UNDERSTANDING THERMOSYPHON FOUNDATION SYSTEMS

HEAT is lost to ambient air

CONDENSER (RADIATOR) SECTION

CONDENSATE

VAPOUR

SHALLOW BUILDING FOUNDATION

INSULATION

EVAPORATOR SECTION

GRAVEL PAD

HEAT extracted from the ground

ARE THESE THERMOSYPHONS WORKING?

MEASURE TEMPERATURE

TRACK RESULTS

* To see trends over time

CONDUCT VISUAL INSPECTIONS

* Prior to freezing season
* During freezing season
* Check for leaks

IN THE WINTER THE THERMOSYPHON FINS SHOULD BE WARMER THAN THE AIR TEMPERATURE



TEMPERATURE DIFFERENCE

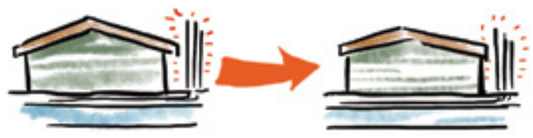
THERMOSYPHONS HELP PROTECT AND MAINTAIN EXISTING PERMAFROST

20 YEARS

WITHOUT THERMOSYPHONS

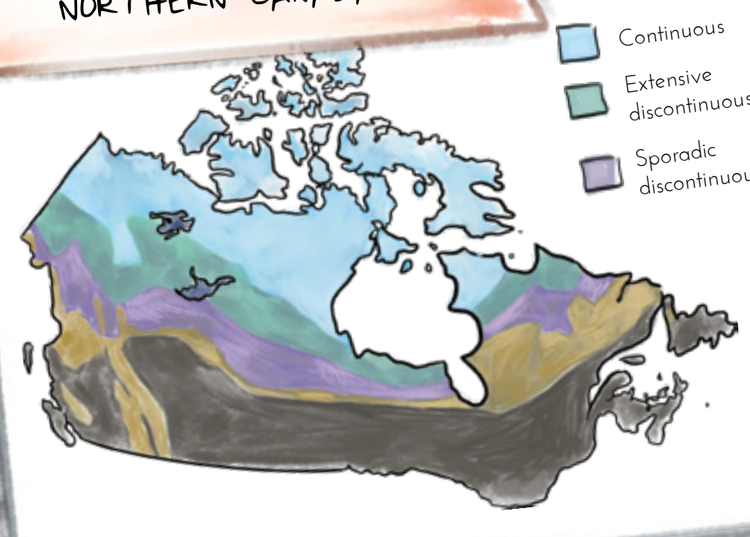


Heat from the building can seep into the ground and cause permafrost to thaw faster



WITH THERMOSYPHONS

PERMAFROST COVERS MUCH OF NORTHERN CANADA



THERMOSYPHONS ARE BEING USED ACROSS THE NORTH



IQALUIT, NU

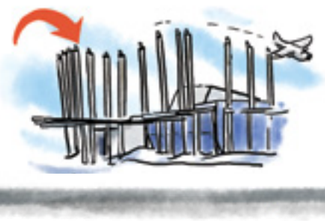


INUVIK, NT

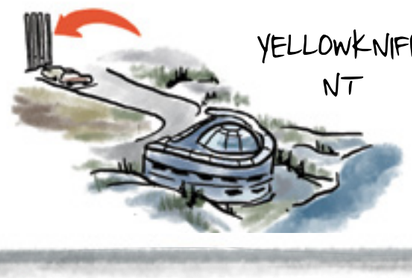
... AND NOT JUST FOR BUILDINGS!



BURWASH LANDING, YT



KUUJJUAQ, NUNAVIK



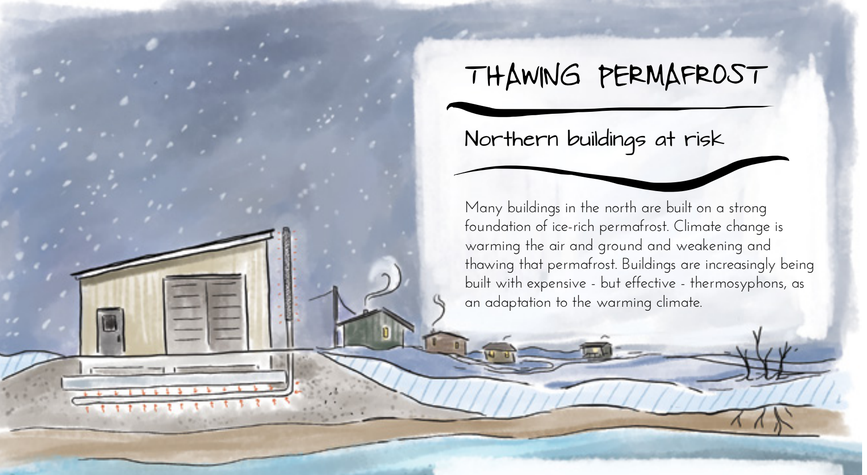
YELLOWKNIFE, NT

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THAWING PERMAFROST

Northern buildings at risk

Many buildings in the north are built on a strong foundation of ice-rich permafrost. Climate change is warming the air and ground and weakening and thawing that permafrost. Buildings are increasingly being built with expensive - but effective - thermosyphons, as an adaptation to the warming climate.

This is a user-friendly outline of CAN/CSA S500-14 Thermosyphon foundations for buildings in permafrost regions.

This guide applies to new buildings that are being built on top of permafrost. It provides basic information about what thermosyphons are, and how and when to use them. Ecology North adapted this guide for building owners and maintainers, community decision makers and contractors across the north.

Permafrost ground that stays frozen for more than two years in a row.

Active layer the ground on top of permafrost that freezes in the winter and thaws in summer.

Thaw sensitive permafrost ground with ice-rich permafrost that settles and loses strength when it thaws.

Thaw stable permafrost ground that does not settle when it thaws.

Thermosyphon a two-phase passive refrigeration device, with a fluid that transfers heat from the ground to the air in winter.



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Contact us or visit our website for information and other guides in this series.

Poster on the inside

Printed on recycled paper 2019

BUILDING DESIGN

Incorporating thermosyphons

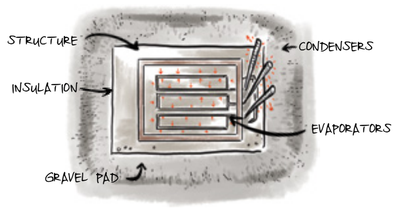
FACTORS TO CONSIDER:

* Plan for unexpected events and changes
* Review the design and construction plans
* Have documents of the full system design

FOLLOW BEST PRACTICES FOR:

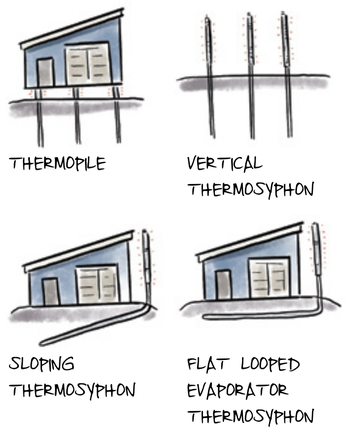
* Evaporator layout, pipes, and radiators
* Granular pads, site excavation, use of gravel
* Final site grading to reduce seepage
* Using sumps and underground services
* Water supply and waste water lines
* Building insulation
* Other features (e.g. sumps or septic tank)

PLAN VIEW FROM ABOVE



A THERMOSYPHON IS...

A passive refrigeration device



A thermosyphon takes heat out of the ground and releases it into the air. They are designed to stop heat from a building damaging the permafrost beow it, keeping the permafrost cold and solid. They work when the air is substantially colder than the ground.

Thermosyphons are effective if installed correctly. They are most ofen used when concrete floors are built over thaw sensitive permafrost.

CONSTRUCTION

Site prep; installing the system

Building in thaw sensitive permafrost areas is a challenge. Good planning is essential.

Ensure materials are ordered, shipped, and installed at the **right time of year**. Usually site preparation has to be done in the summer, when you can compact soil and gravel effectively.

Disturb permafrost as little as possible by installing thermosyphon system quickly.

Make sure ground temperature measuring **sensors** are installed with the thermosyphon system.

Let the prepared site **freeze for one winter** before constructing the rest of the building.

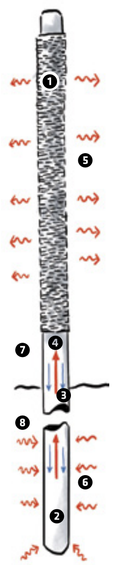
Unless absolutely necessary, **don't excavate** in a permafrost area. If it must be done, it becomes even more important to let the site freeze back for a winter.

Document the process, including any changes to the design.



HOW THEY WORK

Active in winter, not in summer



1. Condenser (radiator) section
2. Evaporator section
3. Condensate
4. Vapor
5. Heat lost to cold ambient air
6. Heat extracted from ground
7. Above ground
8. Below ground

Thermosyphons are sealed tubes that contain pressurized carbon dioxide that is partly liquid and partly gas. The liquid flows by gravity to the bottom of the tube which is buried in the ground, and the gas rises to the upper part that is above ground.

In the winter, when the ground is warmer than the air, liquid in the bottom of the tube warms up, evaporates (turns to gas), and rises to the part of the tube above ground. In the radiators above ground, the gas cools, condenses (turns back to liquid), and flows back underground. This movement of carbon dioxide continually cools the ground and permafrost as long as the air is colder than the ground.

MONITORING PLAN

Are they working?

* Before winter, inspect for damage/deterioration
* Measure radiator temps in winter
* Track ground temps during & after construction
* Monitor building for deformations or shifting

If needed, contact a professional for a more thorough investigation.

Assess thermosyphon fins with a thermometer or infrared temperature measuring device in early winter, when air temperature is 15-20° colder than suspected ground temperature.

Temperatures of the fins should be warmer than the ambient air and nearby structures – this means they are bringing heat up from the ground and dispelling it to the air!



DO YOU NEED THEM?

Ground conditions and materials

Gather information to help buildings designers confirm if thermosyphons are a good option.

USEFUL BACKGROUND INFORMATION:

* Is the building on thaw sensitive permafrost?
* Determine the ground's ice and water content
* Identify surficial geology (soil conditions)
* Identify the depth of the active layer
* Drill boreholes, install ground temp sensors
* Assess surface and groundwater flow
* Review local/traditional knowledge of site

DO NOT USE THERMOSYPHONS IF:

* The building does not sit on permafrost.
* Significant surface water is present in summer
* The ground is thaw stable permafrost
* The building is unheated*

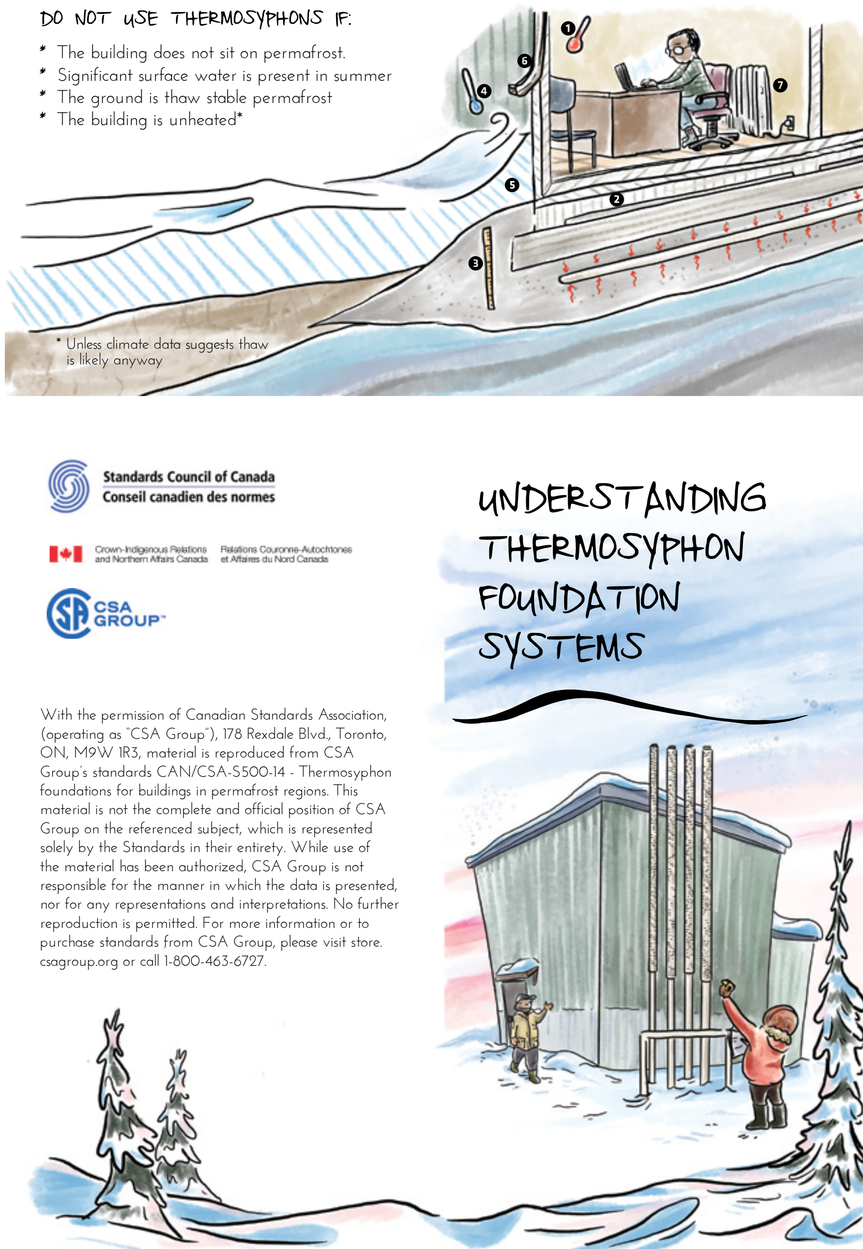
* Unless climate data suggests thaw is likely anyway

SYSTEM DESIGN

What you need to know

Consider site-specific factors that affect how well the thermosyphon system may work. There are many things to understand prior to investing in thermosyphons, this is a partial list:

1. Inside air temp during summer and winter
2. Building insulation, including below ground
3. Thickness of gravel fill
4. Projected climate over the building's life
5. Expected snow buildup, plan to manage snow
6. Management of water and good drainage
7. Building's heating system (in-floor vs. radiators)



Standards Council of Canada
Conseil canadien des normes

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Relations Couronne-Autochtones et Affaires du Nord Canada

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UNDERSTANDING THERMOSYPHON FOUNDATION SYSTEMS

ᐅᓇᖏᑐᒥᓂ ᑲᓱᓕᕆᓂᖅᓯᒪᔪᓂᒃᑯᓂᒃ ᑐᓴᕆᓚᕆᓕᕆᓂᖅ ᐊᑐᖏᑦᑕᐅᓱᓂ

ᐊᐅᓪᓛᖅᑕᐅᓂᖅ ᖃᐅᔨᒪᔭᖅᑐᑦ ᐃᓕᓴᕐᓂᖅ ᐊᑐᓕᖅᑐᑦ

ᐅᑭᐅᓕᖅᑐᑦ ᐊᑐᓚᐅᑦ ᐊᓯᐅᓐᓂᖅᑐᑦ ᐊᑐᓕᖅᑐᑦ ᐃᓄᐃᑦ ᐊᑐᓕᖅᑐᑦ ᐊᑐᓚᐅ

KANGIQHILUGIT UUNAQQUTIT (THERMOSYPHON) TUNNGAVIKHANUT ATURNIINNIK

UUNARNIQ
tammaqpaktuq
ikiarmut

AILAQTAUTIVAKTUQ
(UUNAQUTIT)
ILANGA

AILAQTARNIQ

PUJUNGURNIT

NATITTUT IGLUQPANGNUT TUNNGAVIKHAT

INSULATION

NUNNGUVAUHIANUT
ILANGA

UJARALIAQ
IGLUQPANGNUT
TUNNGAVIKHAQ

UUNARNIQ
unngavaktauhimajuq
nunamit

HAPKUAT THERMOSYPHONS IHUAQUTAUVAT?

NAUNAIQHILUNI UUNNARNINGANIK

NAUNAIJARLUGIT QANURINNIIT

* Naunairutikhanik qanurinninginik hivitunirmi

HAVAKPAGLUTIK TAKUNNAQTUNIK IHIVRIRNIINNIK

* Hivuani qiqivaliqtinnagu
* Qiqivaliutaani
* Ihivriuqhilutit inngariakhainnik

UKIUMI TAMNA THERMOSYPHON QANURINGIT UUNNATQIJAUNIAQTUQ IKIARMI UUNARNIANIT

IMANNAQ

HII

QAJURNARNIINNUT AALLANGANIIT

THERMOSYPHONS IKAJUUTAUVAKTUT PITTAILITIKHANUT IHUAQUTIKHAINNULLU TADJA NUNAP QIQUMANINGA

20 UKIUT

PIITTUMIK THERMOSYPHONS

Uunarniq igluqpangnit ingilrattaaqtuq nunamut imaalu nunap qiqumaninga auktuqpallialuni kajumitqijamik

PILINGMIK THERMOSYPHONS

NUNAP QIQUMANINGA TAMATKIUMAJUQ UKIUQTAQTUMI KANADAMI

Aullaranginnaqtumik

Aullaranginnaqtumik angijumut

Ilainnagut angijumut

THERMOSYPHONS ATUQTAUVAKTUT TAMAINNI NUNANI UKIUQTAQTUMI

IQALUIT, NU

INUVIK, NT

... IGLUQPAINNAUNGITTUNUT

YELLOWKNIFE, NT

BURWASH LANDING, YT

KUUJJUAQ, NUNAVIK

ECOLOGY NORTH

Nunavut

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NUNAP QIQUMANINGA AUKTUQPALIANINGA

Ukiuqtaqtimi igluqpangnun qajarnarniaqtut

Amigaittut igluqpait ukiuqtaqtumi nappaqtiqtauhimajut hikukaqpiaktumi nunap qiqumaningani. Hiluap allanguqtirninganut uunnautivaktuq ikiarnirmik nunamiklu ahiit hakuikpalliadjutaupluni auktuqpallialiqhuni nunap qiqumaninga. Igluqpait amigaikpalliajut nappaqtiqtauhimajut akiturjuaqtumik - kihimi ihuaqtut - thermosyphons, ihuaqqutikhanut hilaup unnakpallianianun.

Hamna aturniinnun-ihuaqtumik naunaiqhitkhat CAN/CSA S500-14 Thermosyphon tunngvikhainnut igluqpangnut nunap qiqumaninga avikturniinni.

Hamna maliktakhaq atuqtaujukhat nuaanut igluqpangnut nappaqtiqtaujunut qanngani nunap qiqumaningata. Tunihidjutaujuq naunaiqhitikhainnik hunaujakhaita ukuat thermosyphons, imaalu qanuqtut qakugullu atuqtauvikhanik. Ecology North ihuaqhaqhimajat hamna maliktakhat igluqpaqaqtunut imaalu munaqtinginnut, nunamingni ihumaliuqtiujunut imaalu kantraqaqtunut taainni ukiuqtaqtumi.

Nunap qiqumaninga: nuna qiqumavaktuq hivitutqijanit malrungni ukiungni atajumik.

Aullaninganut hivjuninga: nuna qannganiittuq haffuma nunap qiqumaninganni qiqivaktuq ukiumi imaalu auktuqpakhuni aujami.

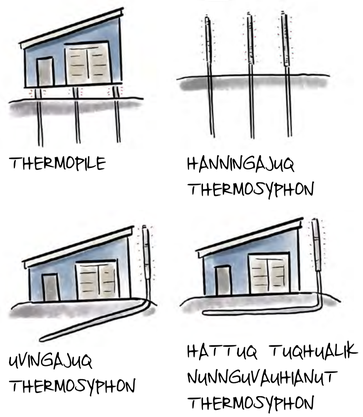
Auktuqpallianinganit pidjutiqaqtut nunap qiqumaninga: nuna hikukaqpiaktumi nunap qiqumaninga nutarangami imaalu hakuiqpalliavakhuni auktuqpalliajarangami.

Aukturinganit aallangujuittuq nunap qiqumaninga: nuna nutqajuittuq aukturangami.

Thermosyphon: malrungnik-aturniqaqtuq niglaqtirutikhaq, imarmik aullaviqaqtuq uunarnirmik nunamit ikiarnirmut ukiumi.

HAMNA THERMOSYPHON IMAITTUQ...

Niglaqtirutikhaq

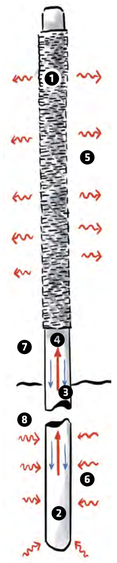


Tamna uunaqutit thermosyphon piijaqpagat uunnarniq nunamit imaalu auulapkaqhugu ikiarmut. Hanajauhimajut nutqaqtinnahuaqhugu uunarniq igluqpangnut huungirnaittumik nunap qiqumaninga ataanit, qiqumanahuaqhugu nunap qiqumaninga aukturnaittumiklu. Havakpaktut ikiarnia qajurnaqhitqijautijarangat nunamit.

Thermosyphons ihuaqtut iliuraqtauhimajarangamik ihuaqtumik. Atuqtaullualiqpaktut simatlingnut natirnut hanajaujarangata auktuqpallianinganit nunap qiqumaninga.

QANUQTUT HAVAKPAKPAT

Havakpaktut ukiumi, aujaungittumi



1. Ailaqtautivaktuq (uunaqutit) ilanga
2. Nunnguvauhianut ilangani
3. Ailaqtarniq
4. Pujungurniit
5. Uunarniq tammaqpaktuq niglaumanirmut ikiarmut
6. Uunarniq unngavaktauhimajuq nunamit
7. Above ground
8. Below ground

Thermosyphons umikhimajut tuqhuat piqaqtut annialaiqhimajut carbon dioxide imigjak ilanganiklu kaasiliik. Kuvijaaqtuq ingaqpaktuq nuhuktaupluni ataanit tuqhuap hauhimajuq nunamut, imaalu gas qulvakpaktuq qulaanun qulaanittumun nunap.

Ukiumi, nuna qaajurnaitqijaujarangammi ikiarmit, kuvijaaqtuq atpahirnianiittuq tuqhuami uunnaalaqivaktuq, ahiit pujunguqhuni (kaasilinguqpaktuq), imaalu qunmuqpalliapluni tuqhuarmut qulaanittumut nunami. Iluani uunaqutit qulaniittut nunap, kaasiliit niglaqpalliavaktut, condenses (kivijaaqtunguffaakhuni), imaalu kuviffaakhuni atanut nunamut. Hamna aullaninga haffuma carbon dioxide niglaktitpalliavaga nuna imaalu nunap qiqumaninga hamn aikiarnia qajurnatqijaukpat nunamit.

ATURNIAQQIGIT?

Nunap qanurinninga imaalu atuqtakhat tamajakhat

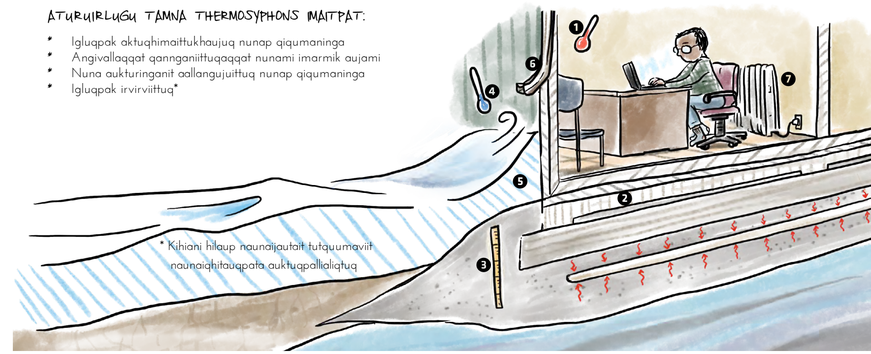
Katiqhiplutik naunaitkutikhanik ikajuutikhanik igluqpkhanik qanurinnikhainnik ihumaliuqtit naunaiqhihimajut tamna thermosyphons ihuaqtut nakuujut atuqtakhaliuqhimajut.

ATURUMINAQTUT KANGIQHIDJUTIKHAT NAUNAIQHITIKHANUN:

- Igluqpak nappaqhimava tahamani auktuqpallianingani nunap qiqumaninga?
- Naunaqhittiarlutit nunap hikua imaalu imaqarnianik
- Naunairlugit ihivriurninqit qannganiittut nunami (nunapqanurinnigillu)
- Naunairlugu ivjuninganik aullaninganut ivjuninga
- Ikuutagit iliurarvikhait, iliurarlugit nunamut uunnarninganik naunaijautikhat
- Naunaijarlugu qannga imaalu nunap iluanni imap kuvinianik
- Ihivriurlugit nunangni/pitquhiinniklu qaujimajaujunik najuugani

ATURUIRLUGU TAMNA THERMOSYPHONS IMAITPAT:

- Igluqpak aktuqhimaittukhaujuq nunap qiqumaninga
- Angivallaqqat qannganiittuqaqqat nunami imarmik aujami
- Nuna aukturinganit aallangujuittuq nunap qiqumaninga
- Igluqpak irvirviittuq*



* Kihiani hilaup naunaijautait tutquumaviit naunaiqhitauqpata auktuqpalliaqtuq

ATUQTAKHANUT QANURINNINGAT

Hunat ilivit ilihimaJakhatin

Naunaijattiaqhimajut najugani pidjutaujut qanuq ihuarninganut thermosyphon aturnikhanut havangniarmangat. Amigaittut kangiqhijakhatit hivuani niuviktinnatit hapkuninga thermosyphons, hamma ilangit titiraqhimajut:

1. Iglum iluanni ikiarni uunnarninga aujami ukiumillu
2. Igluqpait uqququtikhainnik, ilaujut nunap ataani
3. Ivjunia ujaraliamik iliuraiqhimajumik
4. Itqungniarutaanik idjuhikhanik igluqpaum atuqtaunikhanut
5. Nahurijaunianut appidjutikhanik, upalungaijarlutik qanuqtut munaqhidjutikhanik apinninganut
6. Munaqhitikhainnik imarmik imaalu nakuujumik imap kuvivihainnik
7. Igluqpaup uunaqutikhait atuqtauniit (iluanni-natiagut vs. uunaqutit)



ECOLOGY NORTH

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Ecology North maniliungittut tiqutaujuq, piliuqtauhimajuq 1971 ikajuutikhanik ihuaqtut avatilirinirmut ihumaliurutikhainnik inungmut, nunamut imaalu avikturniannut.

Hivajarlutata kuluguluunnit qaritaujakkurvikput nauunairumajarnik imaalu aallanik maliktakhanik hapkutiguuna.

Nivingajukhat Taiguagakhat

Titiranguqtiqhimajut atuqtauffaaqhimajunut makpiaanut 2020

IGLUQPAUM QANURINNIKHAINNIK

Ilaudjutikhannik thermosyphons

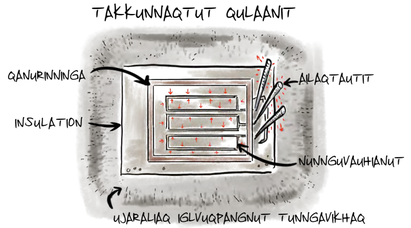
PIDJUTAULAJUNIK IHUMAGIJAUJUKHANIK:

- Upalungaijailutit naahuringnaittunik qanurilinikhangit aallangurnikhainikluuniit
- Ihivriuttiarlugit qanurinnikhait nappaqtirutikhainniklu upalungajautikhat
- Pihimalugit titiqqangit tamainnik atuqtakhanut qanurinningat

MALIGLUGIT NAKUUTQIJAT ATUQTAKHANGIT HAPKUNUNGA:

- Nunnguvauhianut naunaijaut, turhuat, imaalu uunaqutit
- Ahirrujaqhimajunik ujaqqanik tun'ngaviit, najugakhanik algarniit, aturniit ujagaliat
- Kinguliqpaamik najugakhanik pualriharlugu in'ngalaivjavjariangani
- Aturningit attarniit imaalu nunap ataaniittunik ikajuutikhat
- Imiqtarviit imaalu kuvigaqhimajunik imaijarvikhait tuqhuat
- Igluqpangnut insulation
- Aallat atuqtauvangniit (e.g. attarniit imaaluuniit igluum halumaittunik imaijarviit)

IGLUKHAMUT TITRAUJANGIT TAKKUNNAQTUT QULAANIT



NAPPAKTIRINIQ

Najugakhaa ihuaqhaqtaujuq; iliuraidjutikhat atuqtakhat

Nappaqtiriniq uvani auktuqpallianinganni pidjutiqaqtut nunap qiqumaninga ilaani ajurnavjaktuq. Nakuujumik upalungaijautikhaliurniq ihuaqutauhungujuq.

Naunajarlugit tamajakhat aquiqtuqtauhimajakhaita, aullaqtitauhimajakhainnik, imaalu iliuraqtauhimajakhainnik **ihuarningani ukiungata**. Taimaatut najugakhaa ihuaqhaqtaujukhaqiglup tungavikhaa havaktaujukhaq aujami, nuna ingutaalaijariangani imaalu ujaraliakhanik ihuaqhattiaqtaujarangat.

Ingutaaqtitthailinahuarlugu nunap qiqumaninga imaatut iliurailutit thermosyphon atuqtakhanik qilamiurlutit.

Nunap uunnarninganik **naunaitkutikhat (sensors)** iliuraqtaujukhat taffumingalu thermosyphon atuqtakhanik.

Hamna iniqtauhimajuq igluqarvikhaq **qiqimapkarlugu atauhirmi ukiumi** nappaktiriliqtinnatit ilanganik igluqpangmik.

Kihianik algariaqaqqat, **algaktailidjavutit nunamik** nunap qiqumaninganik. Algaktaujariaqaqqat, anginiqaqtuq igluqarvikhaq nuna qiqipkaqtakhaq ukiumi.

Titirarlugit havaktaunikhangit, ilaujut hunat aallangurningit qanurinnikhanut.



AMIQHIDJUTIKHAMINGNIK UPALUNGAIJAUTIT

Ihuaqtutauvakpat?

- Ukiuqtinngu, ihivriuqhilutit huunnirliriakhainnik/nunguvalliairniinnik
- Naunaijarlugit aktilangit uunaqutit unnarningit ukiumi
- Naunaijarlugit nunap uunnarningit hanajautingani iniqqatalu nappaqtirijut
- Munarilugit igluqpaup ahirrurningit imaalu uviqpallianingit

Pijariaqaqqat, hivajarlugit ajuiqhattiaqhimajut ihivriuqhittiaqtukhanik.

Naunaijarlugit thermosyphon qanuringit ihivriuqhidjunmut uunarninganik imaaluuniit qaujihaunmut uunnarninganik ukiulihaqtitlugu,ikiarningata niglaumanningit imaatut 15-20° qajurnatqijautitlugit nahuurijaujumit nunam niglaumaninganit.

Niglaumaninga ukuat qanuringit uunnatqijaujukhat ikiarnirmit imaalu qanittuaniitunit qanurinninganit – hamna tukiqaqtuq imaatut qunmuuktirijut uunnarnirmik iluanit nunamit imaalu tammaqtitpakhugu ikiarnirmut!



Standards Council of Canada
Conseil canadien des normes

Crown-Indigenous Relations and Northern Affairs Canada
Relations Couronne-Autochtones et Affaires du Nord Canada

CSA GROUP

Nunavut

Angiqtaugamik Canadian Standards Association, (aulajut imaatut "CSA Group"), 178 Rexdale Blvd., Toronto, ON, M9W 1R3, tamajaitg havaktauvakhimajut ukunanga CSA Group's atuqpagait CAN/CSA-S501-14 - Nutannguqtiqhugu aktuutauniit nunap puvitquumaninga mahakpalliadjutanut tadja igluqpait tunngavingit. Hamna iniqhimaittuq huli ilitarijauimajut inikhaat CSA Group titiraqhimajukkut uqautaujunut, kivgaqtuqtaujuq taffumangainnaq Atuqpagait tamainnun. Aurnikhait hapkuat titiqqat angiqtauhimajut, CSA Group munaqhingittut titiraqhimajut naunaijautait tunijauhimajut, kivgaqtuijukhanut kangiqhidjutikhainnik. Aadjiliuqtautqujaungittut aallaniklu havaqujingittut. Naunaiqhittiarumaguvit imaaluuniit niuvrutikhanik atuqpagainnik ukunanga CSA Group, takulugu niuvvavik. csagroup.org imaaluuniit hivajarlutin 1-800-463-6727.

KANGIQHILUGIT UUNAQQUTIT (THERMOSYPHON) TUNNGAVIKHANUT ATURNIINNIK

