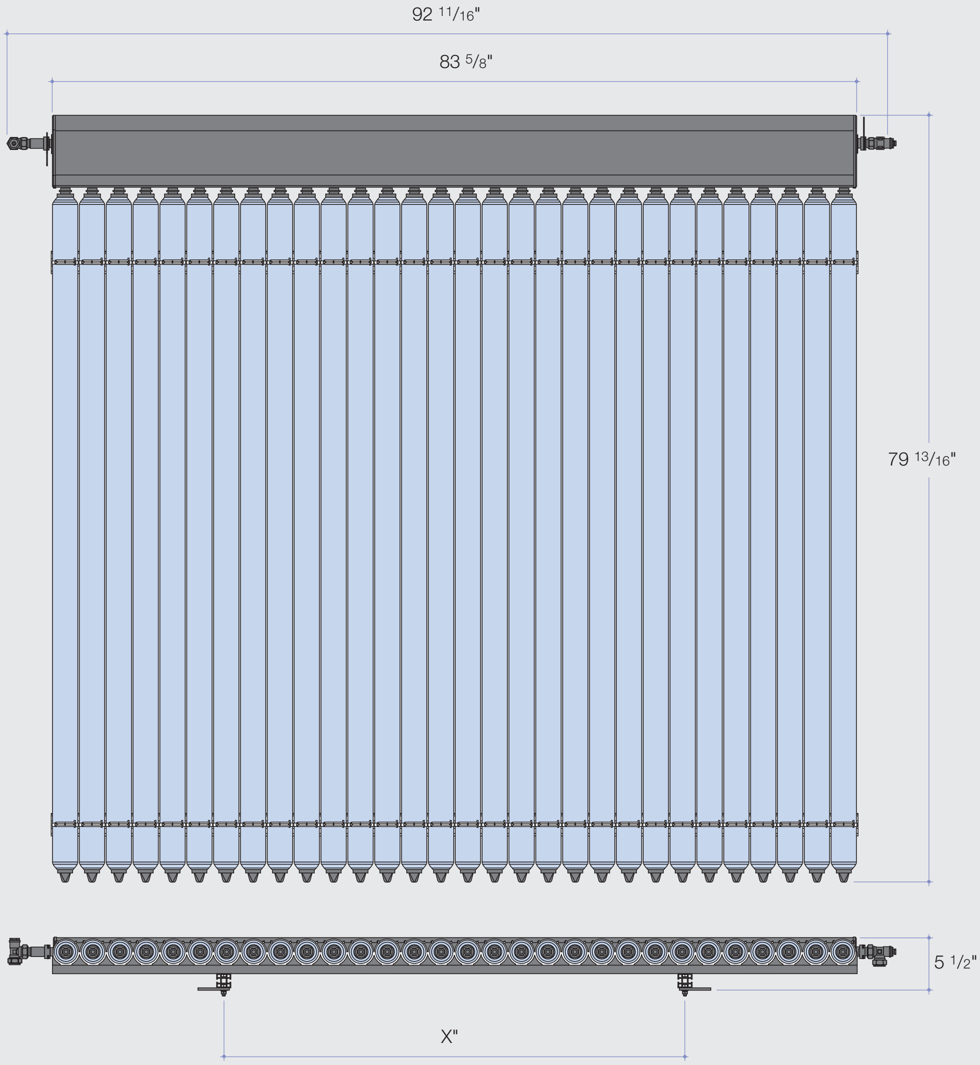
flat plate collectors
efficiency plots

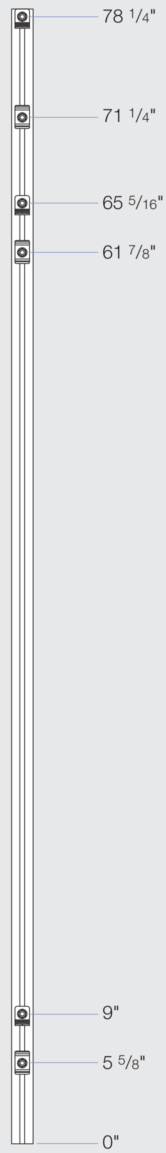
Efficiency – SRCC



technical details

thermomax heat pipe collector
joint plate frame



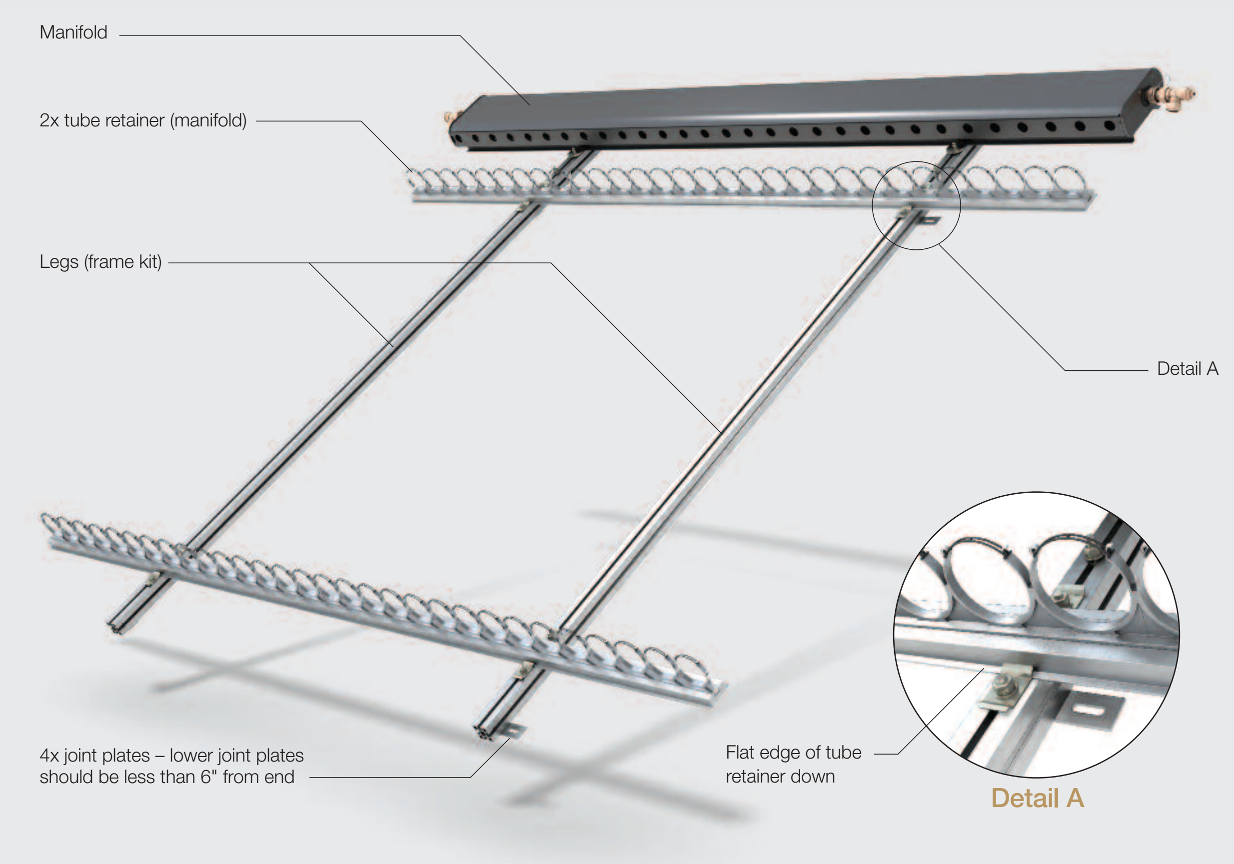


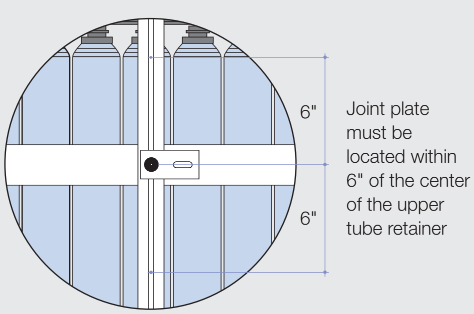
Clip Placement

"X" Min	"X" Max
44"	52"

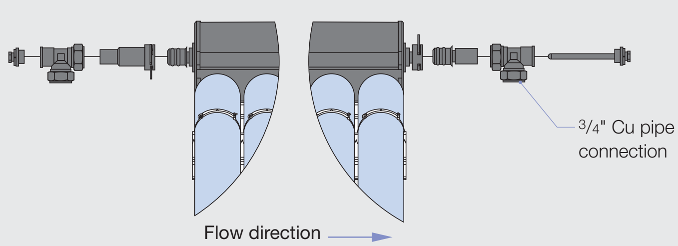
Notes:

1 Collector shall not be located on an overhang





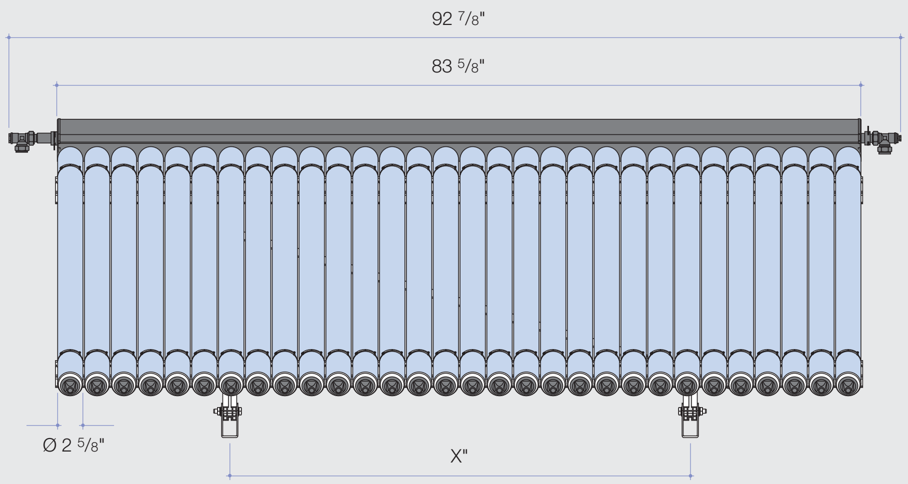
Detail Joint Plate



Return Flow

technical details

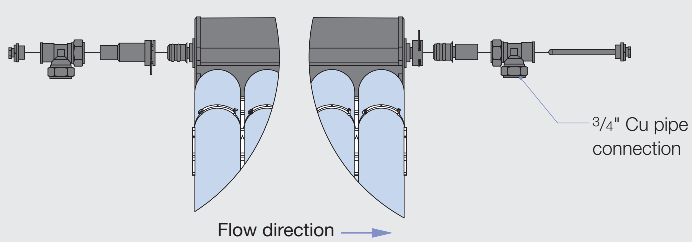
thermomax heat pipe collector
20° frame

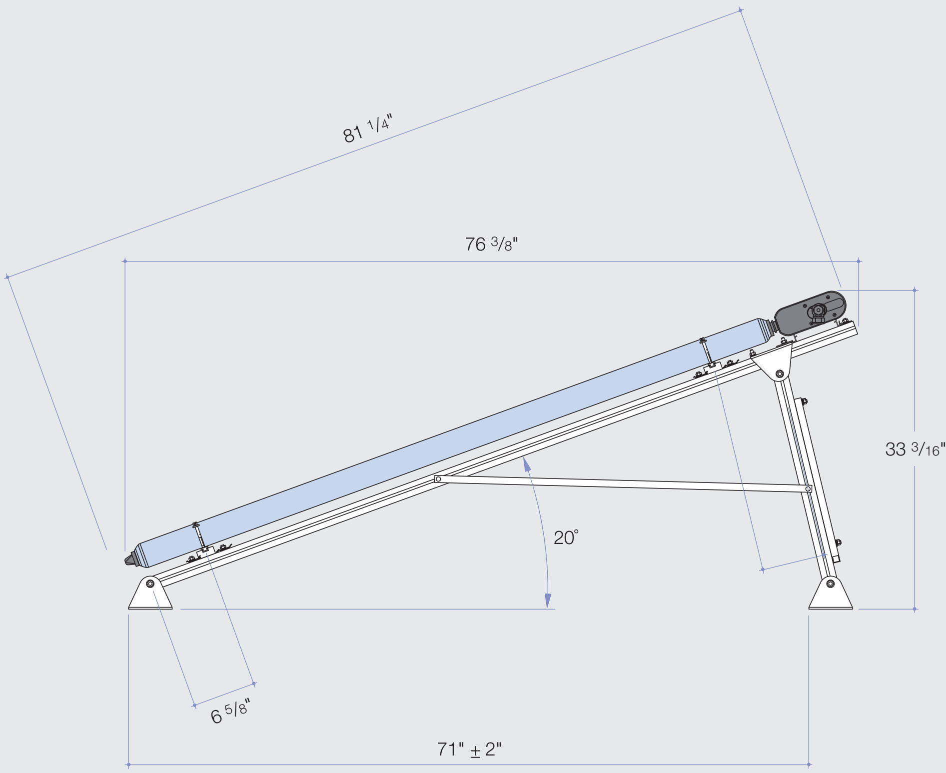


"X" Min	"X" Max
44"	52"
48"	52"

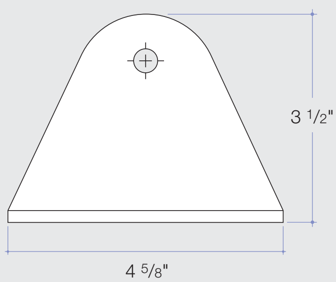
Notes:

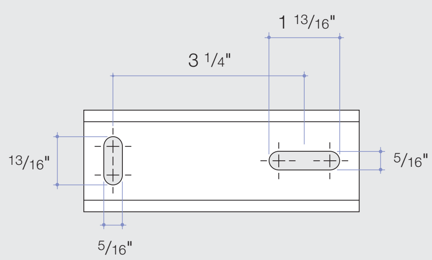
1. For wind speeds in excess of 110 mph and roof slopes less than 7:12, 48" is minimum
2. Collector shall not be located on an overhang





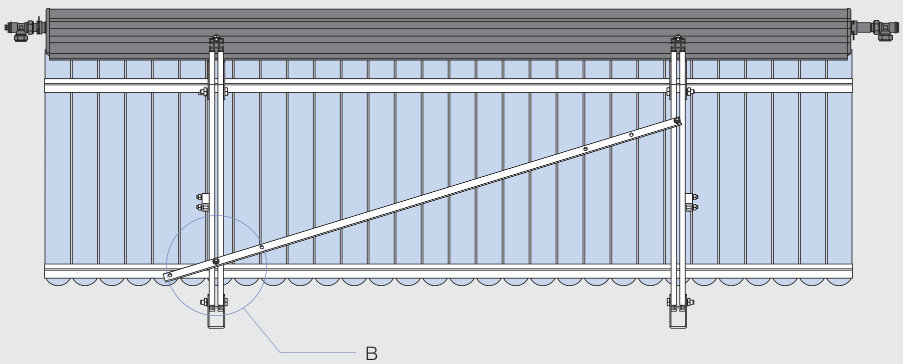
Roof Slope (x/12)	Collector Angle
0	20°
1	24.8°
2	29.5°
3	34.0°
4	38.4°
5	42.6°
6	46.6°
7	50.3°
8	53.7°
9	56.9°
10	59.8°
11	62.5°
12	65.0°

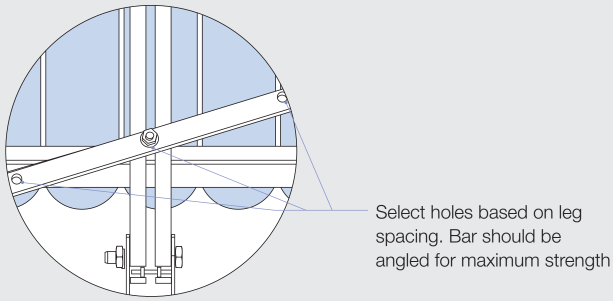




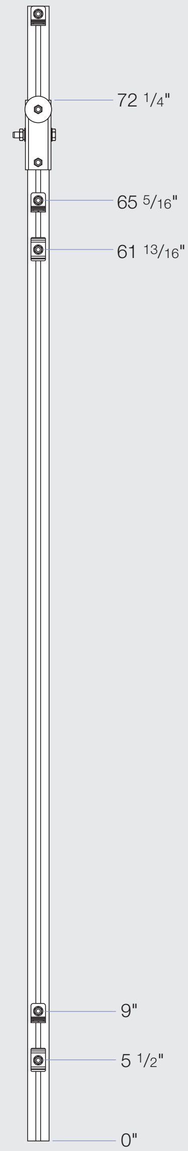
Refer to HP-450 installation manual for assembly instructions.

thermomax heat pipe collector
20° frame

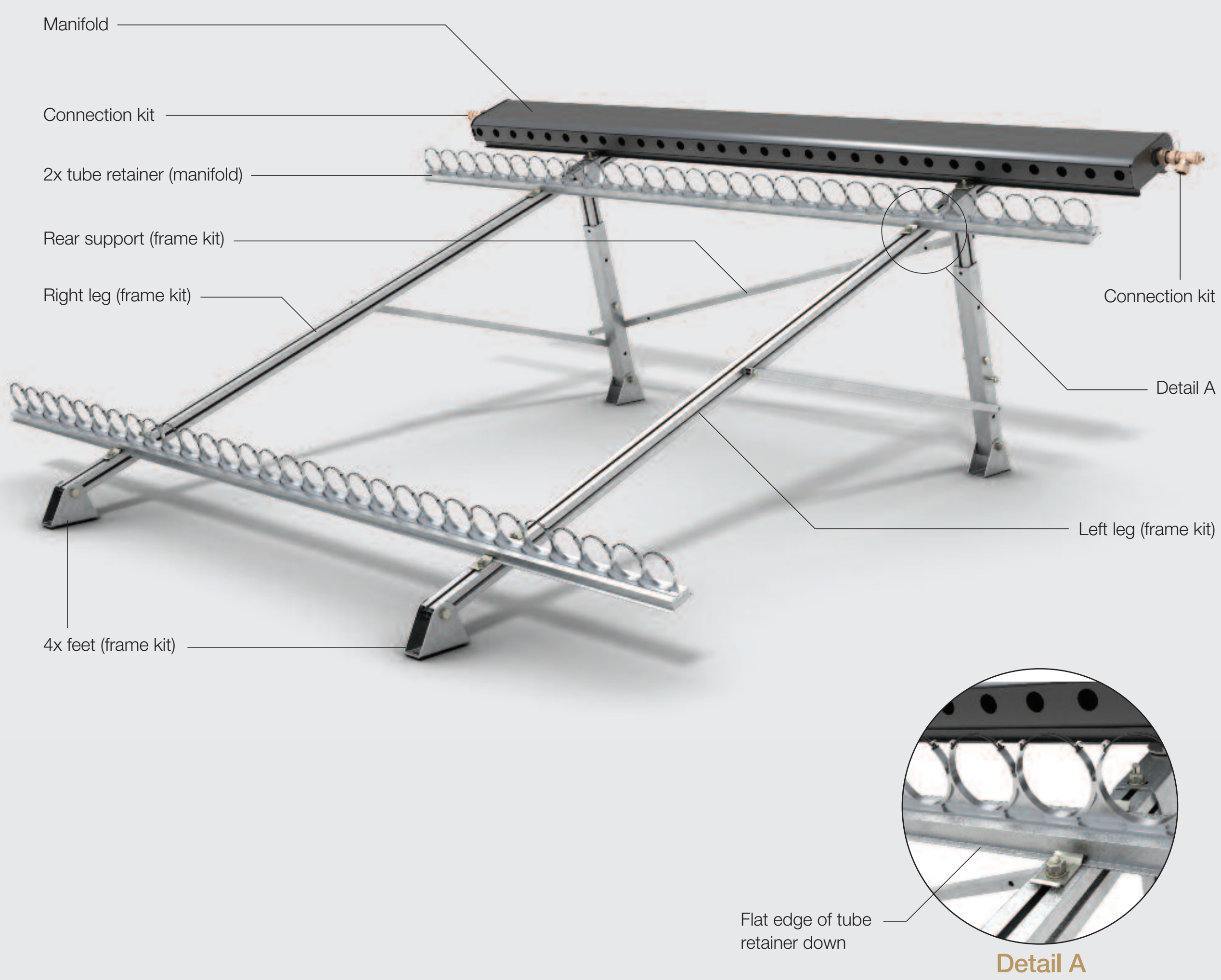




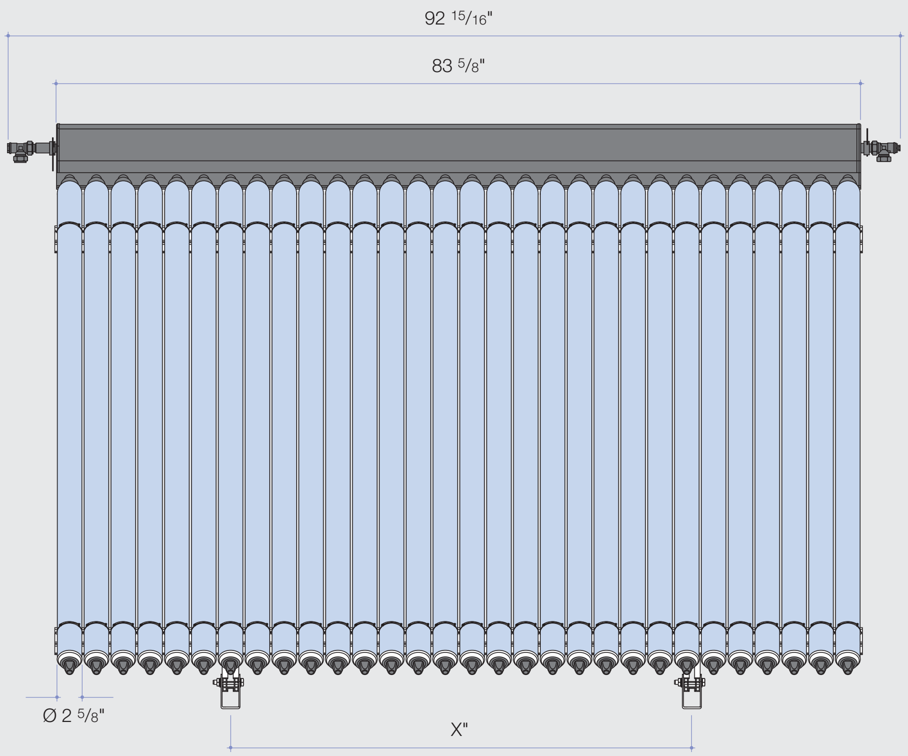
Detail B



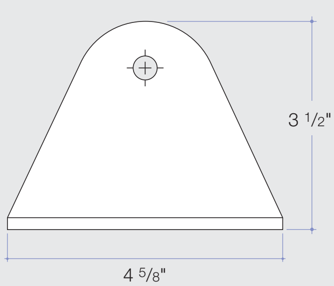
Clip Placement

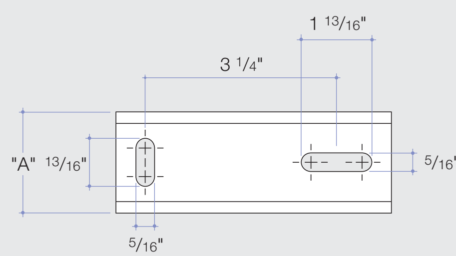

Manifold
Connection kit
2x tube retainer (manifold)
Rear support (frame kit)
Right leg (frame kit)
Connection kit
Detail A
Left leg (frame kit)
4x feet (frame kit)
Flat edge of tube
retainer down
Detail A

thermomax heat pipe collector
variable frame

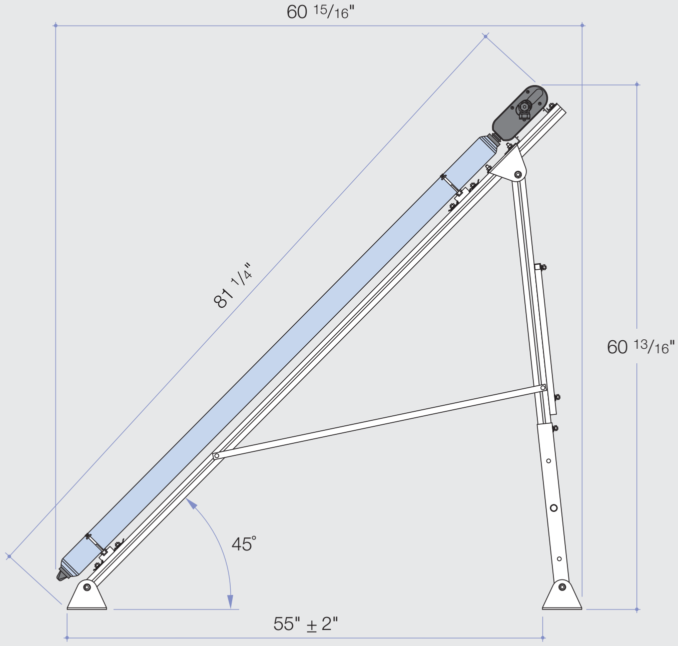


"X" Min	"X" Max
31 1/2"	52"

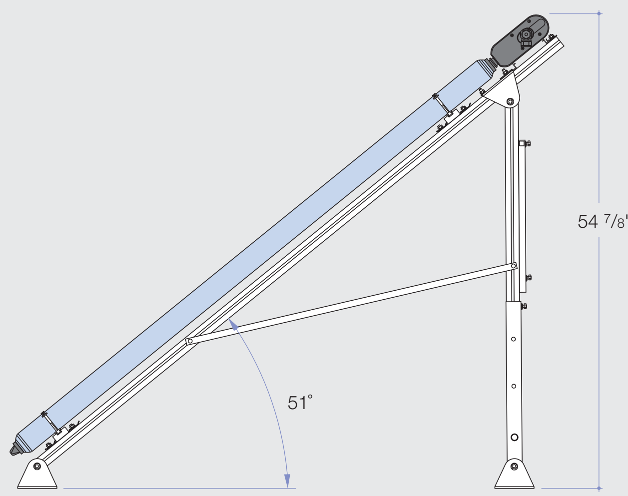




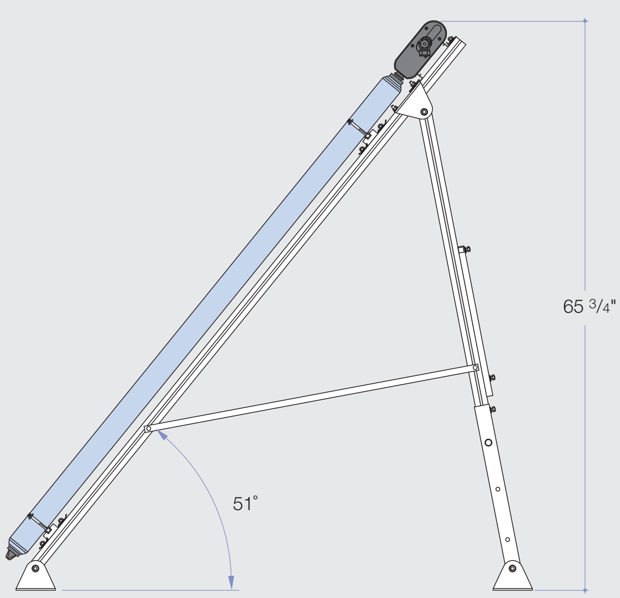
"A"	
Front	Back
1 11/16"	2"



Middle position



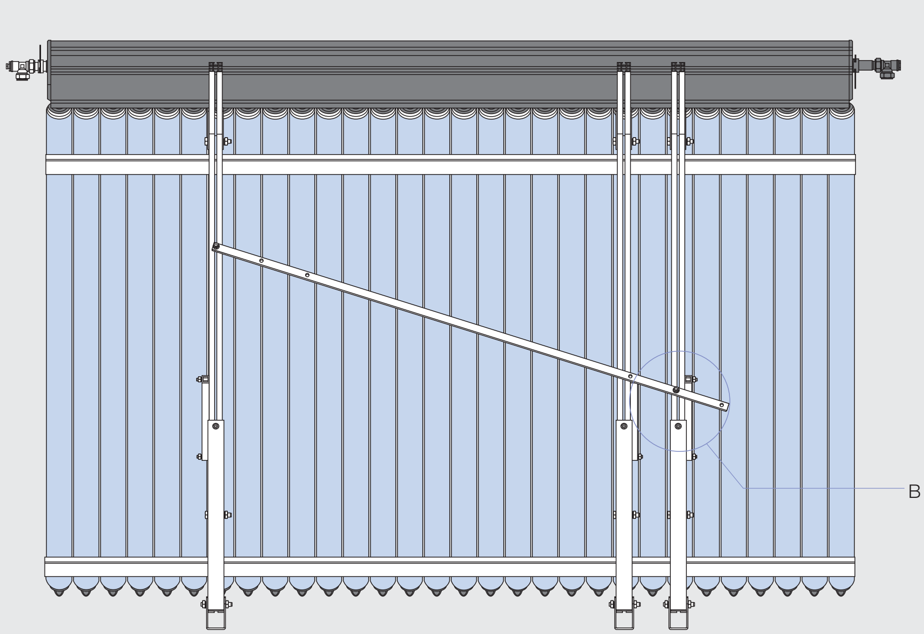
Lower position

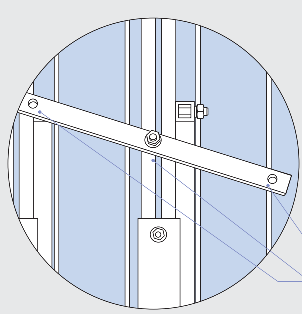


Upper position

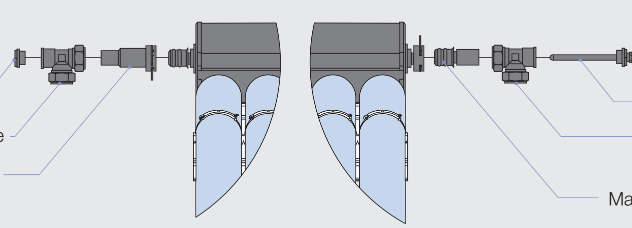
Roof Slope (x/12)	Lower Position	Middle Position	Upper Position
0	39	45	51
1	43.8	49.8	55.8
2	48.5	54.5	60.5
3	53.0	59.0	65.0
4	57.4	63.4	69.4
5	61.6	67.6	73.6
6	65.6	71.6	77.6
7	69.3	75.3	81.3
8	72.7	78.7	84.7
9	75.9	81.9	87.9

thermomax heat pipe collector
variable frame



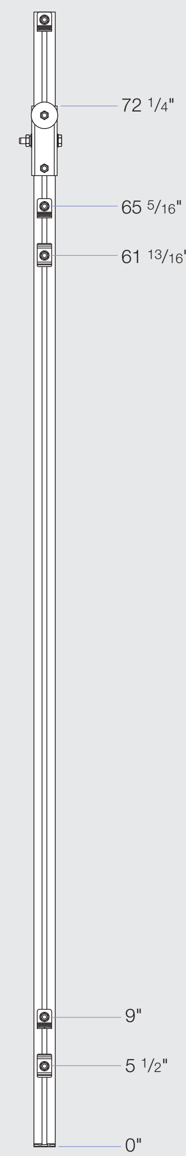


Detail B

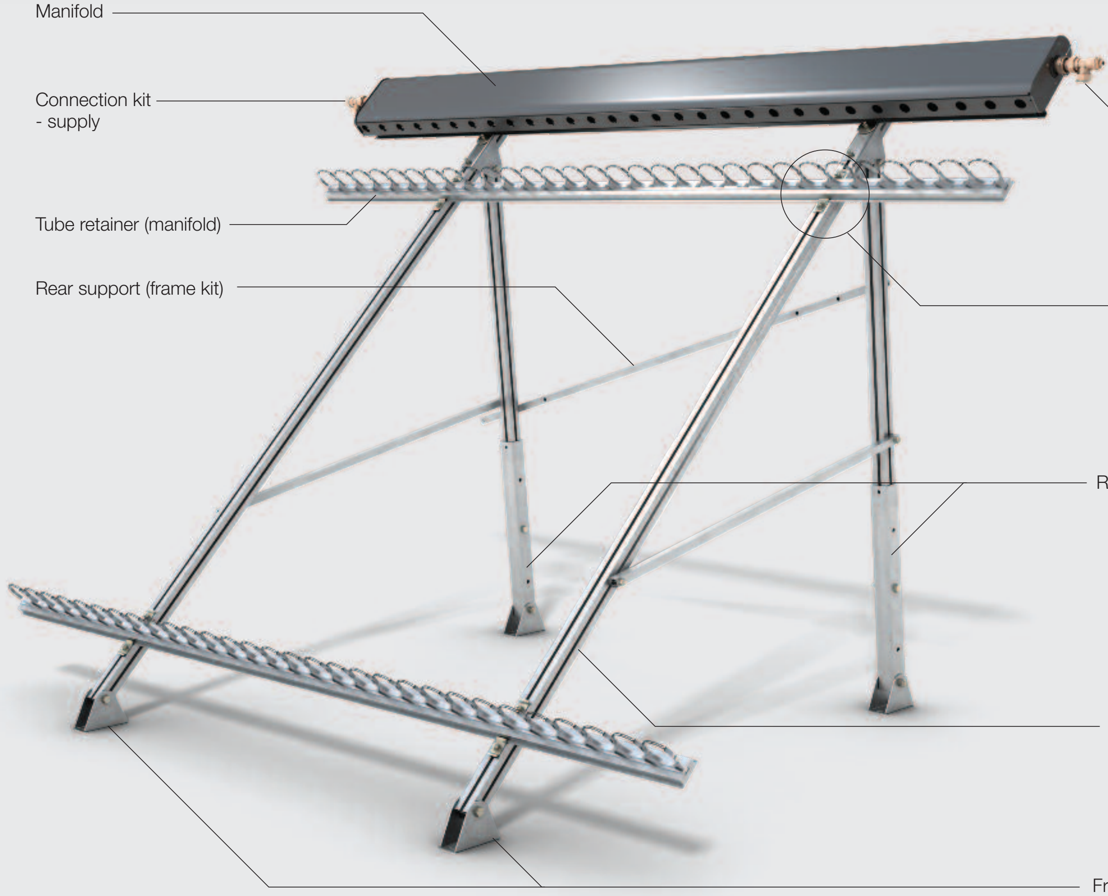


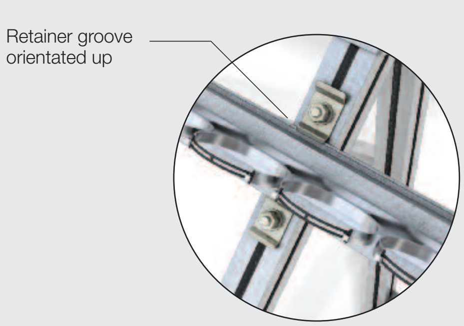
Supply

Return

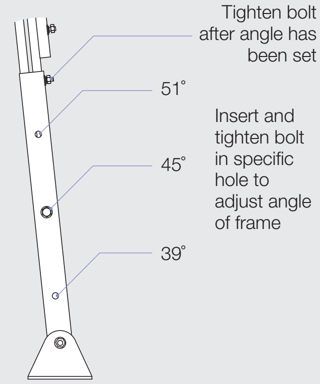


Clip Placement





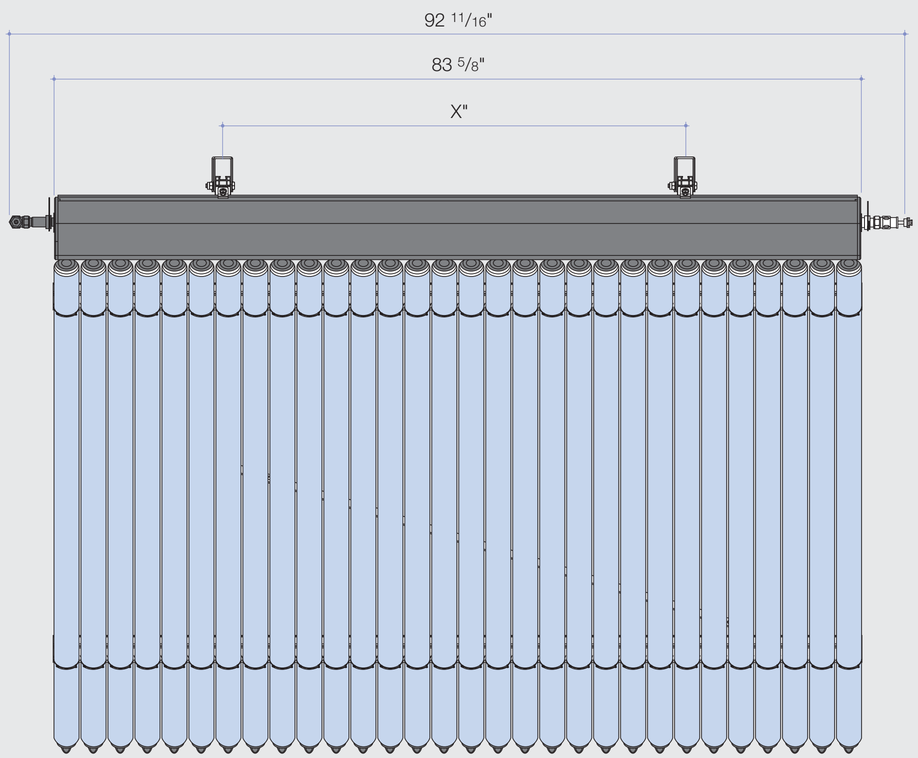
Detail A



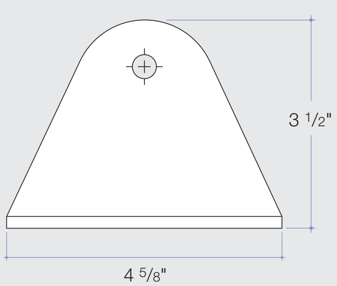
Angle adjustment

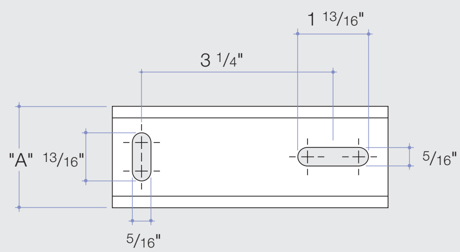
technical details

thermomax heat pipe collector
façade frame

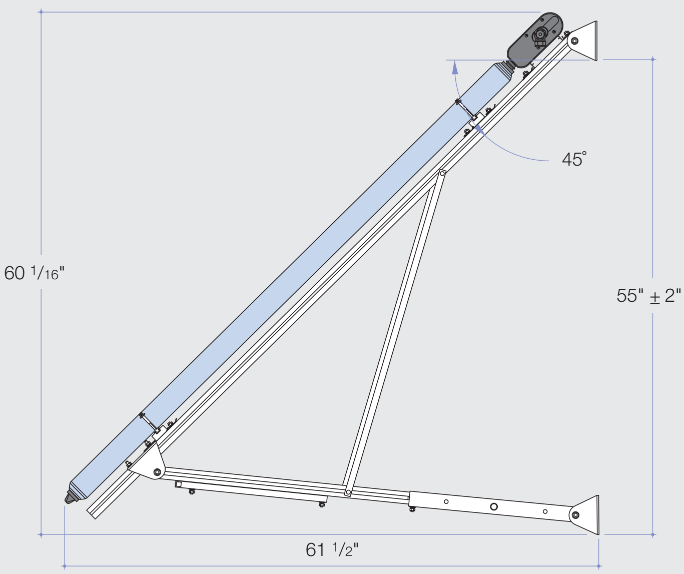


"X" Min	"X" Max
31 1/2"	52"

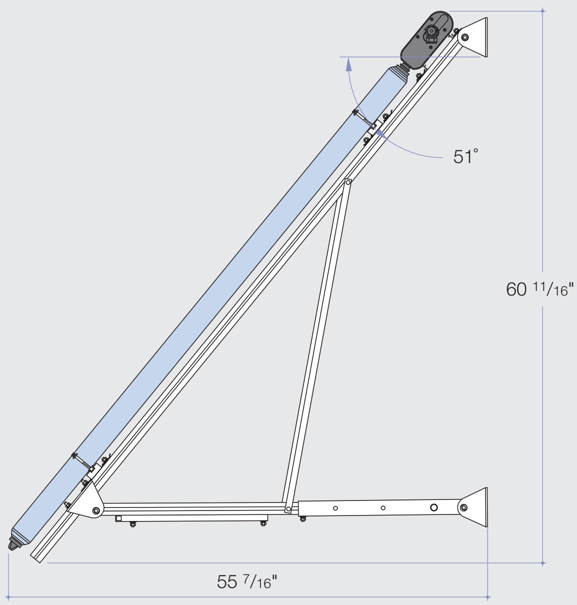




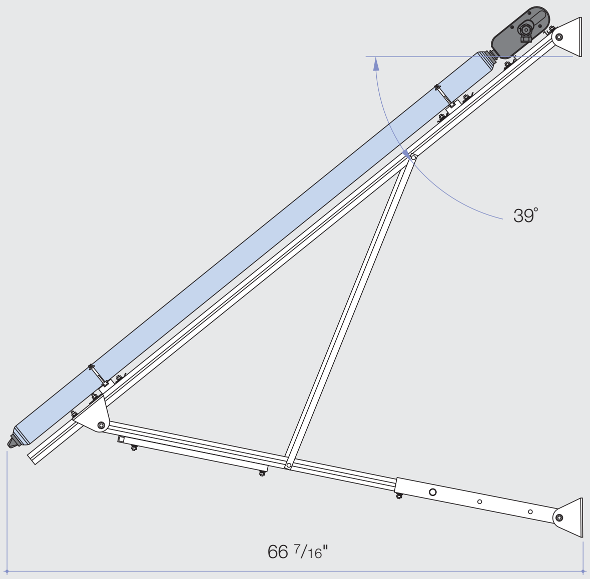
"A"	
Front	Back
1 11/16"	2"



Middle position



Lower position

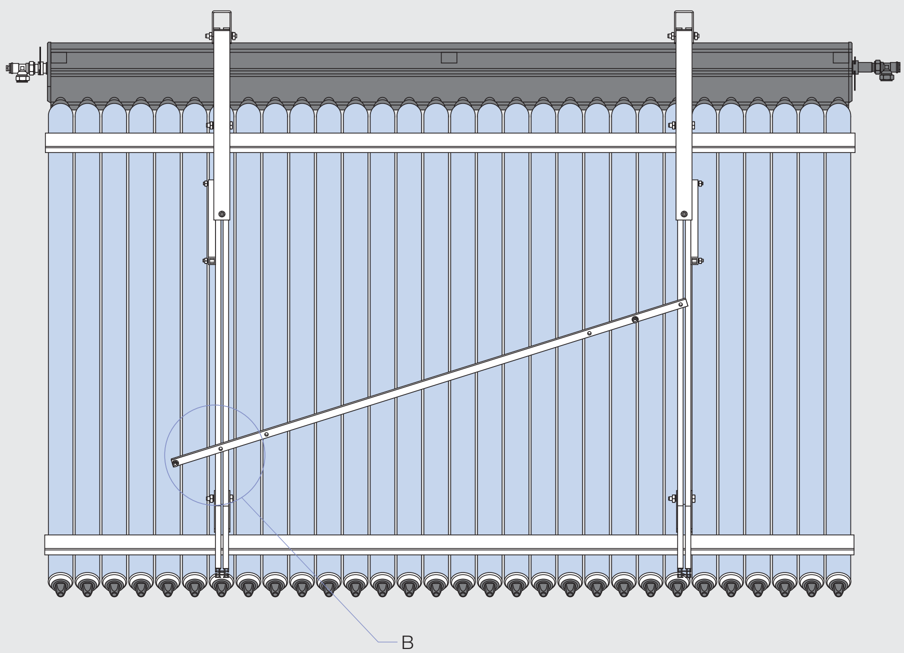


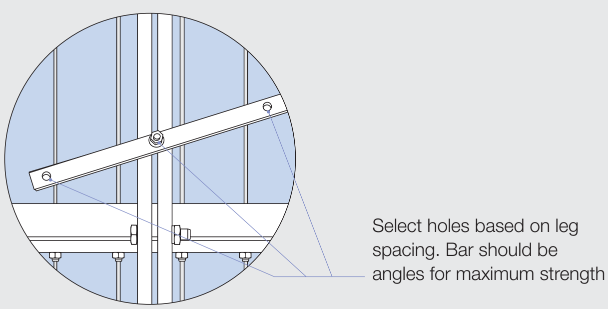
Upper position

Façade mount frame kit can be ordered as part number KSK0018 or a variable pitch frame can be modified (C0599) for this type on mount. Note the clip position on page 126 for modifying C0599.

technical details

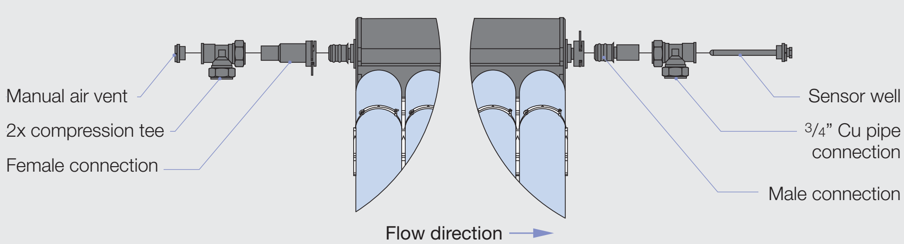
thermomax heat pipe collector
façade frame





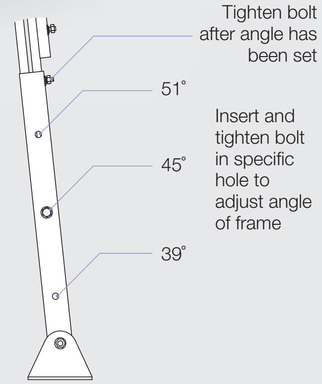
Detail B

Clip Placement



Supply Return

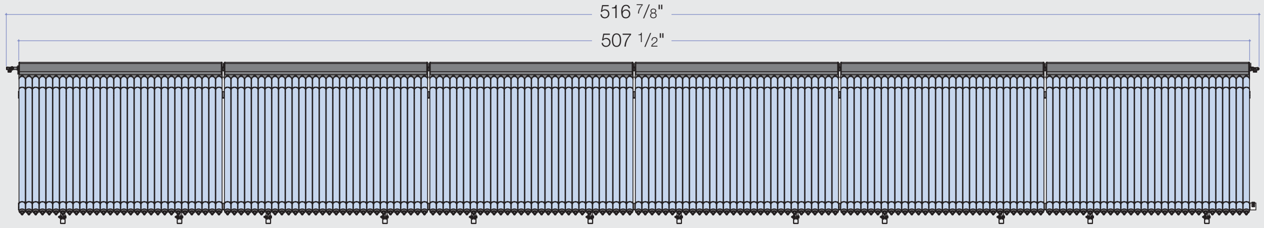
Detail A



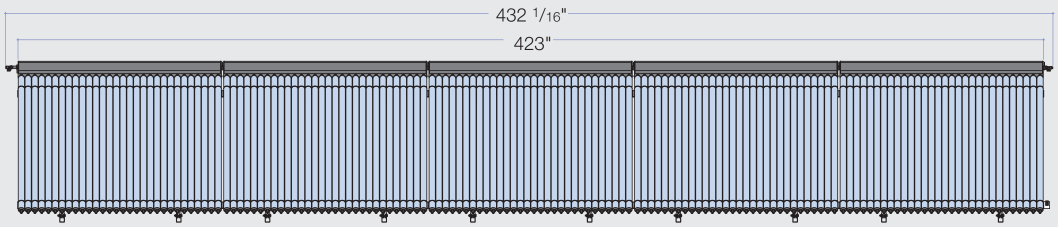
Angle adjustment

thermomax heat pipe collector
collector banks

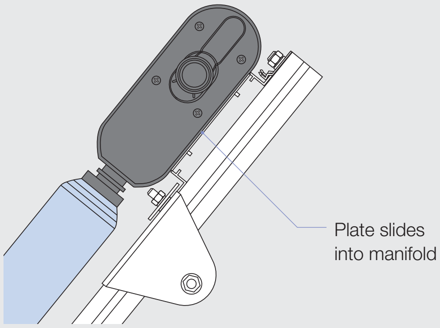
6 Collector

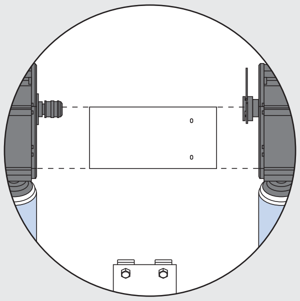


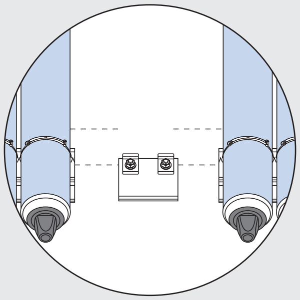
5 Collector



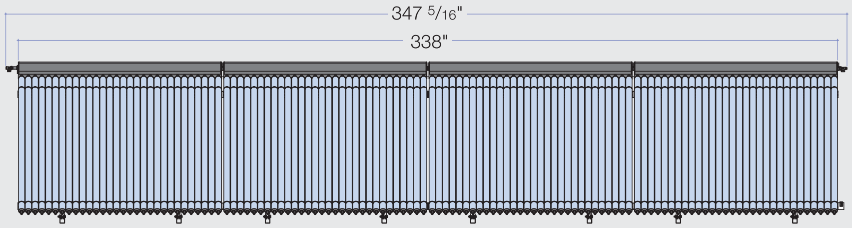
Interconnection Kit



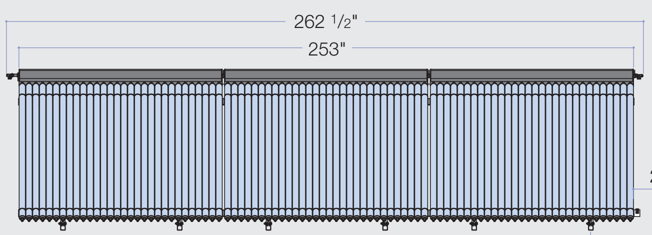




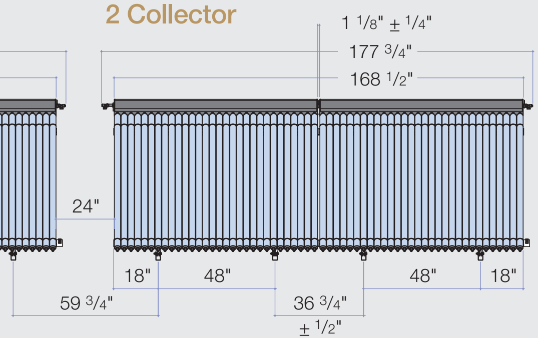
4 Collector



3 Collector



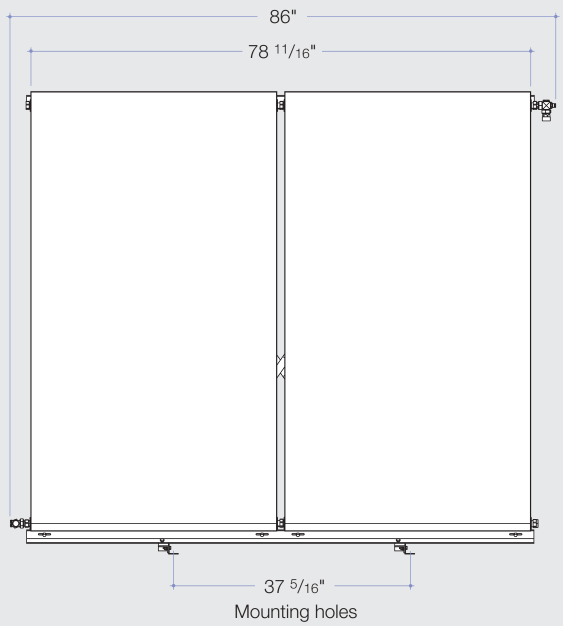
2 Collector

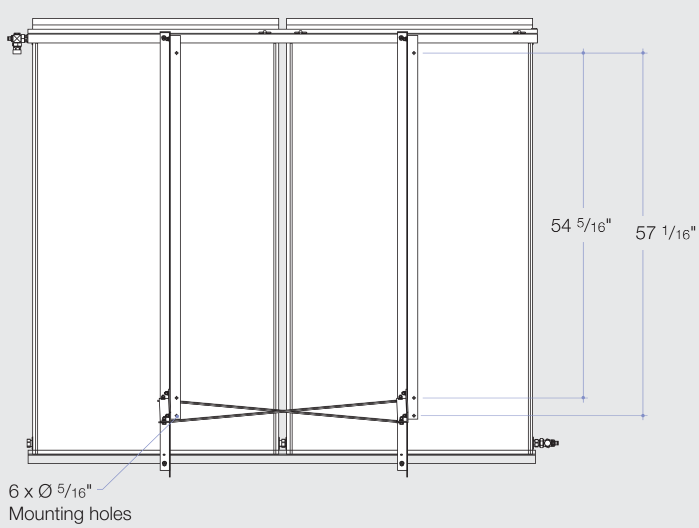


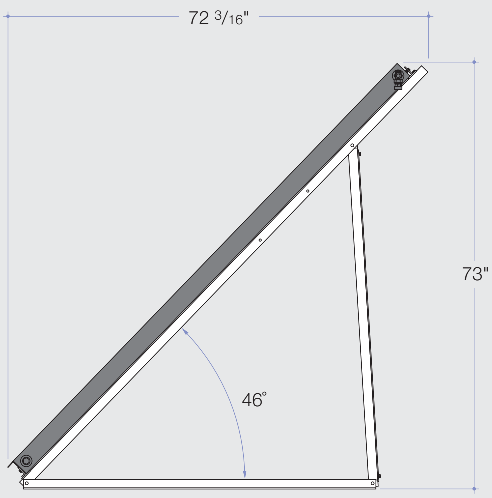
Refer to HP-450 installation manual for assembly instructions.
Refer to HP-450 prints for individual collectors.

technical details

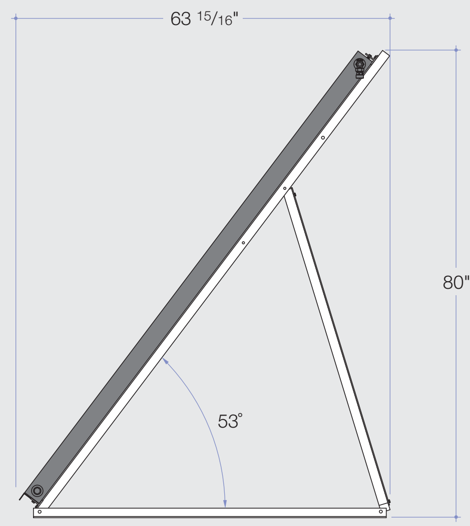
flat plate collector
45°-60° frame



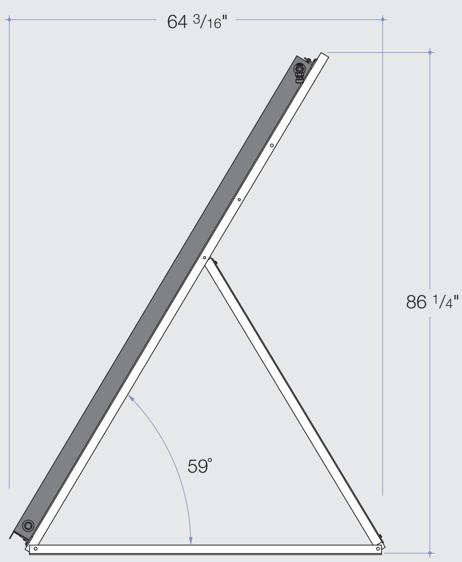




Upper position



Middle position

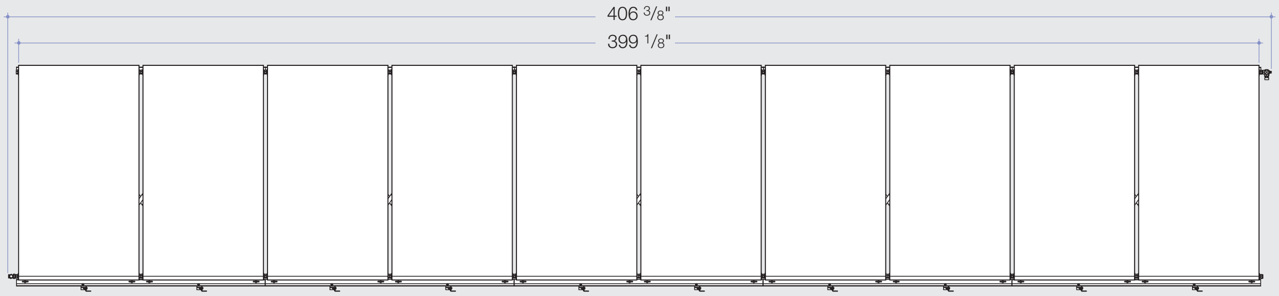


Lower position

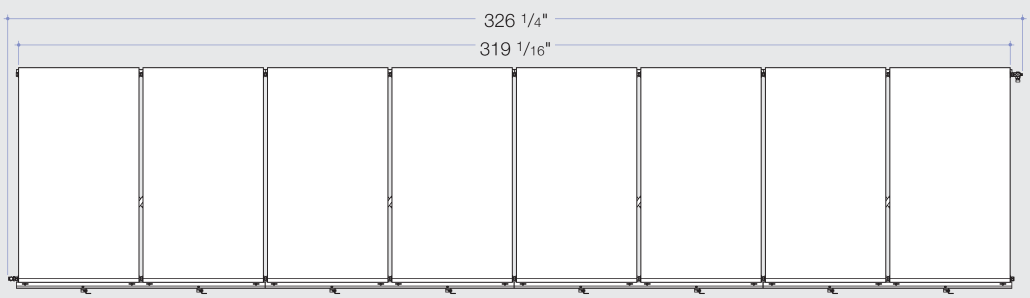
Roof Slope (x/12)	Lower Position	Middle Position	Upper Position
0	46	53	59
1	50.8	57.8	63.8
2	55.5	62.5	68.5
3	60.0	67.0	73.0
4	64.4	71.4	77.4

flat plate collector
collector banks

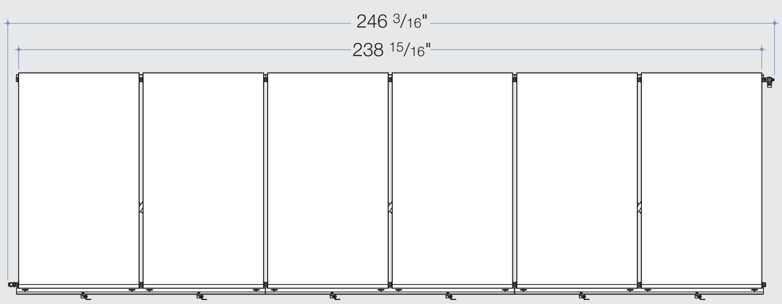
10 Collector



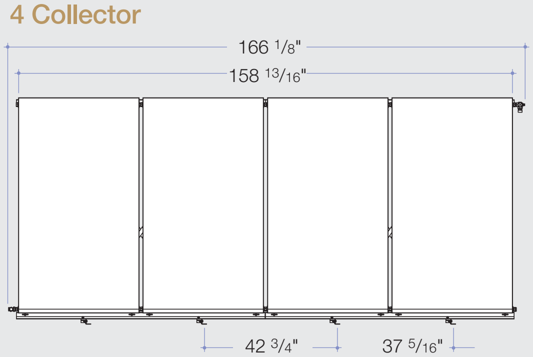
6 Collector



6 Collector



4 Collector



kingspan north america

Kingspan Insulated Panels

Kingspan Benchmark

Morin

Kingspan Insulation

Tate Access Floors

kingspan
north america

Kingspan Insulated Panels

Kingspan high performance insulated metal panels deliver proven sustainable performance in a single component system. We believe in the effectiveness of an EnvelopeFirst™ high performance roof and wall green design strategy.

Behind these effective products and systems stands a company that believes in a green future. As an industry leader that recognizes the serious challenges facing our global ecosystem, Kingspan is committed to reducing the environmental impact of its business operations, products and services.

www.kingspanpanels.us / www.kingspanpanels.ca

Kingspan Benchmark

Kingspan Benchmark are building envelope solutions that can be tailor-made for custom, out of the ordinary projects. Innovation through the years has made creative design freedom possible with architectural panels manufactured using both laminated and foamed-in-place techniques.

From the design stage through installation, the Kingspan Benchmark team offers support to architects, the design teams and contractors which may include custom detailing, assistance with design, application, drafting and installation training to ensure successful project completion.

www.kingspanpanels.us / www.kingspanpanels.ca

Morin

Morin is the industry's most versatile manufacturer of single element metal wall and roof panels. With three production facilities located across the U.S., Morin has a combined production capacity of over 50,000,000 ft^2.

A nationwide sales network and in-house technical and engineering teams provide innovative solutions to help meet the U.S. Green Building Council's LEED® requirements.

www.morincorp.com

Kingspan Insulation

Kingspan Insulation is a market-leading manufacturer of premium and high performance rigid insulation products for roofs, walls, floors, pipework and ductwork in both residential and non-residential applications.

Within its extensive product portfolio is the Kingspan KoolDuct System - the most advanced and innovative system of pre-insulated HVAC ductwork available in the US.

www.insulation.kingspan.us

Tate Access Floors

Tate is the largest raised access floor and underfloor service distribution solution provider in North America. Incorporating TateASP in Ontario, Canada, Tate utilizes 45 years of experience in office and data center applications to provide technical support and education to the design and construction community.

Tate's high performance and sustainable building products contribute significantly towards LEED® points and have helped more than 100 buildings achieve LEED® certification.

Tate are proud members of the USGBC, the CaGBC, EPA Climate Leaders, and the Center for the Built Environment.

www.tateaccessfloors.com

notes

Governor of Maryland's Mansion,
ANNAPOLIS, MD

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