Code of Practice for Manufacture and Installation of Solar Water Heating Systems in New Zealand

SOLAR INDUSTRIES ASSOCIATION

Version: 1 October 2004 (Revision 3)

Background and Status

The Code of Practice has been prepared by the Solar Industries Association (SIA) to provide guidance to manufacturers, suppliers, and purchasers of solar hot water systems of manufacturing and installation standards to be observed in New Zealand. Compliance with the Code should ensure that solar hot water systems are soundly made and installed.

There are a number of New Zealand and joint Australian/New Zealand standards relating to the solar hot water industry, as a result it is often difficult to clearly establish the requirements that are applicable in New Zealand. There are also some aspects where different standards or parts of standards have conflicting requirements. The Code clarifies the requirements applicable in New Zealand and sets them out in a format that is easy to follow and useful for anyone interested in solar hot water. The Code is an umbrella document that attempts to provide guidance to the appropriate standards applying in New Zealand. It also includes aspects that are not covered by existing standards but which the industry considers important.

Some suppliers of overseas manufactured solar hot water systems work to different overseas standards. Where appropriate these standards will be referenced but as is normal practice only New Zealand approved standards will apply. If there is any difference between overseas standards requirements, New Zealand standards, and this Code the issues should be bought to the attention of the Solar Industries Association. The Solar Industries Association administers the management of the Code on behalf of the New Zealand solar water heating industry.

The Code has been prepared by a joint Reference Group involving representatives of;

Solar Industries Association of New Zealand
Energy Efficiency and Conservation Authority
Master Plumbers, Gasfitters and Drainlayers NZ Inc
Department of Building and Housing
Building Research Association of New Zealand
Standards New Zealand

The Code has been prepared by reference to various standards and is considered complete at the date of finalisation of this draft. However it is expected that over time some aspects may be identified as needing to be addressed further and revisions made. Users of the Code are encouraged to provide comment and suggested modifications so that the Code can be revised. It is expected that a revision may be required within six months of the date of this version of the Code.

As conflicting issues in the various standards are addressed the Code will be updated to take these changes into account.

Comments and suggested revisions should be sent to;

Executive Officer
Solar Industries Association
P O Box 11 595
Wellington
brian.cox@solarindustries.org.nz

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Code of Practice for Manufacture and Installation of Solar Water Heating Systems in New Zealand

Revision: 1/10/04

1 INTRODUCTION

The purpose of this Code is to provide guidance and reference for designers, manufacturers, suppliers, installers and purchasers of solar water heating equipment in New Zealand especially for domestic installations. It is also applicable to commercial and industrial installations whose function is comparable to household installations.

This Code is not intended to cover rubber or plastic unglazed solar equipment used solely for swimming pool or space heating. Such equipment can be used for swimming pools etc but the equipment or its installation is not covered by the Code.

The primary purpose of this document is to elaborate ways in which solar water heating installations can be provided which:

a) provide a worthwhile contribution to the energy requirements of a typical household
b) have a reasonable low-maintenance life
c) do not endanger the health and/or safety of the users
d) do not endanger the structures to which they are applied

It aims to:

- give adequate information to enable manufacturers and installers to provide conventional equipment without excessive amounts of research

- encourage the development and use of innovative designs of equipment

- give purchasers confidence in the manufacture and installation of their system

- assist building authorities provide Building Consents for the installation of systems

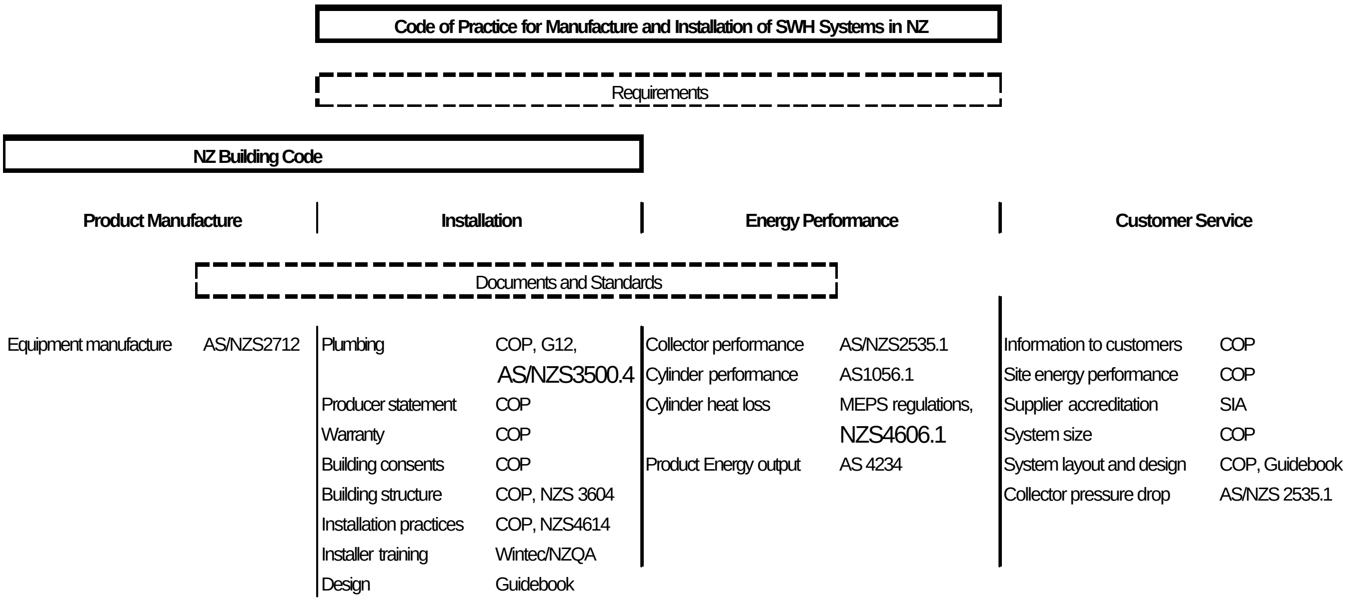
The form of the Code contains elements that follow those of the New Zealand Building Code in that it has statements of the desired Requirements of the system. These are usually associated with an account of "Acceptable Solutions" which are in essence prescriptive. These describe procedures which will be deemed to achieve the Requirements. There may be a number of Acceptable Solutions. This is to enable manufacturers to produce equipment, and installers to install, without limiting innovation or requiring extensive efforts to demonstrate compliance. In other words if the prescriptions are adhered to then the installation will be deemed to be satisfactory and thereby be an “Acceptable Solution”.

The Code is a voluntary document which the industry is essentially using as an umbrella document integrating standards and common practice as shown in Figure 1. The document integrates formal standards as Acceptable Solutions where appropriate. Over time it is expected that inconsistencies will be ironed out.

Relevant technical standards and those referenced in the Building Code as requirements of SWH installations include;

AS/NZS 2712
AS/NZS 3500.4
NZS 4613
NZS 4614
NZS 1056

Figure 1 Solar Water Heating Quality Standards in NZ



COP = Code of Practice for Manufacture and Installation of SWH Systems in NZ
Guidebook = Guidebook for Building Professionals in preparation

The new Building Act allows for licensed building practitioners and in the future SWH installers could fall within this definition. Licensing will be a formal activity undertaken by the Building Practitioners Board.

It is expected that the Building Code will be revised within the next two years.

The SIA and EECA are working with Standards NZ to develop the current industry Code of Practice into a formally recognized Publicly Available Specification (NZ PAS) and then an Approved Document within the Building Code. During this process the industry will clarify the Code's relationship with the approved technical standards and the Building Code. To become a formally recognized New Zealand Publicly Available Specification it will also have to be processed through the Standards NZ quality assurance process.

The Code draws for its content from the standards listed at the end of the document. For ease of presentation the Code is based around domestic water heating systems in which the collector array consists of flat plate collectors with fixed solar orientation and inclination. It also covers collectors which are not flat plate devices but which (as for instance with arrays of evacuated tube absorbers) are used in the same way as flat plate collectors. It is intended for installations of up to about 12 square metres of collector area and about 750 litres of storage capacity. However, many aspects of the Code will be applicable to larger systems. The Code will also provide guidance for some aspects of tracking systems even though it is not specifically designed for this purpose. Some parts of the Code will also be applicable to domestic water heating systems such as solar assisted direct air-to-water heat pumps, although the Code is not written specifically for such installations.

In its present version the Code covers design manufacture and installation of solar water heating equipment. It will not be specifically concerned with thermal performance testing of collectors or of complete systems as these are still under development. Nevertheless some guidance is provided on test methods to enable developers to determine whether or not their equipment will meet reasonable overall performance standards. This section will be addressed further in the next revision of the Code.

2 ARRANGEMENT OF THE CODE OF PRACTICE

The Code is organised as follows:

Section 3 is a description of the basic layout common to the majority of solar water heating systems. Section 4 lists the major components of solar water heater systems and their construction alphabetically. Under each heading is a definition (if needed) followed by a performance statement. The prescriptive statements follow, corresponding to the "Acceptable Solutions". Many Acceptable Solutions will refer to specific parts of relevant standards. Adherence to the prescription(s) will be taken as automatic acceptance of that aspect of a system. After the prescriptions come advisory notes. Section 5 is a description of procedures to be followed by installers. Section 6 contains references to the means of demonstrating collector and system acceptability including some standard performance test methods.

The appendices provide detailed guidance and standard forms referred to in the body of the Code.

Disclaimer
While diagrams have been included to aid demonstration of particular aspects of installation the diagrams are diagrammatic only and should not be assumed correct for every application. Installers should adhere to the manufacturer’s instructions with reference only to the diagrams to aid understanding.

3 THE BASIC SOLAR HOT WATER SYSTEM

The working principle of a solar water heater is illustrated in figure 2.The essential elements are:

a) a collector (I)
b) a cold water supply (II)
c) a solar store (III)
d) a main hot store with secondary heater or a secondary heating system(IV)
e) a hot water delivery system (V)

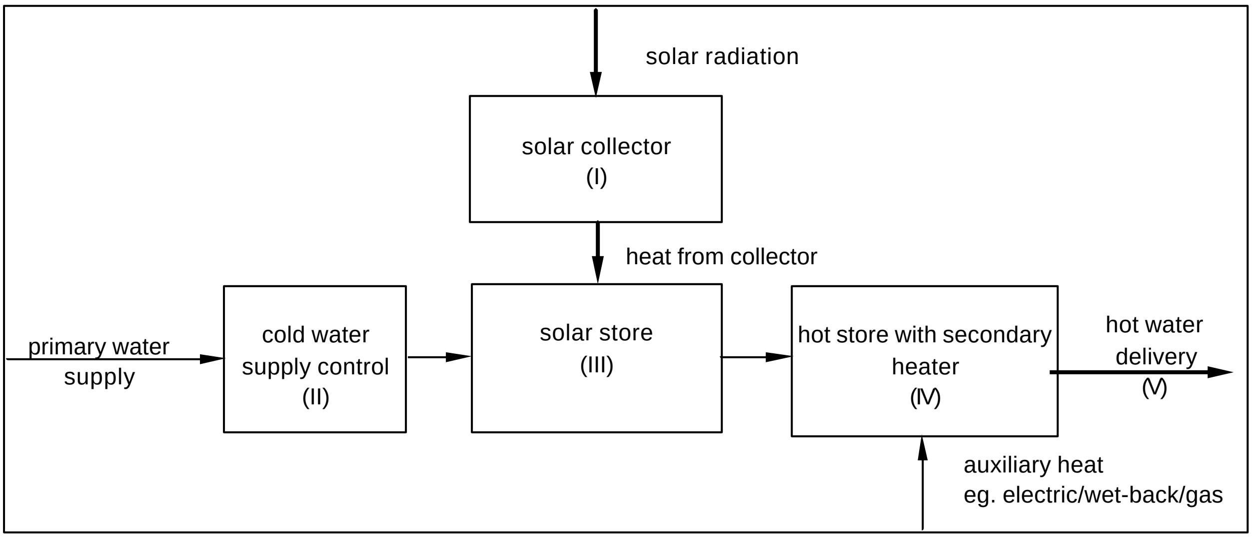


Figure 2 Basic solar hot water system

Systems can consist of one or more individual units. In many cases the solar store is incorporated with the main hot store, the separation of these two stores being via the thermal stratification of water above and below an auxiliary element and thermostat as shown in figure 3.

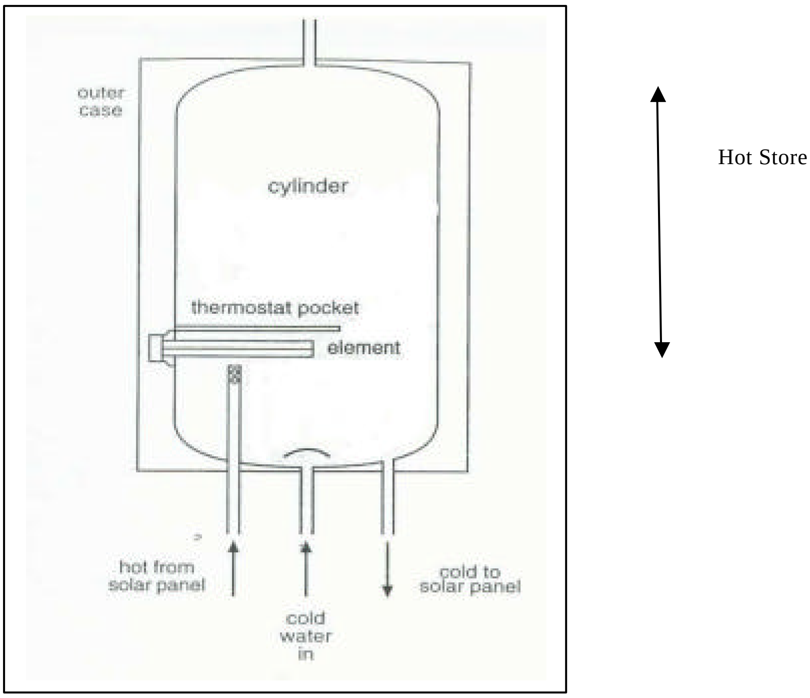


Figure 3 Solar storage cylinder

In some cases additional primary heating devices such as a wetback may also be connected to the store as shown in figure 4.

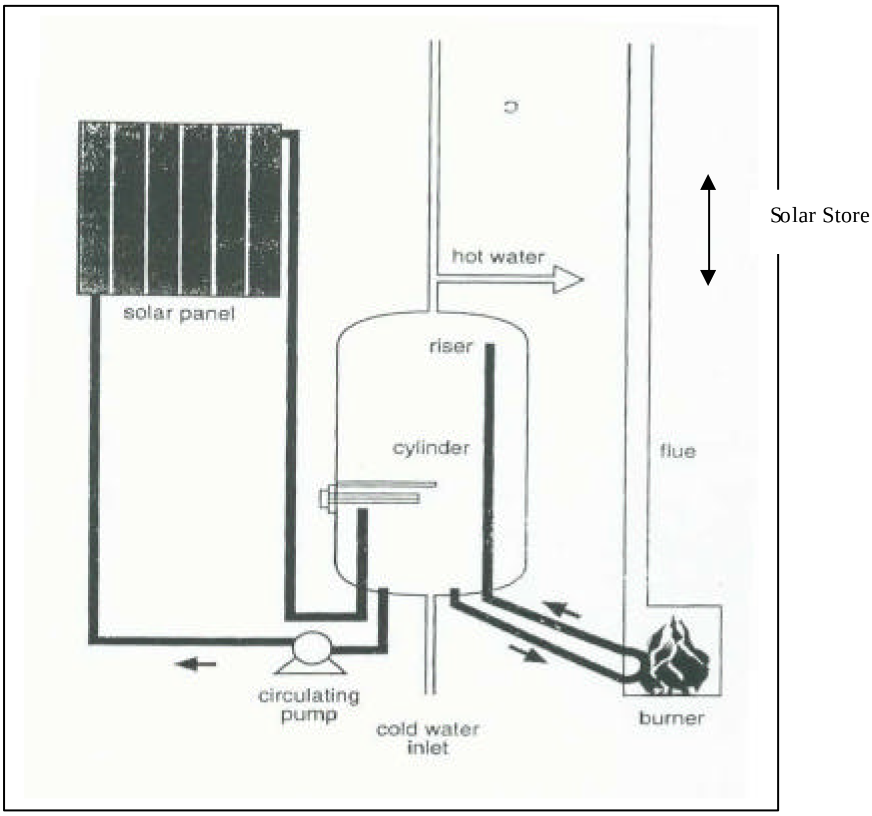


Figure 4 Solar system plus wetback

The cold water supply may come from a header-tank or directly from a mains supply via a pressure reducing valve which controls the operating pressure of the hot water supply at one of the common values usually in the range up to 50m head. The arrangement of the cold water supply and the control of the pressure in the supply shall be in accordance with the New Zealand Building Code, Approved Document G12 and the appropriate New Zealand Standards including AS/NZS3500.4. The collector is normally mounted on the roof of a building and is connected to the solar store by piping which allows cold water from the lower part of the store to be circulated through the collector and returns the solar heated water to above the lower cold zone in the store.

The collector and hot store may be close coupled as in the case of most thermosiphon systems when the collector and hot water storage cylinders are adjacent to each other, or pumped when the collector and hot storage cylinder are located quite separately.

In simple "direct or open loop" systems potable water from the cylinder flows through the collector.

In an "indirect or closed loop" system, the fluid in the collector exchanges heat with the water in the hot storage cylinder via a heat exchanger.

Heat exchangers are of several common types:

a) primary fluid flows through the collector and circulates in a jacket around the hot water cylinder containing the domestic water as shown in figure 5
b) primary fluid flows in the collector and circulates in a heat exchanger coil within the storage cylinder as shown in figure 6

c) primary fluid flows in the collector and exchanges heat to the water, which circulates from the cylinder through the secondary side of a heat exchanger situated between the cylinder and the collector as in figure 7

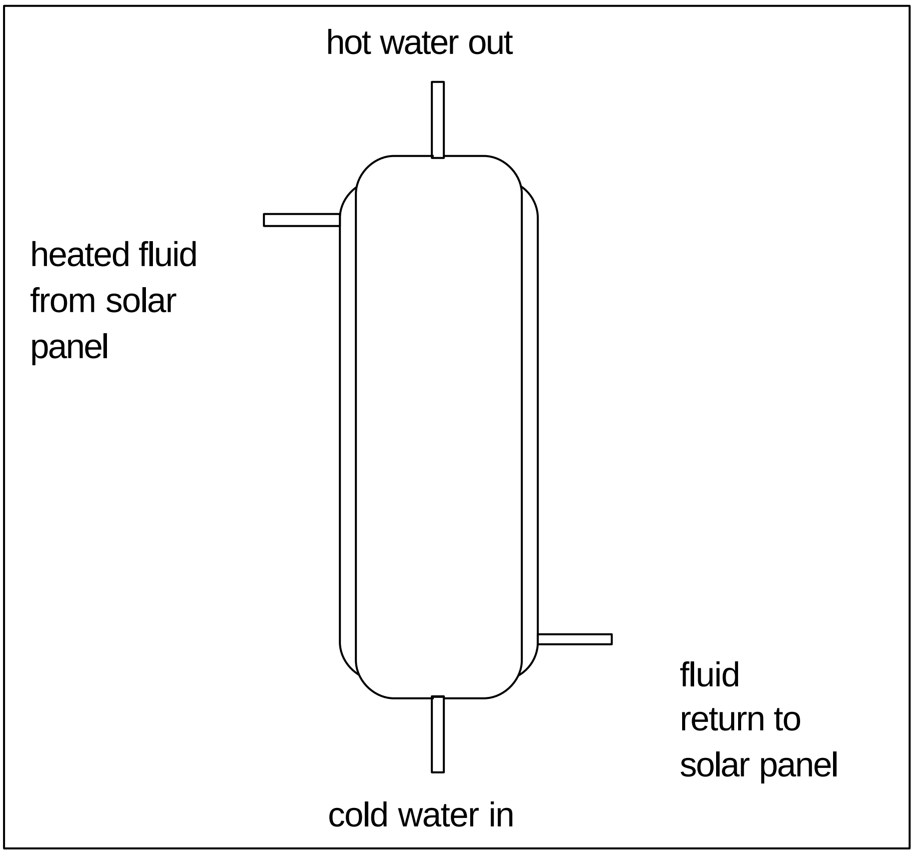


Figure 5 Solar hot water jacket indirect system

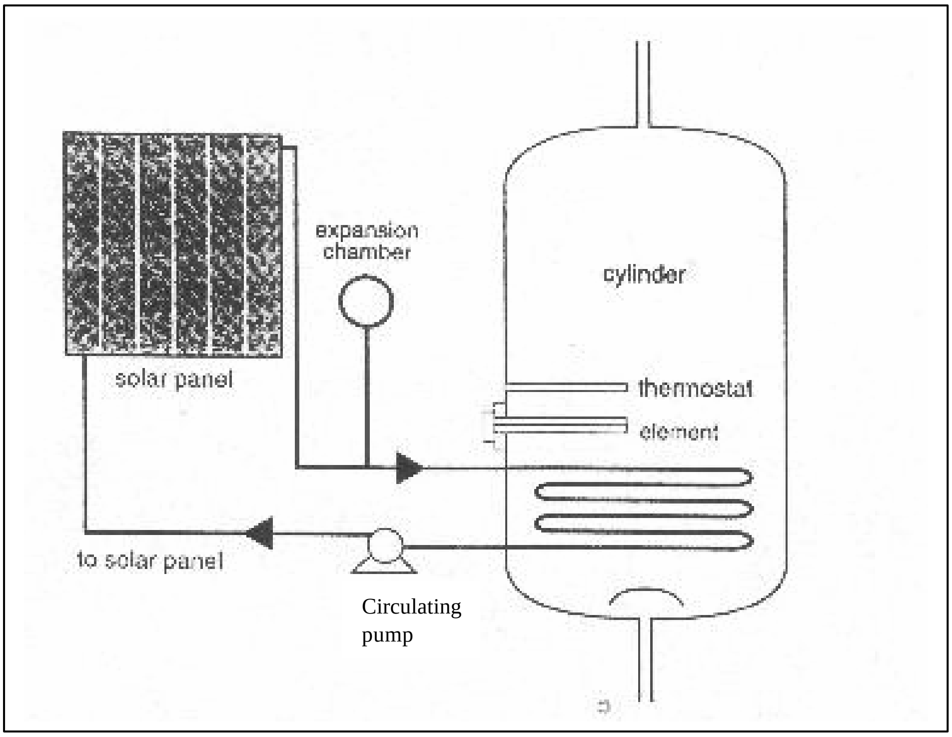


Figure 6 Solar hot water system with internal heat exchanger

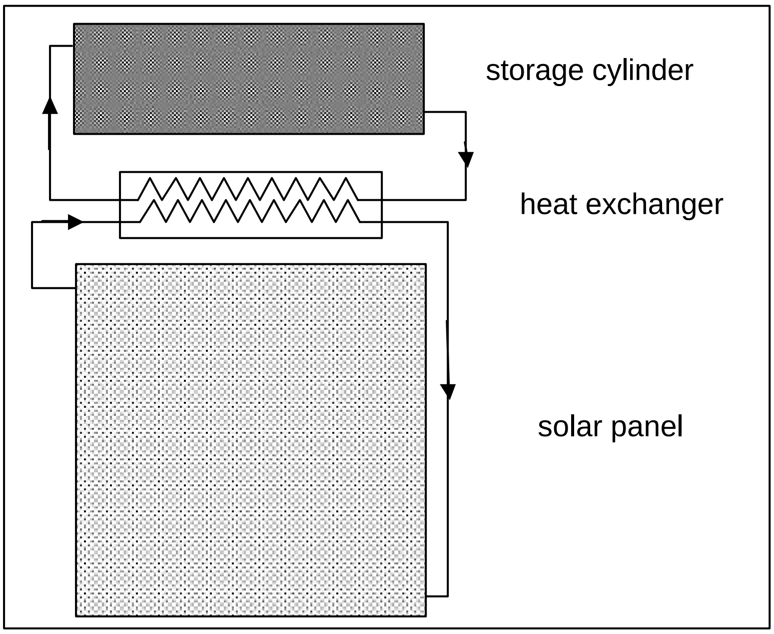


Figure 7 Solar hot water system with external heat exchanger

Solar water heating can be installed as a complete system including the hot water cylinder, or it can be installed as a retrofitted extension to an existing electric or gas heated hot water cylinder. The hot storage cylinder can be an integral part of the installation or it can be a separate item. Circulation between the collector and the cylinder may be by thermosiphon as in figure 8 or by pumping (forced circulation) as in figure 9.

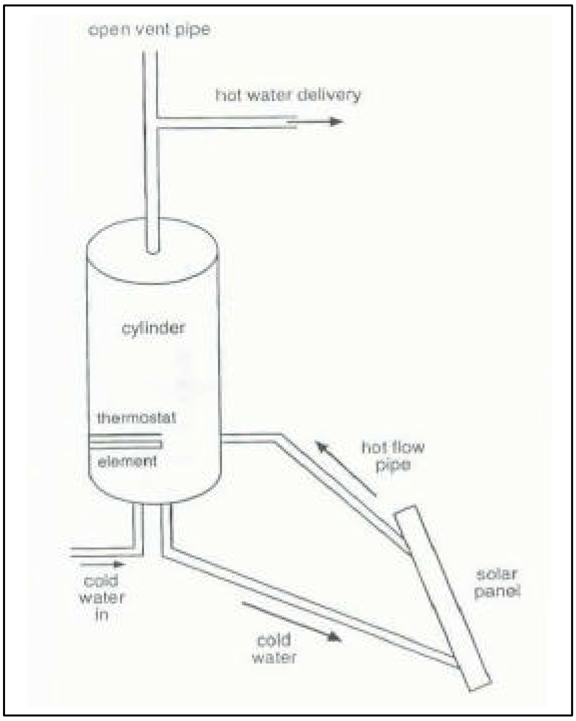


Figure 8 Thermosiphon flow water heater with remote container

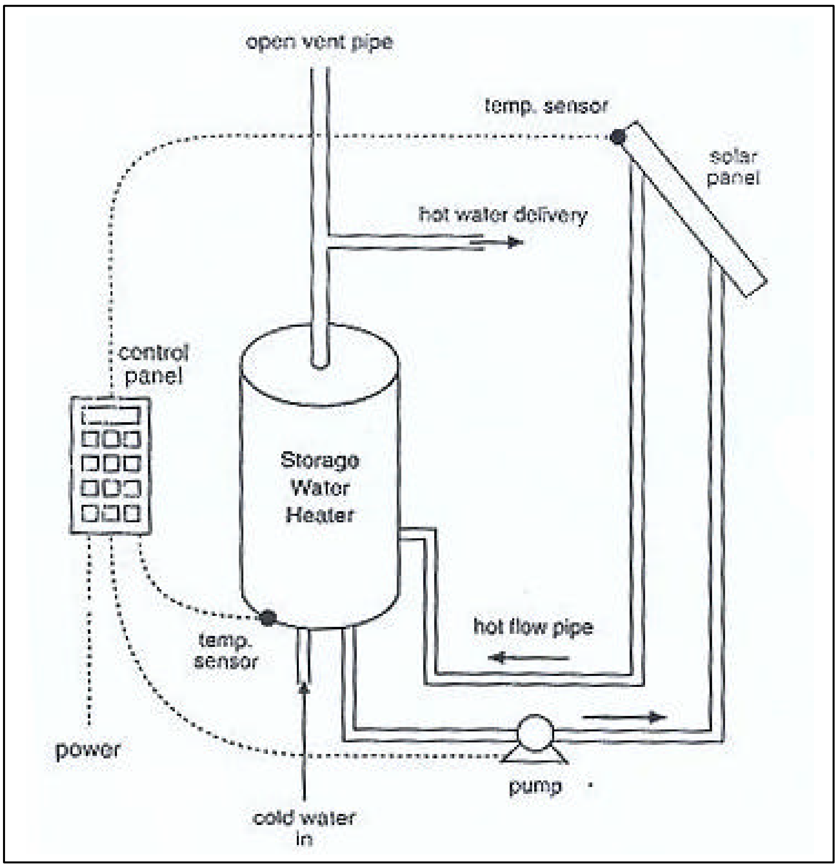


Figure 9 Pump circulated system

Thermosiphon systems often have the cylinder mounted horizontally on the roof directly above the collectors as in the close coupled or integral system shown in figure 10.

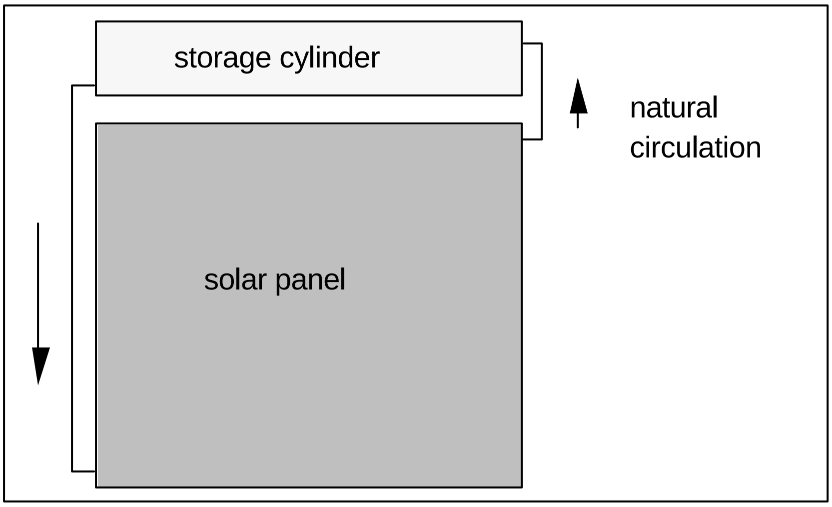


Figure 10 Close coupled or integral thermosiphon system

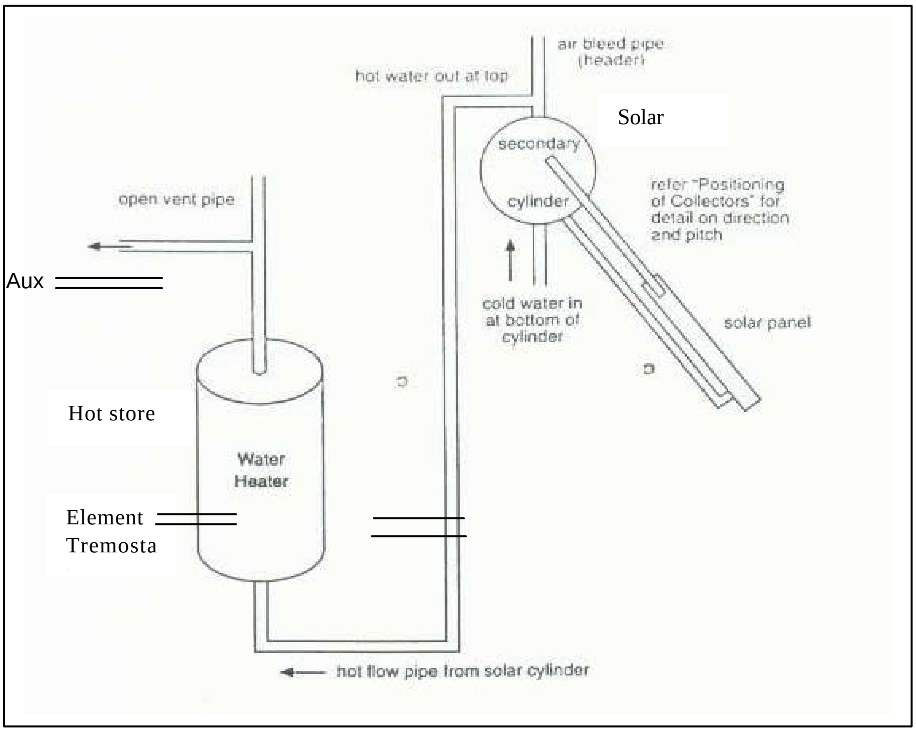


Figure 11 Dual cylinder system

Some thermosiphon systems use two cylinders as shown in figure 11 with primary circulation to a cylinder above the collector which then feeds by displacement to a secondary cylinder containing the auxiliary heater. This second cylinder is the vessel in which heated water is stored in readiness for use. An extension of this are solar systems which have two containers - a solar pre-heater in which the solar heated water is stored and from which it is pump circulated to a secondary container in which the water is further heated if necessary and passed on to the domestic outlets. Such an arrangement is shown in figure 12.

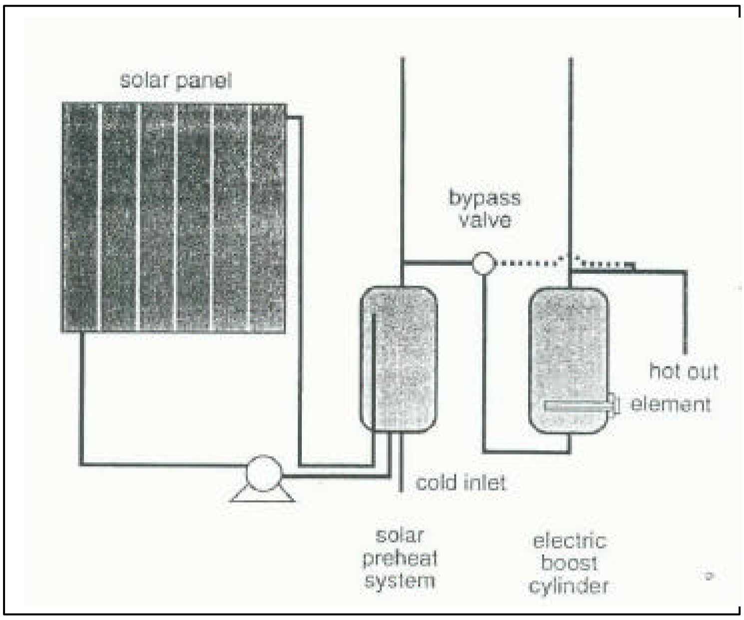


Figure 12 Two-tank system

Other systems have a cylinder in which the solar pre-heater function is served by having the solar circulation in a section below the element as shown in figure 3. Such an arrangement allows preheating of the cold water which enters to displace hot water drawn from the top of the cylinder and allows mixing of the preheated water with the rest of the cylinder when water returning from the collector is hotter than the thermostat setting.

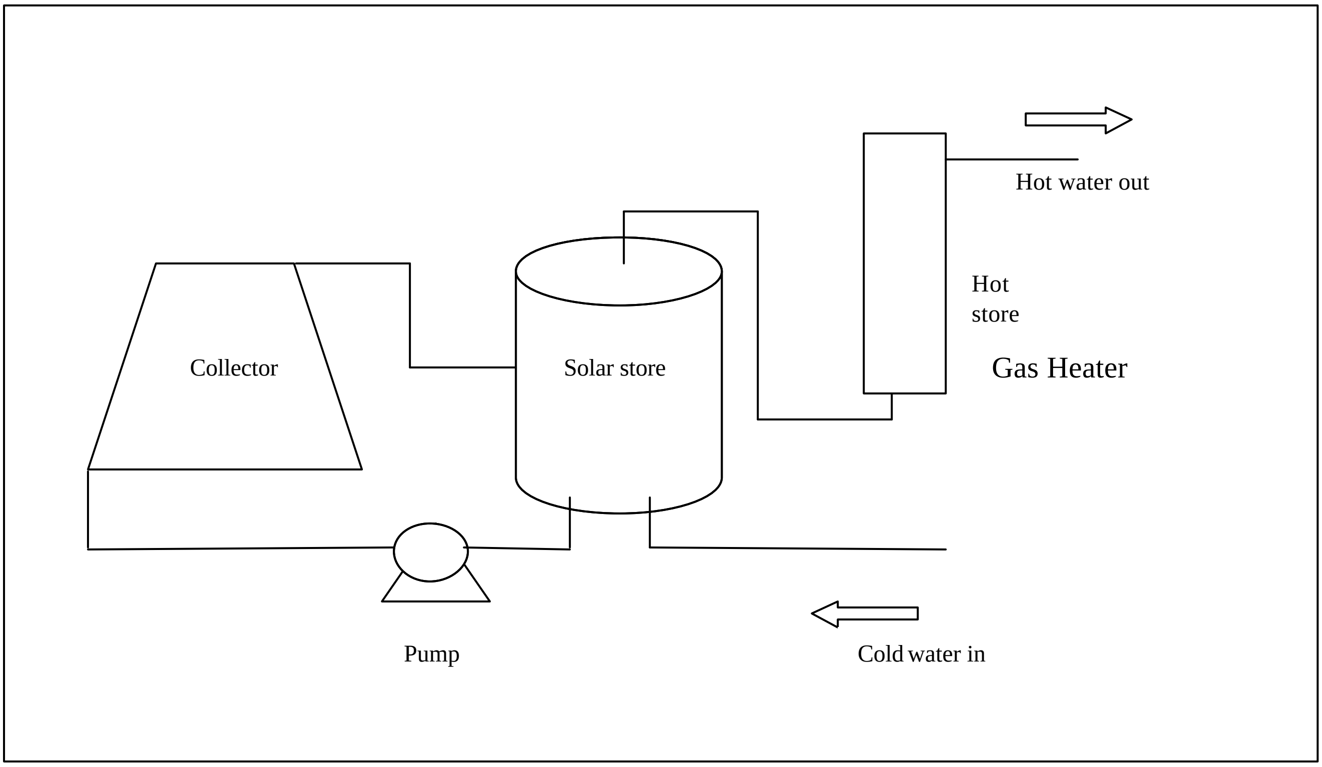


Figure 13 Solar pre-heater - gas storage heater

Solar collectors can be used to pre-heat water used in an existing gas hot water system as shown in figures 13 and 14

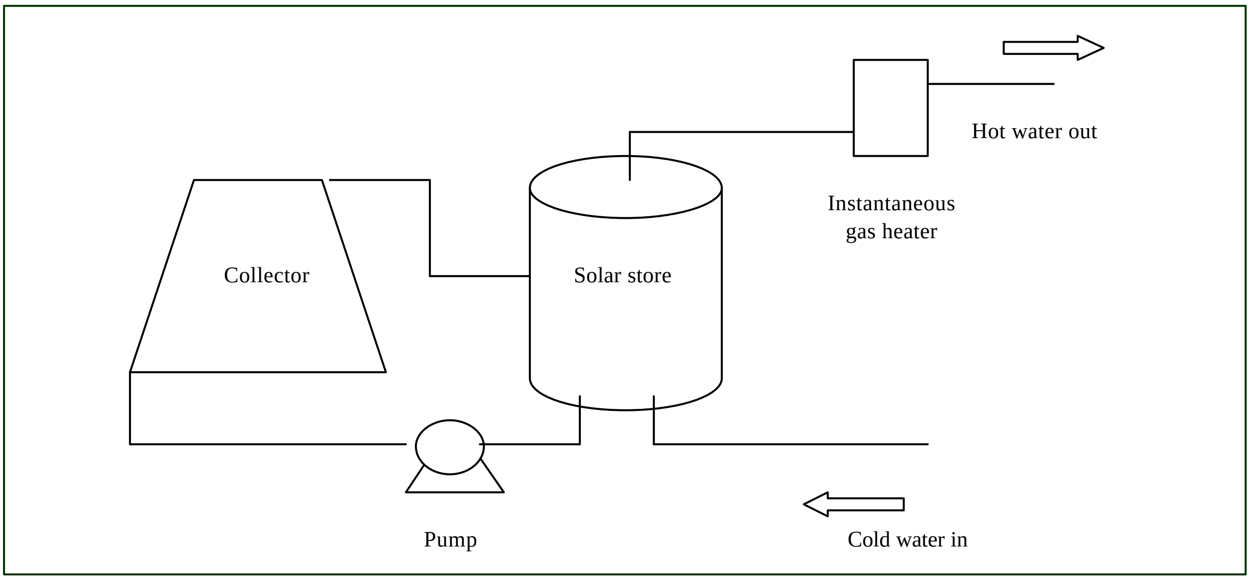


Figure 14 Solar pre-heater – instantaneous gas heater

An array of solar collectors can be used as a pre-heater providing energy to an existing heat plant such as a boiler as shown figure 15.

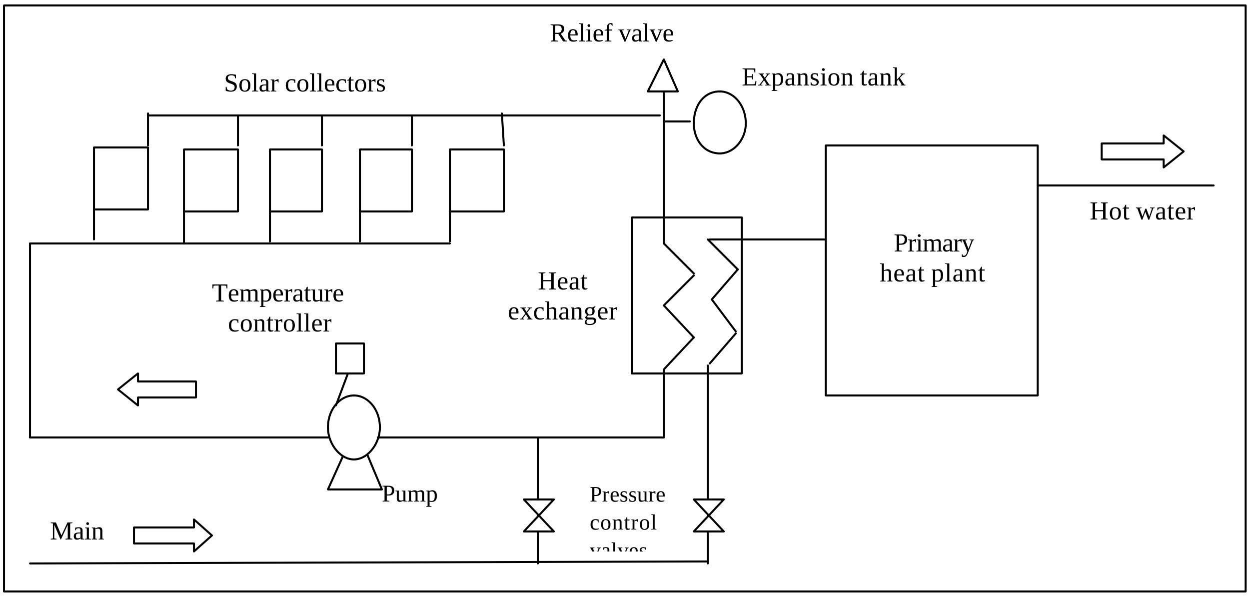


Figure 15 Solar pre-heater – industrial heat plant

4 MAIN COMPONENTS OF SOLAR WATER HEATING SYSTEM CONSTRUCTION

4.1 ABSORBER:

An absorber is a device for absorbing solar radiation and transferring the energy gained as heat to a fluid such as water.

Common absorbers are:

a) flat plates with attached risers and headers through which the primary fluid circulates
b) flat plates in the form of envelopes with a primary fluid flowing between two plate surfaces
c) arrays of evacuated tubes with a heat exchanger manifold at the top of the tube array

The common structure of a tube-on sheet absorber is shown in figure 16.

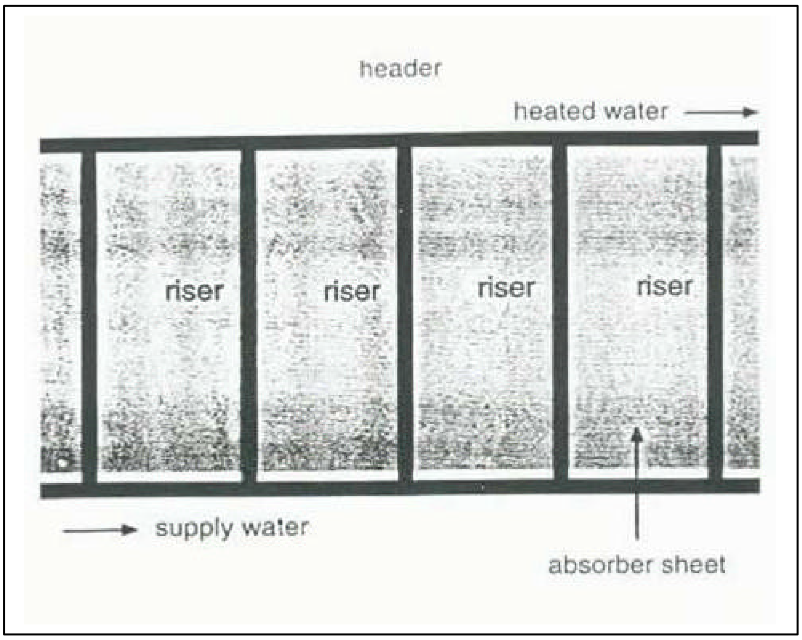


Figure 16 Tube on sheet absorber

An array of evacuated tubes can be used in much the same way as a flat plate collector. This type of collector generally consists of an evacuated tubular glass jacket surrounding a tubular absorber which may be directly connected to the water flow or which may be in the form of a tubular heat pipe transferring heat to a water filled cylinder or manifold.

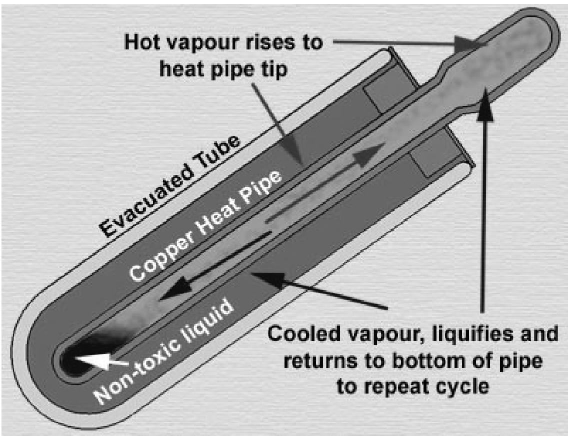


Figure 17 Typical evacuated tube design

Requirements:
Absorbers shall remain leak-free at the maximum operating pressure for which they are intended to be installed.

The absorbing surface shall not be significantly degraded over the expected working life of the collector.

Where the heat transfer from the absorbing sheet to the heated fluid is by way of tubes attached to the absorber sheet the integrity of the thermal connection between the tubes and the sheet shall be maintained for the expected life of the collector.

Evacuated tube absorbers must be able to hold a vacuum for the stated life of the tubes. Each tube must have a vacuum indicator that can be observed at a glance to indicate that the vacuum remains.

Evacuated tube absorbers in areas where there may be large hail stones must be protected by a hail guard.

Acceptable Solutions
Warnings about the need for attachment of guards to protect against impact from large hail stones must be included in documentation provided to potential purchasers prior to sale

Notes

1. Early designs of evacuated tubes featured a glass to metal seal for maintaining a vacuum and over time significant numbers have lost their vacuum. This should not the case with the "sydney tube" or other design of evacuated tube.. These feature an inbuilt vacuum between two glass tubes and no metal or o-ring seal for vacuum. The expected life is in excess of 15 years for quality tubes. If the vacuum fails the output will however still continue similar to that of a flat plate but cold weather performance drops off.
2. Care should be taken with handling evacuated tube absorbers so that they do not break as they have thin sharp splinters. Gloves should be worn when handling broken glass.

4.2 AUXILIARY HEATING:

Auxiliary heating is heating supplied to bring water to a usable temperature when the solar energy input is inadequate. The auxiliary heating may be from gas or electricity energy, or heat from a wetback.

Requirements:
Auxiliary heating equipment shall have sufficient capacity to supply normal hot water needs in the absence of solar input.

Auxiliary heating systems shall be capable of raising the temperature of the stored water to at least 60 ^{0}C in accordance with the New Zealand Building Code to prevent the growth of Leigonella.

Acceptable solutions:
The commonest form of auxiliary heating is electric. In an electrically heated system the heating element shall be at least of the same wattage as would normally be fitted to the particular cylinder volume in a system without solar heating.

Systems designed for auxiliary (boost) heating by gas shall be installed in accordance with the manufacturer’s instructions and the relevant gas supply regulations. Gas and electricity installation work must be undertaken and approved by an appropriately licensed tradesperson.

Systems with electric auxiliary heating shall comply with the requirements of AS/NZS3350.2.21 which specifies those electrical requirements that are prerequisites for approval for the sale or connection of electric water heaters.

NOTE –

1. Auxiliary storage heating may be controlled by a time switch so that it is only activated at controlled periods of the day. This eliminates activation in the morning ahead of reception of solar energy during the day. A time switch may also control night-time heating until just prior to when hot water is needed. Use of a time switch can significantly improve the overall performance of a solar water system.
2. It is possible to use an in-line gas heater in conjunction with a solar pre-heat system (figures 13 and 14). In this case the installer shall confirm that the gas heater will operate satisfactorily when supplied with water at a temperature equal to the maximum which will be obtained from the solar pre-heater. In the absence of such an assurance the feed from the solar pre-heater shall be fitted with a tempering valve set to reduce the feed to the gas heater to a temperature below the maximum which the gas heater will accommodate.

4.3 COLLECTOR:

A collector is a device containing an absorber or absorbers in a form suitable for installation on a building. Frequently a collector will consist of an absorber mounted in a casing with glazing in front of and insulation behind the absorber, the complete assembly being arranged as a unit ready for mounting on a roof as shown in figure 18. Collectors may also be built into the roof structure itself.

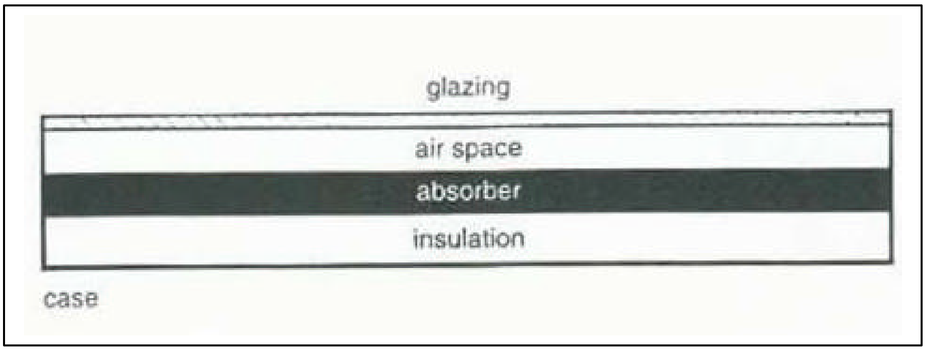


Figure 17 Flat-plate collector cross-section

Collectors may be flat plate devices or arrays of evacuated tube absorbers. The difference between these forms of collectors is largely a matter of detailed design and shape.

Some collectors (for example those used with solar boosted heat pumps or swimming pools) do not use glazing or insulation but consist of a bare absorber and the means of mounting it.

Requirements:

Collectors mounted on the exterior surface of the roof shall be mounted in accordance with the New Zealand Building Code clauses B2 and E2 and AS/NZS3500.4 clause 6.5.2.

Where mounting frames are used for orientation and connection to the roof surface the mounting frame and its attachment to the roof structure will be designed for appropriate wind conditions in accordance with relevant structural standards.

Collectors built into roof structure shall be treated as water containing devices within the roof structure. When these are over living space the collector structure shall include a safe-tray draining effectively to the outside of the building.

NOTE - Collectors may be supplied singly or as arrays supplying to a common container.

4.4 COLLECTOR APERTURE:

The collector aperture is the area of the collector through which solar radiation falls onto the absorber. In a glazed collector this is the transparent area of the cover. In an unglazed collector it is the area of the absorber itself. In a tubular collector array it is the sum of the plan areas of the absorbing parts of the tubes. Some non-tracking collectors have partial or non-imaging concentrators as part of their structure. In such collectors the aperture is taken as the plan area of the reflector surfaces which focus onto the absorbers.

4.5 COLLECTOR CASING:

The casing is the enclosure of a freestanding collector. It usually consists of a weatherproof housing for the absorber, the front surface of which is glazed with a material transparent to solar radiation.

Requirements:
The casing shall be made from a material suitable for the purpose and its durability shall be not inferior to materials approved in the New Zealand Building Code for use as external cladding or roof covering of buildings.

Where the design of the collector is such that sealing materials, gaskets, grommets or hoses are exposed to heat and sunlight under operating conditions these components shall be of such quality that they retain their ability to fulfil their function throughout the normal life of the collector. Sealants and gaskets shall continue to adhere to their substrates and withstand the normal forces generated by thermal expansion of the collector components. Hoses shall remain crack-free and grommets shall retain their flexibility.

The casing shall be constructed in a way that prevents the ingress of wind blown rain and dust.

The casing shall have means of ensuring that condensation is vented and that pressure changes resulting from temperature changes within the collector are relieved. Where breather/drain holes are provided in the collector body they shall be formed in such a way as to prevent ingress of wind blown dust and water.

The completed casing (with the glazing) shall be of a strength and rigidity such that normal handling does not damage the collector during shipping and installation.

Acceptable solutions:
Collector casings are made of standard roofing materials such as galvanised steel and aluminium of appropriate thickness. Collector casings which are normally used in outdoor situations may be constructed of plastic materials such as Acrylic, ABS, and resin bonded fibreglass of outdoor quality.

The provision of breather/drain holes, usually at the lowest point in the collector in its normal mounted position shall be of such a size that they do not block with debris.

Sealants shall be types normally specified for external use in buildings.

4.6 COLLECTOR CONSTRUCTION:

Requirements:
The collector shall be made from materials which in their application to the collector shall meet with the requirements of the New Zealand Building Code Approved Document B2.

Materials exposed to the weather shall be capable of withstanding the commonly encountered conditions such as solar radiation at the intensities normally encountered at the installation site, maximum and minimum temperatures at the installation site, and rain. The collectors shall withstand snow loadings likely to be encountered. Collectors shall be capable of withstanding impact by hail up to the sizes commonly encountered at the installation site. Collector insulation shall not absorb moisture.

Materials of construction of the collector (including the absorber) shall not degrade under the conditions met in normal operation. Nor should they become damaged or degraded under repeated stagnation.

For direct collectors, components of the absorber which come in contact with potable water shall comply with the requirements of the NZ Building Code, Approved Document G12 and of AS/NZS 4020.

Acceptable Solutions
Collectors shall be constructed to meet the requirements of Section 4 of AS/NZS 2712.

4.7 COLLECTOR EFFICIENCY:

Collector efficiency is the fraction of the solar energy falling on the aperture of the collector which is transferred to the primary fluid. The instantaneous efficiency varies with operating conditions such as solar intensity, ambient temperature, operating temperature of the collector, fraction of the casing which is exposed to the ambient conditions, and wind speed over the collector. For a flat plate collector the instantaneous efficiency can be designated reasonably accurately by a relatively simple graph as shown in figure 19. Typical and indicative values are shown.

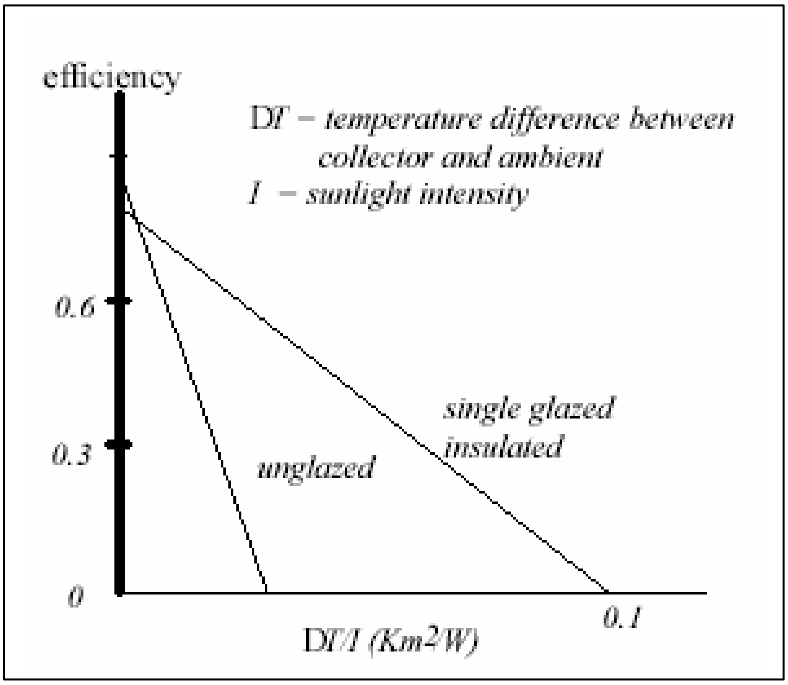


Figure 18 Hottel-Whillier-Bliss relation

For measurement of solar system efficiency see section 5.

4.8 COLLECTOR GLAZING:

The glazing of a solar collector is the transparent cover through which solar radiation reaches the absorber. Its purpose is to transmit the solar radiation to the absorber, and to reduce losses of energy from the collector by convection, conduction and radiation. As part of the casing the glazing must also protect the absorber from damage from the ambient conditions such as wind cooling.

Requirements:
The glazing shall be of a material which can withstand the atmospheric conditions to which it is exposed in normal service, such as temperature, wind, solar radiation, rain and hail, without physical degradation or loss of transparency over the expected life of the collector. The glazing must also be able to withstand damage from animals and birds.

To ensure safety in event of breakage during install or normal use the glazing must be made of non dangerous material. Where glass is used for glazing it must be of safety glass.

The glazing shall be attached to the body of the casing by a means which prevents the ingress of wind blown rain and dust.

Glazing materials shall be of a type which is either unaffected by solar radiation for the design life of the collector, and which can be replaced under the instructions of the manufacturer.

Acceptable solutions:
Glass of appropriate thickness (usually 3-6 mm depending on the supported area), plastic sheet of polycarbonate or acrylic, and plastic film of suitable strength and solar transparency are appropriate glazing materials. In the case of plastic film the collector manufacturer's instructions as to inspection, maintenance and replacement shall be clearly stated in the installation manual and in the owner's manual provided by the supplier.

Glazing shall meet the requirements of Section 4 of AS/NZS 2712.

4.9 CONNECTION OF COLLECTOR TO CYLINDER:

The coupling of the collectors to the storage cylinder may be direct or indirect as described in section 3.

Requirements:
Indirect collectors which have a primary circuit containing a heat transfer fluid are required to have fluid of low toxicity. When a single barrier heat exchanger is used to transfer the heat to the potable water supply the heat transfer fluid shall be coloured with a non-toxic dye at a concentration such that any significant failure of the heat exchanger will lead to a visible indication in the potable supply.

The manufacturer shall indicate in the installation instructions, and in the owner’s manual provided by the supplier, the nature of the heat transfer fluid and any requirements for its maintenance.

4.10 HOT STORE CYLINDER (CONTAINER):

The hot store cylinder is the vessel in which heated water is stored in readiness for use. It is sometimes referred to as the container, or the storage cylinder, or the storage container or tank. Most hot store containers are housed in an outer jacket with a layer of insulation between the container and the jacket. Cylinders may be made of a variety of materials but are usually copper (low pressure), stainless steel, or mild steel with vitreous lining. Any solar cylinder equipped with an auxiliary heater shall be treated as a hot store cylinder for the purpose of this Code.

Requirements:
Containers shall be suitable for the water condition and the supply pressure to which they are to be connected. They shall be of a design suitable for the mounting position and general area of installation. Some cylinders are designed only for specific orientation (with axis vertical or horizontal) and care should be taken to ensure that the manufacturer's instructions are followed.

Close coupled cylinders used solely for solar systems shall meet the requirements of AS/NZS 2712.

Where a stand alone new hot water storage cylinder is used as part of a split solar system it shall be manufactured and installed in accordance with the New Zealand Building Code and the appropriate NZ cylinder standards NZS 4602, NZS 4606 and AS/NZS 1056..

Storage containers shall be installed to meet the requirements of AS/NZS3500.4 Clause 6.4.

4.11 DIRECT AND INDIRECT SYSTEMS:

The collector may transfer heat directly to the domestic water (direct system) or it may transfer heat to a primary fluid which in turn transfers that heat to the domestic water (indirect system) via a heat exchanger as depicted in figures 5, 6 and 7.

4.12 DISSIMILAR METALS:

Requirements:
The installer shall ensure that all materials that are jointed directly to, or in contact with other materials shall have sufficient chemical compatibility with those materials to prevent corrosion or other deterioration that would impair their function during their intended service life.

Acceptable solutions:
All fixings used for support or fastening shall be hot-dip galvanised after fabrication, or shall be of type 316 stainless steel or other suitable corrosion resistant material complying with the relevant corrosion zone stated in the New Zealand Building Code Approved Document B2.

4.13 DOMESTIC SOLAR WATER HEATER:

A domestic solar water heater is a domestic water heating system consisting of a solar collector and a cylinder(s) arranged as a domestic storage water heater. The cylinder(s) may be integral with the collector array (close-coupled) or they may be remote or “split” from the collectors. Domestic solar water heaters usually have a controlled auxiliary heater in addition to the solar collector so that hot water supply can be maintained in the absence of solar input. In some cases other inputs such as a "wet-back" attached to a fuel burner or a heat pump are also used.

4.14 DOMESTIC STORAGE HOT WATER SYSTEM:

A domestic storage hot water system is a system consisting of a water storage container equipped with one or more means of heating water and connected so as to be able to heat the water to at least 60 ^{0}C, maintain its temperature at a desired temperature, and deliver it to the domestic outlets. Domestic hot water systems include systems with water storage capacity up to 750 litres.

Requirements:
Domestic water systems must meet the requirements of the New Zealand Building Code Approved Document G12.

4.15 FREEZE (FROST) PROTECTION:

Freeze protection is a means of preventing the water in the exposed parts of a solar water heating system from freezing.

Requirements:
At sites where conditions are such that it is possible for the water in the collectors or exposed pipe work to fall below 0 ^{o}C the solar water heating system shall be equipped with appropriate freeze protection mechanisms..

Suppliers of solar water heating systems shall advise potential customers of the potential for freezing to occur. This information shall be in documentation provided prior to purchase. Suppliers shall also advise potential customers of the ability of their specific system coping with freezing.

Acceptable solutions:
Installers should ensure that where freezing is a possibility a freeze protection mechanism approved by the manufacturer is fitted to the system. The mechanism must be able to protect the system from damage from freezing in a sustained electricity outage condition.

At sites where conditions are such that the water in the collectors or exposed pipe work is likely to fall below -9°C (Appendix B, figure B5) the solar water heating system shall be equipped with freeze protection mechanism of:

a. Indirect system with a suitable concentration of anti-freeze liquid

b. Drain-down

c. Auxiliary panel heater

NOTE –

1. It should be noted that under clear sky conditions the temperatures of panels may fall to several degrees below the ambient air temperature. The extent of this temperature depression will depend on the absorber surface type and on the type of glazing and insulation.

2. The commonest freeze protection systems include:

a) Freeze protection valves ("frost bleed valve") which are often fitted to simple thermosiphon collectors are thermostatic devices designed to open when the temperature falls to a preset value and allow a flow of water to pass through the collector to waste. These valves should be installed at positions in the circuit which ensure that the water flow flushes as much of the at risk section of the circuit as possible. The discharge from frost valves should be arranged so as not to present a risk of water freezing at the outlet of the valve or in any attached drain and so as not to inconvenience the householder.

b) Panel heaters:
In some collectors, particularly simple tube on sheet panels, a small heater is mounted behind the absorber and is activated by a thermostatic switch which turns on when the temperature falls below a critical value.

c) Pump circulation:
Is used in simple direct connected pump circulation systems. The pump controller senses when the absorber temperature falls below a trigger temperature (usually about 3o C) and turns the pump on to circulate water from the cylinder through the absorber. When the temperature of the absorber rises by a (predetermined) few degrees above the trigger temperature the pump is turned off and the temperature drifts down until the cycle repeats.

d) Indirect systems:
These operate with a primary circuit containing an antifreeze fluid (with freezing point below the expected lowest ambient temperature) circulating in the absorber and any pipe work exposed to possible freezing. This fluid flows though a heat exchanger transferring heat to the water. Such systems circulate either by pump or thermosiphon in the "collect" mode. They are non-circulating in the cold mode but do not freeze because of the low freezing point of the primary fluid.

e) Compressible element:
In such systems the waterways incorporate a flexible compressible element which is compressed if ice forms and relieves the forces which would otherwise develop.

f) Drain-down:
An arrangement whereby the fluid in the collectors is drained either into the cylinder or to waste whenever incipient frost conditions occur. The installation of drain-down systems should ensure that all the water is drained from the collectors and all exposed piping liable to freezing.

4.16 HEAT EXCHANGER:

A device or arrangement for transferring heat between two fluid streams while preventing mixing of the fluids.

Heat exchangers are of several types and forms as shown in Figures 5,6 and 7.

Single barrier heat exchangers have one element between the two fluid streams. Double barrier heat exchangers have two elements between the two fluids.

In a single element heat exchanger failure of the single element will allow mixing of the fluids. In a double element heat exchanger two separate elements must fail before mixing of the fluids can occur.

Heat exchangers may be separate from the hot storage cylinder or may be incorporated within the cylinder structure. In some structures the heat exchanger is a jacket around the outside of the hot storage cylinder. In others it can be a coil within the cylinder. Both of these forms are usually single barrier types. Other single barrier types are tube-in-tube systems in which one fluid flows in a tube enclosed by a second tube within which the other fluid flows, or plate exchanges in which a set of plates is arranged so as to form a stack within alternate layers of which the two fluids flow.

Double barrier heat exchangers usually consist of separate fluid channels which are joined by a thermally conductive adhesive. For example one may have two separate copper tubes soldered together.

Requirements:
Heat exchangers shall be designed to prevent any exchange of fluids in normal use. Each circuit of the heat exchanger shall be capable of withstanding the maximum pressure to which it may be exposed in normal service. The materials of construction shall be such that no contamination of the potable water shall occur in normal service. The heat exchanger shall be capable of withstanding the highest temperatures and the highest temperature gradients to which it is likely to be exposed in service without damage or loss of performance.

4.17 HEAT TRANSFER FLUID:

The heat transfer fluid is the medium which is in direct contact with the absorber and which carries the thermal energy away from the absorber. In a direct system the heat transfer fluid is the domestic water. In an indirect system it is some other fluid which may be water or a solution of other substances such as glycol in water or, as in the case of some solar assisted heat pumps, a non-aqueous refrigerant.

Requirements:
Heat transfer fluids used as the primary fluid in indirect systems shall be non-corrosive and stable at temperatures up to the highest temperature likely to be encountered in normal service. When used in single barrier heat exchangers the primary fluid shall be non-toxic or of low toxicity and in order to provide an indication of fluid loss be coloured with a non-toxic dye at a concentration high enough that leakage into the secondary (potable water) circuit shall be readily detected.

Acceptable solutions:
The red food colorant 1618, C1 food red 9 (amaranth) and resorcinolphthalein (fluorescein, sodium fluorescein, uranine,) are listed as possibly suitable colorants in NZS 4613:1986.

4.18 HYDROSTATIC HEAD:

The fluid head is the pressure difference between two parts of a fluid circuit. This is usually expressed as the equivalent physical height of a column of the fluid in the circuit. The hydrostatic head is the head between two points in a fluid circuit when no flow is occurring.

4.19 INSOLATION:

Insolation is the intensity of the solar radiation reaching the collector. It is usually indicated in kW/m^2. Insolation is also given as $kWh/m^2/day$. The typical insolation on a surface normal to the sun on a clear sunny summer day at noon in New Zealand is 1000 W/m^2. Values a little higher than this are achieved in certain conditions (e.g. when there are reflections from other building surfaces or from clouds). The daily energy input from the sun on a surface varies with inclination and season. Some typical values are shown in Apprendix B.

4.20 HOT STORE CYLINDER INSULATION:

Insulation is necessary to reduce heat loss from hot storage cylinders.

Requirements:
Cylinders shall be insulated to a standard at least as high as that required for hot water cylinders in conventional non-solar systems. The standing heat loss under standard conditions (NZS 4606) shall not exceed that shown in figure 20.

Standing Heat Loss	
Cylinder Capacity (Litres)	Maximum 24 hr Loss (kWh)
6.5	0.5
13	0.5
22	0.6
45	0.8
90	1.2
135	1.4
180	1.6
225	1.8
270	2.0
360	2.5
450	2.9
540	3.4
630	3.8

Figure 20 Allowable heat loss. Source NZS 4606 (1989)

Cylinders mounted externally to the building shall be insulated to a standard adequate to reduce the average energy loss in normal operation to that required by the NZS 4606.

NOTE –

1. The Energy Efficiency (Energy Using Products) Regulations 2002 require all electric storage water heaters manufactured or imported for sale after 1 February 2003 to meet the maximum heat loss requirements set by New Zealand Standards 4606 Part 1 1989 (Storage water Heaters) and NZS 4602 1985 (Low Pressure Copper Thermal Storage Electric Water Heaters).
2. Suppliers of indirect (closed loop) systems which use a heat exchanger are currently exempt from compliance with the Regulation as NZS 4606 does not apply to heat-exchanger systems.
3. Importers of Australian manufactured hot store cylinders designed solely for solar water systems which meet the legal requirements for installation in Australia are currently able to sell their systems in New Zealand under the Australian-New Zealand Closer Economic Relations (CER) Trans-Tasman Mutual Recognition Agreement.

4. The hot store cylinder regulations are being reviewed but are not expected to change within the next few years

2. The current Minimum Energy Performance standards are under review and it is expected that the New Zealand standard will be covered by AS/NZS 1056 for split solar water heating systems. Close coupled thermosiphon systems will horizontal cylinders are expected to be covered by AS/NZS 2712.

4.21 OPERATING PRESSURE:

Domestic water heating systems are usually operated at controlled pressures from hydrostatic heads as low as 10kPa up to as high as 500kPa. Cylinder manufacturing and installation requirements for various heads are described in the appropriate standards (NZS 4602, NZS 4603, NZS 4606, NZS 4607).

Solar water heating systems can be designed to work at any of the common domestic hot water system operating pressures. Most systems are rated for mains water pressure.

As for any hot water system solar systems shall be equipped with means of pressure control and relief appropriate to the operating pressure. Low pressure systems should be open-vented with the vent pipe extending at least 600 mm above the standing water level.

Storage cylinders associated with domestic solar water heating systems shall be installed in accordance with requirements of the building code and in particular AS/NZS3500.4 as they would apply to other domestic water heating cylinders.

Where valve vented cylinders are used in conjunction with a wetback the wetback shall be on a primary loop open vented to atmosphere and transferring heat to the domestic water through a heat exchanger. This is usually a coil built into the cylinder.

Requirement:
Solar equipment manufacturers of collectors that are not mains pressure rated shall indicate on the collectors the range of operating pressures for which the collectors are built.

Installers shall confirm that the system they are installing is compatible with the household's hot water system operating pressure.

Note: 1m hydrostatic head is equivalent to 10kPa.

4.22 PUMP CIRCULATION SYSTEM:

Is one in which circulation of the primary fluid through the collectors is achieved by a pump which mechanically displaces the fluid through the heating circuit. It is sometimes known as forced circulation.

Schematics of pumped systems are shown in figures 4 and 6.

Requirements:
Pumps are usually electrically driven but some pumps can be driven thermally by arrangements which make use of the temperature differences in the primary fluid itself. Pumps which depend on the pipe layout for their operation (e.g. thermally driven pumps) shall be installed strictly in accordance with instructions of both the pump maker and the suppliers of the solar equipment).

The pump in a direct system shall draw water from the low point of the cylinder, circulate it through the collector(s) and return the heated water to the cylinder at a point higher than the draw-off point.

The pump used in a pumped system shall be one specified by the solar system manufacturer.

The manufacturer's recommendations regarding pipe sizing and layout shall be followed to ensure adequate flow in the primary circuit.

Pumps shall be installed with fittings which will allow their easy removal for servicing and maintenance, preferably without draining the system or disturbing adjacent pipelines.

Where possible valves shall be provided which will allow routine maintenance to be performed without draining the cylinder.

The return pipe from the collector in a direct system or from the potable water side of a system with an external heat exchanger pumped system shall be arranged so that the returning water does not generate undue mixing particularly with the heated water above the return point. This is usually achieved with a baffle at the return pipe entry or a diffuser incorporated in the return pipe. In some cases the appropriate measure is built in to the cylinder. Installers should ensure that this is the case.

Acceptable solutions:
Glandless pumps are commonly used but where a pump with an exposed gland is used it shall be situated so that any leakage from the gland cannot cause damage to the structure or contents of the building. Where an exposed-gland pump is used inside a building where leakage could endanger the structure or inhabitants it shall be installed inside a safe tray which effectively drains to the outside of the building or an approved outfall.

Only connection points provided on the cylinder for this purpose or special fittings provided or approved by the system manufacturer shall be used. In either case the manufacturer's instructions shall be strictly adhered to.

Where the pump is not an integral part of the cylinder it shall be mounted according to the pump manufacturer's and the system manufacturer's instructions. The position of the pump and associated piping shall be such as to minimise the transmission of sound and vibration to the building.

Pumped systems are frequently installed with the collectors mounted at a higher level than the cylinder. In such situations care shall be taken to ensure that unwanted circulation ("back circulation") of fluid from the cylinder to the collectors does not occur when the pump is not operating. Such circulation can be prevented by the inherent design of the system itself for example by the use of anti-thermosiphon loops at the points of entry of the circulation pipes to the cylinder. If this is not the case the system shall be fitted with a non-return valve (check valve). This shall be of a type recommended by the manufacturers and installed in accordance with their instructions.

The pump shall be of a type capable of producing a hydrostatic head greater than the physical height between the pump and the highest point of the collector. This is to ensure that air released from the primary fluid does not form an air lock. Provided the top of the solar circuit is under positive water pressure, as an alternative the system may be fitted with an automatic air eliminator at the highest point.

Note: Occasionally a pump will operate on and off at close intervals when this should not be necessary. If this occurs solar system owners should get the installer to check the pump controller settings.

4.23 SACRIFICIAL ANODES:

Storage tanks manufactured from metal can be susceptible to corrosion. The combined effects of water pressure, temperature and water chemistry can create an aggressive environment for corrosion of some metals.

Requirements:

Vitreous enamel lined steel cylinders shall be provided with a sacrificial anode of a material suitable for the water in the area where the cylinder is to be used. The anodes shall be in electrical contact with the container and shall, when new, extend to within 100 mm of each end of the cylinder. The anodes shall be capable of being replaced and the cylinder manufacturer shall provide instructions on the type of anode to be used and the normal replacement interval.

Vitreous enamelled cylinders fitted with sacrificial anodes shall be delivered with instructions which include the following warning as required by AS/NZS 1056.

> WARNING: THE CYLINDER OF THIS SOLAR HOT WATER SYSTEM IS FITTED WITH A SACRIFICIAL ANODE. IF THE CYLINDER IS NOT USED FOR TWO WEEKS OR MORE, A QUANTITY OF HYDROGEN GAS WHICH IS HIGHLY FLAMMABLE MAY ACCUMULATE IN THE WATER HEATER. TO DISSIPATE THIS GAS SAFELY, IT IS RECOMMENDED THAT A HOT TAP BE TURNED ON FOR SEVERAL MINUTES AT A SINK BASIN OR BATH, BUT NOT A DISHWASHER, CLOTHES WASHER OR OTHER ELECTRICAL APPLIANCE. DURING THE PROCEDURE THERE MUST BE NO SMOKING, OPEN FLAME OR ELECTRICAL APPLIANCE OPERATING NEARBY. IF HYDROGEN IS DISCHARGED THROUGH THE TAP IT WILL PROBABLY MAKE AN UNUSUAL SOUND AS WITH AIR ESCAPING.

To allow for change of dwelling owner, this warning should also be permanently displayed within the dwelling in a prominent location agreed with the dwelling owner.

Installers of steel cylinders shall also attach a notification to the system in a prominent position where dwelling owners can see the notice advising the system owner of the need to replace the sacrificial anode at the appropriate replacement interval. The date of installation shall, be shown so that it is clear when the next replacement time will occur.

4.24 SAFE TRAY:

A safe tray is a tray placed under water containing apparatus to collect any leakage or other discharge and connected to a suitably sized drain discharging to the outside of the building. The tray and drain shall be of material capable of withstanding the maximum temperature of any water which might be discharged into the safe tray.

4.25 SOLAR CONTROLLER:

A solar controller is a device for controlling the action of the pump in a pumped system. The controller usually consists of two or more temperature sensors which measure the temperature of the collector and the storage cylinder respectively and which are connected to a circuit which will turn the pump on and off as required. Controllers are usually also capable of turning the circulating pump on and off to circulate water in the collectors as a protection against freezing under low temperature conditions (see "Freeze Protection").

Controllers may incorporate a time switch in order to control when auxiliary heating is activated. A time switch can significantly increase the benefits of a solar system as it can be used to allow auxiliary boosting for short periods when needed. It avoids auxiliary boosting occurring prior to the reception of solar energy.

Care should be taken to ensure that such timers are installed in such a way that ripple control does not disturb the settings.

Requirements:
Manufacturers of pump-circulated systems shall provide recommendations for appropriate solar controllers and appropriate instructions for the fitting of temperature sensors. Manufacturers shall provide instructions on the placement of sensors and installers shall ensure that the

temperature sensors are installed on the collector and at the cylinder in accordance with the solar system manufacturer's instructions. Sensors shall be installed so as to be protected from the weather and from condensation. Sensor cables shall be installed neatly and (if possible) in a way that allows their easy removal, along with the controller, for servicing. This is particularly important with controllers in which the calibration includes the specific sensors attached to the controller. Cables shall be protected from degradation by weather and attack by animals (particularly birds and rodents).

Installers shall check that controllers are operating according to the manufacture's requirements. Ideally this will be done as a test on the completed installation. Where this is not possible the operation of the controller functions, "pump on", and "pump off" in both the normal and the frost protect mode shall be checked according to instructions which shall be supplied by the solar controller manufacturer.

The solar controller shall be equipped with an indicator to show when the pump is operating. The controller shall be mounted in a position which enables the indicator to be seen easily. Where an external (remote) indicator is used it shall be mounted in a position acceptable to the user.

The solar controller shall be installed in a position where it is accessible for servicing. It shall be connected to the mains supply via a standard outlet plug situated in a position where it is unlikely to be disturbed or accidentally turned off (controllers should not be "permanently wired").

Where possible controllers and the pumps that they control should be connected to a dedicated electricity circuit. In any case the circuit and circuit breaker (or fuse) for the solar system shall be clearly marked on the switchboard.

4.26 SOLAR PRE-HEATER:

A solar pre-heater is a container with solar collector but no auxiliary heating which takes cold water and supplies solar heated water to a domestic water heating system. Schematics of preheater layouts are shown in figures 13 and 14.

4.27 STAGNATION TEMPERATURE:

Stagnation is the condition where the collector is exposed to solar radiation but no energy is drawn from it as hot water. The steady state temperature of the collector under this condition is known as the "stagnation temperature".

Requirement

Collectors should be designed so that after (repeated) exposure to stagnation temperature conditions under insolation of 1200W per m^2 and an ambient temperature of 30°C, there will be no permanent damage to the collector or its fittings or the glazing and no significant reduction in the collector efficiency.

4.28 TEMPERATURE CONTROL:

Solar water heating systems can reach quite high temperatures especially in summer if no water is drawn for some time. Temperature / pressure relief devices are included in a system to ensure that the pressure and / or temperature do not reach unsafe levels.

It is essential that the relief devices have sufficient capacity to protect the system.

The installation of a relief device(s) sized for the particular application is especially important as there are a significant proportion of hot water cylinders with isolation valves mounted close to the cylinder on the incoming mains. Therefore, depending upon the system layout, the solar collector is able to be isolated from the cylinder thereby leaving the solar collector to potentially stagnate and overheat. This leaves a single relief point to protect the system and the property / occupants.

Requirement
To avoid danger from possible high temperature hot water open loop solar water heating systems shall be fitted with a temperature pressure relief valve on the outlet from the cylinder.

The size of the relief valve must be adequate for the size of the solar system and have a relief temperature that shall be not less than the total output power of the collectors at 99^{o}C and 1200W/m^2 and 40^{o}C effective ambient, plus any auxiliary heater.

Acceptable Solution
An installer must be able to provide documentation on the performance of the collector or capacity of the valve to demonstrate that the size of the temperature/pressure relief valve is adequate for the size of the solar system.

Cylinders equipped with an auxiliary heating device (electric element) shall be controlled by a thermostat. This should preferably be of the 'consumer adjustable' type.

4.29 TEMPERING VALVE

A tempering valve is a mixing device between the outlet of a water heater and the user fitting eg domestic tap. It limits the delivered hot water temperature at the tap so that users are not scalded.

Requirement
To ensure that users of water from a solar system are not injured by hot water a tempering valve must be installed.

Acceptable Solution
A tempering valve complying with NZS 4617 is an acceptable device for controlling the delivery temperature.

4.30 THERMOSIPHON SYSTEM:

A thermosiphon system is one in which the circulation of the primary fluid is achieved through the density difference resulting from heating of the fluid in the collector as shown in figure 21(a).

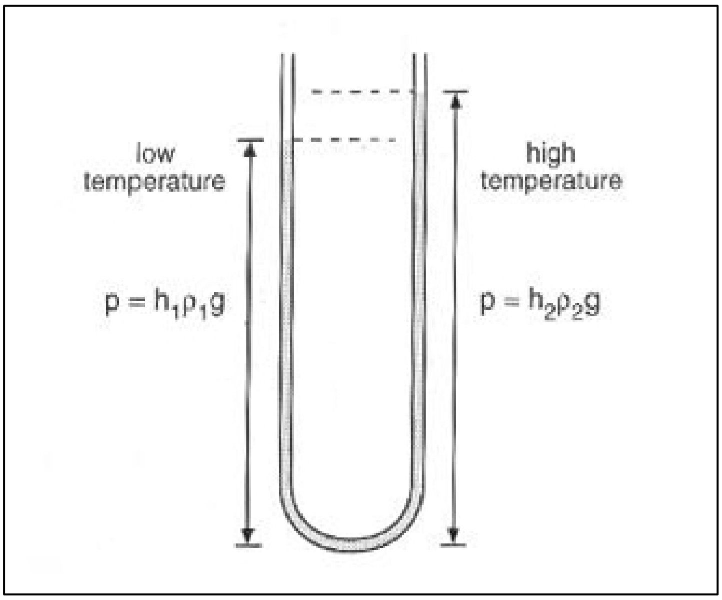


Figure 21 (a) Columns at different temperatures

The thermosiphon head is the hydrostatic head due to the differences in temperature between the two sides of a thermosiphon loop. Thermosiphon head is dependent on the physical heights of the hot and cold columns in the circuit and the temperature differences in the two columns. This is illustrated in figure 21(b).

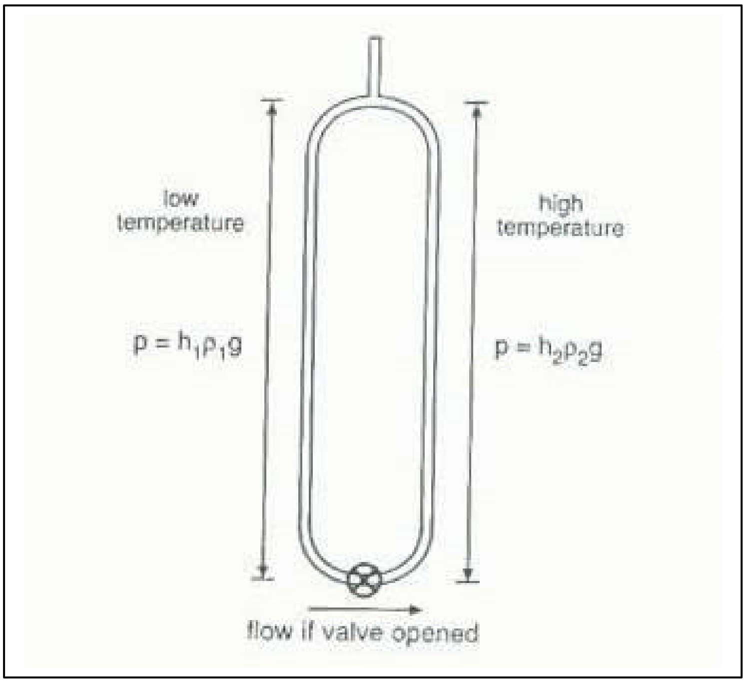


Figure 21 (b) Columns at different temperatures connected at the top

In simple domestic water heating water circuits the maximum thermosiphon head will be less than 3% of the physical height of the hot and cold columns and is generally much less than this.

Because of the low heads involved, thermosiphon systems need special care in installation to ensure that adequate circulation is achieved between the collector and the cylinder. In particular, care must be taken that there is sufficient "rise" between the collector and the cylinder to ensure an adequate thermosiphon head for the effective circulation of the primary fluid. Because this head is quite low (of the order of a few centimetres or less) special care must be taken to ensure that there is a continuous rise of the pipe-work between the collector and the cylinder. Without this there is a high degree of risk of forming an air lock from the accumulation of air released from the fluid heated in the collector. This risk is even greater in "open" circuit systems in which the fluid circulating in the collectors is the domestic water itself from which dissolved air can be evolved during heating.

Requirements:
In a thermosiphon system the circulation pipe from the top of the collectors to the entry point in the cylinder shall have an average upward slope of not less than 1 in 7. The minimum upward slope at any point shall be not less than 1 in 12 unless the pipe is vented at that point. All pipe bends in thermosiphon loop shall be smooth and of large radius.

Because the thermosiphon head is small it is also necessary to ensure that the frictional resistance to flow is small. This means that relatively large diameter piping is needed between the collector and the cylinder. Systems should be installed with pipe diameters as recommended by the system manufacturer.

Installation of containers and collectors of thermosiphon flow water heaters with remote containers shall be in accordance with AS/NZS3500.4:2003 clause 6.7 and for installation of close coupled and integral solar water heaters will be in terms of AS/NAS2712 clause 6.6.

4.31 UNDERFLOOR HEATING

Solar water heating systems may be connected as a heat source to underfloor heating in a dwelling. It is not generally installed as a primary heating source but to take the chill off the floor and provide background warming of the house.

There is often about four times the amount of solar panels for system used for underfloor heating compared to a hot water-cylinder only solar system. The solar system may be integrated with wetback, gas and other boost backup options.

The underfloor heating system should not be considered part of the solar system as it could be heated by other energy sources. The demarcation between the solar system and the underfloor heating system is the outlet of the manifold on the solar hot piping.

4.32 VENTING:

Venting is an arrangement which enables the water heater to be permanently vented to atmosphere. Venting is usually, but not always, achieved by a pipe attached to the cylinder and projecting above the roofline.

An un-vented system has no permanent opening to the atmosphere.

Valve venting allows relief of internal pressure above a specified value by means of a relief valve. Valve vented cylinders shall be equipped with relief valves for both over pressure and over temperature as prescribed in NZS 4607.

4.33 WETBACK:

A wetback is a heat exchanger incorporated in a fuel burner (usually a log burner or hot water boiler) which transfers heat from the burner to the domestic water heater as shown in figure 4.

Wetbacks can be direct or indirect. The direct form is shown in figure 4, an indirect form is shown in fig 22. A wet back circuit must be open-vented to the atmosphere. Where a wet-back is used in conjunction with a cylinder operating at a pressure which cannot be conveniently vented open to atmosphere it is usual to have the wet back on an indirect loop with a heat-exchanger coil built in to the cylinder to transfer heat from the low pressure wet-back to the higher pressure domestic supply. Such arrangements must be open vented as illustrated in figure 22.

Where a wetback is used in conjunction with a solar water heater the circuits for the two heat sources shall be arranged so as not to interact hydraulically with each other. This is usually achieved by having the two sources with independent piping as indicated in figure 3. Common piping should only be used when technical literature is available from the manufacturer indicating this is possible.

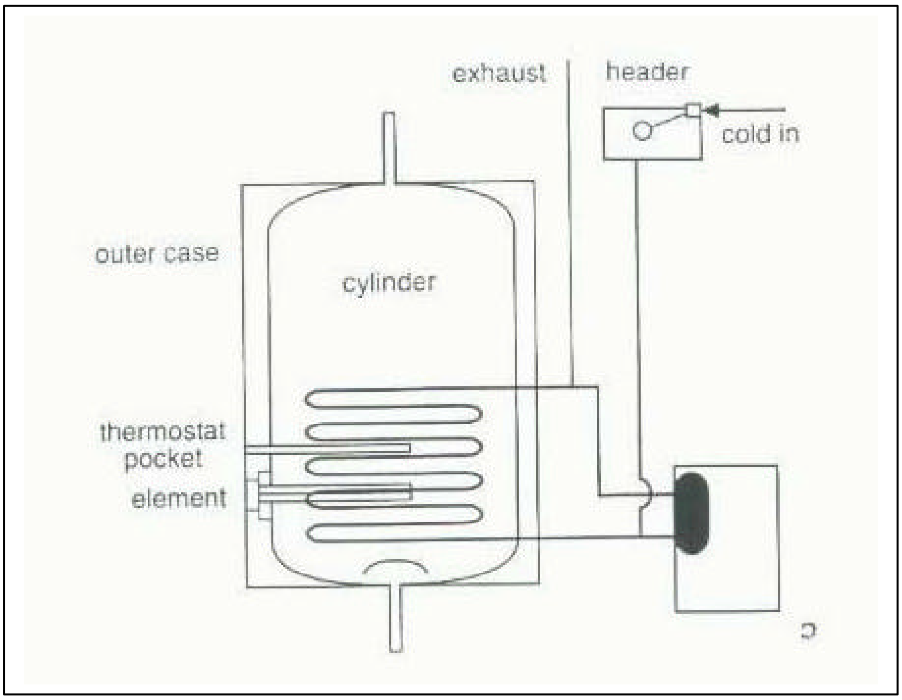


Figure 22 (a) Indirect wetback installation with header tank

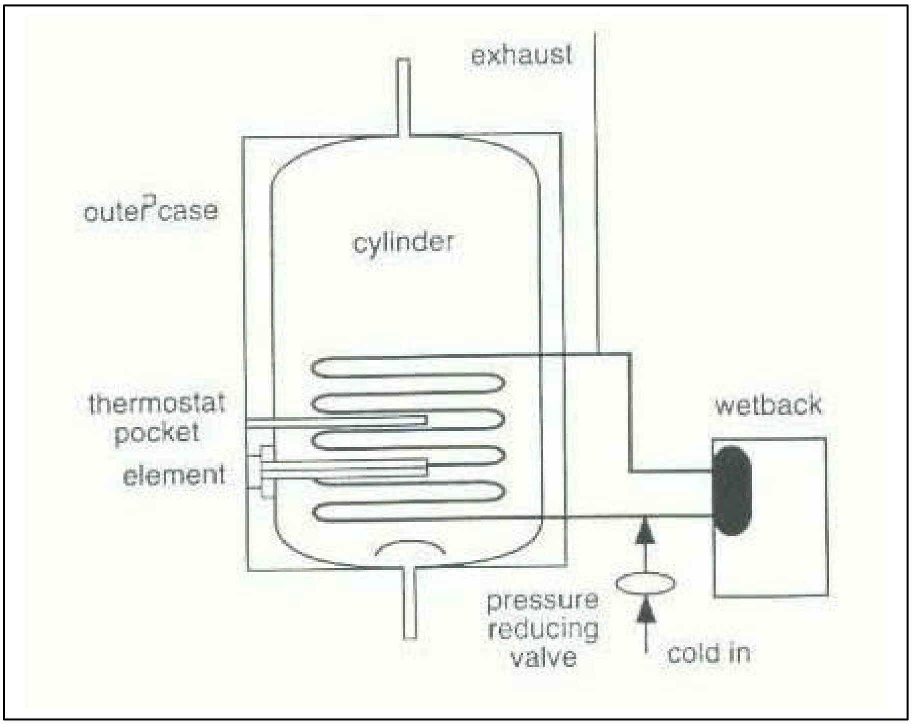


Figure 22 (b) Indirect wetback installation with pressure reducing valve

5 PROCEDURES FOR INSTALLERS

5.1 PRECAUTIONS DURING INSTALLATION:

This part of the Code is intended to ensure that the solar water heating system is installed in such a manner that it is effective and that the installation imposes no significant stress upon the structure of the building on which it is installed and poses no unreasonable physical or thermal risks to its user.

The solar water heating system may require installation of electrical wiring. This may be for the system controllers or electrical booster.

Solar water heating systems with gas booster auxiliary heating will require installation of gas pipes and other equipment.

Requirements:

Plumbing and electricity

The Plumbers, Gasfitters and Drainlayers Act 1976 requires that all sanitary plumbing is done by persons licensed by the Plumbers, Gasfitters and Drainlayers Board and under the direction of a person with a craftsman plumber's licence.

Approved Document G12 of the New Zealand Building Code specifies the performance requirements relevant to the water supply aspects of the system and compliance with G12/AS1 is an acceptable solution. A licensed electrician or a SWH installer who holds a tradespersons electrical work certificate shall undertake electrical connections to permanent wiring.

Where mains electrical wiring is installed to a cylinder outside the building envelope the cables or conduit exposed to the elements shall be of weatherproof quality. Electrical connections at such cylinders shall be in a weatherproof enclosure.

Penetrations of the roof surface required to bring electrical wiring and water piping to the collector shall all be made in such a way as to ensure that the integrity of the roof as a waterproof surface is maintained.

Gas connections

All gas work must be undertaken under the direction of and certified by a gasfitter holding a craftsman's licence.

Pipework

Allowance for thermal expansion shall be incorporated in the design of relatively long pipe runs and fixing points by the installation of expansion loops or bends, where significantly large temperature differences occur. Expansion loops and offsets shall be placed horizontally to avoid forming air locks at the top of loops and to ensure proper circulation of the water.

Avoidance of damage

Installers shall take every care to ensure that the occupants of the building and the public are not endangered by their activity. Care shall be taken to keep tools and other materials from falling from the installation site.

Care shall be taken to prevent incidental damage to any part of the building and any such damage shall be reported to the owner and made good.

Installers shall take care that ladders do not scratch or damage the building, in particular guttering.

Installers will not damage the roof surface by improper walking between roof support points, nor with inappropriate load placement. Care will be taken when moving cylinders and collectors to ensure they do not slide on slopes or damage the roof surface.

Care shall be taken to ensure that there is adequate drainage under solar collectors mounted on roof surfaces so that they do not act as collection points for leaves and other debris.

When installing a system involving a pipe heat exchanger in the hot store cylinder it is important that the collector is covered when the cylinder is empty of water otherwise the pipes may be damaged.

5.2 PRELIMINARY INSPECTION OF SITE:

The proposed collector site shall be checked to ensure that there is an adequate area of roof for an installation of appropriate size and oriented in an appropriate direction at an appropriate inclination. The site should be checked for shading by trees, other buildings, chimneys or other objects. In particular this should be done allowing for low sun angles in winter. In the event that any features are found which might impair the performance of the installation these factors shall be discussed with the owner prior to beginning installation. Inappropriate sites should be avoided.

Requirements:
Prior to beginning an installation the installer shall confirm with the customer that the roof structure is capable of accepting the solar water heater, both in area and in strength and that appropriate means of attachment of the collectors are available. Roof loadings of installed collectors in operating condition shall be in accord with the requirements of the New Zealand Building Code, Approved Document B2. In the case of close-coupled systems this includes the weight of the cylinder full of water.

The availability of a suitable route for piping between the cylinder and the collector should be confirmed. Where a system with an integral cylinder is used the distances between the cylinder and the important hot water outlets should be checked to ensure that excessively long hot water delivery times are avoided. For pump-circulated systems the availability of a suitable electricity supply for the pump and controller shall be confirmed.

Acceptable solutions:
To ensure that the system purchaser is satisfied with their solar system, the supplier/installer should undertake a site inspection with the purchaser prior to sale and clarify all aspects of system performance and installation. Guarantees should be made available. The information discussed and installation aspects agreed should be confirmed in writing.

NOTE - A simple check sheet recording such information and signed by both supplier/installer and purchaser should be adequate documentation.

5.3 BUILDING CONSENTS:

Because solar water heating systems can involve heavy loads on roof structures installation of a solar water heating system may require a building consent. A consent may also be required where there is a change to the potable water supply. A consent may also be required to cover electrical alterations.

All plumbing work will require certification by a Craftsman plumber and possibly an electrician. This may be in the form of a Producer Statement as required by the Building Consent.

Solar water heating installations fall into four categories with regard to risk to structures and inhabitants. The level of scrutiny for consideration of a Building Consent varies for each category.

Category 1
The solar water heating system involves a split system where only the collector panel(s) are on the roof and the storage cylinder(s) is either an existing cylinder or replacing an existing cylinder at the same location in the building. This category also covers a split system installed onto a new building where the Building Consent may already have been issued.

Category 2
The solar water heating system is included in a new building for which a building consent has yet to be obtained. This category excludes category 1 split systems.

Category 3
The solar water heating system is installed on an existing building and includes a cylinder to be located on the roof or within the roof framing.

Category 4
The solar water heating system is “non standard” with regard to the water system, or complexity of system layout.

Requirements:
Solar water heater systems are to be installed in such a way as not to endanger the roof structure.

Solar water heating installers are to ensure that any necessary Building Consents are to be obtained by the installer and adhered to.

An installer of a SWH system must be able to demonstrate to the Consent Authority that the installation confirms to this Code of Practice and requirements of the Building Code.

Installers are to provide a signed Producer Statement confirming that they have installed the solar water heating systems in terms of the requirements of this Code of Practice.

Acceptable solutions:
The installer shall check with the local City or District Council to confirm the requirements for a building consent. Any such consents will be obtained by the installer prior to commencing installation. The installer is responsible for ensuring compliance with the consent conditions.

To assist installers obtain building consents with the minimum of effort system suppliers may provide pre-prepared supporting documentation to accompany an application. The documentation will include acceptable structural support arrangements for specific system models.

The level of documentation provided with a consent application may depend on the category of installation:

1. A Category 1 application is made with the following information appended and as set out in form D1 include in Appendix A.
   - Name and model of SWH system to be installed.
   - The SWH system is supplied by an accredited SWH supplier
   - The SWH system will be installed by an installer approved by the SWH supplier
   - The names of the supplier and installer are shown, including contact details.

- A sketch of the building layout showing the positioning of the collector and hot store cylinder and piping arrangement. Location of TPR valve(s) is to be shown with indication of where any hot water discharged would be collected.
- The installer is to provide a signed PS3 certificate in the format set out in Form D2 of Appendix D.

2 A Category 2 application will have the SWH system included in the building consent issued for the new building. The required PS1 certificate for the Building Consent will include the loadings of cylinders on roof structures.

- The installer is to provide a signed PS3 certificate in the format set out in Form D2 of Appendix D.

3. A Category 3 or 4 application is to include a PS1 certificate for the Building Consent will include for the loadings of cylinders on roof structures. Or
A Category 3 application is made by an accredited supplier or their approved installer under a prior agreement with the Consent Authority. The prior agreement to be obtained once the Consent Authority is satisfied that the accredited supplier or their approved installer met the following criteria;
    - Standard SWH products are located in standard locations
    - The installer is trained to install the product on existing buildings
    - The supplier has provided the installer with guidelines and procedures for checking and strengthening existing structures under cylinders.
    - The installer provides the information required and specified in Form D1 of Appendix D
    - The installer provides a PS3 certification in the format set out in Form D2 of Appendix D

NOTE –

1. To assist in reducing the cost of obtaining a building consent and demonstrating compliance District and City Councils are encouraged to frame the issuing of consents around use of this Code of Practice. If a solar water heating system is installed in terms of the requirements and acceptable solutions set out in this Code the issuing of building consents should reduce compliance costs.
2. By signing a Producer Statement indicating that the solar water heating system has been installed in terms of the requirements of this Code of Practice this should provide assurance to Building Inspectors that the system has been installed properly.

5.4 CYLINDER INSTALLATION:

Solar systems are to be installed so that all cylinders are soundly supported by the structures that they are installed upon and do not form a hazard to people or the building. Cylinders full of water can produce significant loadings on building structures and installation should only be undertaken by competent installers.

All gas work will be required to be certified by a Craftsman Gasfitter and a copy of the form submitted to the Plumbers, Gasfitters and Drainlayers Board for audit purposes.

The installation of a solar system must safeguard people from illness caused by infection from contaminated water.

Externally mounted cylinders shall be adequately weatherproof and shall be insulated and enclosed in an outer sheathing which will resist weathering and corrosion and protect the insulation for the expected life of the installation.

Where vitreous-enamel lined steel cylinders are used they shall be installed in accordance with the manufacturer's instructions and where such cylinders are equipped with protective sacrificial anodes the cylinders shall be installed in such a way that the anode can be replaced as necessary and in accordance with the manufacturer's requirements.

(a) Structural Support

Requirements:

The NZ Building Code Approved Document B1 requires cylinders to be installed so as to safeguard people from injury and property from physical damage.

Storage cylinders shall be mounted in a seismically secure manner and so that in the event of leakage damage will not occur to any adjoining property or its contents. Cylinders shall be installed so that access and clearance are available for the inspection, routine maintenance, removal, and replacement of all relief valves, elements, thermostats and other protective devices (such as sacrificial anodes) with minimal displacement of the associated plumbing and piping. Ready access should be available for adjustment of thermostats.

Where a system uses a cylinder mounted externally on the roof or within the roof cavity of a building the installer shall ensure that the roof structure is adequate to support the container when filled with water and that the mounting is seismically secure and complies with NZ Building Code Approved Document G12. Additional struts may be required to support such an installation. Straps should be bolted or secured with multiple fastenings adequate to take earthquake forces, particularly when located on steep roof slopes.

Solar systems are to be restrained against earthquake in terms of the NZ Building Code Approved Document G12.

Acceptable solutions:

An acceptable solution is that the installer has satisfied the Local Authority that the requirements for meeting structural loadings have been met. This may be achieved by ensuring;

- that cylinders are located appropriately over multiple roof structures;
- solar system meets manufacturers installation guidelines, and
- in the case of installation on new buildings that the building designer has included for installation of the particular solar system under consideration in plans covered by the building consent, or
- the support structure complies with Tables 5 and 6 of the "Manual for Structural Assessment for Installation of Solar Water Heating in Domestic Dwellings" referenced in Appendix A.

Where there is any doubt about the strength of a structure to carry the loading of a storage cylinder the installer should obtain an engineer's advice. The engineer may use the information in the "Manual for Structural Assessment for Installation of Solar Water Heating in Domestic Dwellings " referenced in Appendix A to provide advice. Where considered necessary, or appropriate, an engineer's certificate should be obtained.

Storage cylinders should be located so that they are supported either directly by load bearing walls or by framing members. Where additional support is required this can be provided by underpurlins, struts, strutting beams and the like to transfer loads to load bearing walls.

5.5 PLUMBING

(a) Plumbing of Potable Water Supply

Requirements:

Solar systems are to be installed in terms of NZ Building Code Approved Document G12 . As noted in 5.1, the Plumbers, Gasfitters and Drainlayers Act stipulates requirements relating to the licensing of persons doing plumbing work.

A craftsman plumber is required to submit a consent to the Territorial Authority to have approval for the installation of all components through which potable water flows. (The whole installation is then checked/certified by the Territorial Authority Building Inspector).

In some areas of New Zealand building inspectors will allow trained solar water heating installers to install the system components up to the point of connection into an existing hot water cylinder. A craftsman plumber should take responsibility for the installation overall and sign certification in the format of Form D2 of Appendix D

The plumbing installation must be designed to ensure thermal convection caused by a source of heat other than the solar collectors does not result in the water heated by another source being circulated through the collectors. This means that back circulation shall be prevented from cylinders with electrical or gas heating and thermosiphon circulation from wetbacks shall not take place to the collectors.

Acceptable solutions:
To minimise heat losses and water wastage, the storage cylinder should be located as close as possible to the point of maximum hot water draw off.

(b) Precautions against Leakage
Requirements:
Cylinders mounted in a roof space or a space not directly accessible by a hinged or sliding panel, or in a space above a living area shall be on a safe tray. The enclosure shall be designed so that the cylinder can be accessed for servicing or replacement without major interference with the structure.

Where cylinders are mounted in a ceiling space above a living space or above a space where damage could be caused by leakage of the cylinder a safe tray shall be provided. The radial clearance between the safe tray and the cylinder shall be not less than 50 mm. The tray shall be fitted with a drainpipe not less than 40 mm diameter discharging clear of the building. Where a metal tray is used it shall be of adequate thickness, (not less than 0.45 mm). Electrical contact between the tray and the cylinder casing shall be avoided, by the use of insulating pads where necessary. Pressure and temperature relief valves, where used, shall be fitted with drain lines discharging to an approved outfall. The drain lines and receptors shall withstand the maximum temperature of discharge without distortion or other failure.

(c) Hot pipes
The pipes taking hot fluid from a solar collector to a storage cylinder can reach temperatures in excess of 100 ^{o}C. To guard against injury in the event of split piping the NZ Building Code G12 requires that pipes and pipe fittings used for piping of hot water shall be suitable for the temperatures and pressures within that system.

The pipe material may be copper or an appropriate plastic. Most systems will be installed using copper. Some types of plastic pipe will be suitable for use where the solar heating system is protected by use of temperature/pressure relief valves. Where there is a risk of temperature/pressure relief valve failure, or for pumped systems there is a risk of pump failure, plastic piping is not recommended. The limiting condition to be covered by the choice of piping material is that where a fault in the system occurs and high temperatures and pressures arise.

In some locations in NZ the composition of water flowing in the pipes will be harmful to copper and other pipe materials will have to be used.

Some types of plastic pipe may be appropriate for some low pressure cylinders that are fitted with the temperature/pressure relief valves.

The choice of hot fluid pipe material will depend on the solar system design, fluid composition, and equipment configuration.

Requirements:
Any hot fluid pipe must be used only within its specification.

The choice of hot fluid pipe material should be such that it can withstand the temperatures and pressures that could arise with the failure of the temperature/pressure relief valve or the circulating pump. Water composition should also be determined prior to system installation and taken into account with choice of pipe material.

Plastic piping is not suitable for use when the hot water system includes an unlimited heat source such as a wetback.

Acceptable Solutions:
The use of copper pipe for transfer of hot fluid is acceptable.

Polybutylene (PB) and cross-linked polyethylene (PEX) piping systems are acceptable for hot water if the temperature and pressure limitations of those materials are not exceeded by the system under normal operating conditions or under fault conditions, such as failure of the TPR valve or of the circulating pump.

Notes:
1. Cross-linked polyethylene is a different product from the types of polyethylene (LDPE, MDPE and HDPE) used in cold water, agricultural and other applications.
2. G12/AS1 and AS/NZS 3500.4 require the first metre of length of pipe from water heaters to be in metal.
3. Use of a short length of copper as a transition between a heat source and distribution pipe is to allow for the effect of heat conducted down the pipe from the heat source (solar panel or water storage cylinder). It does not affect the ability of the plastic pipe to withstand circulating water at high temperature.
4. Few grades of cross-linked polyethylene pipe obtainable at a reasonable price will tolerate 100 ^{o}C water for any significant length of time.
5. One supplier of cross-linked polyethylene piping gives the following technical data:
   Working temperatures and pressures:
   Central Heating 3.0 bar at 92 ^{o}C
   Hot Water 6.0 bar at 65 ^{o}C
   Cold Water 12.0 bar at 20 ^{o}C
   Cross-linked polyethylene can withstand 114 ^{o}C intermittently for short periods.
6. A supplier of solar water heaters who has used polybutylene, and Speedfit® fittings, with a one metre thermal break (copper pipe at the panel hot outlet) but no longer does so advises “The controlling items were that the controller cut out the pump when the storage cylinder reached 65 ^{o}C. The system also included a 99 ^{o}C TPR valve at the panel. TPR valves can fail on mains pressure panels, with the result that the middle of the panel can reach 140 ^{o}C before the TPR at the outlet is aware of this. If there were no TPR valve the water in the panel can reach 155 ^{o}C when the pump is off. When someone opens a tap introducing cold water, the pump will re-start and extremely hot water will flow through the piping.”
7. New piping products, such as the macrocomposite PEX/Al/PEX, are becoming available and may be suitable for some applications above the temperature and pressure limits of PEX and PB pipe.

5.6 INCLINATION

Inclination is the inclination angle between the plane of the absorber surface of the collector(s) and the horizontal.

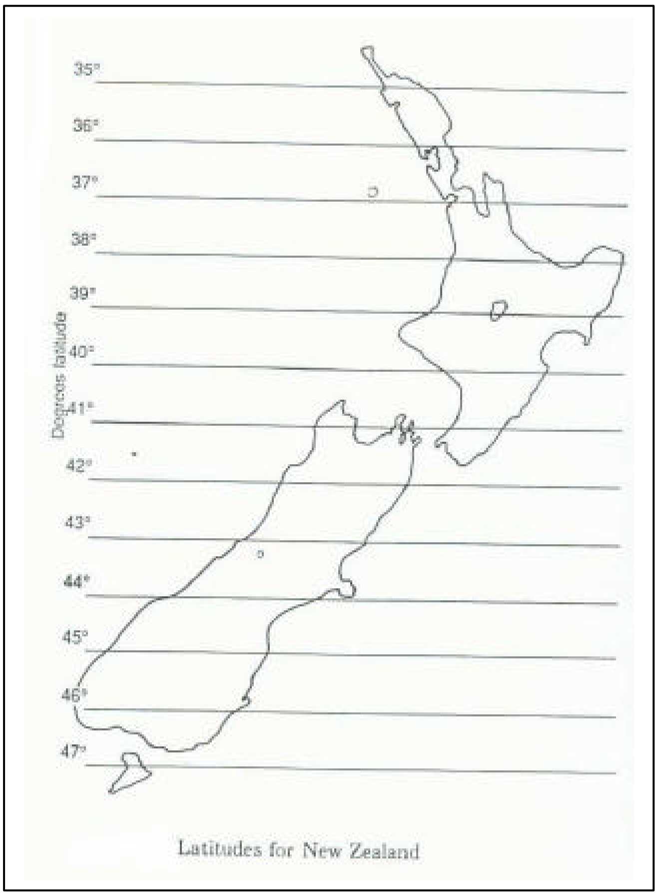


Figure 23 Latitudes for New Zealand

The ideal inclination is at an angle to the horizontal equal to the latitude at the site. Deviations from this are permissible but should not exceed ± 20 degrees, or the manufacturer's recommendation, whichever is the more restrictive. Angles less than the latitude angle will enhance the summer performance at the expense of the winter performance and vice-versa. In systems combining a solar water heater with a wet back there can be advantage in mounting the solar water heaters at an angle less than the latitude angle. So long as the deviation is not too great this gives about the same annual performance but with enhanced summer performance and reduced solar performance in the winter when the wetback is active.

Latitudes in New Zealand are shown in figure 23.

5.7 MOUNTING OF COLLECTORS (NOT INCLUDING HOT STORE CYLINDER):

Collectors may be mounted directly on a roof, on frames on a roof, or inset into the roof.

Requirements:
The New Zealand Building Code Clause B1 requires solar water heating systems to be installed so as not to endanger people or property.

Collectors should be mounted strictly in accordance with the manufacturer's instructions. When the manufacturer supplies mountings they shall be used without modification except with the specific approval of the manufacturer.

The weight of collectors (and where relevant the filled cylinder) mounted on the roof shall not exceed the loading prescribed for that roof type in the relevant building regulations.

Collectors and cylinders where fitted shall be mounted so as to be able to resist the expected wind loading at the site.

Collectors shall be arranged so as not to collect rainwater or debris on the roof.

The installation on a roof should be in such a manner that it is mounted on a suitably strong part of the roof, and mounted equally spaced over 3 roof rafters. In no case shall the connecting pipes be used to provide support for the collector or cylinder where fitted.

Acceptable Solutions:
Collectors shall be mounted according to the manufacturers instructions.

If the collector (including support frame but not hot store cylinder) weighs less than 30 Kg/m^2 then installation will be determined to comply with this requirement.

Where there is any concern about the ability of a roof structure to withstand collector loading the advice of an engineer should be sought. The engineer may use the information in "The Manual for Structural Assessment for Installation of Solar Water Heating in Domestic Dwellings " referenced in Appendix A to provide advice.

Note: Collectors are often mounted directly on the roof surface at the inclination and orientation of the roof surface. Direct mounting of collectors should only be done where the inclination and orientation of the roof surface are appropriate.

Methods of attachment to the roof should not damage the waterproof character of the roof. Contact between the collector or the collector mount and the roof should not introduce any electrolytic contact liable to promote corrosion of the collector casing or the roofing material. These conditions can usually be met by mounting the collector on battens attached to the roof by screws of appropriate metal passing where possible through the "high point" of the roofing material profile, for example in standard corrugated iron through the top of the corrugation. Where necessary the collector should be electrically separated from the roof material by the use of an insulating layer at points of contact.

The battens shall comply with the durability requirements of the New Zealand Building Code and be compatible with the roofing material.

In other cases the collector may need to be mounted on a frame designed to be attached to the roof and to present the collector(s) at an appropriate inclination.

In any case the penetrations of the roof surface needed to fix the collectors or the frame to the roof should be sealed around the fixing screws with a good quality long-life sealant of a type which will not promote corrosion of the roof metal (e.g. if self-vulcanising silicone is used a neutral-cure type should be used).

5.8 OPERATING AND MAINTENANCE INSTRUCTIONS:

Requirements:
Systems shall be supplied with a set of operating and maintenance instructions which shall indicate normal operating requirements and any regular maintenance requirements of the system including replacement of sacrificial anodes or replacement of collector casing glazing. The instructions shall include the contact details of the installer and the manufacturer of the system and if the system is not New Zealand made the contact details of the importer.

NOTE: As a solar water heating system may be operational on a dwelling for a number of years and in that time ownership may change, installers are encouraged to attach the operating and maintenance instructions permanently in an obvious location adjacent to the hot storage cylinder or some other suitable location.

5.9 PIPEWORK INSULATION

Insulation is necessary to reduce heat loss from pipework.

Requirements:
Pipework between the solar collectors and the storage cylinder shall be insulated according to the makers' instructions and where there are long runs of pipe, it shall be insulated with an appropriate heat insulating material, unless the manufacturer specifies otherwise. Where this

pipework is exposed to weather the insulation shall be weatherproof or shall be protected with an approved weatherproof covering.

Pipes shall not be installed in direct contact with metal roofs. Where it is necessary to run piping across a metal roof, it shall be fixed above the roof and surrounded with a waterproof insulation as appropriate. Consideration should be made for expansion and contraction of the roof material and the pipe runs.

6 PRELIMINARY SITE CHECKS:

The supplier and installer should consult with the system purchaser prior to sale and installation.

6.1 SHADING FROM NEIGHBOURS:

The operation of a solar water heating system may be affected by shading from neighbours large trees or proposals to build large structures adjacent to your property. Owners of solar water heating systems may need to ensure that if any such activities are proposed on adjacent properties that they check that the trees or structures do not produce shading. If this is likely to happen property owners should discuss this with their local city or district council as the neighbour may be required to obtain a resource consent in which case they may have an opportunity to object to the proposed activity.

6.2 SHADING:

Care should be taken to avoid locations where significant shading of the collectors can occur. In particular the collectors should be clear of shade for three hours either side of the time at which the collectors are pointing directly toward the sun (For North facing collectors solar noon is 12:30 pm standard time In summer this is 1:30 pm clock time). Figure 24 shows solar altitude at mid winter for various locations. By checking the solar altitude as observed at the position of the lower edge of the collector(s) one can determine whether or not nearby buildings, trees etc will cast a shadow on the collector(s). For example if a building or tree as observed from the bottom edge of the collector is above the mid-winter solar altitude then that building will cast a shadow on the collector.

City	Latitude	9.30 am	12.30 pm	3.30 pm
	deg.	deg.	deg.	deg.
Auckland	37	16	30	16
Wellington	41	13	25	13
Christchurch	44	11	23	11
Invercargill	46	9	20	9

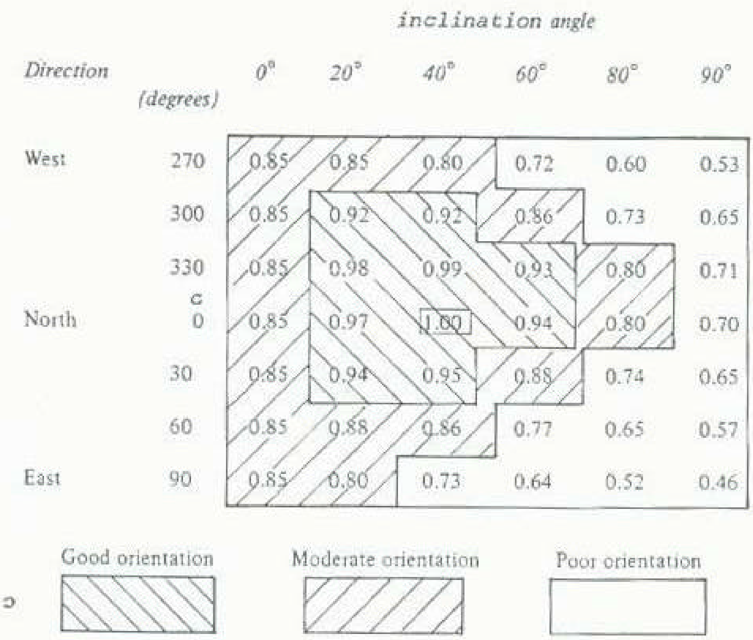
Figure 24 Solar altitude in mid winter Source TABLE B1 FROM NZS 4614

The solar altitude may be determined using a commercial 'sun locator'. A simple solar altitude sight may be constructed using the diagrams given in Appendix C.

6.3 SOLAR ORIENTATION:

Solar orientation is the angle between the horizontal projection of the normal to the surface of the collector and the North meridian expressed as either East or West of North.

Collectors should be oriented facing geographical North wherever practicable.



Direction	(degrees)	0°	20°	40°	60°	80°	90°
West	270	0.85	0.85	0.80	0.72	0.60	0.53
	300	0.85	0.92	0.92	0.86	0.73	0.65
	330	0.85	0.98	0.99	0.93	0.80	0.71
North	0	0.85	0.97	1.00	0.94	0.80	0.70
	30	0.85	0.94	0.95	0.88	0.74	0.65
	60	0.85	0.88	0.86	0.77	0.65	0.57
East	90	0.85	0.80	0.73	0.64	0.52	0.46

FACTORS FOR INCLINATION AND SOLAR ORIENTATION

The relative performance of flat plate collectors in different orientations is illustrated. It is clear that collectors should face within about 45° of north, and be fitted at an inclination angle between 20° and 50°.

If for some reason it were necessary to place collectors facing due west at 60° inclination, then to avoid loss in performance, the collectors would have to be 1/0.72 (or 1.4) as large, i.e. increased by 40 % in the collector area.

Where collectors other than flat-plate type (cylindrical shape for instance) are used similar optimum requirements for orientation will apply, i.e. the axis of the cylinder should be inclinded at 20° to 50°. The performance loss by using poorer orientations has not been as fully explored as for the flat-plate case.

Figure 25 Factors for inclination and solar orientation Source: NZS 4614 fig 12

Deviations from North will affect the performance of the collectors. It should be noted that in New Zealand geographic North is approximately 20 degrees West of magnetic North as shown by the compass. The magnetic deviation at various points in New Zealand is shown in figure C3. In general orientations lying in the quadrant between NE and NW are acceptable. Orientations outside this range will require special consideration and may need greater than normal collector area to maintain reasonable performance. This effect can be estimated from the values given in figure 25. For more precise performance details system owners should check with specific suppliers on the performance of their systems.

6.4 SIZING OF SYSTEM:

Two aspects of the sizing of solar water heaters are important. These are the total energy which it is expected to collect, and the other is the temperature to which the water is to be heated. The total energy collected is a function of the area of collector (and its efficiency) and the temperature to which water is heated. The temperature to which the water will be heated by the solar collector is a function of the volume of the solar store and the amount of solar input and the rate of use of the heated water.

Manufacturers will normally provide an indication of the expected annual input to the hot water system from their equipment for a given annual insolation. These figures can be used along with the insolation of a proposed site to estimate the likely performance of the installation at that site.

Annual sunshine hours are also a fair guide to the relative solar fractions of a given system at different sites. Information on annual insolation at various sites in New Zealand is shown in Appendix B.

Comparisons between different installations and different collector types are fraught with uncertainty and should be treated cautiously unless they are the product of direct comparisons under identical operating conditions conducted with well calibrated measuring equipment. Nevertheless some reasonably accurate estimates of overall performance can be made by taking into account the performance under standard conditions and allowing for the local sunshine figures the latitude and inclination of the installation and its orientation. As a guide most installations should be sized to give up to 70% of the normal annual hot water energy requirement of the household.

The cylinder capacity should be not less than one day's expected use. Generally better overall solar performance can be obtained with a somewhat larger cylinder, up to 1.5-2 time the daily use. In particular if the system is time clock limited or used with off-peak (night rate) auxiliary electric heating then a cylinder capacity of at least 1.5 times the daily use is recommended.

The ratio of cylinder volume to collector area should be in the range 40-90 litres per square metre of collector area. For a given area of collector ratios at the lower end of the range will give quicker response to solar input. Those at the higher end will give better overall solar savings but generally slower recovery.

Depending on the local ambient temperature and the local insolation 4 m^2 of collector will normally give between 50 and 70 percent of the normal household hot water energy required for a year.

Where possible the manufacturers' recommendations should be taken ahead of these estimates.

6.5 HAND OVER OF SYSTEM:

Requirements:
Before handing over the installation the installer shall check to ensure that all necessary electrical and water connections have been made, including the controller and sensor units in systems with circulating pumps. The installer shall test the equipment as far as possible to ensure that it is in working condition and that there are no water leaks or exposed electrical connections. Where possible this check should be reported to the owner (occupant) before leaving the site. When handing over the installation the installer shall instruct the owner in the correct operation of the solar water heater and shall give to the owner a copy of the manufacturer's operating and maintenance instructions and guarantees. If the owner or their representative is not present at the time of commissioning the installer shall leave the operation and maintenance instructions in a prominent place. To allow for change of dwelling owner, a copy of the operating and maintenance instructions should be displayed in a location agreed with the dwelling owner.

The installer shall supply with written guarantees the name, address and signature of the supplier and the installer. The guarantees will explicitly describe the responsibilities of the owner supplier and installer in a manner and wording that is easy to understand by the system owner and minimize any likelihood of dispute. Copies of such documentation will be shown to the potential purchaser of a system prior to purchase. A producer statement modelled on Form D2 in Appendix D is a suitable document and its use will meet this requirement.

6.6 OPERATING AND MAINTENANCE INSTRUCTIONS:

As a solar water heating system may be operational on a dwelling for a number of years and in that time ownership may change, installers are encourage to attach the operating and maintenance instructions permanently in an obvious location adjacent to the hot storage cylinder or some other suitable location.

Requirements:
Systems shall be supplied with a set of operating and maintenance instructions which shall indicate normal operating requirements and any regular maintenance requirements of the system including replacement of sacrificial anodes or replacement of collector casing glazing where this is relevant. The instructions shall include the contact details of the installer and the manufacturer of the system and if the system is not New Zealand made the contact details of the importer.

Acceptable Solution:
The information required to be provided to system owners is set out in Form D2 of Appendix D. Providing system owners with a copy of this form will meet this requirement.

For systems involving sacrificial anodes the posting of the information in a prominent position for dwelling owners to see as set out in section 4.23 will meet this requirement.

In a region where freezing may occur the installer shall post instructions on the freeze protection mechanisms applying to the solar system and advise what monitoring or other action if any should be taken by the system owner in the event of freezing occurring.

7 PERFORMANCE TESTING OF COLLECTORS AND SYSTEMS

7.1 GENERAL:

The overall performance of a solar water heating system is the resultant of the characteristic performance of the collectors, the area of collectors, the arrangement of the collectors (including inclination and orientation) and the arrangement of the system as a whole including such factors as the size of the storage cylinder in relation to the collector type and area. It depends also on the management regime of the system including factors such as thermostat temperature, water draw-off pattern and auxiliary heating pattern. For these reasons it is not easy to predict the performance of any given system in the field and the full testing of a system under standard conditions is a lengthy and expensive process.

Collector tests are described in detail in AS/NZS 2535 (Based on ISO 9806) and system tests are described in NZS 4613.

Some indications can be obtained from relatively simple tests. That described below is a simplified version of the full test for collector performance.

[It should be noted that this section is currently under revision by SIA]

Collector test:
The characteristic behaviour of a simple flat -plate collector can be represented usefully and with reasonable accuracy on a so-called HWB (Hottel -Whillier- Bliss) plot as illustrated in figure 18.

Precise measurements for the HWB plots are best done in a properly equipped solar simulation laboratory. However a reasonably good representation for a given panel can be obtained with open sky measurements as follows using simple water flow and temperature measurements.

The equipment required is:

a) a solarimeter
b) a means of controlling the temperature of a water flow of the order of 1-2 litres per minute
c) a means of measuring volumes of water up to several litres with an accuracy better than 5 %
d) a stopwatch or watch readable and accurate to better than 1 sec
e) three thermometers accurate and readable to 0.1 ^{0}C

Procedure:
a) choose a day with clear sky
b) set the panel up so that its surface is normal to the solar inclination
c) establish a steady water flow through the panel such that there is a measurable temperature difference between the inlet to and the outlet from the panel.
d) measure the water flow rate V/t in cubic metres per sec.
e) measure the inlet temperature, $T_{(i)}$ of the water to the collector
f) measure the outlet temperature $T_{(o)}$ of the water from the collector
g) measure the ambient air (shade) temperature $T_{(a)}$
h) measure the incoming solar flux, I. In the absence of a solarimeter the insolation on a clear sunny day may be assumed to be 1000 watts per square metre with an accuracy of about 10 %
i) the energy collected per unit time as heated water $E_{(w)}$ can be calculated as

$$E_{(w)}/\text{Watts} = 4184(V_{(w)}/\text{litres})((T_{(o)} - T_{(i)})/^0\text{C})(1/(t/(\text{sec})))$$

The "instantaneous" efficiency ? of the collector is the ratio of the energy collection rate to the insolation

? = ($E_{(w)}$/(watts))/(A/(m^2)) (I/(watts/ m^2))

Calculate the quantity

?T/I = ($T_{(a)}$ - ($T_{(i)}$-$T_{(o)}$)/2)/^{0}C/(I/(watts/ m^2))

and plot ? versus ?T/I

This measurement should be repeated for several values of inlet water temperature. Generally these measurements can be made over a sufficient temperature range to enable a moderately accurate graph to be drawn. If it is possible to measure the temperature within one of the waterways of the collector under stagnation conditions (that is with no energy being taken from the collector as hot water), T(s) then the intercept on the x axis can be determined from

?T/I (stagnation) = ($T_{(s)}$- $T_{(a)}$)/I

7.2 SYSTEM TESTING:

Accurate system tests require rather more elaborate and expensive equipment and longer time frames (up to a year), precise measurements and careful monitoring of the system and the ambient conditions. Even then the relation of the results to the performance of similar systems in the field is likely to be heavily influenced by the particular configurations and operating regimes adopted. System tests carried out with only simple measurement and monitoring are capable of giving unreliable results which could give misleadingly optimistic or pessimistic impressions.

These involve a complete installation with controlled water draw-off to a specified daily pattern and accurate measurement of insolation and all temperatures and water flows. The short test takes a minimum of three days operation of the system. The more accurate test is extended over a longer period determined by the weather conditions, usually between 23 and 33 days, and is believed to produce results which would agree with those of a full 12 month test within about 10%. Comparative testing is somewhat less arduous. One can get useful results by comparing the performance of a system side by side with one of known performance.

7.3 SYSTEM PERFORMANCE:

This is the net input of solar energy to the domestic water heater. This is a function of the total installation including the sunshine pattern at the site potential shading, collector type, the collector area, the orientation and inclination of the collector(s), the relation between the collectors and the cylinder and operation of the system including the water draw-off pattern and the operating temperature of the overall system.

The overall system efficiency and system performance are very site and installation specific. A typical system performance will range between about 500 and 700 kWh/m^2 /yr.depending on the factors listed above.

8 RELEVANT AND RELATED STANDARDS

AS/NZS 3350.2.35: 1999 Instantaneous water heaters

AS/NZS 3350.2.73: 1996 Fixed immersion heaters

AS/NZS 3500.4: 2003 Plumbing and drainage Part 4: Heated water services
NZS 4305: 1996 Energy efficiency domestic type hot water systems

NZS 4506	
Part 1: 1986	General requirements
Part 2: 1989	Specific requirements for water heaters with single shells. Identical to AS 1056.2 with modifications for NZ conditions
Part 3:1992	Specific requirements for water heaters with composite shells Identical to AS 1056.3 with modifications for NZ conditions
NZS 4602: 1988	Low pressure copper thermal storage electric water heaters
NZS 4603: 1985	Installation of low pressure thermal storage electric water heaters with copper cylinders (open vented systems)
NZS 4606:1989	Storage water heaters
NZS 4607: 1989	Installation of thermal storage electric water heaters: valve vented systems Referred to in BIA approved document G12
NZS 4608:1992	Control valves for hot water systems.
NZS 4611: 1982	Non thermostatic shower mixing valves
NZS 4613: 1986	Domestic solar water heaters
AS/NZS 4614: 1986	Installation of domestic solar water heating systems
NZS 4617:1989	Tempering (3 port mixing) valves
NZS 6214: 1988	Thermostats and thermal cutouts for domestic thermal storage electric water heaters (ac only)
AS/NZS 2712: 2002	Solar water heaters
AS/NZS 2535:	Test methods for solar collectors
AS/NZS 2535:1: 1999	Thermal performance of glazed liquid heating collectors including pressure drop This is technically equivalent to ISO 9806-1:1994

APPENDIX A:

STRUCTURAL ASSESSMENT FOR INSTALLATION OF SOLAR WATER HEATING IN DOMESTIC DWELLINGS

1. Objective

The information for assessing the structural assessment of domestic timber framed dwellings for the installation of solar panels (Collectors) and solar store tanks on the roof is provided in the document "Manual for Structural Assessment for Installation of Solar Water Heating in Domestic Dwellings". It is intended to supplement NZS3604 and identify when specific engineering design will be required.

Note: It is intended that the information in the Manual may eventually be called up in the *New Zealand Building Code Clauses* as an Acceptable Solution for meeting the requirements of the New Zealand Building Code for Structure B1.3.1; B1.3.2, B1.3.4 for loads from 13.1.3.3 (a), (b), (f), (g), (h), (j), (m), (p) and (q). i.e. for loads arising from gravity, earthquake, snow, wind and human impact, differential movement, non-structural elements and contents and creep and shrinkage. In the meantime they are provided as a guide for structural assessment.

2. Scope

2.1 Buildings covered by this Manual shall be as defined by NZS3604 with the additional limitations prescribed herein.

2.2 The Manual does not cover the structural support and fixing of the Collector panels or Solar Store tanks, any piping or other penetrations to the roof surface. The supplier of the relevant items shall provide design and details for installation on the roof.

Note:
The Manual is available on the Solar Industries Association website www.solarindustries.org.nz

APPENDIX B:

NEW ZEALAND SOLAR INSOLATION VALUES

MEAN DAILY GLOBAL RADIATION

MEAN DAILY GLOBAL RADIATION (megajoules/square metre)
Data are mean monthly values of mean daily global radiation for the 1971-2000 period for locations having at least 5 complete years of data

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ar
KAITAIA	21.7	19.4	16.4	11.6	8.5	7.0	7.7	10.1	13.5	16.9	19.9	22.1	
WHANGAREI	20.8	18.4	15.5	11.3	8.4	7.1	7.4	10.3	13.7	16.9	18.8	20.4	
TAURANGA	23.0	20.2	16.4	11.4	8.1	7.0	7.1	9.8	13.7	17.2	20.4	22.6	
ROTORUA	22.5	19.6	16.0	11.1	8.0	6.3	6.7	9.4	12.9	16.6	19.5	21.6	
AUCKLAND	23.1	20.1	16.0	11.7	8.3	6.6	7.9	10.0	13.8	17.5	20.9	23.1	
HAMILTON	21.7	19.2	15.8	11.1	7.7	6.2	6.7	9.0	12.7	15.9	19.9	22.0	
NEW PLYMOUTH	23.2	20.9	16.3	10.8	7.6	6.1	6.7	9.7	13.0	16.7	20.9	22.6	
MASTERTON	21.7	19.0	15.2	9.7	7.0	5.5	5.9	8.6	12.6	17.0	20.6	22.5	
GISBORNE	22.6	19.4	15.4	10.8	7.9	6.6	6.8	10.0	13.9	18.5	20.7	23.0	
NAPIER	22.1	19.4	15.5	10.8	7.8	6.3	6.8	9.7	13.6	18.4	20.8	22.5	
PALMERSTON NORTH	21.9	19.2	14.7	10.1	6.8	5.2	5.9	8.4	11.8	15.7	19.0	20.9	
WELLINGTON	23.6	19.9	15.1	10.3	6.6	4.9	5.7	8.1	12.3	16.9	20.9	22.6	
WANGANUI	23.8	21.5	15.6	10.9	7.7	6.1	6.9	9.3	13.3	17.1	21.2	23.7	
WESTPORT	20.9	18.7	14.5	9.2	6.5	4.8	5.7	8.2	11.6	14.4	19.5	20.0	
HOKITIKA	20.7	18.1	13.8	9.2	5.8	4.5	5.3	7.7	11.5	14.9	19.2	20.5	
NELSON	23.4	20.5	15.6	11.2	7.6	5.7	6.2	8.8	13.2	17.2	21.0	22.9	
BLENHEIM	23.1	19.8	15.9	11.1	7.5	5.8	6.5	9.0	12.9	17.5	20.8	22.5	
KAIKOURA	21.3	18.7	14.9	10.1	7.1	5.3	6.1	9.1	12.8	17.8	21.1	22.4	
CHRISTCHURCH	21.9	18.6	13.9	9.5	6.1	4.6	5.1	7.7	12.1	16.8	20.6	22.2	
TIMARU	20.0	17.3	14.4	9.3	6.2	5.5	6.2	8.9	13.0	16.7	20.4	21.2	
DUNEDIN	18.5	17.2	12.3	8.1	4.9	3.6	4.5	6.8	11.0	14.3	17.1	18.9	
MANAPOURI	21.4	18.5	13.6	8.4	5.0	3.7	4.2	7.2	11.4	15.8	19.9	22.5	
QUEENSTOWN	23.9	20.8	15.5	10.2	6.3	4.7	5.7	8.6	13.0	18.0	21.7	24.3	
CLYDE	22.2	19.2	15.0	10.0	5.9	4.3	4.7	8.0	12.3	17.5	21.3	22.8	
INVERCARGILL	20.4	17.5	12.6	7.9	4.6	3.6	4.3	7.0	11.1	15.5	19.8	21.5	
CHATHAM ISLAND	20.0	16.9	12.8	8.6	5.1	4.0	4.7	7.2	10.9	15.2	18.9	20.7	
ANTARCTICA, SCOTT BASE	25.4	13.7	4.5	0.4	0.0	0.0	0.0	0.1	2.5	11.2	23.3	29.3	

Figure B1 Mean Daily Radiation Received on a Horizonatal Plane

Source National Institute of Water and Atmosphere

AVERAGE RADIATION ON ANGLED SURFACES

(Wellington)

Radiation received (kWh/m^2) on surfaces at various angles:

Inclination Angle	Daily Radiation (kWh/m^2)
0°	3.80
10°	4.06
20°	4.23
25°	4.29
30°	4.31
35°	4.31
40°	4.29
50°	4.17

Comprehensive values of radiant energy received are available only for the main centres of population of Auckland, Wellington, Christchurch, and Invercargill plus Ohakea. The values of Wellington are given because these are very close to the average for these main centres (refer Bensemann and Cook, 1969).

Figure B2 Radiation per day in Wellington

Month	Horizontal Surface kWh/^{m2}/day	40^0 Inclined Surface kWh/^{m2}/day
January	5.98	5.47
February	5.45	5.53
March	3.98	4.76
April	2.80	4.14
May	1.78	3.18
June	1.38	2.74
July	1.51	2.78
August	2.53	4.07
September	3.29	4.18
October	4.86	5.21
November	6.27	5.92
December	6.98	6.18
Mean Value	3.9	4.5

Figure B3 Daily average energy per day in Christchurch from Bensemann and Cook).

The relative amounts of energy available annually in different parts of the country are indicated approximately by the daily radiation shown in figure B4.

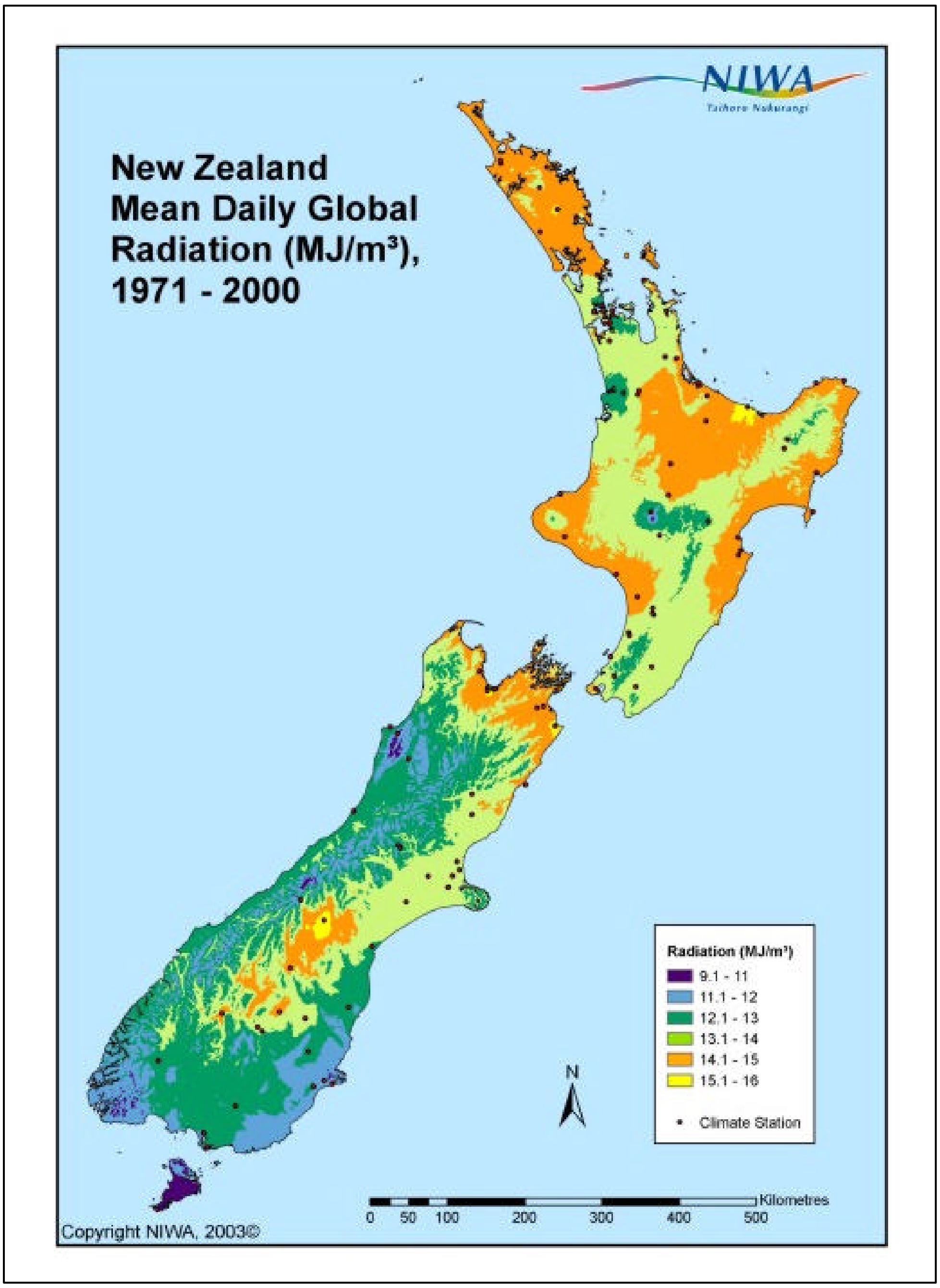


Figure B4 New Zealand average daily radiation Source NIWA

Note:
This map of mean daily solar radiation for New Zealand is based on an interpolation of climate station data collected during the period 1971–2000. The location of these climate stations is shown on the map. Areas close to climate stations have a higher degree of accuracy than areas where there has been no collection of solar radiation data.

NIWA makes no representations or warranties regarding the accuracy of the information shown on this map, the use to which the map may be put, or the results to be obtained from the use of the map. Accordingly NIWA accepts no liability for any loss or damage (whether direct or indirect) incurred by any person through the use of or reliance on the map, and the user shall bear and shall indemnify and hold NIWA harmless from and against all losses, claims, demands, liabilities, suits or actions (including reasonable legal fees) in connection with access and use of the map to whomever or how so ever caused. The copyright and all other intellectual property rights in the map remain vested solely in NIWA.

Freezing areas within New Zealand

Table B5 indicates the number of days each month when the ambient temperature reaches freezing temperature.

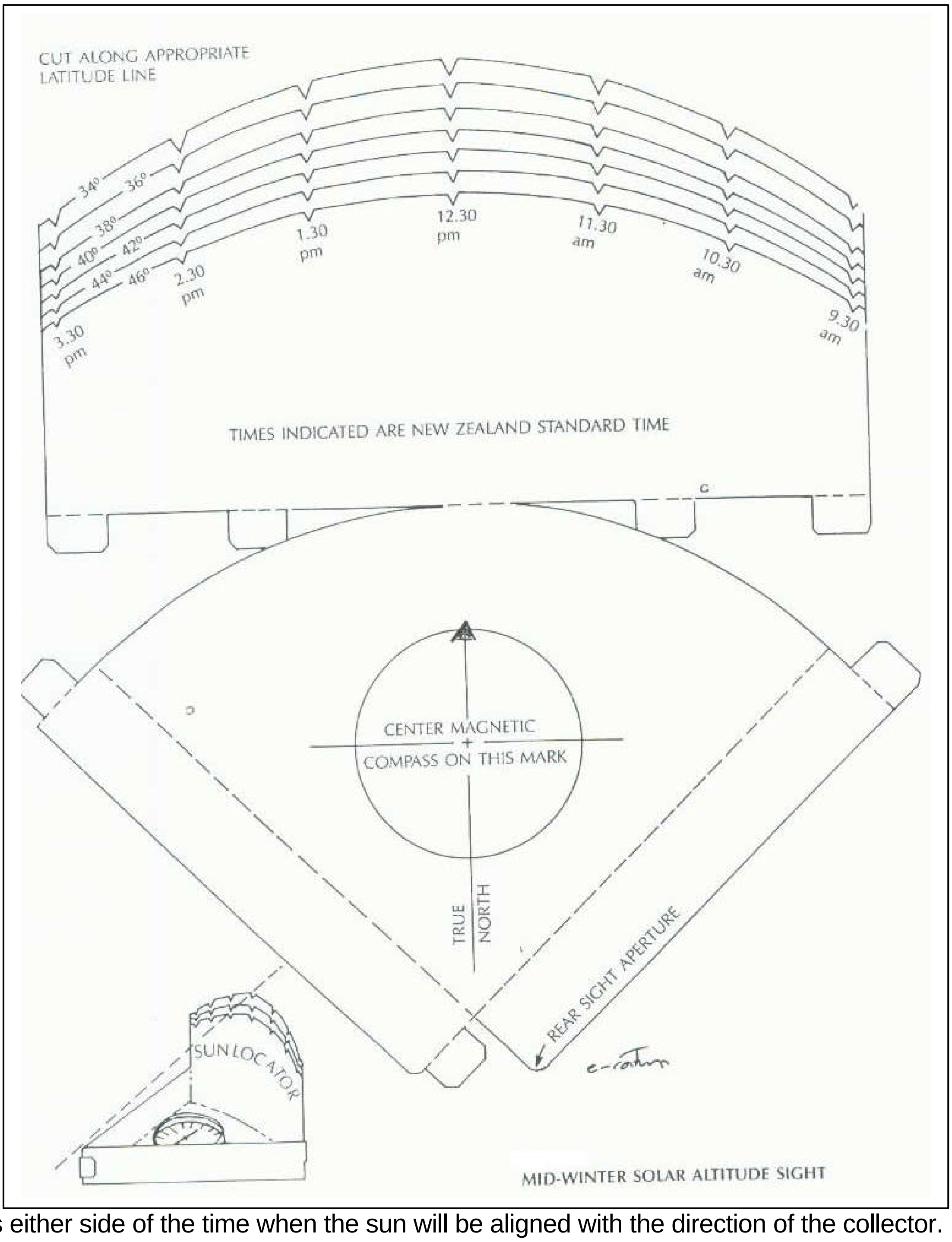
Location	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
KAITAIA	0	0	0	0	0	0	0	0	0	0	0	0	1
WHANGAREI	0	0	0	0	1	3	4	2	1	0	0	0	11
AUCKLAND	0	0	0	0	1	3	4	2	1	0	0	0	10
TAURANGA	0	0	0	1	5	9	12	9	4	2	1	0	42
ROTORUA	0	0	0	2	8	12	14	11	7	3	1	0	57
TAUPO	1	1	1	3	8	12	16	14	9	7	3	1	69
HAMILTON	0	0	1	3	8	11	14	11	7	3	1	0	63
NEW PLYMOUTH	0	0	0	0	1	4	4	3	1	0	0	0	15
MASTERTON	0	0	1	2	8	11	13	12	8	5	2	1	60
GISBORNE	0	0	0	0	3	8	9	8	3	1	0	0	33
NAPIER	0	0	0	0	3	7	7	7	3	1	0	0	29
PALMERSTON NORTH	0	0	0	1	4	8	10	8	4	2	1	0	38
WELLINGTON	0	0	0	0	1	2	3	3	1	0	0	0	10
WANGANUI	0	0	0	0	0	1	3	2	0	0	0	0	7
WESTPORT	0	0	0	0	2	6	8	6	2	0	0	0	26
HOKITIKA	0	0	0	2	5	12	15	12	5	2	1	0	54
MILFORD SOUND	0	0	0	1	7	14	16	13	5	2	1	0	56
NELSON	0	0	1	4	12	18	21	17	10	4	1	0	88
BLENHEIM	0	0	0	1	6	15	16	13	6	2	0	0	60
KAIKOURA	0	0	0	0	2	6	8	6	4	1	0	0	27
MT COOK	1	1	3	9	19	22	24	23	14	8	3	1	140
CHRISTCHURCH	0	0	0	2	9	16	16	15	9	3	1	0	70
LAKE TEKAPO	1	1	5	11	21	25	27	25	16	9	5	3	149
TIMARU	0	0	2	5	12	21	23	19	12	5	3	0	100
DUNEDIN	0	0	0	2	6	13	16	12	7	3	1	0	58
QUEENSTOWN	0	0	1	5	13	21	24	21	14	7	3	0	107
ALEXANDRA	1	2	3	10	19	26	27	26	19	12	6	2	148
INVERCARGILL	1	2	3	6	9	16	18	16	11	6	4	2	94
CHATHAM ISLAND	0	0	0	0	0	1	1	1	1	0	0	0	4

B5 Freezing areas Source: National Institute of Water and Atmosphere

APPENDIX C:

SUN LOCATOR

The sight is assembled by gluing the diagram to cardboard or metal as shown in the diagram C1. The solar altitude sight is used by aligning the arrow due North using a compass or map and with the base horizontal sighting at the relevant times from a viewpoint near the base of the collector(s). Any object that can be seen above the sight will cast a shadow on the collector(s). For a North-facing collector the relevant times are 9:30 12:30 and 15:30 standard time. If the collector is aligned away from true North one should check for the times corresponding to 3



hours either side of the time when the sun will be aligned with the direction of the collector.

Figure C1 Mid-winter solar altitude sight (Source FIGS B1-B3 OF NZS 4614)

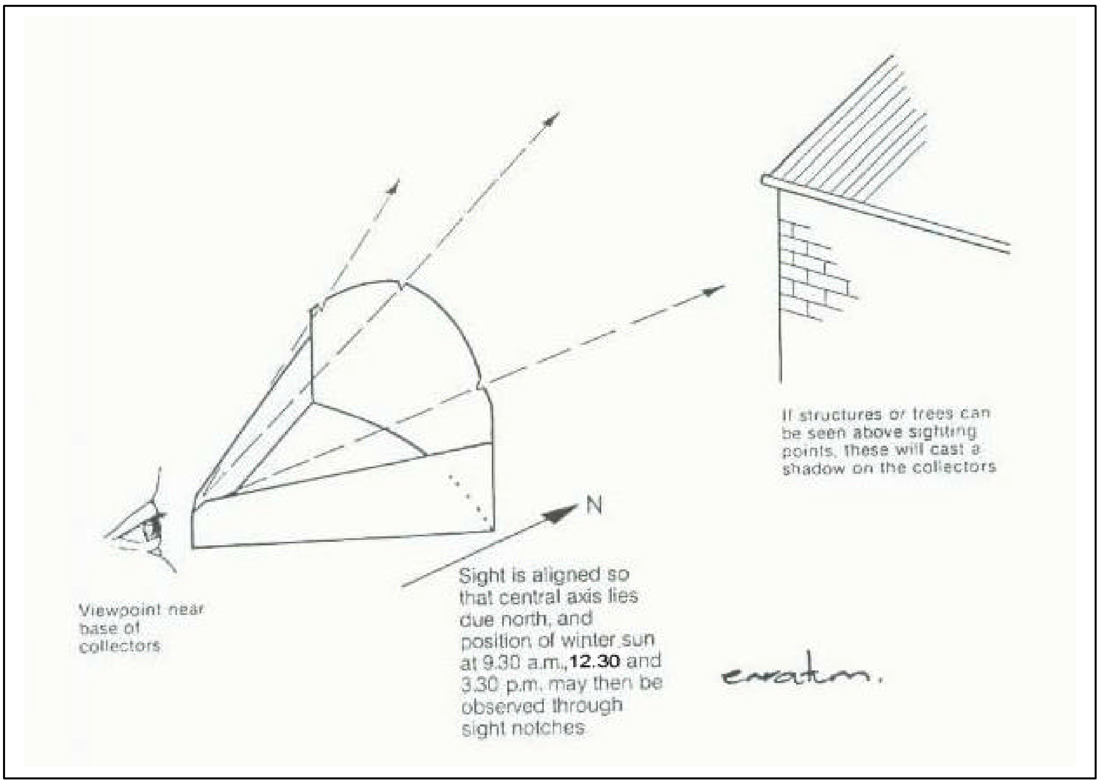


Figure C2 (a) Use of solar altitude sight

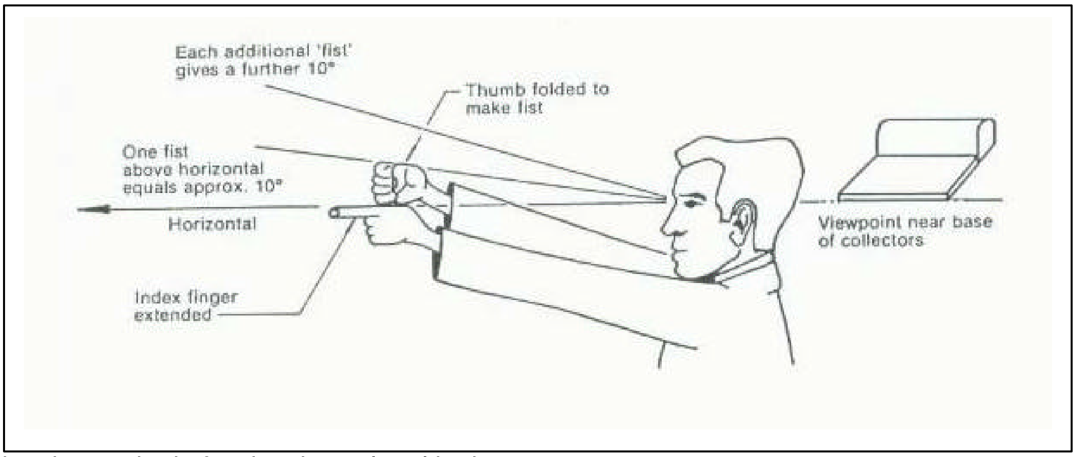


Figure C2 (b) "Fist" method of estimating solar altitude

In setting up a solar collector and when making solar altitude sightings one should be sure to use true North. Magnetic North as shown by the compass is in New Zealand significantly East of True North. The deviation for a number of sites in New Zealand is shown in figure C3.

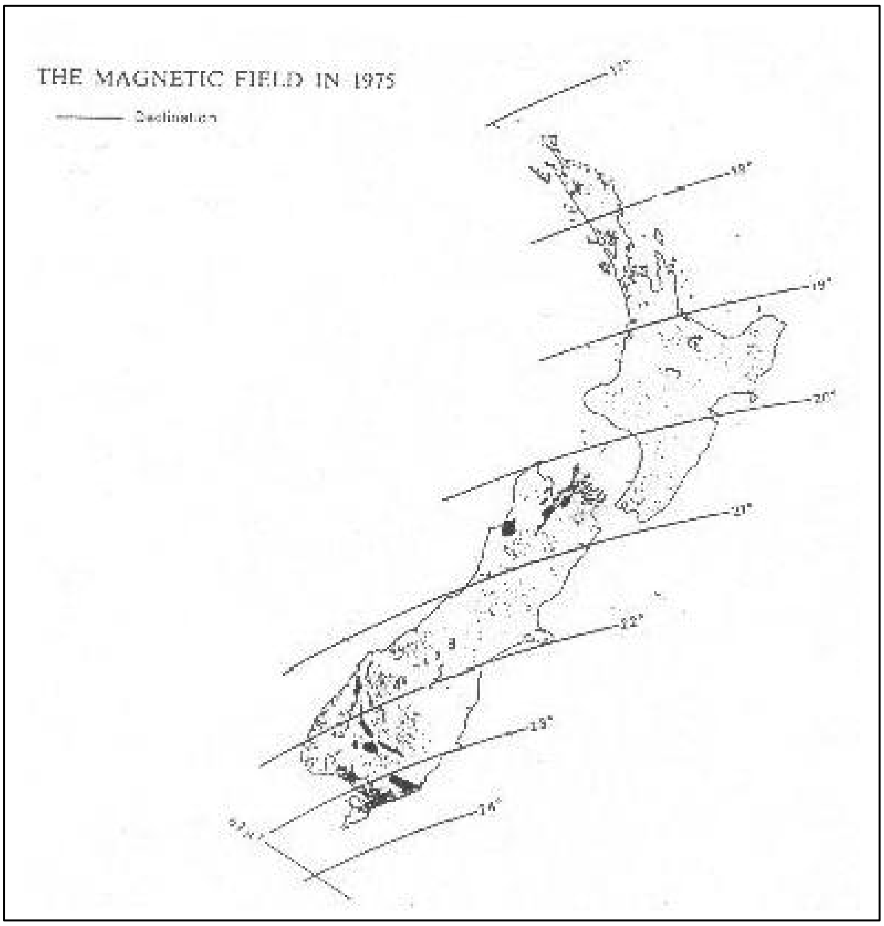


Figure C3 Magnetic field in 1975

APPENDIX D: BUILDING CONSENTS

Form D1

Building Consent for Installation of Solar Water Heating System
Application Requirements

Applications for Building Consent for Installation of Solar Water Heating Systems are to provide the following supporting information.

Council:………………………………………………………………………….

Installer Making Application:………………………………………………….
(Suitably qualified solar water heating system installer)

Address of Installer:……………………………………………………………

Telephone Number for installer:……………………………………………….

Product and model number installed:…………………………………………….

Supplier of Product:……………………………………………………………

Craftsman Plumber:……………………………………………………………

Address of Property on which installed:……………………………………….

Location of installation:………………………………… Property description: Lot…………DP…………

Owner of Property on which installed:………………

Confirmation from the Installer that:

- the system will be installed such that the requirements of the New Zealand Building Code have been met.
- Plumbing work has been installed to meet the requirements of standard AS/NZS3500.4.
- the system described will be installed on a dwelling on the named property according to the Code of Practice for Manufacture and Installation of Solar Water Heating Systems in New Zealand.
- A check will be made by a suitably qualified person to ensure that the system is located over suitably sound load bearing walls and strengthening of roof framing will be undertaken according to the guidelines provided by the system supplier and meets the requirements of Approved Document B1 of the New Zealand Building Code.
- the installation will be undertaken in terms of manuals and instructions from the Product Supplier
- The Product Supplier is a Solar Industries Association Accredited Supplier.
- The installer has been appropriately trained in the installation of the named Product by the Product Supplier and operate under that Supplier's accreditation.
- A tempering valve will be installed.
- The installer is covered by a current Professional Indemnity Insurance Policy to a current value of $..................

The Installer will provide clear sketch drawings showing the layout of the system and position with regard to roof framing and sound load bearing walls. Any strengthening required will be specified.

The seismic restraint system is to be shown on each application.

Installer Signature:……………………… Date:……

Form D2

Model Producer Statement PS3
Installation of Solar Water Heating System.

Council:…………………………………………………………………………….

Building Consent No:……………………………………………………………

Producer Statement Issued By:…………………………………………………….
(Suitably qualified solar water heating system installer)

Address of installer:………………………………………………………………

Telephone Number for Installer:………………………………………………….

Product and Model Number Installed:…………………………………………….

Supplier of Product:………………………………………………………………

Registered Plumber (if applicable):…………………………..…Registration No…………

Registered Electrician (if applicable)…………..…………….Registration No…………

Address of Property on which installed:…………………………………………….

Location of installation:…………………………………………………………...

Owner of Property on which installed:………………………………………………

Property description: Lot………….DP………….

The system has been installed such that the requirements of the New Zealand Building Code have been met. Plumbing work has been installed to meet the requirements of standard AS/NZS3500.4.

Registered Plumber Signature:…………………….. Date:……

The solar water heating system described above has been installed on a dwelling on the named property according to the Code of Practice for Manufacture and Installation of Solar Water Heating Systems in New Zealand and the requirements of the Building Consent.

The system has been located as shown on the drawings provided with the Building Consent Application. A check has been made by a suitably qualified person to ensure that the system is located over suitably sound load bearing walls and strengthening of roof framing has been undertaken according to the guidelines provided by the system supplier and meets the requirements of Approved Document B1 of the New Zealand Building Code.

The installation has been undertaken in terms of manuals and instructions from the Product Supplier who is a Solar Industries Association Accredited Supplier.

I certify that I have been appropriately trained in the installation of the named Product by the Product Supplier and operate under that Supplier's accreditation. As an independent solar water heating system installer I am covered by a current Professional Indemnity Insurance Policy to a current value of $..................

Installer Signature:……………………… Date:……