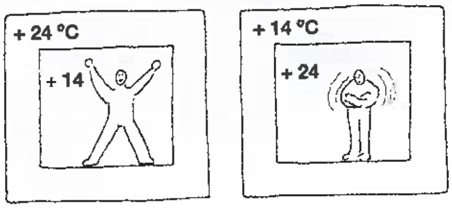
1.2.0 Interior Climate

There are many factors affecting interior climate, and constructing a healthy, comfortable building must be well thought through. Consideration needs to be given to the location of the building, especially with regard to air pollution from traffic and industry. Building materials may release unhealthy emissions. The building's services affect interior climate, with the ventilation system exerting the greatest influence. Electrical systems affect the electro-climate. Heating and cooling systems affect comfort. Water and sewage systems cause no problems until they leak. Even activities that take place inside a building, such as smoking, significantly influence the air quality.

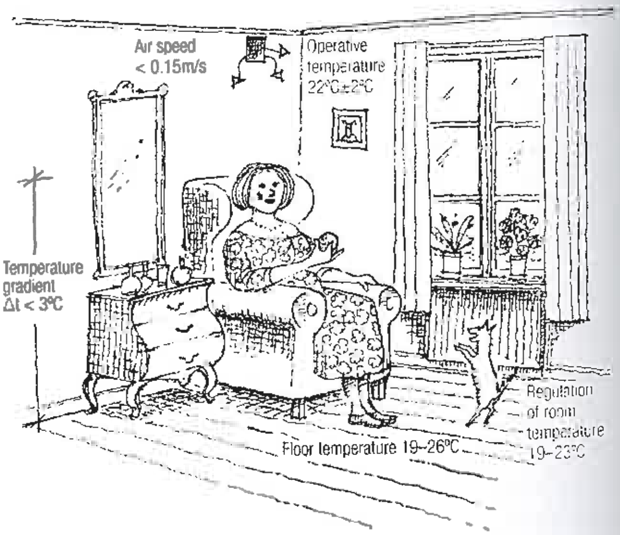
Comfort

Comfort can be divided into the following categories: thermal comfort; humidity; air, sound and light quality; electro-climate and ease of adjustment. With regard to thermal comfort, the term operative temperature is used, which takes into consideration room temperature, surface temperature draughts and temperature variations within the room. Relative humidity has to do with air moisture levels that are neither too dry nor too moist. Optimal comfort is achieved between 40–60 per cent relative humidity. Air quality addresses fresh air and quantities of air, as well as smell, dust, particles, emissions and fibres. Sound quality has to do with sound level, speech comprehension, reverberation time, echo, as well as noise, impact sound, infrasound and vibrations. Light quality has to do with lighting, light strength, colour reproduction, availability of daylight and sunlight, as well as glare and reflections. The electro-climate depends on electrical and magnetic fields as well as static electricity. Ease of adjustment has to do with being able to control the interior climate, i.e. temperature, ventilation and light, an important comfort factor for many people.

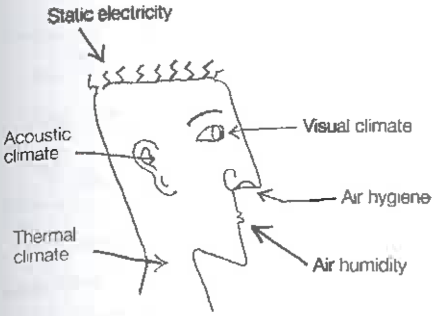


The temperature of the walls influences how the room temperature is perceived more than the air temperature. If the walls are warm but the room air cold, the room is experienced as warmer than if the air temperature is warm and the walls are cold.

Source: Architects Eva and Bruno Erat, Finland



The most important comfort parameters are temperature and humidity. It's impossible to please everyone; 10 per cent always complain and therefore it is good to be able to control our own interior climate.



Interior comfort is influenced by many different factors, including air cleanliness, temperature and humidity as well as light conditions, sound levels and electro-climate.

Interior air may be polluted by a variety of sources, including unhealthy and unpleasant contents.

Control and Regulation Systems

Interior climate may be adjusted either manually or automatically. Manual regulation includes opening and closing windows and ventilation outlets, as well as turning the heating up and down. This can be done using simple methods but requires participation by the occupants. Automatic regulation has developed considerably in recent years, concurrent with computer development. Current regulation systems are usually connected to a local computer control system that controls everything affecting interior climate such as ventilation, heating, cooling, lighting, etc. In principle, a building is equipped with various sensors that monitor temperature, air humidity, pressure, light conditions, etc. All the sensors are connected to the computer control system programmed to control dampers, vents, lamps, etc. The goal is to achieve a good interior climate while conserving energy and other resources. New, efficient regulation equipment can save up to 10 per cent of energy consumption in multi-family dwellings, and 20 to 30 per cent of energy consumption (heat and electricity) in office buildings in

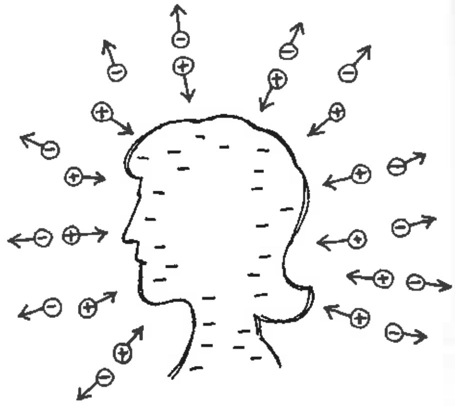
INTERIOR CLIMATE REQUIREMENTS

Ventilation experts Torkel Andersson and Håkan Gillbro, specialists in reinforced natural ventilation, have made the following list of requirements for interior climate in schools and offices:

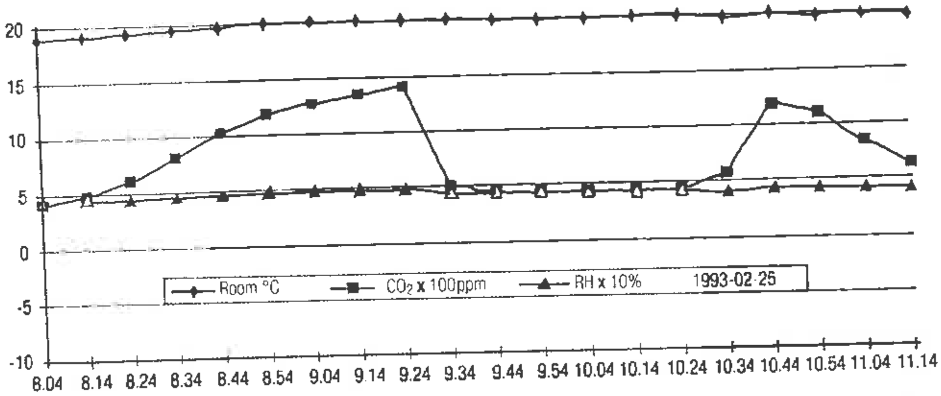
- equivalent room temperature 20–21°C
- relative humidity 30–40 per cent during the cold season and 40–60 per cent during the warm season
- low static electricity
- no audible or inaudible sound
- low concentration of particulate substances
- low concentration of gaseous substances
- good and pleasant lighting and lighting level
- good natural lighting

Sweden. For every degree that the average interior temperature can be lowered, there is a 4–5 per cent savings in total energy consumption.

When functions in a building are computer-controlled, these functions can be extended. Buildings controlled by such systems are referred to as 'smart' or 'intelligent'. Functions that can be added include burglar alarms, fire alarms, overflow alarms, humidity alarms, motion detectors to adjust ventilation or lighting, magnetic switches that indicate whether or not windows or outer doors are open, timers, etc. A display screen can be connected where it is possible to regulate the system, and to observe electricity and water consumption, interior and



A human being can be electrostatically charged. A negatively charged person attracts positively charged dirt particles. A shock is received when an electrostatically charged person touches an earthed object.



Fredskulla school in Kungälv, Sweden (designed by architect Christer Nordström) has natural ventilation, adjustable as required. Climate monitoring shows that they succeeded in keeping the room temperature at about 20°C and the relative humidity at about 50 per cent. During the winter, the level of CO_2 sometimes exceeded 1500 parts per million (ppm). That level does not affect health but exceeds earlier recommendations. When staff and pupils take regular breaks and open the windows, the CO_2 level can be quickly lowered.

Source: Ventilation consultants Torkel Andersson and Håkan Gillbro, DELTAte, Gothenburg

outdoor temperature, who's standing at the front door, and to reserve a slot in a shared laundry room, etc. When spring sun shines in through a window, a good control system would immediately detect the free heat and lower the output from the radiators. Opening windows for a short time may cause cold air to sink and trip a thermostat that regulates heating. A smart system can be programmed so that heating is not turned up during this short period. In a waterborne system, old thermostats can be replaced with new ones that are part of the control system.

Such systems open up completely new possibilities for property managers. Systems can be connected together, functions checked, problems detected, and comparisons made between buildings to determine where various energy-efficiency measures should be used.

1.3.3 Sound and Noise

Noise problems are common in everyday life. People are disturbed by traffic and unwanted sounds from ventilation and heating systems. People are also affected by low-frequency sound, infrasound, that is not consciously perceived, such as noise from fans. People may be bothered by impact sound and air sounds in buildings. These problems can be prevented by using heavy construction materials, discontinuous construction, special window designs, etc. In a noisy locality, sound insulation measures should be included in any new construction.

Noise

The unit decibel, dB(A), is often used to describe sound volume. The 'A' refers to the different frequencies being weighted to correspond to how the human ear interprets the sound volume. An increase of 3dB(A) is equivalent to experiencing a doubling of the sound volume.

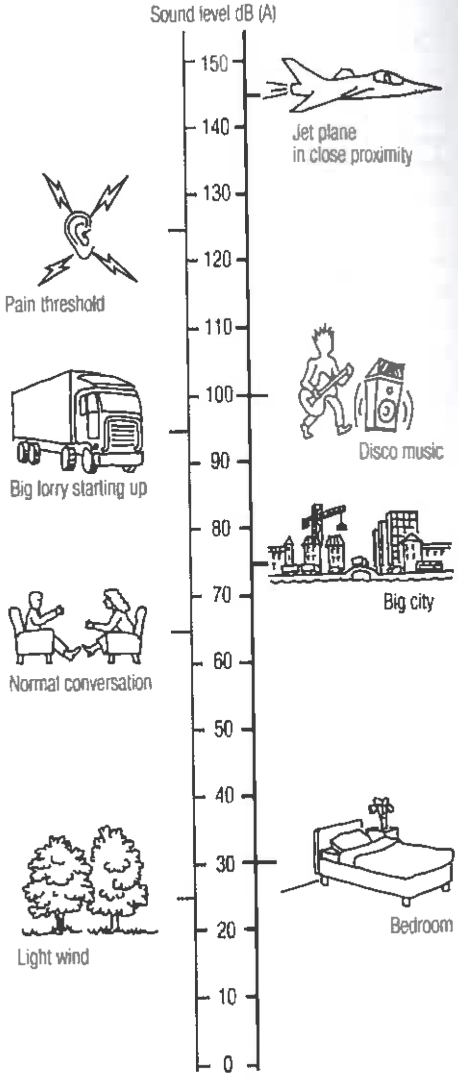
In Sweden, slightly more than two million people are exposed to noise that influences health and almost one million report being bothered within the vicinity of their home, often by traffic noise that is over 55 decibels. Noise from all sources together should not exceed 55 decibels. The sound from a normal conversation is 60 decibels. EU countries are required to map noise problems and establish remedial measures in cities with a population of more than 100,000 by 2013.

The National Board of Housing, Building and Planning (*Boverket*) has set the following long-term goals according to the noise guidelines supported by the Swedish Parliament:

By the year 2020 noise levels in home environments will not exceed:

- 30dB(A) equivalent indoors;
- 45dBA maximum level indoors at night;
- 55dBA equivalent level outdoors (at the façade);
- 70dBA maximum level in outdoor areas associated with homes.

These are guidelines for new construction or substantial roadway reconstruction.



Sound level is measured in decibels on a logarithmic scale.

Sound Reduction

In our stressful society more and more people strive after more tranquil and quieter environments. Several studies unequivocally show that a good sound environment is high up on residents' wish lists. In Sweden in 1999 a new sound standard came into force that takes into consideration frequencies down to 50Hz, in other words the base level that sound systems emit. It can be difficult to comply with the standard using common light construction techniques. It is easier to meet the requirements using heavy building systems.

Following are the Swedish sound classes according to standard SS 252 67. The difference between classes is normally 4dB.

Sound class A: corresponds to very good sound conditions.

Sound class B: corresponds to significantly better sound conditions than sound class C.

Sound class C: provides satisfactory conditions for the majority of residents and can be applied as a minimum requirement according to the National Board of Housing, Building and Planning regulations.

Sound class D: corresponds to conditions meant to be applied when sound class C cannot be achieved. An example is older homes that for particular reasons cannot be renovated in a way that meets the requirements of sound class C, e.g. when careful restoration work is being carried out.

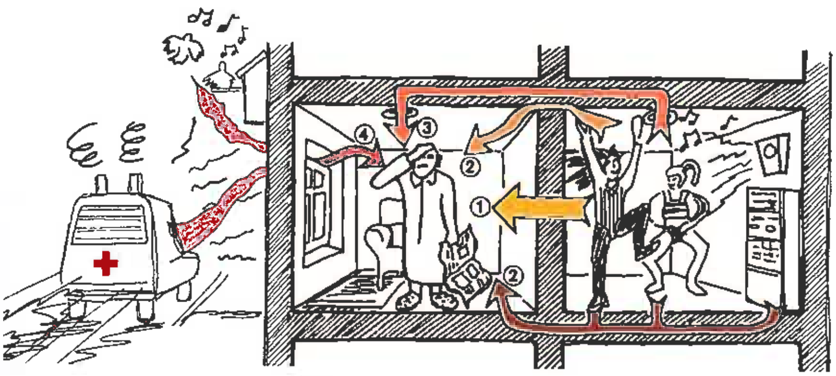
Sound class B is usually applied for new construction.

The Quiet Building

It is possible to build quiet flats. With the help of common sense, holistic thinking and collaboration, housing free from noise disturbances has been built, for example in a project called 'The Quiet Building' in Lund, Sweden. Neither traffic, neighbours, plumbing nor fans disturb those who live there. The quiet buildings were constructed using thicker concrete, floor plans and services designed to minimize sound disturbances. The cost of constructing buildings that are experienced as quiet can be 2–3 per cent higher, which may be considered to be within reasonable limits.

Separating Walls and Floors in Flats

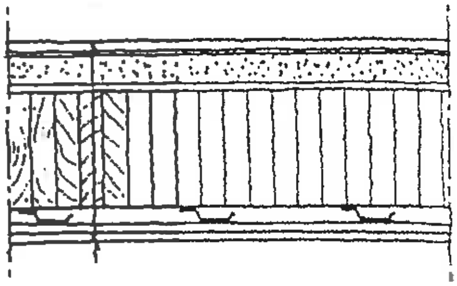
There are three ways to reduce sound transfer: one is to use heavy materials; a second is to use double rather than solid structures; and a third is to fill empty spaces in structures with insulating material. Increasing the thickness of walls also improves the sound climate. Impact sound can be muffled through proper choice of floor covering or by putting insulation between the floor covering and the load-bearing construction.



1. Direct sound transmission
2. Flanking transmission
3. Overhearing
4. Noise leakage

Today many people live in a poor sound environment. The need for sound insulation has grown due to an increase in new sources of disturbing sound, such as heavy traffic, powerful stereo systems and fans. Sound transmission through the air between two spaces is usually given as a total of direct transmission, flanking transmission, overhearing and leakage.

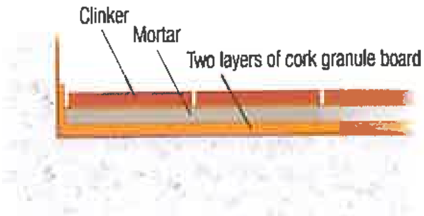
Timber frame buildings with more than three storeys make it especially important to consider sound insulation between flats. Several new construction methods for this have been developed. In 'The Quiet Building' in Lund, walls separating the flats were made using 240mm concrete instead of the usual 160mm. The thickness of the floor structure was increased from the usual 200mm to 290mm, and the outside walls' inner concrete layer from 150mm to 240mm. It is important to know that one consequence of increasing the amount of concrete is an extended drying time.



A solid timber floor between flats. Under the floor joists, metal acoustic sections are attached to plasterboard. The outer floor surface consists of parquet flooring laid on top of impact sound-absorbing material.

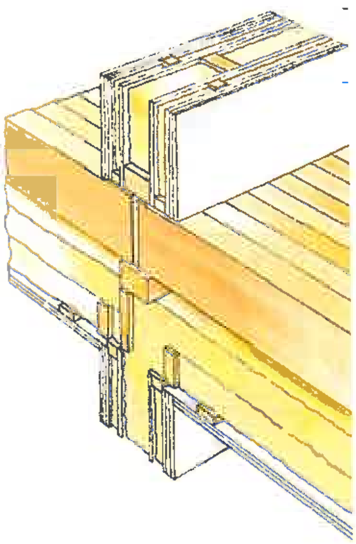
Sound-Insulating Windows

Special sound-insulating windows are available for buildings exposed to a lot of outside noise. Better windows are considered the most appropriate preventative measure in at least half of all buildings exposed to noise. An unfortunate consequence is that many desirable sounds from outside are also excluded, such as birdsong, children playing and the patter of rain. Renovation to improve noise reduction can include adding inner windows (with a glass thickness of about 1cm) onto existing windows, which can reduce noise by about 35dB.



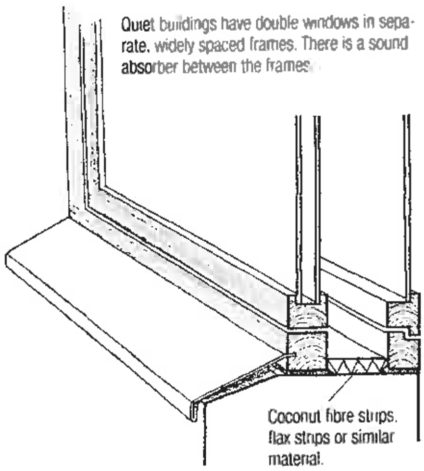
An example of impact sound insulation with cork granule board under a expanded clay floor set in mortar.

Source: Cementa



For walls separating flats, using discontinuous construction does not usually provide sufficient noise reduction. Double walls are often built and the floor structure should also have separated sections. Solid timber floors between flats should be insulated on the underside if the solid wood acts as a floor surface without any other floor covering.

Source: *Massivträ*, Teknisk beskrivning, Trätek, 2000



Window with reinforced sound insulation. It is now most common to use laminated glass with sound-absorbing foil in the insulating glass.

Source: Projektet 'Det tysta huset', JM Byggnads och Fastighets AB, Lund, 1989

Quiet Services

Since dB(A) values do not give a true picture of disturbance by low-frequency sound, requirements for the highest sound level in dB(A) should be supplemented by requirements in dB(C). If the C-level is more than 15dB higher than the A-value, the sound can be said to be dominated by low frequencies. If the C-level is above the A-level by 25dB units or more, it is a question of more serious sound disturbances.

There is a lot to consider on this subject. Circular channels are better than rectangular ones. Pipes can be laid in well-insulated ducts and in a vibration-absorbing manner. Circulation pumps and fans can also be mounted so as to prevent vibration. In addition, pressure-reduction valves can be placed in heating pipes.

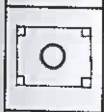
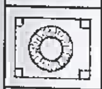
The following is a checklist of things to consider in order to achieve a quieter ventilation system:

- location of fans and ducts;
- sound absorption;
- sound insulation;
- choice and location of fans;
- fan connection;
- ducting and sound insulation;
- duct mounting;
- ventilation fixtures;
- vibration insulation.

R'_w, D_{nTw}	Murmur	Normal speech, Office machines in calm environment	Normal speech, Office-machines	Loud conversation	Shouting	Sound from a loudspeaker, moderate level	Discomusic
35	grey	grey	yellow	yellow	yellow	yellow	yellow
40	white	white	grey	yellow	yellow	yellow	yellow
44	white	white	white	grey	yellow	yellow	yellow
48	YELLOW – audible			white	grey	yellow	yellow
52	WHITE – inaudible				grey	grey	yellow
60	GREY – audible but not diturbing under normal conditions						yellow

Subjective interpretation of sound with various types of sound insulation.

Source: 'Bullerskydd i bostäder och lokaler', Boverket, 2008.

	Sound insulation measure	Sound reduction
	a) No insulation	0dB(A)
	b) 50mm mineral wool preformed pipe section (glass wool 50kg/m2 or rock wool 150kg/m2)	12–14dB(A)
	c) Box of 13mm plasterboard (dimension: 300 X 400mm)	14–18dB(A)
	d) Box as in c) and mineral wool as in b)	25–30dB(A)
	e) Box as in c) and 50mm mineral wool sheets (glass wool 36 kg/m2 or rock wool 75kg/m2)	24–28dB(A)

To reduce the noise from services, ducts can be encased and insulated. The illustration shows an example with a vertical plastic (high density polythene) pipe.

Source: 'Regnvalleninstallation', Svensk Byggtjänst, 1978

2.1.4 Architecture

The approach of the architect greatly influences energy consumption. It has to do not only with insulation and technology, but also with an understanding of passive techniques. The goal of every architect should be to use their skills to contribute to energy efficiency.

Building Design

Smaller, well-planned buildings save energy. Architectural devices that influence energy efficiency include a building's shape and type, temperature zones, how much it is dug into the earth, as well as options that make it possible to use passive solar heat.

Building Shape

The objective for an energy- and materials-efficient construction is to encompass the largest possible volume with the smallest expanse of outer wall. Theoretically, the best shape is a sphere, but it is difficult to make efficient use of the space inside a sphere. So when it comes to single-family houses, the preferred shapes are a two-storey cube, a one-and-a-half-storey square shape with a hip roof and a finished attic, or an eight-sided two-storey house with a sloping roof to minimize the total volume of the building.

Building Type

The type of building is very significant. The number of storeys and how the various parts are put together can make it possible to reduce the surface area of the outer walls and roof. In semi-detached houses, there is one less outer wall and so heat loss is reduced. In terraced housing, there are two fewer outer walls, and in blocks of flats, there are three or four fewer outer walls as well as a reduced roof area.

Temperature Zones

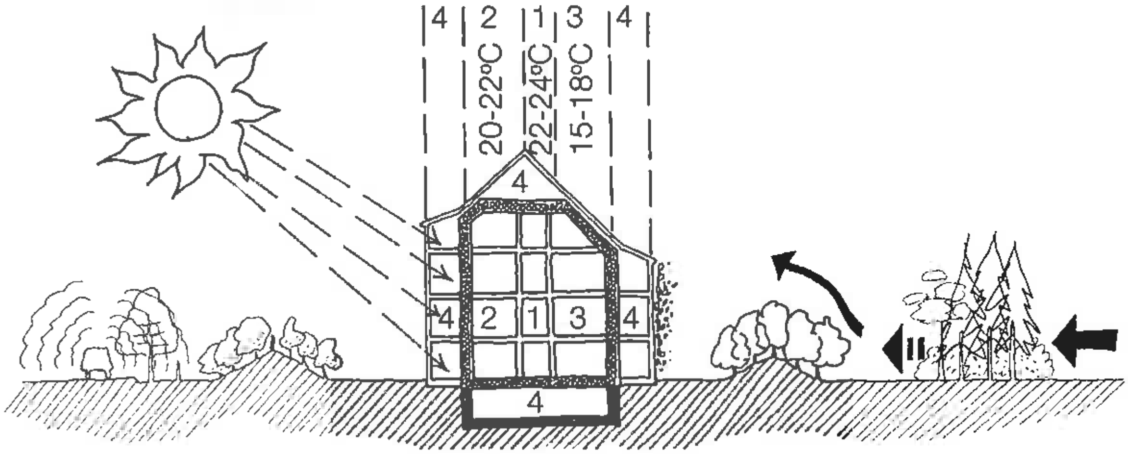
One way to reduce heat loss is to reduce the volume heated. This can be done by dividing a building into different temperature zones, e.g. a cool larder, wood shed and storage area that are not heated on the north side of the building, and a veranda and porch, both glassed-in, on the south side. Different temperatures in the living areas can also be considered, but this is often difficult to achieve in a compact and well-insulated house.

Dug-out Buildings

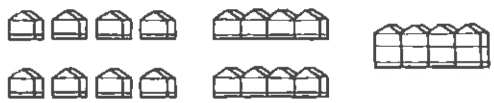
Heat loss through the foundation varies depending on the type of foundation. In a plinth foundation, the floor is in principle like an additional outer wall. A slab foundation on the ground is not exposed to outside temperatures but to the ground temperature, which is relatively constant year-round and is equal to the average annual temperature. In a hillside or semi-subterranean house, some of the walls are built into the ground. In these 'earth-sheltered' buildings, only the windows and part of the walls come into contact with outside temperatures. The more a building is dug into the earth, the less heat is lost.

Heavy Mass

Experience has shown that heavy buildings often require less energy than light constructions. This is because heavy materials have the ability to store heat until the excess heat is required, just as the heavy mass functions in a tiled stove. According to a former building norm, U-values are adjusted by a certain factor for heavy walls. To reduce energy requirements in super-insulated buildings, it is possible to deliberately add thin layers of heat-storing material.



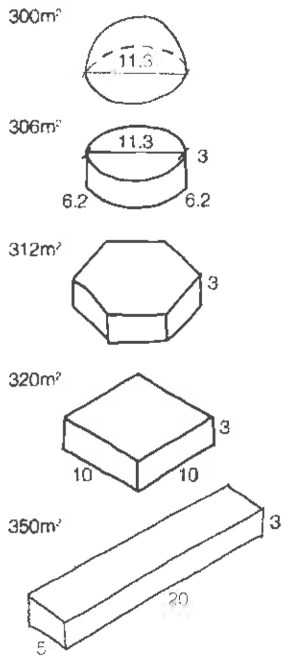
To save energy, a building can be divided into different temperature zones according to the purpose of the zone. Architect Joachim Eble divided his house in Schafbrühl in Tübingen, Germany into four temperature zones.



Eight **homes as:**	separate buildings	**Terraced houses**	2-storey **block**
Ground area	100%	70%	34%
Exterior surface area	100%	74%	35%
Heating requirements	100%	89%	68%
Costs	100%	87%	58%

This is a comparison of ground floor area, exterior surface area, heating requirements and construction costs for eight living units in different types of buildings. By building the units together in terraced houses or multiple-storey buildings, the outside wall area is reduced and thus also heat loss.

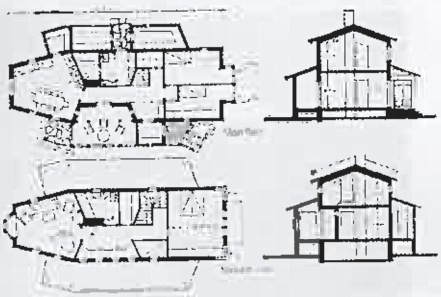
Source: *Ökologische Baukompetenz*, H. R. Preisig et al, Zürich, 1999



The area of the outer walls of a building depends on the building shape. The most energy-efficient shape is a hemisphere. The example shows the area of the outer shell (walls, roof and floor) for five differently shaped houses, each with a 100m² floor area.

The Tuskö House

This two-storey, 144m² house in Tuskö, near Östhammar, Sweden, is super-insulated and built using healthy materials. On the second floor, the ceiling height is lower at the outer walls in order to reduce the surface area of the outside walls. The stud frame is made of wood and the insulation material used is cellulose fibre. The house is divided into zones. On the south side there is an insulated and unheated glassed-in veranda that can take advantage of passive solar heat. On the north side, an extension with a storage area, wood shed and larder serves as extra insulation. There is an open stairway in the house that distributes excess heat from the veranda and kitchen to the other rooms. A soapstone stove in the ground floor kitchen is the main heat source. As the house is well insulated and has good windows, it has a small heat requirement. When passive solar heat and wood heat from the soapstone stove are insufficient, there are small electric radiators as a reserve. There are two urine-separating dry toilets in the house. There is a suspended foundation that is easy to enter from the outside, where the small faeces container for the dry toilets is located. Urine is collected in an underground tank beside the building.

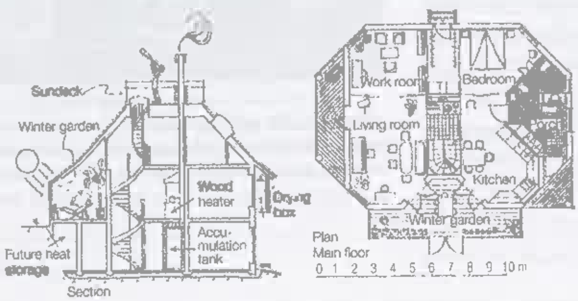


In a house in Tuskö, near Östhammar, Sweden, there is a larder, wood shed and storage area in an unheated zone on the north side. The veranda and porch are solar-heated zones on the south side. The suspended foundation under the house is a frost-free zone where all the services are located.

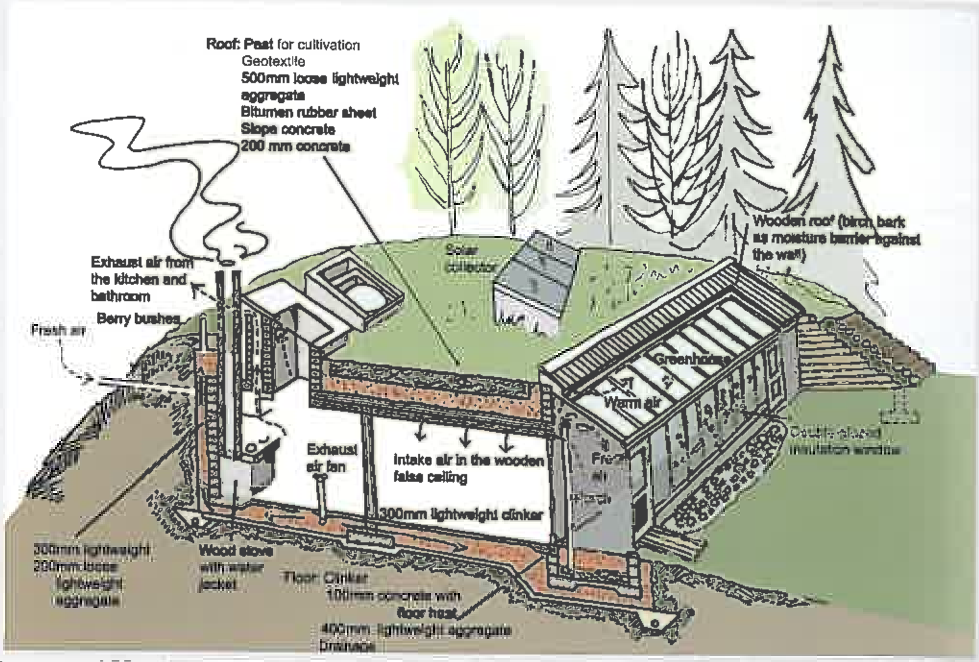
Source: Architect Lollo Riemer von Platen, Stockholm. Eco-architect Varis Bokalders, Stockholm

The Torrång Eight-sided House

This three-storey house is a good example of how architectural techniques can be used to reduce outside wall area. The house is also well planned with regards to temperature zones – the fireplace, stoves and accumulation tank are centrally located, and a winter garden and drying cabinet are unheated outer zones. The winter garden faces south to take advantage of passive solar heat. Doors to the winter garden can be opened to allow solar-heated air to flow into other parts of the house. The open floor plan makes it possible for the heat to spread. Heavy material in the house stores the passive heat.



Architect Ola Torrång designs eight-sided houses with a sloping roof and sloping ceilings at the edges, large glassed-in verandas facing south, and a warm zone in the middle with a chimney stack, stoves and heaters.



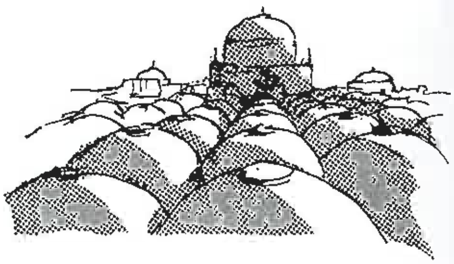
Architect Anders Nyquist's home (built 1991–1993) in Rumpan, near Sundsvall, Sweden, is extremely energy efficient. It is not only well insulated but also dug into the ground. The only façade, facing south, is glassed in and used as a greenhouse.

Passive Cooling

In hot climates it is important to design buildings so that excess temperatures are minimized and then to work with passive methods of cooling. In order to minimize excess temperatures, there are many architectural design factors to consider. The building itself can be protected from the sun and the indoor heat load can be reduced. Among other things, all windows should be shaded so that direct sunlight is blocked while indirect daylight can illuminate rooms.

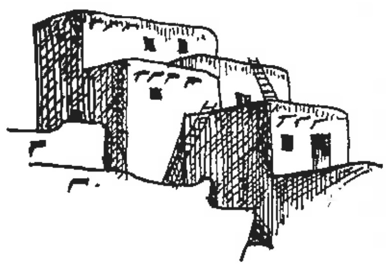
Shape and Colour

How much a building is heated by the sun depends, among other things, on its shape and colour. A large, south-facing area gets very hot from the sun, while a dome only has a small surface area facing the sun's rays. A light coloured surface does not become as hot as a dark, absorbent surface. An insulated wall does not let as much heat into a building as an uninsulated wall.



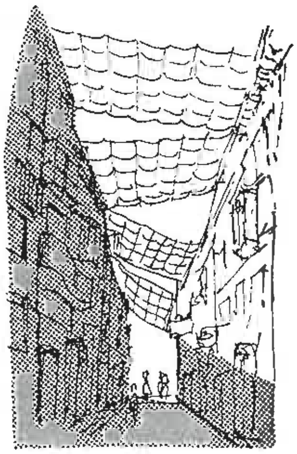
Heavy Mass

In many climates it is hot during the day and cold at night. If a building is constructed of heavy material, the material's ability to store heat or cold can help provide a more pleasant indoor climate.



Shading a Building

There are various ways of shading a building so that it isn't heated by the sun. Buildings can be placed close together so that they shade each other, and double roofs or other construction details can be used to shade a building's shell.

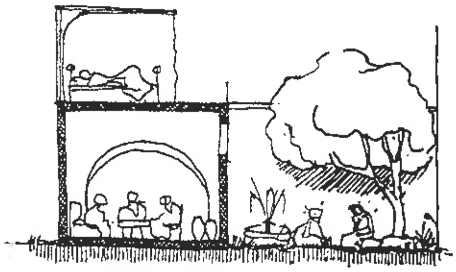


Window Shading

It is especially important to shade windows in order to reduce internal heat load. This may be done in a number of ways, contributing to the overall design.

Zoning

In extreme climates, it is possible to build houses in which occupants move according to season. People in the Nordic countries

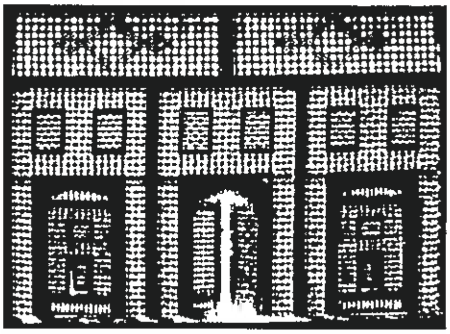


Zoning.

used to move into the kitchen for the winter. In hot climates, people can move out into the courtyard to get some shade, live on the roof to enjoy the evening breeze, or move into the basement on extremely hot days to be cooled by the earth.

Indirect Daylight

Though direct sunlight isn't desirable, letting in daylight is. This can be achieved by locating windows so that they aren't facing in the sun's direction, by shading windows with roof overhangs or by letting daylight filter in through a screen.

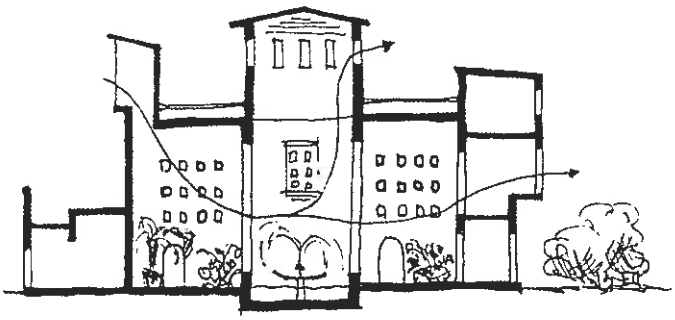


Sunlight and heat go together. In hot climates, screens are often used in windows for shading. They let some daylight in to illuminate the room while simultaneously keeping out most of the sunlight and heat. In addition, screens allow visibility outward without allowing visibility inward. The illustration shows window openings with screens (*Mashrabiya*) in a traditional Egyptian building in Cairo.

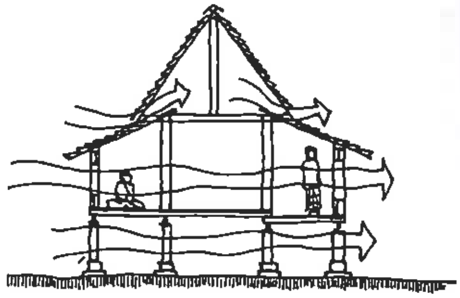
Source: *Natural Energy and Vernacular Architecture*, Hassan Fathy, 1986

Ventilation

In some climates, ventilation is the only thing that can provide a little cooling. Therefore buildings are designed so that they are easy to ventilate. Floor plans are used that allow cross-draughts. Spaces with high ceilings are included in buildings, such as stairwells, and inside courtyards capped with ventilation hoods (cupolas).



An Egyptian building with natural ventilation via a *malkaf.*



Cross-draught in a Malaysian house.

Advanced Ventilation

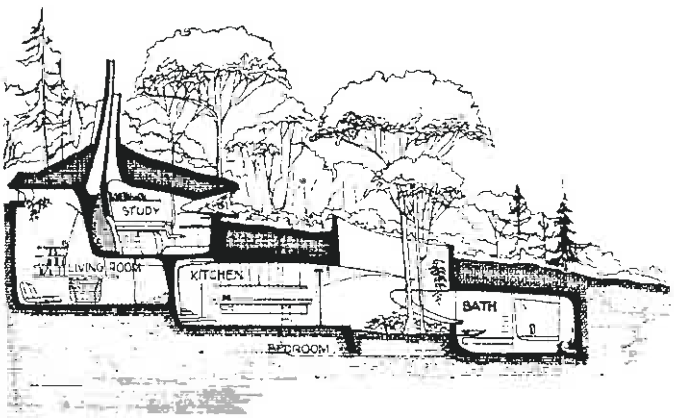
In order to increase ventilation, more extreme architectural elements can be used, such as ventilation chimneys and solar chimneys that increase natural ventilation, and wind-catcher vents (*malkafs*) that direct wind down into buildings. Walls and roofs can also be ventilated in order to cool down buildings.

Evaporation

Evaporation cools. There are many ways to make use of this fact to cool buildings. Indoor fountains can be used or vegetation. Water can be sprinkled on hot roofs, or running or evaporating water (a humidifier) can be placed in the fresh air intake.

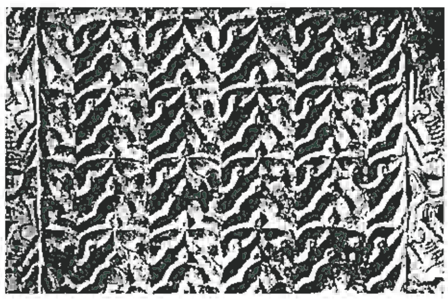
Dug-out Style Buildings

By digging a building into the earth, it is possible to take advantage of the earth's cooling effect. A short way underground, the annual average temperature prevails. Another way to take advantage of the cool ground temperature is to use an underground air intake pipe that brings in air that is cooled in the process.



The American architect Malcolm Wells began designing underground earth-covered homes. He felt that vegetation was so beautiful and valuable that it shouldn't be built upon, and that any lost natural landscape should be replaced with a new version on the roof. In addition, such houses are protected from the weather. They can be well insulated and designed to admit a lot of daylight.

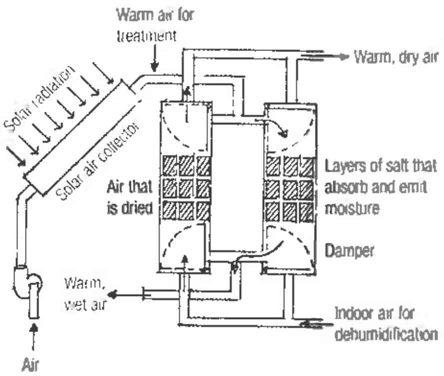
Source: *Underground Designs*, Malcolm Wells, 1977



There is often a '*salsabil*' in traditional Egyptian houses. A *salsabil* is a stone that is sculpted with an attractive relief pattern on the front. Water runs slowly over the stone while intake air blows over it. A cooling system is thus created in a simple and beautiful way.

Dehumidification

In climates where it is both hot and moist, dehumidification can provide cooling. This is because comfort does not have to do only with temperature but with air movement and relative humidity as well. Dehumidification can occur passively using salts that absorb moisture and are then dried using solar heat.



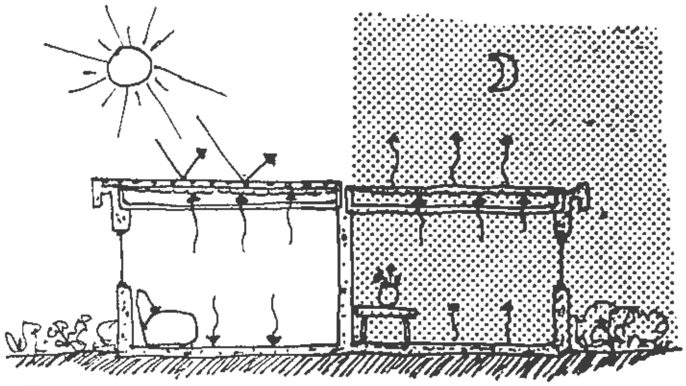
Cooling through dehumidification.

Green walls and roofs

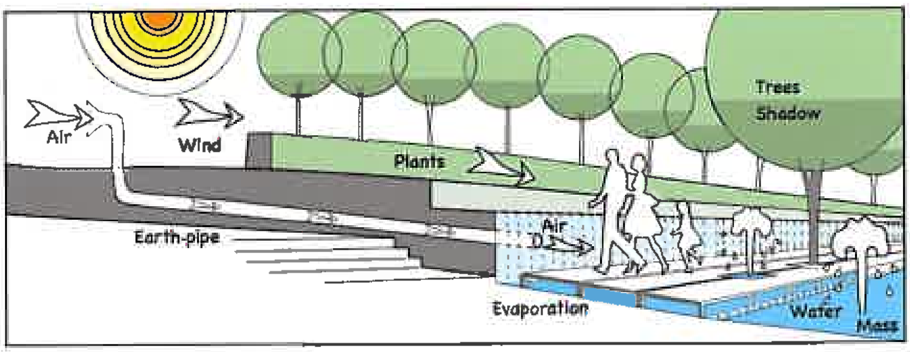
In hot and humid climates experience shows that green plants on walls and roofs can lower the temperature in the wall by 3–4°C. In Singapore special green walls have been developed with vertical elements including integrated pots and irrigation systems. In Switzerland, vertical green walls are used indoors to aesthetically moisturize offices.

Radiation

On clear nights, a strong heat radiates towards the cold, night sky. In the Sahara desert, it is actually possible to make ice in shallow pools that are insulated from the ground. There are various architectural methods for cooling a building with night-time heat radiation, e.g. with the help of a shallow roof pool that is protected (covered over) from the sun during the day. There is also a special type of metal coating that has a great capacity for reflecting and emitting heat. This type of coated metal helps to cool buildings.



House with a roof pool.



At the International Exhibition in Seville in 1992, work was undertaken to temper the hot climate with shadow from trees and plants, wind, and cooling air using earth-pipes, evaporation, water and mass.

4.3.3 Decontamination

For a long time, especially during the 20th century, construction materials have been used that are now regarded as hazardous. Examples include radioactive lightweight concrete, fibres that can cause lung damage (such as asbestos), sealing compounds with PCBs, heavy metals and additives in materials. Current management and renovation practices involve an attempt to systematically remove these hazardous substances and materials from buildings. Some materials must be removed by law. There are special regulations about how this should be done and where the material should be taken.

Inventory of Materials

Carrying out an environmental inventory, e.g. when a building is acquired or prior to demolition, entails identification of all materials considered to be hazardous waste. Even other materials that could be considered hazardous as well as any leftover chemicals should also be identified. An appraisal should be made as to whether or not the activity in and around the building could have caused contamination of building material and/or the ground. When necessary, an analysis of potentially hazardous materials should be carried out.

Hazardous Waste

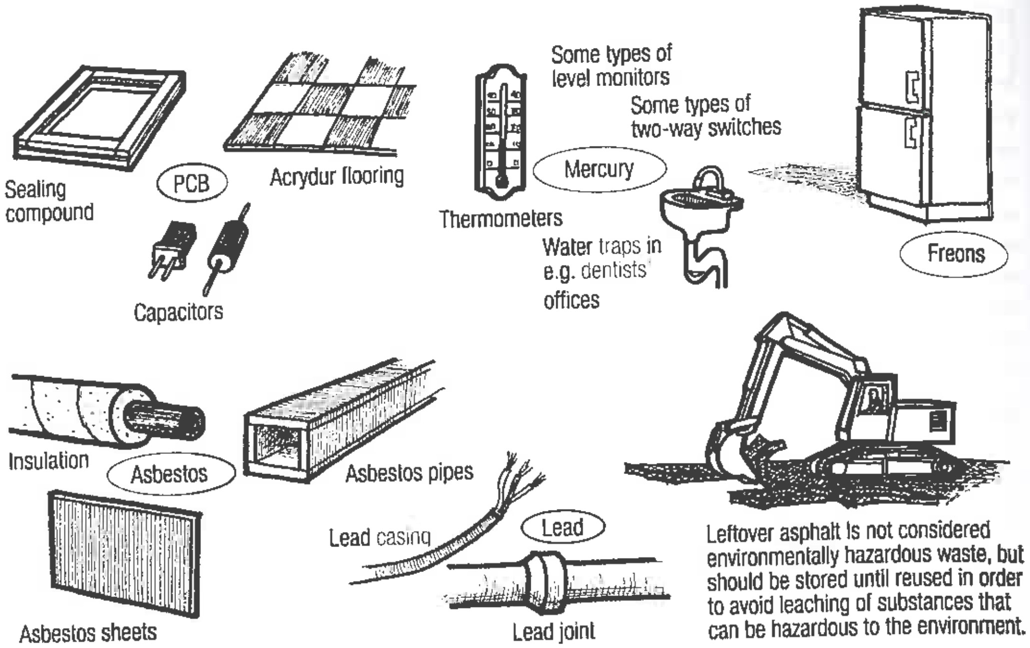
Hazardous waste is waste that can cause damage to the environment and health. Hazardous waste regulations define what waste is considered to be dangerous. Hazardous waste should not be mixed with other waste, but rather must be separated into categories. It is obligatory to ensure that hazardous waste is transported and dealt with by certified personnel in certified facilities. If it is not possible to declare that waste is free of hazardous substances, it should be considered as hazardous waste. Some examples of hazardous waste commonly found during building demolition follow:

Asbestos was mostly used in the 1950s and 1960s, and its use was not prohibited until 1976. Asbestos has been used as fire protection; heat insulation; reinforcement; sound insulation; condensation insulation; in pipes and ducts; as filler in paint, pasteboard and plastic; and in the form of asbestos cement in sheeting (eternite). Asbestos cement sheets have been used as floor, wall and roofing material. A layer of asbestos may also be found under plastic mats, in tile fixative, window putty, sprayed concrete, glue, sealing compounds and window sills. Internite and eternite are perhaps the most well-known brands. Asbestos removal should be carried out by certified decontamination companies. The material is transported in closed containers and is deposited at special sites.

Asphalt can be crushed and reused in new surface coatings on driving and warehouse surfaces. Reused asphalt is, however, not used on surfaces with a large amount of heavy traffic.

Batteries and accumulators contain heavy metals and environmentally hazardous electrolytes such as lead, nickel, cadmium and mercury.

Lead was used in large amounts before 1970 in the joints between cast iron sewage pipes (called caulking). Lead has been used as roof sheeting as well as under the joints between other metal materials (for example in roofs, balconies and bathrooms). Old electricity and telephone lines are often encased in lead. Lead was used to make gas and water pipes. Lead asphalt-impregnated felt was used as foundation insulation. Lead



During demolition there can be many older products that contain environmentally hazardous substances such as materials and objects that contain lead compounds, mercury, asbestos, freon and PCBs.

Source: quoted freely from SIAB brochure

was also used in older window glass. Level transmitters in sump pumps also contain lead. Lead has been used as a stabilizer in plastic and as pigment for shades of white, yellow, green and red. Red lead oxide has been used as outdoor corrosion protection for metals. Lead should be separated out and deposited for metal recycling.

Fire protection equipment such as fire extinguishers may contain halogen. Smoke detectors and some fire alarms may contain radioactive material. There are special regulations for handling radioactive material.

Sealing compounds are used in many places in a building. Since the mid 1950s sealing compounds have been used to seal constructions and make attractive joints. A differentiation is usually made between elastic and plastic sealing compounds. Elastic compounds are able to absorb the greatest amount of movement. Binding agents used in sealing compounds include oil, acrylate, polyurethane, polysulphide, butyl, bitumen and silicone. Sealing compounds can contain one or more of the following environmentally hazardous substances: PCBs, phthalates, chlorinated paraffins, and biocides. It is often difficult to determine which type of sealing compound has been used. Polysulphide-based sealing compounds had their breakthrough in 1957. PCB (20 per cent) was used as a softener until it was prohibited in 1972. Polyurethane based (PUR) sealing compounds were introduced in the 1960s. PUR sealing compounds often contain phthalates as a softener (20–30 per cent). To set sealing compounds, thixotropic substances are added, often PVC (up to 20 per cent). Small quantities of organic tin compounds are often used as a catalyst.

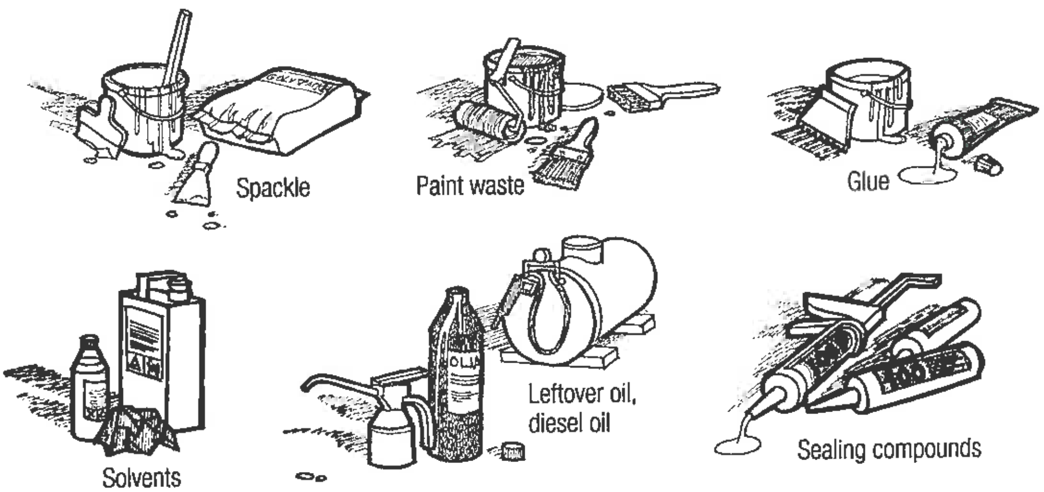
Freons (CFCs = chlorofluorocarbons) can be found in refrigerators, freezers, heat pumps, and cooling and air conditioning plants. CFCs have been used to expand cellular plastic, e.g. extruded polystyrene (XPS) in insulating sheets; as hard polyurethane in insulating sheets, insulation for refrigerators and freezers and as packing around windows and doors; as well as for polystyrene foam for acoustic insulation. Cellular plastic that may contain CFCs is most often blue, red or yellow and never completely white. Regulations about CFCs and halogen, etc. regulate how to look after and destroy cooling equipment/appliances. Since 1995, refrigerators and freezers must be removed and destroyed in a controlled manner to avoid release of CFCs into the air.

Paint, varnish, solvents, sealants and glue often contain environmentally hazardous substances such as solvents, emulsifiers and softeners. Cans containing leftover paint and similar products are considered hazardous waste and should be sent for destruction. Wood products painted with environmentally hazardous paint should be combusted in special facilities. Metal products with a PVC (Plastisol) surface treatment cause a waste management problem because dioxins form during remelting. Leftover paint and varnish are separated into special containers. Solvents are separated out and dealt with on their own, as is leftover glue. They are all deposited at recycling stations to be sent for destruction.

Polluted land occurs mainly around and beneath industries, workshops, vehicle management facilities and heating plants. Polluted ground can contain oils, heavy metals, etc. When the levels are high, the ground is classified as hazardous waste. A pollution analysis should be carried out before measures are taken in order to determine the proper way to proceed.

Polluted land should be decontaminated on site using biological methods, soil washing or thermal treatment after receipt of a special permit, or taken away to a special landfill.

Impregnated timber is found in duckboards, piers, suspended foundations, roof trusses and joists, and other wooden constructions where there is a risk of decay. Impregnating agents used include CCA agents (chromated copper arsenate), which contain oxides of copper, chromium and arsenic. Organic tin compounds such as tributyltin oxide and tributyltin naphthenate were previously used as impregnating agents for window casements. Boron and phosphorus are also used in wood preservatives.



At construction and demolition sites, hazardous waste should always be separated out and specially handled. It can be difficult to determine which waste is hazardous. At new construction sites, wall filler, glue, paint, solvents, leftover oil and sealing compounds are types of hazardous waste that may be present.

In the past, creosote oil was used, especially in railway ties and telephone poles. Between 1963 and 1978 much rough-sawn timber was dipped in fungicide made of pentachlorophenol. Impregnated timber is sent to special facilities for combustion. Timber damaged by dry rot or timber-destroying insects also needs to be incinerated.

Cadmium has been used as a stabilizer or pigment in plastic material (mostly during the 1960s and 1970s). Plastics in bright shades of yellow, orange and red were often based on cadmium pigment. Use of cadmium as a pigment is now prohibited, but materials containing cadmium may still be imported. Cadmium is present in nickel-cadmium batteries (NiCd).

Mercury is found in electronic components and measuring instruments. The sale of mercury has been prohibited for some time but older thermometers, thermostats, level monitors, pressure gauges, door bells, alarm equipment, hot water heaters, older freezers with lights that turn on automatically, and pressure controllers may still contain mercury. Mercury may also be found in electronic switches and contacts, e.g. in timer switches and relays, as well as in mercury lamps and fluorescent tubes. Devices containing mercury are considered hazardous waste and should be dealt with according to local by-laws. There are currently facilities that deal with fluorescent tubes and recover the mercury. If certain activities were located in a building, e.g. a dentist's practice, amalgam containing mercury may have accumulated in the sewage system.

Oil wastes come from oil cisterns, hydraulic fluid tanks, lift motors and other motors, lubrication oils, fuels, transformer oil and used oil. Older transformers may contain oil with PCBs. The oil should be analysed by certified decontamination companies before it is destroyed.

PCBs were first used in the building sector in the 1950s and peak use was reached in the 1960s. Use of PCBs were prohibited in 1972, but it may be present in buildings constructed before 1975. Buildings may contain polysulphide-based sealing compounds containing PCBs (up to 30 per cent) used to join wall panels and to seal insulating glass panes. PCBs were used as a softener in plastics, varnishes and paints and in slip-proof floors with quartz sand (called acrydur flooring). PCBs can also be found in condenser oil in washing machines, oil burners, and fluorescent tube fittings and transformers. According to the law, some building owners must make an inventory of their buildings with regard to the presence of PCBs and report on the inventory as well as measures planned. The Swedish Environmental Protection Agency and some municipalities have instructions on how this should be carried out.

PVC (polyvinyl chloride) plastic is the plastic that has been used the most in the building sector, and accounts for 60 per cent of the total plastic used. Rigid PVC is used for wall panels, boarding, ceilings, window casements, profiled mouldings, skirting boards, cover plates, cable housings, pipes and fittings. Softened PVC is used in carpets, cable insulation, insulating tape, sealing plugs, sheet metal coatings, barrier layers for insulating and wall panelling. The problems with PVC are the chlorine (PVC is the greatest source of chlorine in waste) and the additives. The environmentally hazardous additives most discussed are lead, brominated flame retardants, phthalates, chlorinated paraffins and organic tin compounds. Early imported plastics or PVC may also contain cadmium.