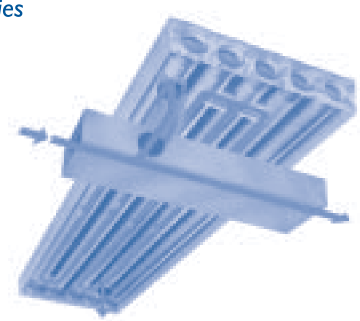
LowEx

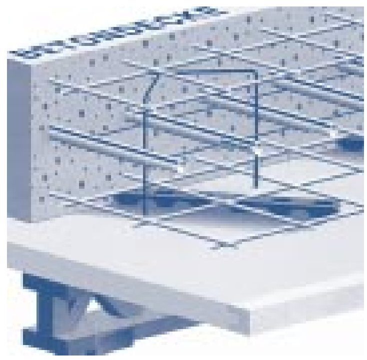
LOW EXERGY CONCEPTS AND TECHNOLOGIES

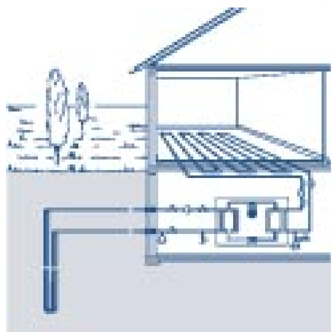
HEATING AND COOLING SOLUTIONS FOR FUTURE BUILDINGS

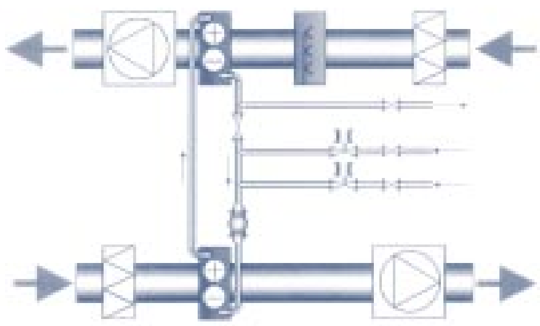
For future buildings, a minimum amount of energy at a very low level of temperature difference between the system and the room should be used for thermal conditioning. In this way a maximum of high quality energy (exergy) can be saved. The big efforts made in the field of energy saving in buildings by constructing nearly perfect thermal envelopes, sufficient window shading and the use of thermal storage have already led to a much better usage of the input energy. But there is still a great saving potential left. To make the energy use in buildings even more efficient, new low temperature heating and cooling systems are required. The presented systems show a step further in the right direction.

Information on existing and innovative low exergy concepts and technologies will be collected in the LowEx Guidebook.









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Some examples of the most typical lowex components are presented in this fourth issue of LowEx News. The presentation of lowex systems and components will constitute an important part of the LowEx Guidebook, which will be the final product of Annex 37 'Low Exergy Systems for Heating and Cooling of Buildings'. For more information on Annex 37, see last page or website in address **www.vtt.fi/rte/projects/annex37**

PRESENTATION OF LOWEX CONCEPTS IN THE GUIDEBOOK

For every presented system a data sheet is given. The systems are sorted in main and sub groups. To improve the understanding of the different systems a small sketch and some main data are given.

Application: Is this a heating or a cooling system? Both might be possible.

State of the art: Is the system available on the market? Could an interested customer order such a system? Is it still at an experimental stage? (Some examples have already been built, measurements might be going on.) Or is it just an innovative concept, just plans or thoughts?

Minimum heating temperature: What is the estimated minimum inlet temperature to the system (i.e. the temperature for the room heating and not the temperature drop in the supply)? A typical range is given.

Maximum cooling temperature: Equal to minimum heating temperature; see above. A typical range is given.

Description: A short description of the system and its function is given here.

Technical risk/benefit analysis: Some most important risks and special benefits are stated.

Special advantages, disadvantages, limitations or side effects: Are there some typical boundaries for the system? Are there even special features?

References: Some (about 3) references where the interested reader could find more information or guidance about the system or the dimensioning. ■

SURFACE HEATING AND COOLING

FLOOR HEATING – EMBEDDED COILS IN SLABS

Application

- [x] for heating
- [x] for cooling

State of the art

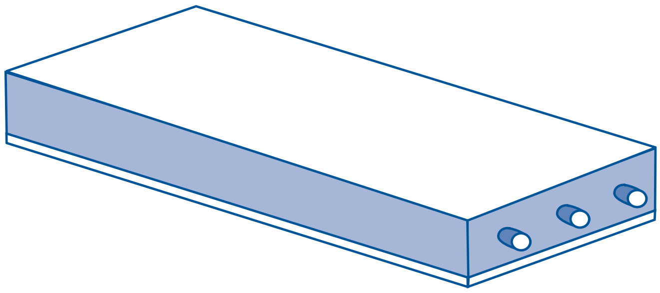
- [x] Commercially available
- [ ] Prototype
- [ ] Innovative concept

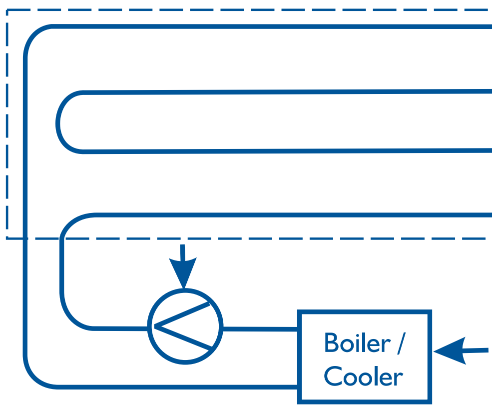
Minimum heating temperature:

23°C (typical range: 25–30°C)

Maximum cooling temperature:

19°C (typical range: 10–15°C)





DESCRIPTION:

The system consists of a concrete slab (about 250mm thick) with plastic pipes in the centre of the slab. The heat-carrying medium in the tubes is water. Because of the fact that the whole floor/ceiling area can be used for the system, a very large area can be provided for heating or cooling purposes. I.e. only a low temperature difference is needed to deliver a certain heating/cooling power to the room. The huge thermal mass of the concrete slab acts as a storage medium. The system responds slowly on supply water temperature changes as well as on temperature changes of the room, it has quite a capacity to absorb large changes of loads in the building. Because of the low heating/ high cooling temperature, the system is self-regulating. The room temperature can not fall below the cooling inlet temperature or rise above the heating inlet temperature.

TECHNICAL RISKS/BENEFIT ANALYSIS:

Risks: The thermal comfort is not perhaps guaranteed all the times of the year. Because of the thermal mass the system reacts slowly on temperature changes in the room. If e.g. the sun is shining and is going to warm up the room, the system is not able to deliver the necessary cooling power to keep the room at a certain temperature. An other risk is the water in the pipes, which should be tight as in every other waterborne system. For cooling in humid climates, the dew point, has to be taken into account. Otherwise there will be a risk of condensation on the floor and ceiling surfaces.

Benefits: Because of this extreme high inlet cooling temperature, the system could be supplied with cold from the ground under the building or other nearly free sources. Even cold produced by a compressor cooling machine could be provided in a more effective way, the COP (coefficient of performance) of these machines is much higher at low differences between supply and return temperatures of the system.

SPECIAL ADVANTAGES, DISADVANTAGES, LIMITATIONS OR SIDE EFFECTS:

Disadvantages: Big areas are needed to deliver the demanded cooling/heating power to the room, the whole ceiling and floor area should be used. The problem of replacing is not solved. It is very expensive to change the piping after the building process.

Advantages: Because of the low temperature differences between surface and room temperature, the air velocities due to convection inside the room are quite low. On conventional heating devices like radiators, the air velocity is much higher. This causes thermal discomfort, and dust movement in the air. The temperatures on every surface are much more equal with this system. The thermal comfort is increased in comparison to the use of a conventional radiator. The fluctuations in the air velocity are also reduced, this means also a better thermal comfort. The utilisation of the big heat capacity of the building construction itself helps to improve the efficient use of energy.

Limitations: The system should not be used for the slab on the ground or only with increased insulation, because heat loss in these cases will be big. Also there will be a moisture transfer from the ground through the slab and a proper vapour barrier is mandatory. Especially in summer time there will be a vapour transport from the ground upwards, this could damage the floor covering. Since the heat capacity of the slab is big, the system will react slowly on temperature changes. The response time is relatively high.

Side effects: Because the system merge together with the building construction, there are a number of interactions in heat and moisture transfer due to these systems. The drying up period of the construction can be shortened, if the heating is put on right after the construction. ■

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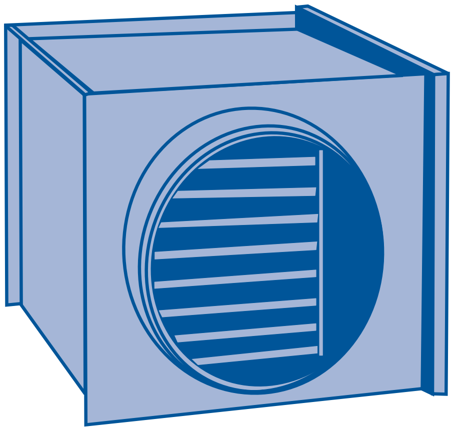
Hauser G.; Kempkes C. (1998): *Wasserdurchströmte Bauteile zur Raumkonditionierung. Bauphysik Berichte aus der Forschung und Praxis* (in German). Fraunhofer IRB Verlag, Stuttgart, Germany.
Olesen, B.W. (1997): *Possibilities and Limitations of Radiant Floor cooling*. ASHRAE Trans V. 103, Pt.1.

WATER TO AIR HEAT EXCHANGER – SUPPLY AIR CONDITIONING



Application

- [x] for heating
- [x] for cooling

State of the art

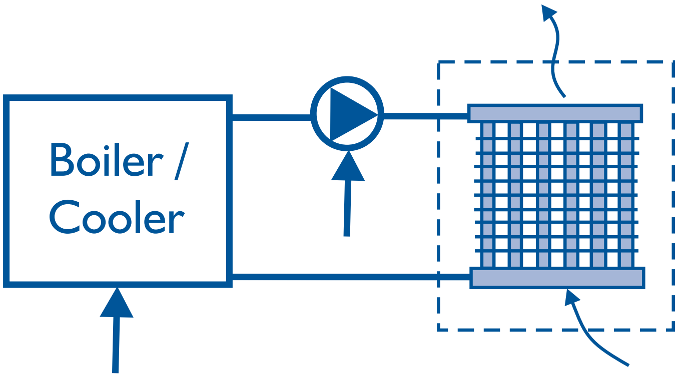
- [x] Commercially available
- [ ] Prototype
- [ ] Innovative concept

Minimum heating temperature:

30°C (typical range: 40–90°C)

Maximum cooling temperature:

19°C (typical range: 10–15°C)



DESCRIPTION:

Typical water to air heat exchangers for cooling and heating of air streams are bare tubes or also tubes with extended or finned surfaces (fin coil tubes). They consist of a single coil section or several individual coil sections built into banks. Often used fin arrangements are smooth spiral, crimped spiral, flat plate and configurated plate. A good thermal bond between the fin and the tube must be maintained permanently to assure low resistance to heat transfer from fin to tube. Fin tubes are usuallyconstructed with copper tubes and aluminum fins. The design of coils with extended surfaces on the air side considers the materials, fin size and spacing, ratio of extended surface area to that of the tube area, tube nesting center dimensions, tube arrangement (staggered or in-line) and the use of turbulators. The coil assembly usually includes a means to protect the coil from dirt accumulation and to keep dust and foreign matter out of the conditioned space.

For cooling purposes chilled water, brines or volatile refrigerants are the usual media. Air heating is usually done by use of hot water. Most cooling coil equipment are designed to remove sensible heat and dehumidifysimultaneously. Cooling coils that use relatively high temperature water usually do not dehumidify the air. Water to air heat exchangers which use hot water to heat the air usually require not more than one or two rows of tubes in direction of the airflow.

TECHNICAL RISKS/BENEFIT ANALYSIS:

Risks: Water to air heat exchanger is a well tested technology. Within their operation usually no technical risks have to be expected. In normal applications the water pressure inside the tubes neither lead to any technical problems. Corrosion problems could appear if the air which has to be heated up or cooled down contains chemical components which attack the tube material when condensing.

AIR HEATING AND COOLING

WATER TO AIR HEAT EXCHANGER – SUPPLY AIR CONDITIONING...

Benefits: Water to air heat exchangers show a very easy and robust construction. They can be used as economic technology for heating and cooling of gas or air in a great range of applications. They can be easily adapted to the heat transfer rate by adding several fins or tubes.

SPECIAL ADVANTAGES, DISADVANTAGES, LIMITATIONS OR SIDE EFFECTS:

Advantages: Due to their well tested technology, the dimensioning rules for water to air heat exchangers are well documented. For different applications, examples of possible solutions for construction are known so that the system integration of water to air heat exchangers usually causes no problems.

Disadvantages: -

Limitations: When using water as heat transfer medium possible freeze problems have to be regarded if the heat exchanger works at low air or gas temperatures. A minimal flow has to be ensured to protect the water inside the tube from freezing.

Side effects: -

REFERENCES:

Howell, R. H.; Sauer Jr., H. J.; Coad, W. J. *Principles of heating ventilating and air conditioning*
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Handbook – Fundamentals, 1997

Recknagel, H.; Sprenger, E.; Schramek, E.-R.; *Taschenbuch für Heizung und Klimatechnik*
R. Oldenbourg Verlag München Wien, 69. Auflage, 2000 (in German)

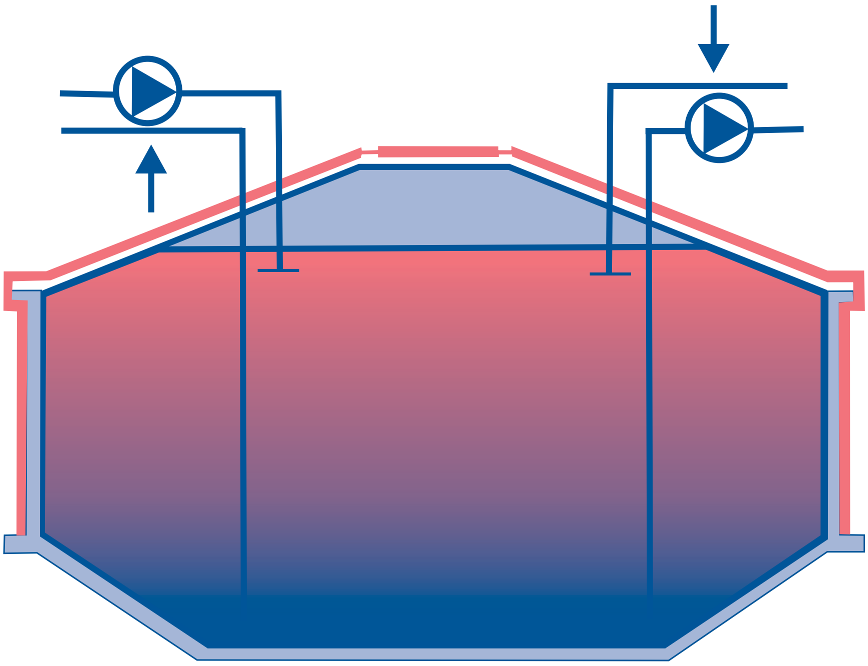
ANNEX 37 WEBSITE

HTTP://WWW.VTT.FI/RTE/PROJECTS/ANNEX37/

On Annex 37 website we have collected information about Annex 37: background, objectives and working methods as well as information on participants, meetings and publications. The website is updated continuously, so the latest information will always be found on the website. There you can find the

- Contact information
- Status reports
- Previous issues of LowEx News (in pdf format)
- Technical Presentations about Annex 37 issues in ECBCS ExCo meetings
- Links to other useful sites

SEASONAL STORAGE – HOT WATER STORAGE



Application

- ☑ for heating
- ☐ for cooling

State of the art

- ☑ Commercially available
- ☐ Prototype
- ☐ Innovative concept

Minimum heating temperature:

35°C (typical range: 35–95°C)

DESCRIPTION:

Hot water storages are used for both short and long-term storage and can be subdivided into two main types. For short-term storage conventional self-carrying steel tanks are a common application with volumes up to 5.000 m³. Due to the expensive construction of these storages for larger storage volumes, cheaper concepts are required. A possible and realized solution is earth pit as seasonal storage which is directly built in the soil acting as carrying element. As a geological pre-condition for the realization of an earth pit the soil has to be soft but static with a low share of ground water. The earth pit storage has to be provided with a water resistant and sustainable coating (e.g. stainless steel, synthetic material or clay) on the inside of the walls (reinforced concrete). The thermally insulated ceiling could be carried out as supporting structure or as a floating plate. Also the walls of the storage has to be provided with a thermal insulation. The insulation material has to be water-repellent and pressure-resistant. In solar assisted district heating systems the needed storage volume can be estimated to 1.5–2.5 m³/m² collector area. The volume of realized earth pit storages varies between 3000 and about 80000 m³. Charging and discharging of the storage typically takes place in a temperature range between 35 and 95°C.

TECHNICAL RISKS/BENEFIT ANALYSIS:

Risks: Self carrying steel tanks are a well tested storage technology. Neither the construction material nor the storage medium lead to technical risks. Earth pit storages are also tested in several applications, different kinds of construction material are in use. By regarding the demands for the structure (e.g. static pressure, temperature gradient), the coating (e.g. tightness, aging resistance) and the thermal insulation no risks need to be expected.

Benefits: The conventional steel tank for short-term storage as well as the earth pit for seasonal storage are the best developed kinds of storages. The earth pit storage is nearly independent of geological boundary conditions so the risk of damages or malfunctions due to the properties of the soil is reduced.

SEASONAL STORAGE – HOT WATER STORAGE...

SPECIAL ADVANTAGES, DISADVANTAGES, LIMITATIONS OR SIDE EFFECTS:

Advantages: Due to the use of water as storage medium in hot water storages, a relatively high charge and discharge power can be achieved. Another advantage of the storage medium is the relatively high storage capacity at greater temperature differences between supply and return temperature.

Disadvantages: Due to their expensive construction, the integration of conventional self-carrying steel tanks as short-term storage usually leads to high investment costs. In the case of earth pit storages used as seasonal storage the necessary excavation of the soil (cost reductions can be achieved by refilling with the excavation), the construction of the storage walls, their water resistance, durable coating and the ceiling in combination with the required thermal insulation also lead to high volume-related investment costs in comparison to aquifer or earth duct storages.

Limitations: To reach acceptable volume referred investment costs, water storages should be carried out unpressurized. To reduce the heat losses, the storages have to be provided with a thermal insulation up to storage volumes of about 50 000 m³.

As a ***side effect,*** the system integration of hot water storages as short or long term storage leads to a greater independence in the choice of the heat source. Solar thermal energy, wood (chip) combustion, CHP, heat pumps or waste energy could be used as the heating source if storage is a part of the system.

REFERENCES:

Fisch, M. N.; Kübler, R. (1998): *Wärmespeicher* Fachinformationszentrum Karlsruhe, Gesellschaft für wisenschaftlich-technische Information mbH, 3. Auflage, TÜV-Verlag Köln, ISBN 3-8249-0442-X (in German)

M. N. Fisch, M. Guigas, J. O. Dalenbäck: *Large-Scale Solar Heating Systems – Status and future in Europe*; ISES Solar World Congress '97 Proceedings (Vol. VII), Taejon Korea, 24.-30.08.97

Fisch et al. *Large-scale solar heating systems - Integration of Large-scale solar heating systems* Project report APAS – Large-scale solar heating systems, Proposal No PL94-0271, Contract No CT94-0057, Sector "Local and regional integration", Stuttgart 1996

NEXT MEETINGS OF ANNEX 37

LowEx

Fifth Expert Meeting

The 5th Expert Meeting of Annex 37 will be held on 23rd to 25th April 2002 in Sophia-Antipolis, France.

Sixth Expert Meeting

Sixth Expert Meeting will be held on 26th to 28th September 2002 in Oslo, Norway. Sustainable Building conference will take place in Oslo on 23rd to 25th September.

Seventh Expert meeting

Seventh Expert meeting will be held in April 2003 in Japan.

Final Meeting

The Final Meeting of Annex 37 will be held in October-November 2003 in Finland.

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Annex 37

LOW EXERGY SYSTEMS FOR HEATING AND COOLING OF BUILDINGS

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