

**TECHNICKÁ UNIVERZITA V LIBERECI
FAKULTA TEXTILNÍ**

M3106 Textile Engineer

Program Master Science of Textile and Clothing technology
Department Clothing Technology

The physiological properties of mattress mad of Foam and Latex material

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Abstract

This master thesis studies the characteristic differences of structure group in mattresses and physiological of mattress materials, therefore we can define mattress structure in three groups; they are 1. with core mattress, 2. Fluid core mattress, and 3. without core mattress or futon mattress. This part can be summarizing by comparing the advantages and disadvantages in mattress groups in today. On the other hand thesis shows a sample of mattress materials; that use today, HR3836,T2140, TC50M, and Latex materials(Matrace Gumotex a.s, Czech Republics). In the testing method reference of ISO 11092 Textile Physiological effects- Measurement of Thermal Resistance and Water- vapour Resistance under steady-state conditions(sweating guarded- hotplate test) The physical properties of textile materials (Foam materials)which contribute to physiological comfort involve a complex combination of heat and mass transfer.

Grateful

This thesis paper has many people have given knowledge and information for Testing and analysis in this thesis. I would like to say thank you to Doc.Ing Antonin HAVELKA. Csc. Head of Department Clothing technology TUL, Czech Republics, who is my thesis supervisor and help me everything while studying this program, Prof.Dr-Ing habil. Hurtmut Roedel, ITB. TU Dresden,Germany. ,Ing. Rudolf Tresnek Technician of Comfortable LAB, Matrace Gumatex a.s (CZ) for very kind support mattress materials, Thank you TUL that gave me this chance Master degree studies and everybody else who helped me in this thesis.

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Introduction

In the 14th century the poorest people slept on a straw mattress on the floor with whatever warm covering they could get. ••• However many different types of beds are manufactured today, using vertical or horizontal coil springs, or other materials. For the common mattresses, the term "orthopedic" was used by manufacturers themselves and they have nothing to do with the discussed purpose. The mattress itself cannot cure anybody itself. One should clearly understand it and not to wait for a wonder of healing from osteochondrosis or scoliosis by the "orthopedic" mattress. But the good mattress can relieve the pain syndrome, caused by certain problems with the backbone that means it can help to make the sufferings easier or just to make you feel more comfortable.

The reasons of recommendations for a rigid "orthopedic" mattress are connected with our memories about beds with lath. In such kinds of beds the body of a sleeping person looked like a ship bottom, very often the back was almost on the floor and legs and a head were somewhere higher. People, with certain dysfunction of backbone who are treated by a doctor should be concerned about his recommendations. It goes without saying, that in such cases the efforts of doctors for the backbone state correction go together with recommended position of the body during the rest time. In this case one has only a few variants. But modern world with lots of possibilities can offer different kinds of "orthopedic" variants of cushions and bolsters; one more variant is the combined surface or with artificial rigidity.

In this case all these stuff can be called "orthopedic" because they help a concrete person for a concrete purpose (to keep up the loins, to heft the legs to keep the cervical in a right position according to his configuration). The mattress can be called "orthopedic" only if it was made especially for a person, according to his or her physiology and the recommendations of the doctor that helps him or her to have rest without an uncomfortable feelings. So, this way we agreed once more that the mattress and the accessories are very individual and should be checked carefully. If the person was used to sleeping on the soft mattress for

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some years, it means that his or her backbone is also used to such kind of surface and it also means that a kind of deformation was made to the backbone itself according to that soft mattress deformation. In such case even the best mattress will not help in having rest. All the pictures in the textbooks or brochures demonstrate us that the backbone is not completely straight.

This “line” is very individual and it is different for different people. A very rigid mattress will bend. Is this right? We are sure that it not. The effectors, inside of vertebral joints will be also changed. And that is the moment when the problems can start! The regulations and standards for elasticity of the soft elements, their flexibility, the width (height) of the cushioning are not only technical matters. It means that the body of the person, who is sleeping on it should settle down to some extend into the soft layer, making a kind of “bed” for the body.

Influence of human physiology is necessary for bed comfort system therefore the human body must maintain heat balance if it is to survive. If it generates more heat than is needed, it must lose heat to its surroundings or its temperature will rise and it will become ill and could die. Likewise, if it loses too much heat to maintain a constant temperature, its temperature will lower and it could die. When conditions surrounding the body are not ideal, it has adaptation mechanisms that help adjust the amount of heat loss. When the body has to take adaptive measures, it is known to be under thermal stress.

Thermal stress equates to discomfort while a minimum of thermal stress provides comfort. During sleep conscious regulation is excluded. But for a sleeper thermal neutrality is important for a good sleep quality as shown by investigations of the influence of ambient thermal conditions on sleep. Even if an active thermal regulation during sleep is impossible, heat and mass transfer can vary over a wide field. Depending on sleep stage metabolic rate and sweating rate change significantly. On the other hand thermal load cause reflecting compensation, e.g. by changing of the effective surface for heat transfer or of the topical clo-value. The intensity of unconscious thermal regulation depends on

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2. Sleeping theory and Bed system

2.1 Sleeping theories

Sleep and external influence [www.schlaf.de] •leep and external influence for our individual sleep social compulsions, personal customs and drastic experiences are at least as important as physical changes. Many people sleep during the week shorter than it corresponds to her individual sleeping need. Also psychic and physical charges, as for example stress, fears or pains, can impair the quality of our sleep temporarily. As sensitively we react in the sleep to external factors like noise or a bad bed. Our sleep is just no self-evident fact, but rather a sensitive indicator of our personal well-being. •

Generally binding aspects:

First: The mattress should pass of a piece (not two or 3-part. Some married couples prefer a mattress more than both beds. This has many advantages, above all for the sexual life. If a partner is very sensitive, however, then he can by body movements of the other which spread about the whole mattress.

Second: This mattress should lie possibly on a steady base or on an only slightly fitting with springs subsoil. Head and part of feet of the bed should be adjustable. Duckboards of wood are an advantage compared with spring mattresses. No bed should have iron-magnetic parts disturbances of the geomagnetic fields.

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Specific aspects:

First: The body weight: Mattress and bedstead must be adapted to the body weight. Treacle weighty ones need a stronger mattress, lightweight against it a thinner one. Who already awakes after some hours as a result of pains in the hip joint bone or the backbone, the base should change.

Second: Orthopedic aspects, discharge of the backbone. People with back pains, vertebral disc wears should get used to a level steady base. Duckboards, laid under a medium thick mattress with middle body weight, are often enough to improve of the lying and therefore to the sleep.

Third: Protection of a good respiration and circulatory function, a circulatory-healthy will manage with every bed. People ill from Kr or sensitive to circulation cannot normally sleep level as the rest of the backbone requires. Therefore, a high storage of the head or the head-breast cut is to be recommended. Also a bolster can help. The same one counts to patient with difficulty in breathing, e.g., bronchitis or asthma.

Fourth: Protection of a psychic relaxation and switch-off is an important condition for the sleep. Herewith sensitive and fearing as well as conflict-loaded people have problems. Therefore, such a condition must be created by mattress and Covering that no additional sensitize irritation can occur. Also light and noises can look annoying, e.g., the tick of an alarm clock. Some nervous people cannot fall asleep with full moon, others are disturbed by promotional lighting or auto floodlight. But also perfume and cigarette smoke and-retexture. If the causes are known for bad sleep, i.e. the Sleep disturbances in the bedroom, they should be removed.

Fifth: Guarantee of an undisturbed dear act. Not few pairs get the suitable physical and psychic relaxation for the restful sleep by the dear act or begin the sleep in common embrace. In such cases bed scratches are very obstructive. Therefore, a wide couch which offers better conditions than two beds with a wooden frame is to be recommended.

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Sixth: Lighting and window curtains should be adapted according to the individual needs.

Seventh: Putting up the beds in the space is mostly determined by the residential structure.

Sleep in magnetic fields [modified to G.Blumrich]

After the today's, on no account quite perfect level of knowledge the person can be confronted with the following phenomena of magnetic fields and be interfered with in his sleep:

- By disturbances or distortion of the natural geomagnetic fields.
- By magnetism, i.e. decrease of the effects of natural magnetic fields.
- By effects of different electromagnetic fields, above all by microwaves the radio, radio, and television systems.

As already in the preceding chapter mentions, the person has adapted himself in the course of the evolution to the natural geomagnetic field environment and lives in good harmony with them, while the rhythms of this environment with belonging to body Rhythms of the people and animals synchronizations enter. Every annoying influence can lift this synchronization partially or completely, produce i.e. a Desynchronize and release above all with psychically, psychosomatic and changes Ill from heart circulation in the residential condition and in the sleeping quality.

One lays the head in south direction and the feet in north direction. This preferential direction the south the north is founded with the river by geomagnetic field lines in lay of the bodies by which the cells are straightened, while they influence the ions of the cell membrane. The east west position or west east position, i.e. the river of the geomagnetic field lines straight through the body, should be unfavorable for the sleep.

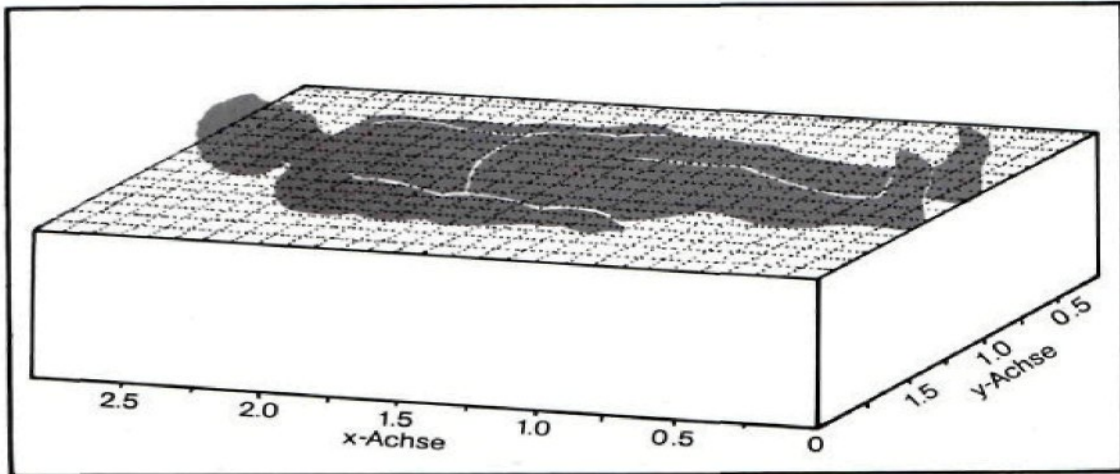


Figure 1: Lying surface of the bed with natural relations of the earth-magnetic field, Base: upholster and mattress free of metal, [modified to G.Blumrich.]

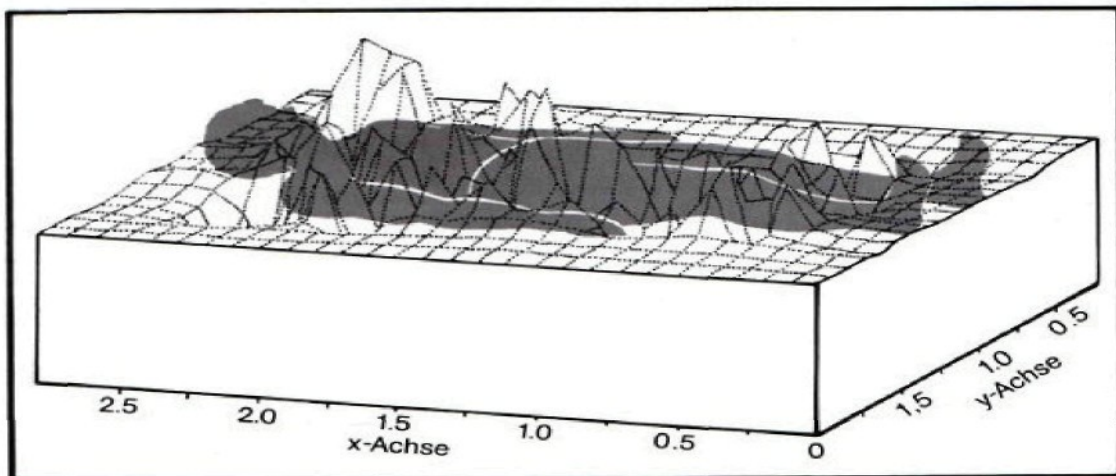


Figure 2: Couch surface of the bed with distortion of the intensity of the natural earth magnetic field, released by a spring core mattress,

[modified to G.Blumrich.]

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2.2 Bed system: [www.schlaf.de]

A vote of under springs and mattress is necessary for an ergonomically right mechanical functionality and an optimum bed climate. These must be tuned so on each other that a highest possible couch comfort can be reached, i.e. it should support every user in all sleeping positions properly and provide for a pleasant couch feeling.

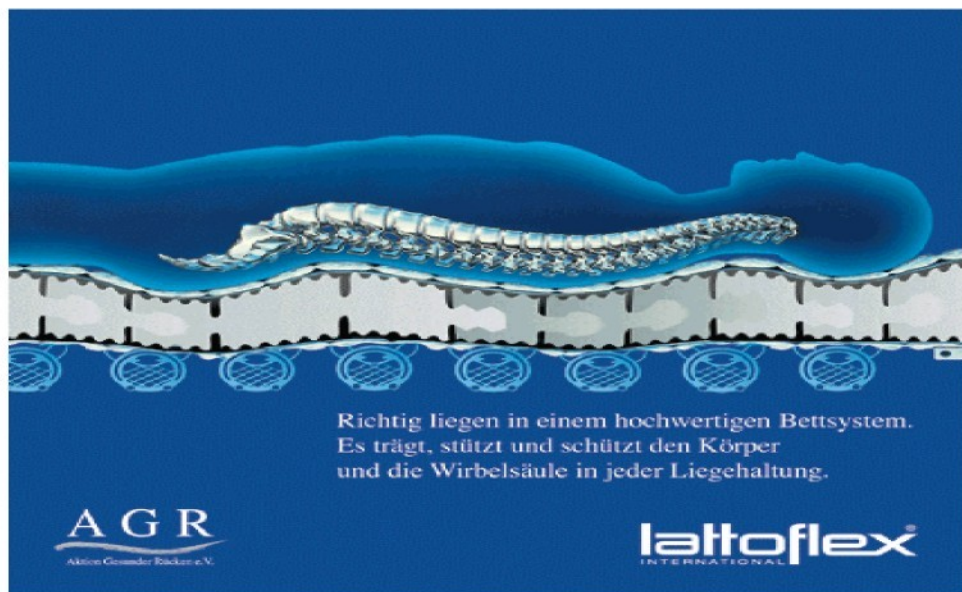


Figure 3: Properly lie [www.schlaf.de]

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Comfort: For the freedom of movement, a sufficient bed size is important. A single bed should be at least 100 cm wide; the bed length should amount to at least 20 cm more than the body height. According to body height a bed height of 45 to 55 cm is ideal. She makes easier the rising and putting down, above all with older people. Also the bed climate is thereby influenced positively (floor cold climbing up hot air).



Figure 4: Dimensions mattress [www.schlaf.de]

The individual adaptation is necessary for a body-appropriate, anatomically right storage. This also counts to spinal-conditioned Animalization as for example Hyperlordose, ankylosing spondylitis, Scoliosis, and other degenerative changes. Besides, the function of the spring in bed of primary is meaning. The under springs adapt itself in the ideal case very perfectly to the individual form of the backbone, as for example a gypsum impression. Importantly it is natural with the fact that this adaptation functions adapt ably. The natural night motion sequences / position changes of the Sleeper cause a maximum in flexibility of the under springs. Because anatomical circumstances

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can change, the bed system should be also adaptable during the whole useful life changeable/. By the bed purchase certified consultation and detailed test lying are unavoidable, not only for getting to know of the bed technology, but if necessary also for the adaptation optimization for the purposes of objectively correct body storage. Besides, of course such a consultation and test must take into consideration the subjective "couch feeling" and come on individual needs.

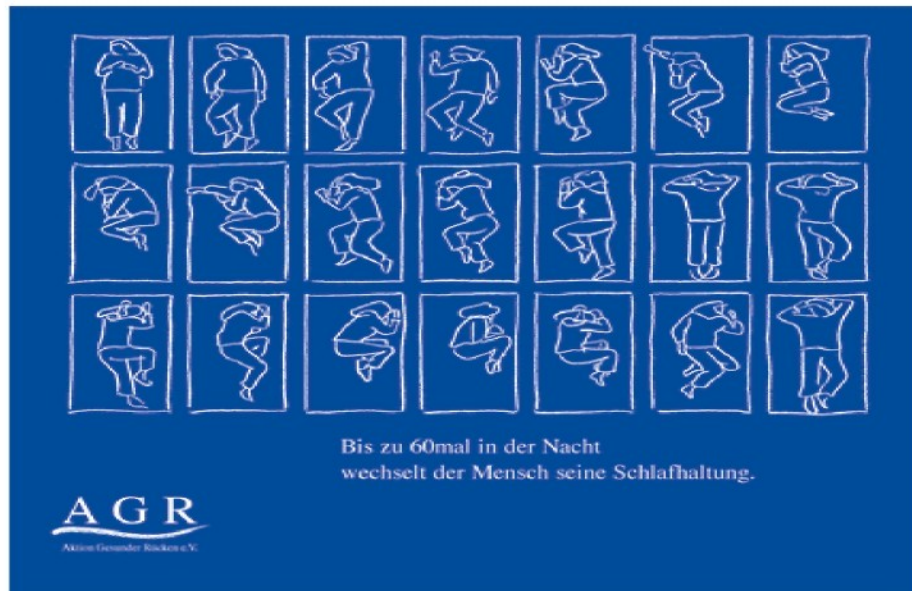


Figure 5: Movement of the person protecting of the sleep
[www.schlaf.de]

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Hygiene: Also, a bed is defeated by mechanical wear and wears which is also caused hygienically. The useful life for a spring of bed lies with about 10 in rare special cases with 20 years (an examination of the effectiveness is earlier advisable); for a mattress with maximum 10 years. Also age-conditioned and/or illness-conditioned physical changes require another, new bed.

With allergies, how and a House dust allergy or latex allergy, is to be respected to a suitable choice of the materials of the bed equipment and to good cleansing ability. Synthetic materials are often suitable here.

Climate: A cubicle climate with a temperature from approx. 18°C and a relative air humidity of 50% is recommended Under these conditions heart-circulatory activity and muscle tone correspond to the requirements of the sleeping rest. Warm delicacy or cold's delicacy can be steered through the choice of the materials with the bed equipment. The temperature in the bed, i.e. the temperature felt by the Sleeper, should amount according to season between 28°C and 32°C With so-called deeply area one can change in the inlaid scope the deeply behavior of the feather elements individually (e.g., with distinctive hollow cross or for a limited period with pregnancy) Counts only to motor adjustable under springs: So-called space connections or net connections are recommended for problems with this appearance.



Figure 6: Climate in the bedroom [www.schlaf.de]

Ergonomic: A so-called body sloping storage can be a good therapeutic help for the circulatory discharge, with the Restless Legs syndrome and with varicose veins. Besides, it is to be noted that a low body sloping storage with which the deepest point of the skew level should lie with the shoulders, for a long-term use during the night to some higher which is sensible at short notice is to be preferred. So-called shoulder comfort zones in inlaid scope and mattress are sensible, preventively as well as with spanning and support problems in the cervical area, cervical area or shoulder area. Individually adjustable pillows (size of 40 x80 cm) are to be used here in addition. Besides, for asthmatics inlaid scope with motor or manual seat adjustment (are on anatomically right seat position pay attention) advantageously, just as synthetic bed materials.

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It is clearly evident that if "Correct Posture" is required, then the person's shape needs to be considered and accommodated, not just their weight.

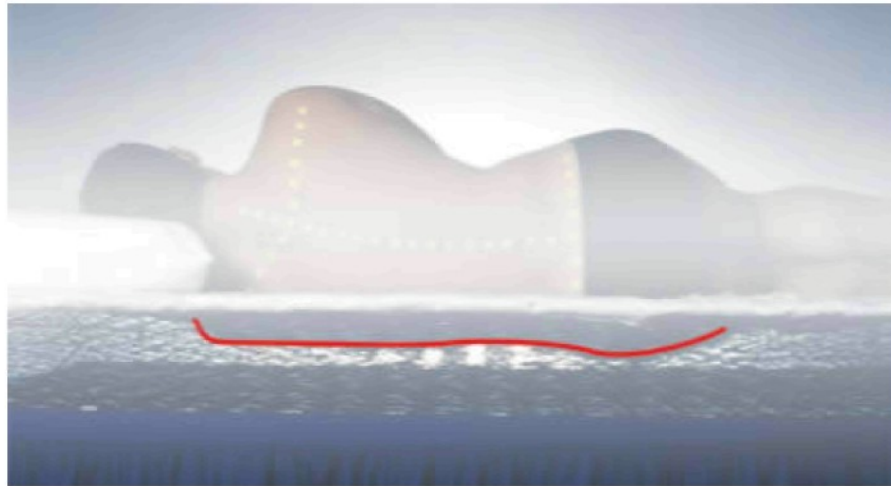


Figure 7: The usual profile take by mattress [www.spinalsupport.com]

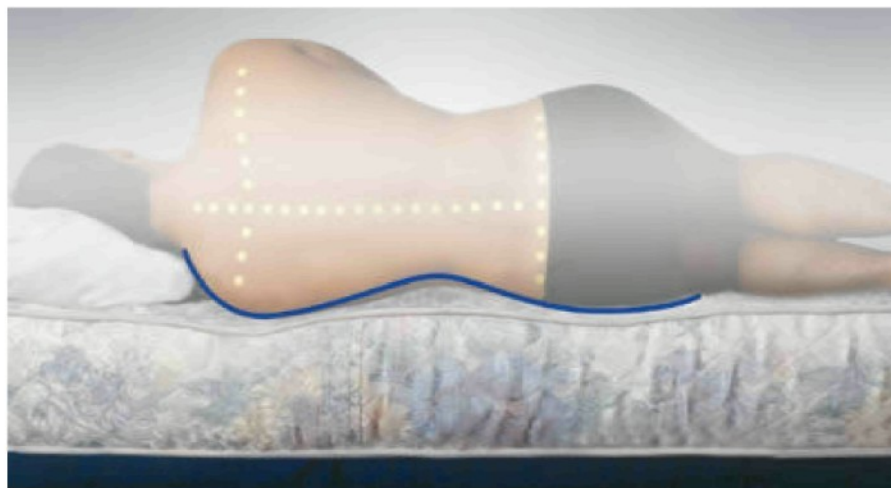


Figure 8: The profile the mattress should take to support the sleeper with correct posture [www.spinalsupport.com]

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When the two profile are combined you can see the “Weight Curve” take by conventional mattress is different to the “shape Curve” of the sleeper posture and shape when stand provides correct spinal alignment. When you lie down the posture and shape is change due to gravitational forces and the inability of the bed to alter the level of support when required at all points in the critical zone from shoulders to hips.

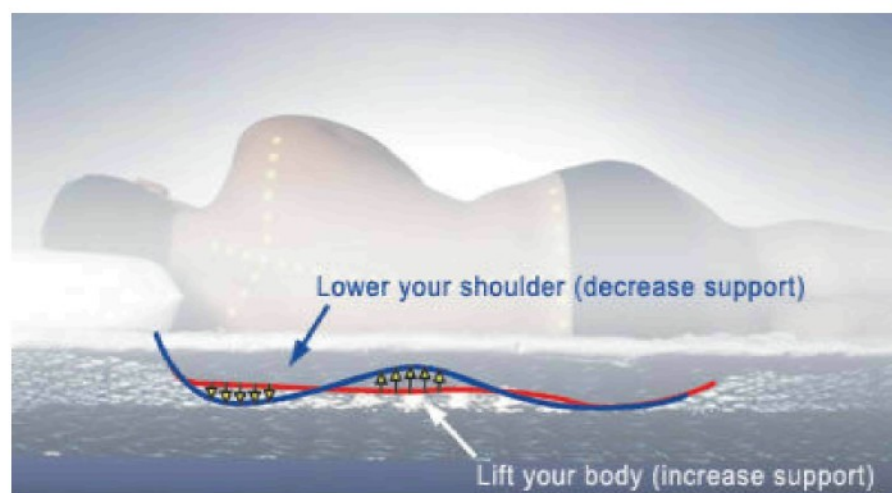


Figure 9: The different hard and soft zone of mattress
[www.spinalsupport.com]

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3. Definition and mattress groups

3.1 definitions of the concept Mattress [22]

Mattress is a concept derived from the Arabian which signifies so much like ground cushion. We understand by it a couch upholsterer of the bed which, after a huge number of technologies production and construction technologies covered made and with ticking, on the spring frame or the duckboards of the bed frame lies. By upholsterer beds the mattress is a steady component of the bed.

Requirement profile: The body by change finds the consciousness his neutral position with the sleep and many unaware bodily functions adapt themselves. Body temperature and pulse sink, the muscle tension decreases and the body can regenerate. In the course of the different sleeping phases cycles of different sleeping depth and dream phases alternate. If the deep sleep phases are disturbed, and this is in an inexpedient bed often the case, the person becomes ill. The sleep is a determining factor for our health; he donates to us the strength to the next day, serves the relaxation and renews the efficiency. A healthy sleep assumes optimum bed equipment.

The mattress is important for the backbone: As a couch upholsterer of the bed a function-appropriate mattress for the healthy sleep plays a quite determining role. She must support the relaxation-destitute backbone during the sleep by different couch zones well measured, allow thus a steady, orthopedic support of the body and give way more or less where in the lying pressure originates (point elasticity). The horizontally lying backbone must correspond to the backbone of a person standing normally and freely, slightly curved "S". A good mattress should react elastic to everybody at the side and longitudinal pressure of the body and return with movements in the sleep without much too frequent going on sounding immediately again in her old position. The blood circulation of the skin as well as the pigment layer fabric is also raised by the pressure distribution; metabolisms and hermit monk's innovation are influenced for a good price.

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The climate qualities of the mattress are important: Season, surroundings temperature, constitution, body height, weight, body temperature and the affection sweat of the Sleeper are important criteria for optimum bed equipment. Accordingly mattresses as well as underbids and covers are judged etc. by the humidity transport and the support ability warm. Then from it the requirement profile is derived near the modern bed. The human body delivers at night between 0.5 to approx. 1 l of humidity. It can lie with men twice as high like with women. According to ambient temperature, air humidity as well as also state of health these values can still increase. Of it possibly one third are breathed out, the body eliminates two thirds of the humidity by transpiration which is taken up by bed stuff and mattress and must be derived fast. Under favorable conditions the aerial circulation within the mattress (air cushion) provides for the humid transport, because it comes, otherwise, to moisture education. Besides, the structure of the mattress core is determining. Important it are for the upholstery or cover to used materials which allow the humid transport and the warm isolation. Also covers and documents must be aerial-permeable enough. The normal bed caves dampness lies possibly between 30-60% rel. Humidity.

The lying zones: An ideal body position is reached by the right selective support of the body. Heavy body parts, like shoulder, lumbar area and thigh, should sink more deeply into the mattress than the remaining body. This is possible with good foamed plastic mattresses as well as with mattresses with feather core. Body weight and body height influence the deeper, therefore, many mattresses are offered in different hardness grades. The ideal mattress is too soft neither nor too hard. An important criterion for the judgment of a mattress is the adaptability to the individual body form to reach the optimum position of the sleeping person in every couch position. Sleeping researchers advise a rather harder mattress which can become a little anyway softer in the course of the time. In addition, the fabric of the relation material stretches, so that a perhaps available preliminary tension is decreased by which slight wave educations can appear. Besides, the use of the mattress is limited in no way. Nevertheless,

naturally no hollow may originate. A too hard base carries out to pressure points and blood buildups and can impair the restful sleep too frequent movements as a result of that. The backbone is wrong loaded by the low deep to sink and is not supported in her natural form. A too high pressure on the mattress is especially with long term to laying which cannot change her couch position so easily on account of her illness or her age, problematically. In addition, the body is not surrounded enough by which the bed caves temperature sinks, to the Sleeper gets cold.

With a too soft mattress into which especially the hip area sinks too deeply the backbone is brought in an unnatural position, as in a hammock. The natural position changes are thereby limited in the sleep and with it also the humidity transport.

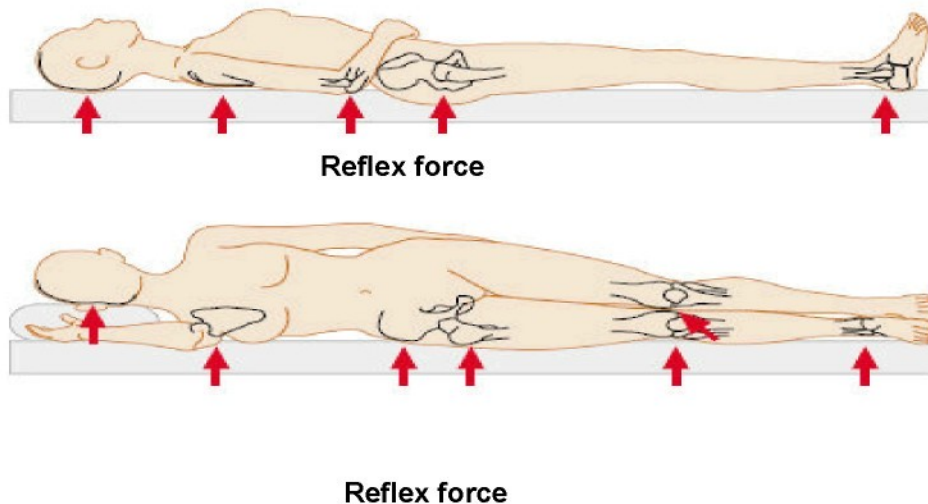


Figure 10: The lying zones.[5]

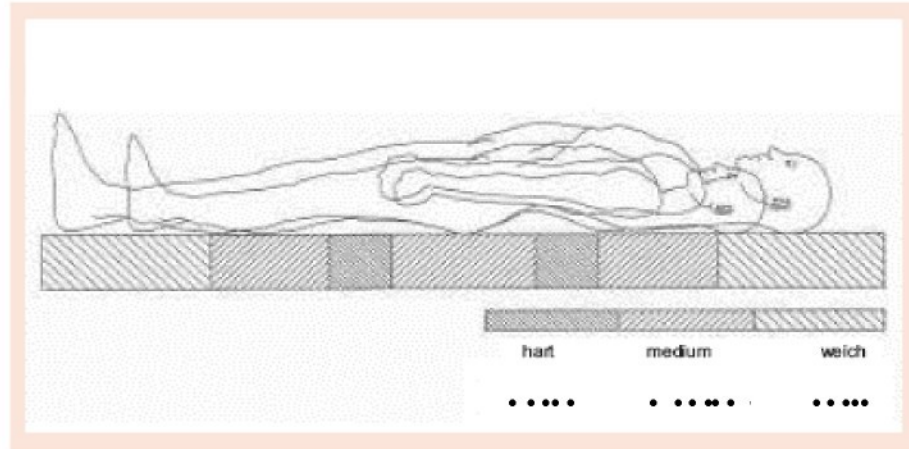


Figure 11: The zones of hard and soft mattress.[kettenwirk-praxis 4/2005]

Test parameters	Unit of measurement	Standard hospital mattress
Max. head pressure	kPa	11.4
Max. shoulders pressure	kPa	12.0
Max. basin pressure	kPa	13.0
Max. calves pressure	kPa	6.7
Max. heels pressure	kPa	30.4
Number of responding sensors	kPa	1146
Surface contract	Cm ²	1848

Table 1: Contract pressure value in standard hospital mattress

[kettenwirk-praxis 4/2005]

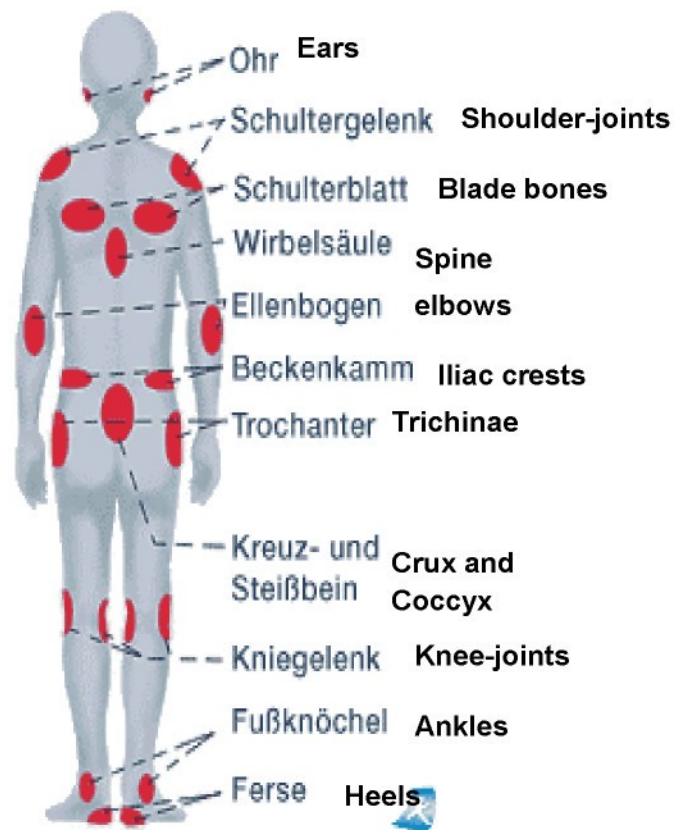


Figure 12: A pressure sore areas of risk.[5]

3.2 mattress groups

Form: One, 2-part and 3-part mattresses. The trend goes predominantly in the direction of the one-piece mattress. This is especially also to be led back on health reasons.

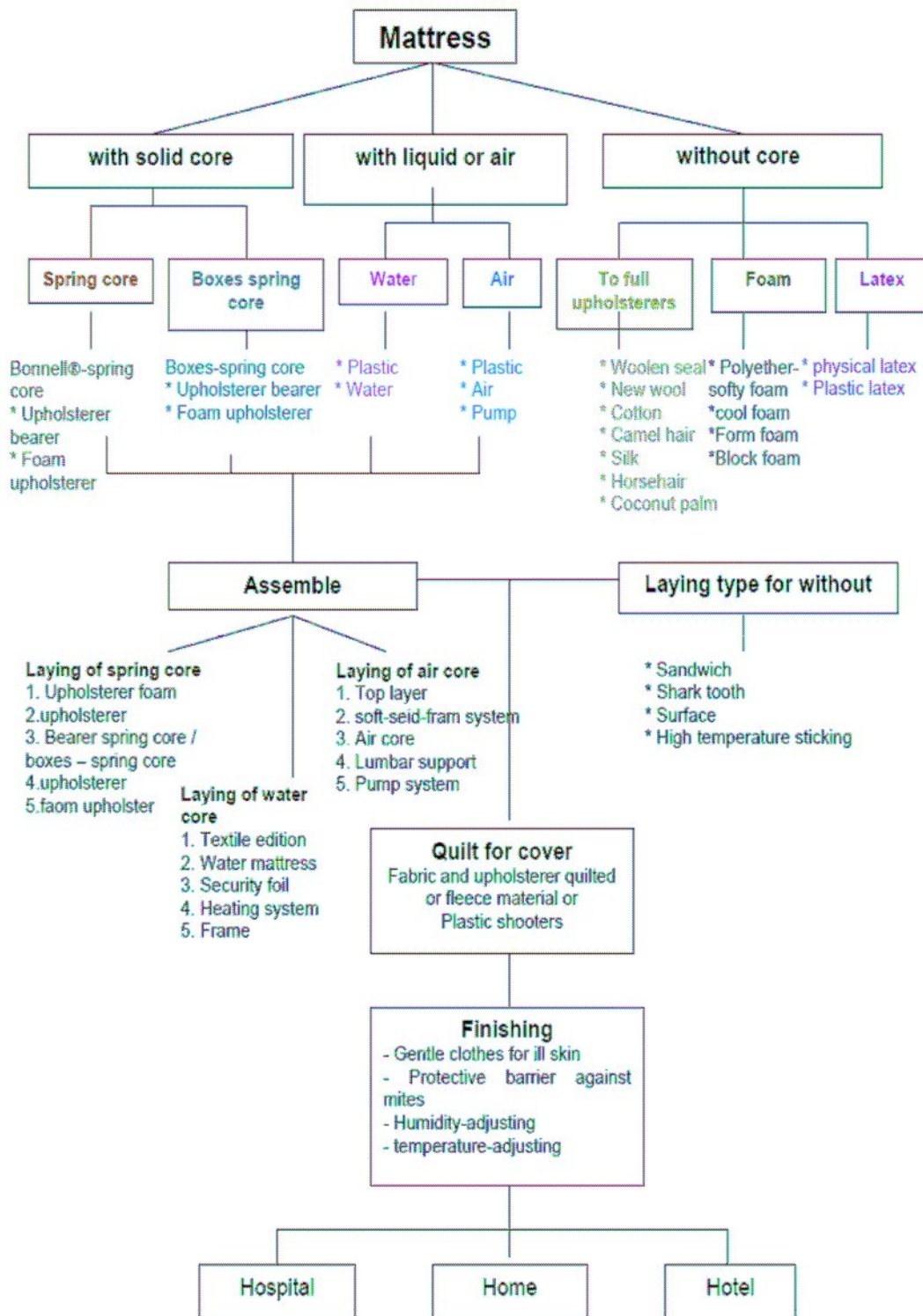


Figure 13• : Mattresses groups' diagram, [company training period Wangkanal P].

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4. Mattress constructions

4.1 mattresses with solid core

This is an upper concept for a mattress kind which exists inside of a regular system of mostly hot-dip galvanized steel feathers which are connected by a network with each other and can move individually and independently of each other. Will be surround the feather core of a fine upholsterer from wool, cotton, silk or foamed plastic material. Spring core-mattresses are made on account of differentiated requirements for the most different purposes. The construction is multi-layered and different. Between the current Bonell®-spring core and the more comfortable boxes- spring core there are considerable differences.

Spring core: This spring core is made by machine out of a huge number of waist spring which are connected in the upper and lower spring ring by spiral spring trains with each other. Upper and lower frame are formed by a band steel or steel wire frame which owns a lower number of spring with a bigger head diameter in contrast to cylinder spring core. The big space originating from it is bridged with a steady upholsterer bearer by which less touch points of spring arise to spring. With this mattress kind a harder spring effect is with low load soft, with stronger load.

Spring core GR: Endlessly the lined up spring body with which a level course of the surface of the spring core is reached. The system is one single being springy element which works without knot, creases or impairments in all load zones of an upholstery. Under patent law protected spring cores GR are produced by machine and have a wire thickness of 1.4 -1.8 mm; they show with rel. of low spring height a good elasticity and load-carrying capacity.

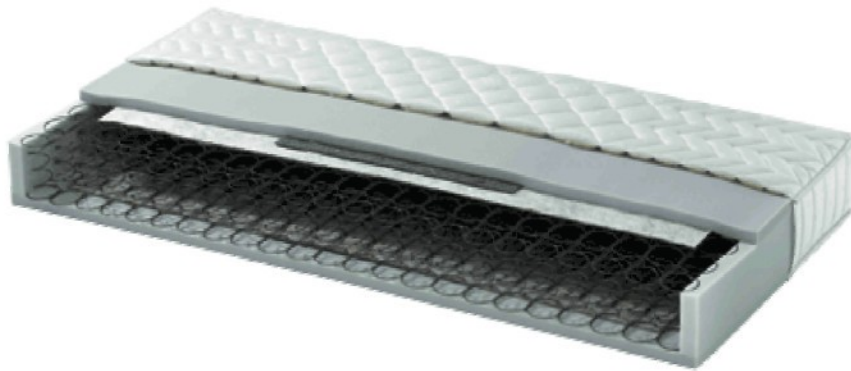


Figure 14: Construction of a mattress with Bonnell ® - spring core
[www.baretti-collection.de]

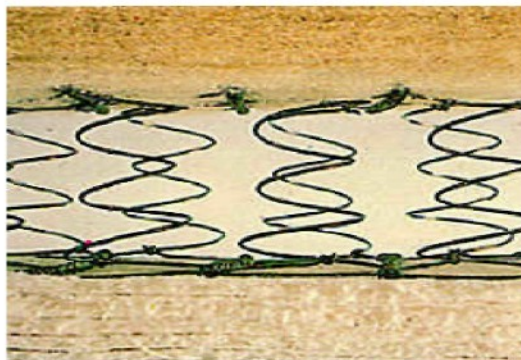


Figure 15: Construction of a Bonnell ® - spring core [www.raumausstattung.de]

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Boxes spring core: With this spring core kind single cylinder springs are sewed in according to small little bags from nettle and are connected in her touch points with each other by which also the quietest noises are avoided. With the free springs can made extremely softy, the installable up upholsteries. This mattress kind adapts itself to the individual body form and allows by points-elastic springs with which every single spring can be crushed, without the neighboring spring resonates, a high sleeping comfort. Will be surrounding the spring core of a fine upholsterer from well-chosen upholsterer materials, as for example wool, cotton, silk, horsehair and/or foamed plastic material. About that a cover lies to the admission of the humidity. The mattress ticking forms the external end. The constructive expenditure of this high-quality mattress kind serves the elastic or points-elastic body support to catch the high charges with the sleep. From the knowledge that concerning the body supports a mattress can reach only optimum values if it is tuned to the individual body weight of the user these mattresses are offered in different weight classes.



Figure 16: Construction a pockets feather core [www.baretti-collection.de]



Figure 17: Construction of a mattress with pockets feather core

[www.baretti-collection.de]

Tonnen- Boxes spring core: This is a spring core system with which the single textiles boxes are connected concentric with each other. This is mostly reached by adhesion. As opposed to cylinder spring core the single spring of this system on top and below have a lower diameter than in the middle. This comfort mattress allows an optimum adaptability by selective body support with couch zones differently coordinated on the body (5 or 7). The pollution of the cores with a higher number individually of reactive metric ton feathers damps going on sounding and raises the form stability of the mattress the high respiratory activity provides for a very good humidity transport. The comfort execution with an adaptable pencil hole latex-cover guarantees an especially good orthopedic body support.



Figure 18: Cross section by Tonnen-boxes spring mattress.

[www.raumausstattung.de]

4.2 mattresses with liquid or air

4.2.1 Water core mattress:

In the sixties of 20 Yrs. of the American Charles Hall developed and technically perfected mattress type was also submitted in Europe to detailed scientific investigations and when the health bed was called in itself. Water as a not compressible liquid adapts itself any time completely to the load distribution, hence, the pressure is distributed with individually conformist storage of the backbone absolutely steadily to the body and the individually right supporting function as well as the storage free of pressure is guaranteed by shoulder bone and hip bone. Backache is diminished. Other positive qualities are the support of the blood circulation which is still supported by the warmth of the water bed, the prevention of pressure points with long-recumbent patients as a Decubitus Prophylaxis, discharge of the circulation etc. Also the hygiene is another important aspect. Dirt and bacteria cannot settle in the accumulating conveyor water mattress. By the concluded core house dust mite cannot penetrate into the water mattress.

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With a mattress size of 100 x 200 cm the water core coated in a synthetic foil (vinyl) contains approx. 300 liters of water which is insulated inside to reduce the water movement. Suitable upholsterer editions provide for the right microclimate. The water is continuously tempered by a thermostat-steered foil heating, because the body is not able to adapt the available water volume of his body temperature. The heating element must be secured against high heating and be guarded thus that no electromagnetic radiation can originate. Patented systems are provided with the CE sign and the stamp of quality of safety standards authority Rhineland. One makes a distinction between hard side-and Soft side systems. With the empty Soft side system which can be inserted in every customary bed, the water core lies in a frame of the soft foamed plastic which is fixed by a special fabric and wooden strips. With the cheaper hard side system the water core is held by a steady bed frame in form. This system is not suitable for reequipping of available beds generally.

1st Textile Circulation

2nd Water mattress

3rd Security foil

4th Heating system

5th Frame

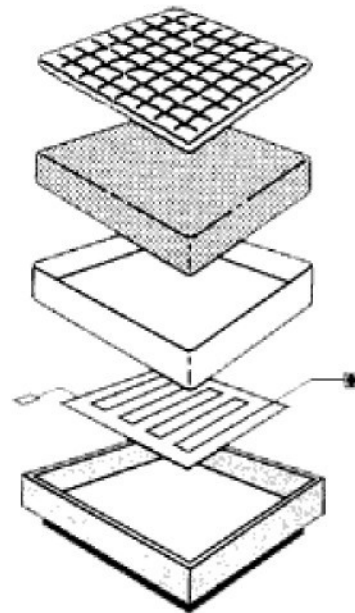


Figure 19: Construction a mattress with water core [www.waterloo.de]

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4.2.2 Aerial core mattress:

The aerial core does the principle of the water bed benefit to itself: Displacement and compression. However, here not water, but air is the weight-bearing, supporting and steering element. Air works after the displacement principle and thereby adapts itself optimally to the body. About a noiseless small pump with remote control the infinitely variable adaptation is reached, regardless of body weight and size. Variable installation is possibilities, no annoying tubes, no complex provisioning system. The pump uses exclusively during the regulation of process stream.

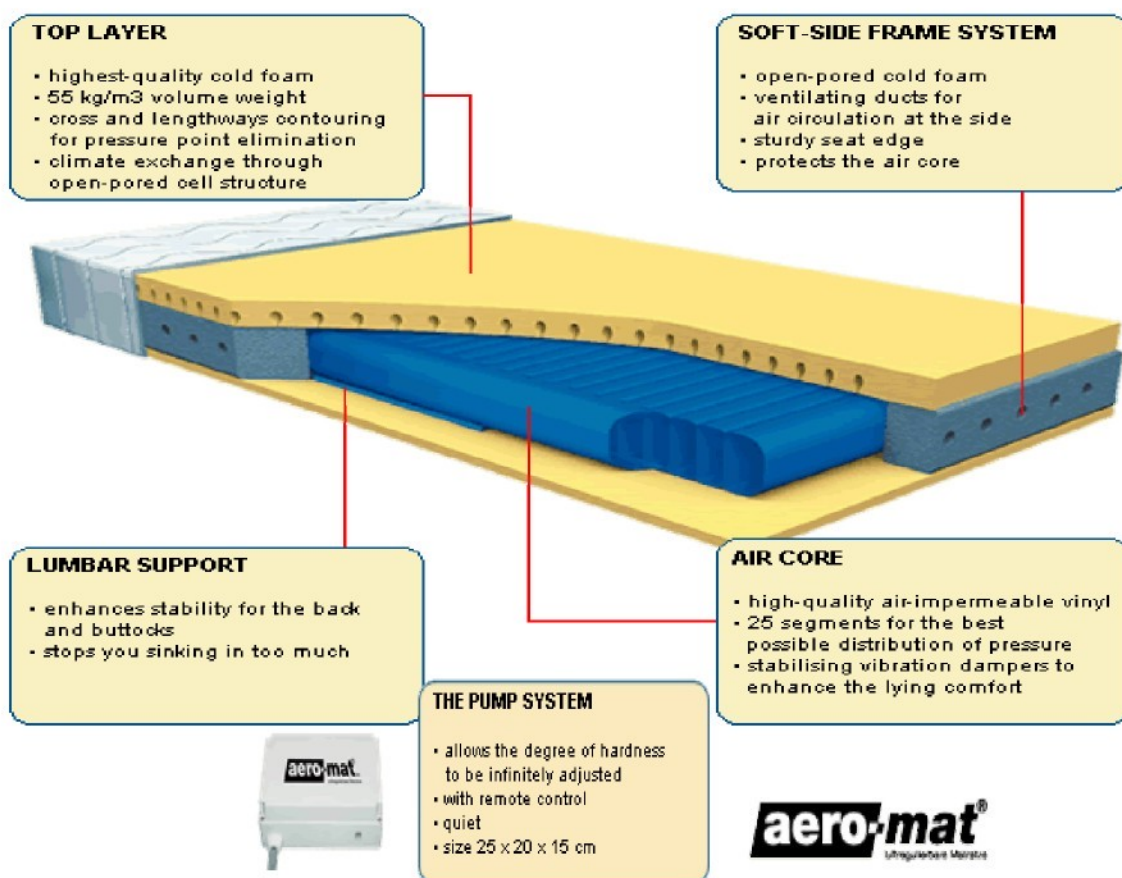


Figure 20: Construction a mattress with aerial core/aero- mat ®

[www.aero-mat.com]

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4.3 mattresses without core

4.3.1 Upholsterer or full upholsterer mattress:

The whole inside core of this mattress kind exists of filling material, as for example horsehair, wool, lake grass or kapok and horsehair is, indeed, the most expensive, but also good material because it is very elastic and tough. Horsehair looks air-conditioning, provides for aerial circulation, it takes up humidity and delivers them again. With however high production costs these have predominantly in manual labor to made full upholsterer mattresses by the possibility the After Polsterns a higher life span.



Figure 21: Construction a full upholsterer mattress [www.allnatura.de]

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4.3.2 Polyurethane Foam mattress (PU-Foam):

Polyurethane is a synthetic material that obtain its flexibility thorough foaming: the material can be applied to perform different functions. Foam mattresses consist of cellular network, giving the material a specific density, elasticity, and air permeability. On a microscopic scale, standard polyurethane cells have a nonisotropic open structure. The cell structure can be adjusted from fine to coarse (about 25 to 8 cells per linear cm), and from regular to irregular, or can imitate a natural sponge pore, depending on the application.

The fact that one can achieve a wide variety of (stiffness) characteristics is one of the main advantages of polyurethane. Further, most polyurethane foams are light and therefore, easy to manipulate. A polyurethane foam mattress core should have a thickness of at least 0.12 m and a density of at least 35 kg/ m³ (which partially contradicts manipulation requirements) to obtain reliable fatigue resistance. In principle, polyurethane foams with higher densities have high a higher stiffness. New chemical processes, however, allow the production of mattress with a high density without a stiffness that is to high.

Standard polyurethane mattress cores give reasonable body support thanks to small hysteresis and reasonable good elastic behavior . They give good heat insulation and reasonable moisture permeability. Polyurethane foams, however, can be adjusted from highly elastic to viscoelastic. Viscoelastic – sometimes called slow recovery. Finally, highly resilient polyurethane foam cells have a differentiated, isotropic, and open structure; the material density is higher. Minimal hysteresis and perfect elasticity give these mattresses very good support qualities; fatigue resistance and moisture transportation are optimal; heat insulatetion is very good, as is the case for most polyurethane foams.

On a macroscopic scale, polyurethane mattress core properties are not necessarily homogeneously distributed; these characteristics may vary along the width or length of mattress to create different comfort zone such as a softer shoulder zone in combination with a firmer pelvic zone.

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4.3.3 Latex Foam Mattresses

Latex Mattresses consist of block of foamed rubber particles and sometimes are called rubber foam mattresses. Rubber particles are of synthetic or natural origin- combinations are possible – and can be foamed firmly or softly. Natural latex mattresses generally contain 80 % natural latex, completed with synthetic additives, which are necessary in order to process rubber to latex and obtain the required elastic properties. Latex is formed by molding and vulcanized to be dimensionally stable and resistant to temperature fluctuations. As opposed to highly elastic polyurethane mattress, latex foams show a rather stric relation between density and firmness.

Latex is especially suited for the fabrication of mattresses with different stiffness zones. Thanks to adequate mold design a material cut-away obtains a softer elastic behavior when requested. Another advantage of the high elastic of latex is that thinner layer can be used, reducing the potential for wear and the restriction of vapor transport.

Each zone with well-defined elastic properties is able to deform independently of other zones; when indenting the hip zone, it only deforms locally without exerting influence on either the shoulder zone or leg zone. Latex, therefore, presents perfect support qualities when the mattress is conceived well; an air chamber with an adjustable volume can even improve the support in the lumbar area. Further, latex is pliable, heavy, and consequently difficult to manipulate; it has low air permeability, but offers very good heat insulation.

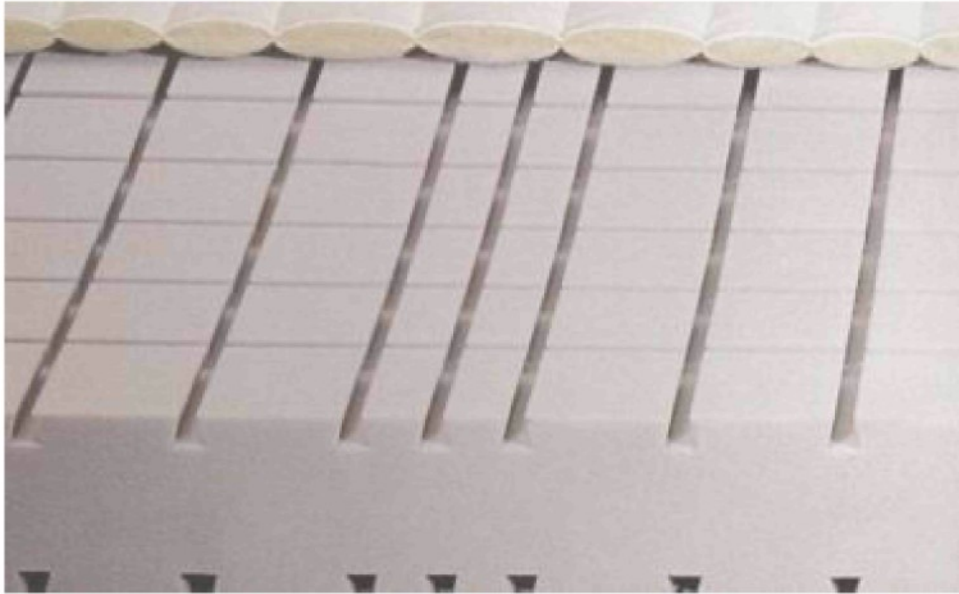


Figure 21: Construction a foam mattress [www.allnatura.de]

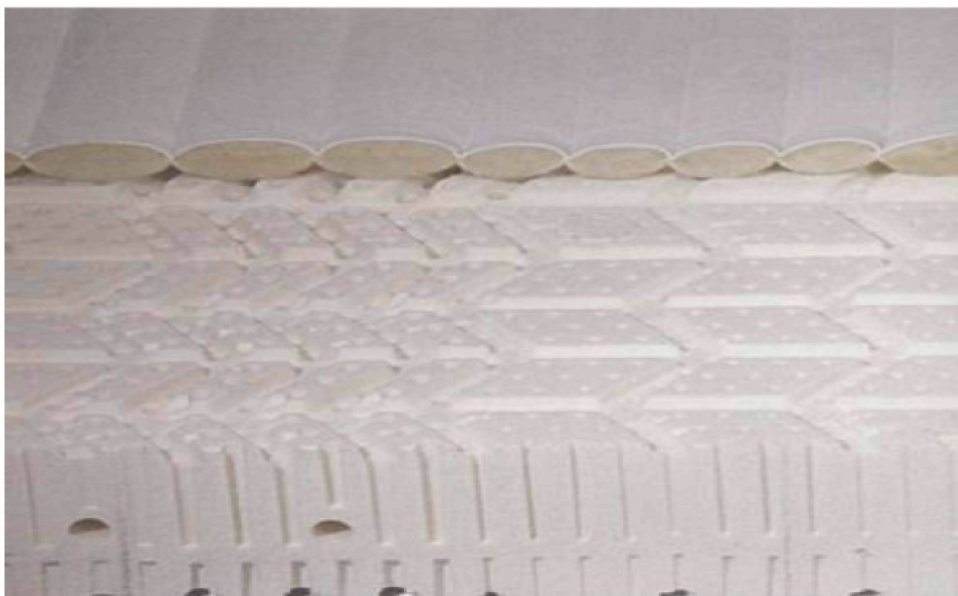


Figure 22 Cross section of the latex mattress [www.allnatura.de]

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4.4 advantages and disadvantages

4.4.1 Solid core groups

Spring-core-mattresses

Advantages:

* High spring tension and supporting strength by feathers linked with each other.

*The best aeration by the construction-conditioned hollow cavity inside of the mattress.

* Different hardness grades offer the suitable mattress for every weight types, Cheap by the simplicity of the product.

* Quick availability at the market.

Disadvantages:

* Stiff, it barely to the body adapting system (can lead to spanning in the body).

* The connection of the feathers is problematic! - In case of that a feather loses the original form all linked feathers with are deformed.

* Susceptibility to "hollow education" which is injurious for the lumbar vertebra.

* For these mattresses washable relations are barely available, this is problematic for the hygiene.

* As a rule with wool quilting and therefore not allergies.

* The contained iron can rust with the time with which and AND health problems originate.

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Result:

Generally we advise against spring core mattresses because you support your body only in the surface and react not in a few points. Should you still want to buy for personal reasons a feather core mattress, then pay attention please to the following points and put to the salesclerk the right questions:

1. Spring core system concerns it around well 5-speed - independently whether waist or endlessly.
2. An upholsterer bearer is important available, so that you do not feel the single feathers.
3. The foam upholstery is high from 22 mms a pleasant upholstery is perceptible, 3 cm there are ideal.
4. The space weight of the foam is high from a space weight of 30 the quality is high enough to guarantee the longevity of the upholstery. (Tip: The space weight is often shortened as a "RG").
5. The relation should exist of cotton. If quilting wool exists, the new wool should show a value of 540 g / m² to count as high-quality (this value provides for optimum temperature balance). The use of other materials for the relation diminishes the quality of the Mattress

Boxes – spring core-mattresses:

Advantages:

- * High spring tension and supporting strength by a higher number of feathers.
- * Bigger flexibility by the insertion of the feathers in the single box which are connected again with each other. By packing the feathers in box an easier upholsterer bearer is for the protection of the relation and the upholstery enough - a less big inflexibility or firmness is guaranteed

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* Different hardness grades offer for every weight types the suitable Mattress.

* The best aeration by the construction-conditioned hollow cavity inside of the mattress.

* By the zonal technology different spring strengths are possible what leads to a better adaptation to the body.

* Relatively quick availability at the market.

Disadvantages:

* In spite of them (in comparison to spring core-mattresses) higher flexibility disadvantages exist in the body adaptation.

* Quick susceptibility to "hollow education". This is injurious for the lumbar vertebrae.

* As a rule not with washable relations available and therefore hygienically questionable.

* Mostly with quilting wool and therefore not just allergies.

* The contained iron can rust with the time with which and AND health problems originate.

Result:

Pockets feather core mattresses are an ideal alternative to cold foam or latex mattresses. They do not reach yet the best body adaptation, however, are quite close in it. Pay attention please before the purchase to the following points and put to the salesclerk the right questions:

1. Boxes spring core system concerns it around it zones which are integrated

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really also in the pockets feather core. Negatively is if the zones are reached only by a zonal upholstery, thus by the foam upholstery.

It from 1000 feathers is more points-elastic and offer therefore the better comfort.

Stuck pockets are the better variation.

2. A jute sisal-upholsterer bearer is available this upholsterer bearer, so that importantly it is for the protection of the foam.

3. The foam upholstery is high from 22 mms a pleasant upholstery is perceptible, 3 cm there are ideal.

4. The space weight of the foam is high from a space weight of 30 the quality is high enough to guarantee the longevity of the upholstery.

5. The relation should be removable from cotton and around. If a quilt wool exists, the new wool should show a value of 540 g / m² to count as high-quality (this value provides for optimum temperature balance).

The use of other materials for the relation diminishes the quality of the mattress.

4.4.2 without core (layers) groups

Coldly and Viscose foam mattresses:

Advantages:

- * In spite of the relative softness the body can be optimally supported.
- * Cold foam and Viscose foam are long-lasting and without problems 10 years long-lasting
- * the point elasticity is guaranteed different hardness grades offer for every weight types the suitable mattress.
- * The porosity of cold foam guarantees a good aeration.

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* The zonal technology is possible in the mattress by different incisions – this offers an ideal adaptation to the body.

* Coldly and Viscose foam is to be recommended on account of his ease very well in the use and just for older persons very much.

Disadvantages:

* Viscose foam is marked by a less good ventilation and therefore by temperature balance problems.

* Viscose foam is very susceptible to temperature and loses his supporting effect with excessive warmth (these mattresses only for bedridden persons and persons with the complex osseous breaks which need an ideal pressure discharge are recommendable).

* Good mattresses are available only in the middle and high prize segment (from 200.00 euros).

Result:

A Cold foam and comfort foam mattresses are the high-quality products which are to be recommended very much. Indeed, there are also by the purchase of this kind of mattresses some important things to follow. Put to the salesclerk the right questions:

1. Rule of thumb: the higher the core, the better the comfort (market average is a height of 14-16 cm).

2. The best mattresses have 7 zones: Head shoulder Lumbar vertebra, middle zone-lumbar vertebra, shoulder, head zones.

3. A cube cut is high-quality and good, a wave cut proves only partly real zonal technology.

4. Space weight the foam is from a space weight of 40 the quality of the mattress is safe (in the market space weights of 20 are usual up to 60)

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5. Relation of the mattress with terry cloth is a standard, Cotton Stretch composite materials, are the higher-quality variation.

The relations should be removable and be washable. The zipper of a relation should run about all sides, so that the relation exists of 2 individual parts.

Latex mattresses:

Advantages:

- * In spite of the relative softness the body can be optimally supported.
- * Latex is long-lasting and long-lasting without problems 10 years.
- * The point elasticity is guaranteed.
- * Different hardness grades offer the suitable mattress for every weight types. The zonal technology is possible in the mattress by different hole strengths and offers an ideal adaptation to the body.

Disadvantages:

- * Latex is marked by a less good ventilation and with it temperature balance problems.
- * Latex is heavy very much and prepares with it in the everyday use problems.
- * Good mattresses are available only in the middle and high prize segment (from 200.00 euros).

Result:

Latex mattresses are high-quality products which are to be recommended very much. Pay attention please before the purchase to the following points and put to the salesclerk the right questions:

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1. Full latex core is higher-quality and offers a special comfort. 2. The mattress you should not be sure, then you request for the pictures in which the core is visible.

The same recommendations like with spring core count to the relations, Boxes spring core and cold foam ama resist

4.4.3 with liquid-/aerial core groups

Water core mattress

Advantages:

- * The water optimally adapts itself to the back (being relaxing lying).
- * Bends forward back is discomfort.
- * Healthy sleeping climate: Delivered humidity becomes fast evaporated by the warmth.
- * The bed is warmed up by the heating always nicely.
- * Hygienically: All material relations wash ably. For the surface of the water mattress there is vinyl cleaner. No mites etc., hence, ideally also for allergy sufferers.

Disadvantages:

- * Possibly problems with the static contact structural engineer with old buildings, before purchase!
- * running costs for stream (heating, few euro / month) and conditioning (1 bottle all 6-12 months)
- * Water can tip over (go off) if one forgets conditioning longer time
- * raised expenditure with relocation (De-and assembly).

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5. Human skin and thermal properties of textile material.

5.1. Human skin

The function of the skin can be considered to act mainly as a protective and containing barrier while allowing necessary interaction between the body and the environment. Two important interactions are the regulation of heat exchange and the sensory perception of the environment. To aid in performing these functions, human skin contains systems for supporting surface hair and mechanisms for controlling moisture on the skin surface (sweat). These systems are based in the dermis of the skin but penetrate the epidermis to the surface of the skin. The dermis is also supplied with blood vessels and mechanisms for controlling the lymphatic vessels and nerve receptors which are sensitive to temperature, superficial touch and pressure, and for controlling the flow of blood through them. The skin therefore functions as a dynamic system, changing its condition depending upon the requirements of the body.

The skin plays a fundamental role in the homoeothermic function of maintaining internal body temperature at around 37°C. If the whole-body becomes 'too hot', blood flows through the dermis (vasodilatation) to release heat through the epidermis to the environment. If greater heat loss is required then the surface of the skin is moistened with sweat so that the latent heat of vaporization may be lost through evaporation. Whole body thermoregulation is controlled by the thermoregulatory system based in the hypothalamus. Local heating of skin however will also cause vasodilatation and sweating, given a sufficient response time. Reaction of skin to contact with hot surfaces may depend upon the initial condition of the skin. From the above discussion, this may vary from cold conditions where there are low skin temperatures, low blood supply, and 'dry' skin to hot conditions involving relatively high skin temperatures, rich blood supply and possibly wet skin due to sweating. Some physical properties of human skin are provided in Table 2. Important factors that will affect intra and inter- human variation in skin condition is provided in Table 2.

<i>Dimension</i>	<i>Units</i>	<i>Values</i>	
<i>Approximate values of physical dimensions</i>			
Mass	kg	4	
Surface area	m	1.8	
Volume	l	3.6	
Water content	%	70–75	
Specific gravity	ND	1.1	
Thickness	mm	0.5–5	
<i>Approximate values for thermal properties</i>			
Density (ρ)	kg m ⁻³	860	
Specific heat (c)	J kg ⁻¹ K ⁻¹	5021	
Thermal conductivity (k)	W m ⁻¹ K ⁻¹	Vasoconstricted	0.2–0.3
		Vasodilated	0.4–0.9
Thermal diffusivity ($a=k/\rho c$)	(m ² s ⁻¹) $\times 10^{-8}$	4.63–6.95	9.26–20.84
Thermal penetration coefficient [$b=(k\rho c)^{1/2}$]	J m ⁻² s ^{-1/2} K ⁻¹	929–1138	1314–1971

Table 2: Thermal properties of human skin [14]

<i>Factor</i>	<i>Explanation</i>
<i>Intra-subject factors</i>	
Area of the body	Regional difference in epithelium structure and thickness; water content; pigmentation
State of vasodilation/vasoconstriction	Instantaneous state of local capillary blood flow
Wet or Dry (e.g. state of thermoregulatory sweating)	Presence of hair, surface oil and contaminants
<i>Inter-subject factors</i>	
Age	Children, adults
Occupation	Use of skin— manual/office worker
Sex	Males/females
Ethnic differences	

Table 2: Factors which influence variation in human skin [14]

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5.2 Thermal comfort

Thermal comfort is a psychological concept that is affected by at least five variables.

Conduction: Conduction is the movement of heat from a warmer object to a cooler one when they are in direct contact with one another. This serves to even the temperature difference between them. For example, when you lay directly upon a cold rock the heat from your warm body will transfer into the rock. You become cooler as the rock becomes warmer.

The rate of heat transfer between two objects of different temperatures depends upon several factors. These include

- The temperature difference between the two objects
- The total surface area where the two objects are in contact
- The efficiency of the insulation that is between the objects

The greater the temperature difference between two objects in contact, the more heat is transferred between them in a given time. For example, when you place your hand on a very hot stove top you will quickly receive a great heat input from the stove to your hand. If the stove top is only warm, it will take much longer to receive the same amount of heat into your hand.

The more surface area in contact between two objects, the more quickly heat is transferred between them. Stick your finger on an icicle for a minute and it feels cold but you will probably not feel too uncomfortable. Strip naked and lay on a block of ice for a minute and you will most likely be very uncomfortable indeed as the ice absorbs heat from your body at a very fast rate.

The amount of heat being transferred between two objects of different temperatures can be slowed by the use of effective insulation. Insulation retards the movement of heat between them by creating pockets of dead air space which trap the flow of heat.

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For example, a spongy foam pad is an excellent insulator between your warm body and a cold floor. However, should you compress the foam pad, thereby removing the small pockets of dead air within it, the pad will become much less efficient at blocking the transfer of heat.

This is why proper insulation beneath you is so important – it must resist the crushing effect of your body weight and be thick and lofty enough for numerous pockets of dead air space to impede the flow of heat as much as possible.

Convection: Convection is somewhat like conduction as mentioned above, but the two objects in contact are also moving relative to one another. Once again, the amount of heat transferred between the two objects is dependent upon their differences in temperature and the amount of surface area in contact. However there is a third important component and that is the speed with which the cold object is moving.

For example, when your warm face is exposed to a blast of cold air the speed of that air matters. If the cold air is moving slowly it may not cool your face very much at all. However if the air is traveling 60 miles per hour you may actually receive a frostbite wound in a matter of seconds.

The blood in your body also transfers heat by convection. As our body cools, its response is to move blood away from the extremities in order to keep the body's core at optimal temperature. The result is that our hands and feet become cooler and may eventually lead to frostbite. This gives impetus to the fact that in order to keep your feet cool you should put on your warm hat.

You can reduce convective heat loss by wearing a windproof out shell. This will stop the air from flowing into your insulative layers of clothing and robbing the body heat that is stored there.

Radiation: Radiation is the transfer of electromagnetic energy between two objects of different temperatures. Since our bodies tend to be 98.6 degrees F, we are often warmer than our surroundings and so we radiate heat to them. In turn we can receive radiative heat from the rays of the sun, fires, and light reflected off from snow, rocks and sand, or water.

Another example of how radiative heat works is the effect of cloud cover on temperature. At night when there are no clouds, the temperature tends to become cooler than on nights when there are clouds. This is because as the earth radiates heat toward the cold outer space, some of this radiation is reflected back by the cloud cover.

Exposed human skin is also a radiator. The more total area of exposed skin, the more energy is radiated to the environment, assuming of course that the body is warmer than its surroundings.

To minimize the amount of radiative heat you lose to your environment make sure all exposed areas of you skin are covered. This includes the head, face, neck, and hands.

Evaporation or water – vapour: When water evaporates its change in state from liquid to a gas takes up a great deal of energy and lowers the temperature of the surface on which it occurs. This is the process of evaporation.

In hot environments evaporation is a welcome process and we may even encourage the process by wetting ourselves down when the need and opportunity arises. In cold environments however, evaporation can be a killer as it consumes a large amount of energy and warmth from your body and transfers it to the outside world. In addition, when the clothing you need to stay warm becomes wet it loses much of its insulative value and exposes you to the risk of hypothermia

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Because of the dangers of becoming wet in cold weather, you should carefully monitor your amount of perspiration during times of heavy exertion. If you are becoming overheated and begin to sweat, remove some clothing or reduce your efforts in order to become cooler and keep sweating to a minimum.

Respiration: Additional evaporative heat loss occurs through breathing. When a dog is hot he will pant. The air he brings into body is filled with moisture that is heated by the body. When the dog exhales he sends this hot moisture laden air out of his body and into the outside world. The dog becomes cooler.

In just the same way as a dog, as you breath in and out you are exchanging heat via evaporation to the outside world. This loss of heat is increased when the air you are breathing in is very cold or very dry. The colder and drier the air and the faster and more deeply you breathe, the greater the loss of heat. In high mountain areas losing heat to the breath rivals that of losing heat through the evaporation of sweat.

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6. Physiological effects – Measurement of thermal and water- vapour resistance under steady-state conditions (sweating guarded- hotplate test)

This International Standard specifies methods for the measurement of the thermal resistance and water-vapour resistance, under steady-state conditions, of e.g. fabrics, films, coatings, foams and leather, including multilayer assemblies, for use in clothing, quilts, sleeping bags, upholstery and similar textile or textile-like products.

The application of this measurement technique is restricted to a maximum Thermal Resistance and Water-vapour Resistance, which depend on the dimensions and construction of the apparatus used (e.g. 2 m²·K/W and 700 m²·Pa/W respectively, for the minimum specifications of the equipment referred to in this International Standard. The test conditions used in this standard are not intended to represent specific comfort situations, and performance specifications in relation to physiological comfort are not stated.

6.1 Definitions

Thermal resistance, R_{ct} : Temperature difference between the two faces of a material divided by the resultant heat flux per unit area in the direction of the gradient. The dry heat flux may consist of one or more conductive, convective and radiant components. Thermal resistance R_{ct} expressed in square meters Kelvin per Watt is a quantity specific to textile materials or Composites, which determines the dry heat flux across a given area in response to a steady applied temperature gradient.

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Determination of R_{ct0} : For the determination of R_{et0} set the temperature of the measuring unit T_m at 35°C and the air temperature T_a at 20°C with a relative humidity R.H. of 65 %. Set the air speed va to 1 m/s. Any deviations from these values shall be within the limits stated in clause 5. Wait until the measured quantities (T_m , t , R.H., HI) reach steady-state before recording their values.

The bare plate resistance R_{et0} is determined from equation (1).

$$R_{ct0} = \frac{(T_m - T_a) \cdot A}{H - \Delta H_c} \quad \Bigg| \quad \dots\dots\dots(1)$$

ΔH_c is a correction term and is determined as described in annex B.

Calculate the thermal resistance R_{ct} from equation (2)

$$R_{ct} = \frac{(T_m - T_a) \cdot A}{H - \Delta H_c} - R_{ct0} \quad \Bigg| \quad \dots\dots\dots(2)$$

R_{ct} = The Thermal Resistance , $m^2 \cdot K/W$

R_{ct0} = The apparatus of constant, $m^2 \cdot K/W$ for measure the Thermal Resistance

T_m = The temperature of measuring unit, °C

T_a = The air temperture in test enclose, °C

A = The area of the measuring unit, m^2

H = The heating power supplied to the measuring unit, W

• H_c = The correction term for heating power for the measuring of Water-vapour Resistance

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Water-vapour resistance, R_{et} : Water-vapour pressure difference between the two faces of a material divided by the resultant evaporative 'heat flux per unit area in the direction of the gradient. The evaporative heat flux may consist of both diffusive and convective components.

Water-vapour resistance R_{et}' expressed in square meters Pascal per watt, is a quantity specific to textile materials or composites which determines the "latent" evaporative heat flux across a given area in response to a steady applied water-vapour pressure gradient.

Determination of R_{et} : Set the temperature of both the measuring unit T_m and the air T_a at 35 c. set the air speed v_a to 1 m/s.

The relative humidity R.H. of the air shall be kept constant at 40 %, corresponding to water- vapour partial pressure p_a of 2 250 Pa. The water-vapour partial pressure p_m directly at the surface of measuring unit can be assumed equal to the saturation vapour pressure at the temperature of this surface. i.e. 5 620 Pa, without compromising the accuracy of the test.

Any deviations from the above values of T_m , T_a , v_a and R.H. shall be with the limits stated in clause 5. Wait unit the measured quantities (T_m , T_a , R.H. H) reach steady –state before recording their values.

The bare plate resistance R_{eto} is determined as from equation (3)

$$R_{eto} = \frac{(p_m - p_a) \cdot A}{H - \Delta H_e} \dots\dots\dots(3)$$

Calculate the thermal resistance R_{et} from equation (4)

$$R_{et} = \frac{(p_m - p_a) \cdot A}{H - \Delta H_g} - R_{et0} \quad \dots\dots\dots(4)$$

Insulation Value, Clo: calculate the Insulate Value for a material system including the face air

$$I_t = (T_s - T_a) \cdot A / 0.155 \cdot H_c \dots\dots\dots(5)$$

Where

I_t = insulation Value, Clo

A = area of the plate test section, m²

T_s = surface temperature of the plate, ° C

T_a = air tempura, ° C

H_c = power input, W

Water - vapour Permeability index, i_m : Ration of Thermal and Water-vapour Resistance in accordance with equation (6)

$$i_m = 0.0094 (I_t / R_{et}) \dots\dots\dots(6)$$

Where

i_m = Water-vapour Permeability index (dimensionless)

I_t = Insulation Value determined in accordance with Clo

R_{et} = Water= vapour Resistance, kPa.m² / W

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Total Heat Loss : in conduction is the movement of heat from a warmer object to cooler one when they are in direct contact with one another. This serves to even the temperature difference between them

$$Q_t = (10 \text{ }^\circ\text{C} / R_{ct} + 0.04) + (3.57 \text{ kPa} / R_{et} + 0.0035)\dots(7)$$

Where

Q_t = Total Heat Loss, W/ m²

R_{ct} = average intrinsic Thermal Resistance of laboratory sample K·m² / W

R_{et} = average apparent intrinsic Water-vapour Resistance of laboratory sample kPa·m² / W

Water-vapour permeability W_d : Characteristic 'bf/a textile material or composite depending on water-vapour resistance and temperature in accordance with equation (2):

$$W_d = \frac{1}{R_{et} \cdot \phi_{T_m}} \dots\dots\dots(8)$$

Where

ϕ_{T_m} is the latent heat of vaporization of water at the temperature T_m of the measuring unit

Equals, for example, 0,672 W·h/g at $T_m = 35^\circ\text{C}$

Water-vapour permeability is expressed in grams per square metre hour pascal

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6.2 Measurement and Testing Method

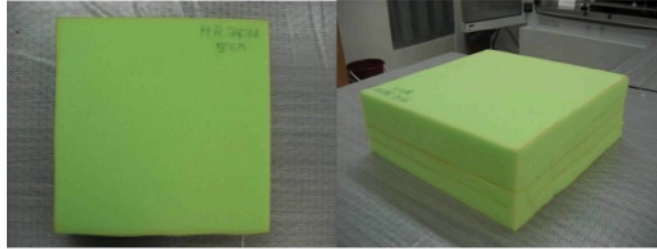
For this investigation, they are 4 samples with different material compositions but with a similar surface area and thickness of PU -foam and Latex - foam materials (HR3836, T2140, TC50M and Latex materials : Matrace gumotex a.s , Czech Republics).

Prepare Material Samplings

- Human Skin Simulate Testing

An Experimental test of Human Skin Simulate Testing was designed and constructed according to the specifications provided in ISO 11092 (1993 E) Textiles Physiology effects measurement of Thermal and Water – vapour Resistance under steady – state condition(sweating guard – hotplate test)

The 2 types of sample of material are PU – Foam materials (HR3836, T2140, and TC50M) and Latex- Foam material. These samplings thickness are 100 mm, except TC50M thickness is 60 mm. Human Skin Simulate Testing maximum thickness in 50 m., therefore the experiment must cut these samples in 50, 30, and 20 mm. from 100 mm. and 60 mm. The mattress material samples are 280 x 280 mm. for space of hotplate of Human Skin Simulate Testing (shown in Figure 23 On the left hand side). For separate cut these of material for the Testing, the layer is 50 mm. in bottom, the middle material is 20 mm. and the top layer is 3 cm high. (shown in Figure 23 on the right hand side) Static experiments were run for each of three replicates of the four samples as temperature, surface area, and time. Each replicates of one sample test in 30 min. An surface area hotplate test section 280 x 280 mm. These test set up a surface temperature of plate (T_s) is 35 ° C , and an air temperature (T_a) is 20 ° C. After the material sample assembly reaches steady- state conditions record measurements are made for power input a test period in 30 min. to determine the total Thermal Resistance of material plus air layer. From this result insulation value of Thermal Resistance was higher when testing was run a second and third replicates at 200 mm, 300 mm., and 500 mm,



HR3836



T2140



TC50M



Latex

Figure 23: Top view shown in surface and side view shown in thickness of Sample Mattress material

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- Air penetration Testing

The penetration Testing SDL M21S (ISO 9237- 800817) is maximum high thickness is 10 mm. These cut samples are 10x 50 x 50 mm. (shown in Figure 2...and 2....)

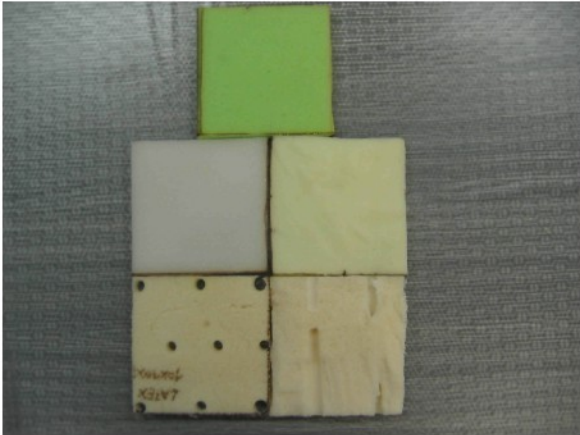


Figure 24: top view of Sample material for SDL M021S Testing

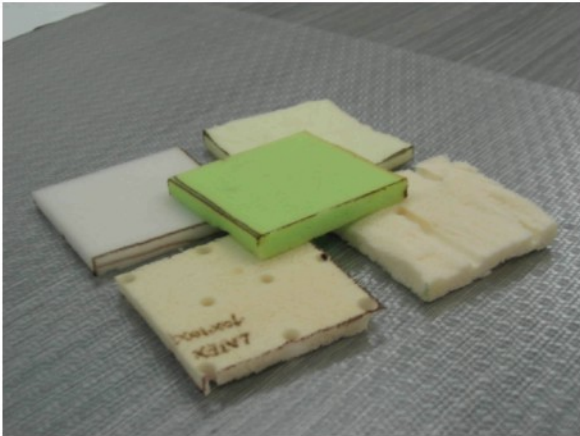


Figure 25: side view of Sample materials for SDL M021 Testing

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For this measurement Density Testing, the cuts are 50 x 50 x 50 mm., In these sample, Latex has holes , we cut part without holes or a few holes in material for testing.

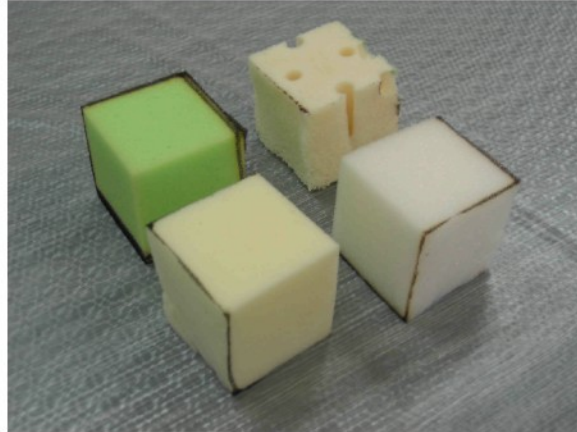


Figure 26: Top view Sample materials for measurement Density

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6.3 Results and Discussion

6.3.1 Result Density and Air penetration Measurement

In Testing Study had four Sample Materials that they are Polyurethane Foam (PU) and Latex – Foam, The Latex- foam has more difference than other material, these in constructions is made holes around in material. Shown figure in index IX. The Elasticity Characteristic of PU – Foam (HR3836 and T2140) have as well as hard and good Elasticity. T50CM has soft and slowly Elasticity more than normal PU- Foam. On the other hand, Latex- Foam has good and soft flexible ability, not hard in material. (Shown in table 3)

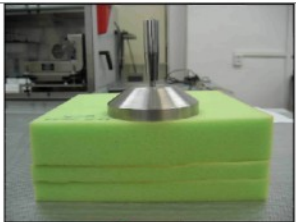



Sample	Material	Specific Density (kg/m ³)	Air-Penetration mm/s at 5 Pa	Construction	Original mattress thickness mm.
HR3836		1.28	2	flat PU foam	100
T2140		0.561	6	Flat PU foam	100
TC50M		1.425	2.265	Flat PU foam	60
Latex		1.618	8.5, 5.5	Latex – foam with holes	100

Table 3: Characteristics of Mattress material samples

Comparing the characteristic of these samples, the result tells me that T2140 have good Air penetration Characteristic when is compared with Latex2 (without hole), other sample because in Latex1 (with holes was very high Air penetration of course). Latex was high Density and high Air penetration as well. For HR3836 and TC50 M low Air penetration but high density. So that result allowed, Latex Mattress is heavier more than PU – Foam mattress group. (shown in Figure 27)

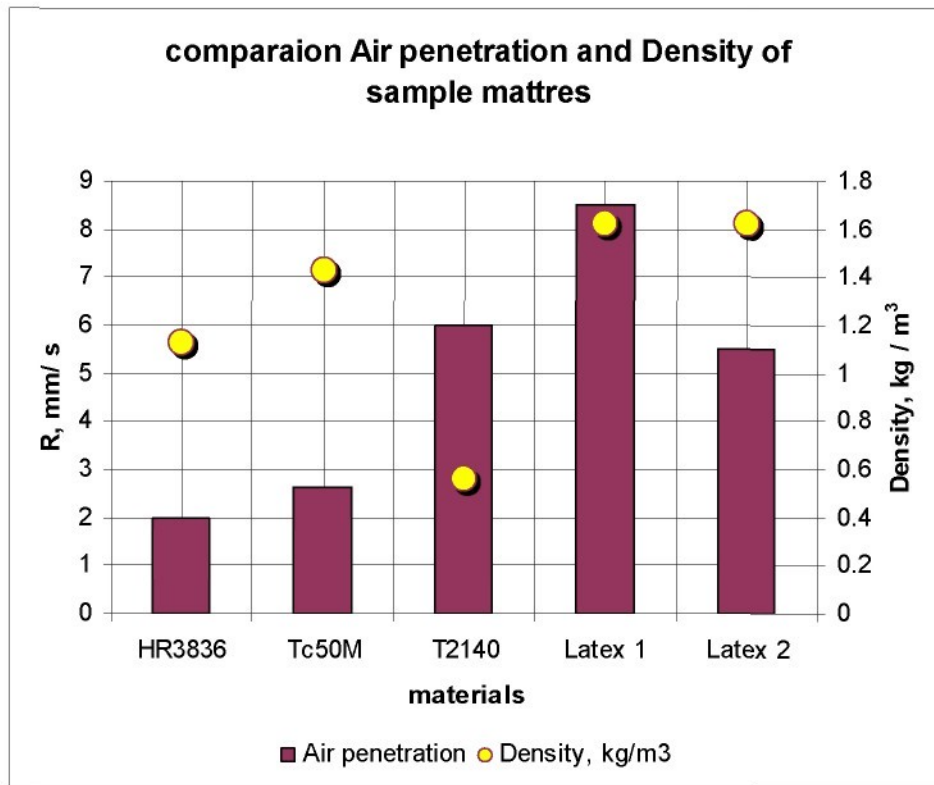


Figure 27: Air penetration and Density of Mattress material Sample

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6.3.2 Result of Static Thermal Resistance and Water- vapour Resistance using with Human Skin Simulate Testing

In measurement was showed the result T2140 Thermal Resistance was lowest of samples in 200 mm(2 cm) and TC50M was highest Thermal Resistance. In these testing, In 300 mm(3 cm) and 500 mm(5cm) thickness samples T2140 and HR3836 was increased, on the other hand TC50M was decreased in 300 mm (3 cm); was increased again in 500 mm (5 cm) samples. And latex was increased in 300 mm that was highest Thermal Resistance but was decreased in 500 mm samples that was lowest (shown in Figure 28)

For data from measurement we can calculate forecast value Thermal Resistance in 100 mm(10 cm) thickness sample (HR3836, T2140, and latex)and 60mm (6 cm) of TC50M material sample. In forecast diagram (shown in Figure 29) trend of T2140 and HR3836 materials was increased and Thermal Resistance was HR3836: $1.315 \text{ m}^2\text{K} / \text{W}$, T2140: $1.090 \text{ m}^2\text{K} / \text{W}$ and TC50M , Latex was not more increased in forecast data in 10 cm; TC50M: $1.131 \text{ m}^2\text{K} / \text{W}$, and Latex : $0.437 \text{ m}^2\text{K} / \text{W}$.(shown in Index III)

For forecast, data can tell us HR3836 was highest Thermal Resistance and Latex was lowest Thermal Resistance of these mattress materials. The forecast value Thermal Resistance of T2140 and TC50M was closer value about $0.9 - 1.3 \text{ m}^2\text{K} / \text{W}$. We can see that trend line of T2140 material was long straight line in diagram that mean result from measurement good result and maybe exactly or closer realizable Thermal Resistance value

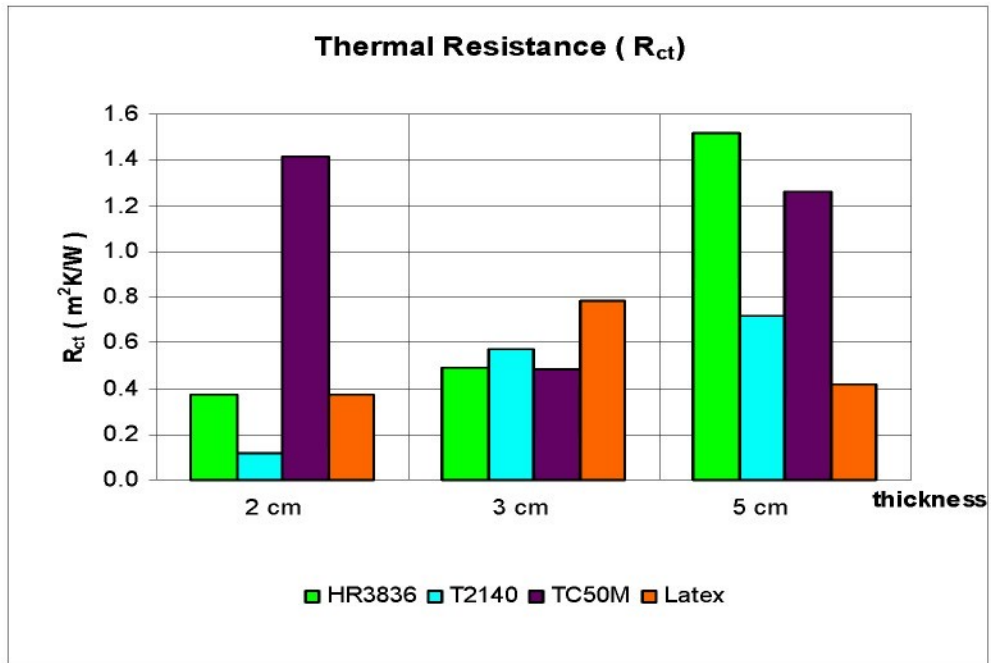


Figure 28: Thermal resistance R_{ct} result from measurement testing
(Human skin simulate)

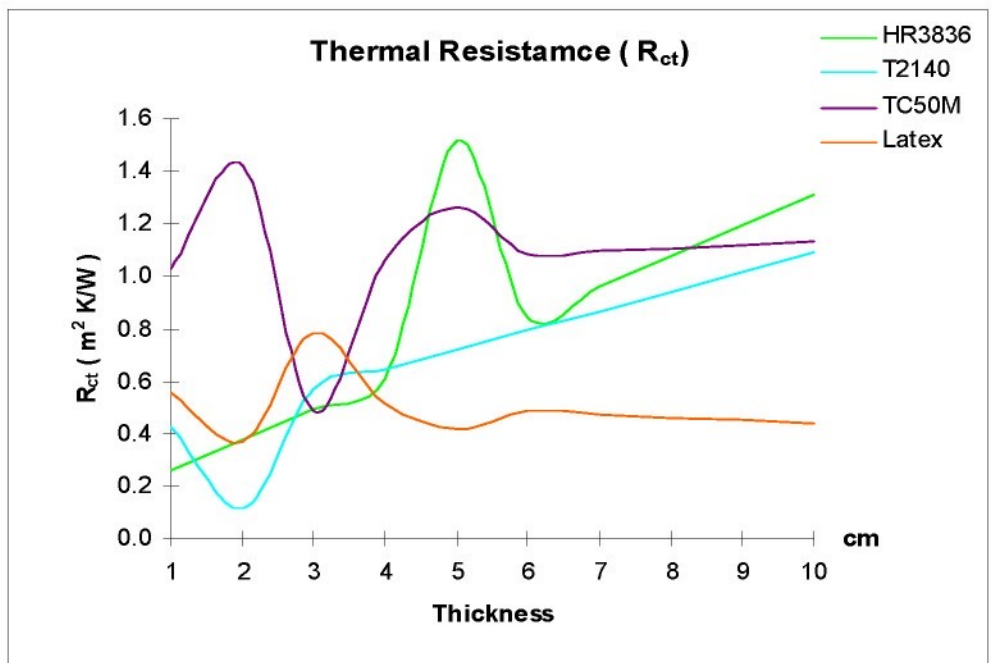


Figure 29: Thermal resistance R_{ct} result from measurement (2, 3, and 5 cm)
and forecast statistic

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For relatively Thermal Resistance value can calculate Thermal Conductivity value from these testing. (Shown in Index IV) The result from calculate (shown in Figure 30) tell us Latex material was highest Thermal Conductivity and HR3836 was lowest that mean Thermal Conductivity is invert of Thermal Resistance

These measurement for Thermal Resistance in report gave power input that it can take data relative calculate find a Insulation (Clo) (shown in index VII) This materials testing TC50M and T2140 were high Insulation and Latex was lowest Insulation

In Figure 28 and 29 the Thermal Conductivity and Clo of forecast data gave a little increase value or maybe very closer Constance value, so that we can predicable data PU – Foam mattress material group are high Clo

This measurement value Water – vapour Resistance gave HR3836 and T2140 increase value when thickness is higher, However HR3836 was a little increase . For TC50M was decreased when high thickness but is not more difference. On the other hand forecast data gave value of TC50 M a little increased from thick 100 mm and 500 mm, but lower than value thick 200 mm. whenever material higher should be Water –vapour Resistance higher too allow from forecast data. In these testing and forecast, tell us Mattress materials were higher Water – vapour Resistance value than $30 \text{ m}^2\text{Pa} / \text{W}$ up. (Shown in Figure 32 and 33)

The Latex material should be many factors for distribution data therefore in these material is not as well in difference thick because in thickness 500 mm. many holes around in material but in 300 mm. a few holes in material, and in 200 mm thick without hole (Shown in Index)

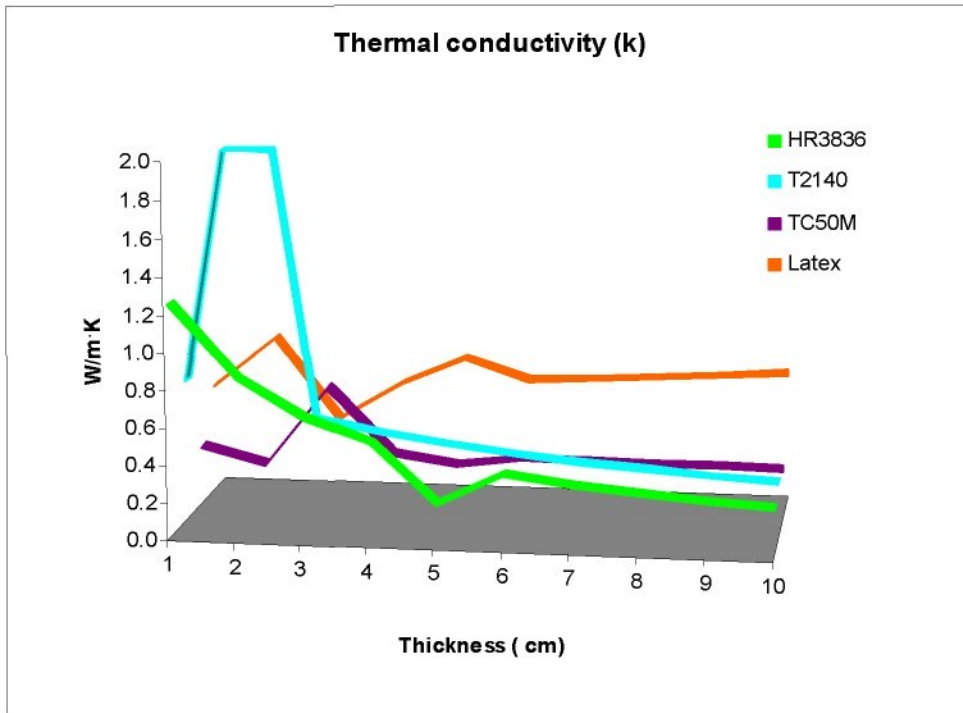


Figure 30: Thermal conductivity•

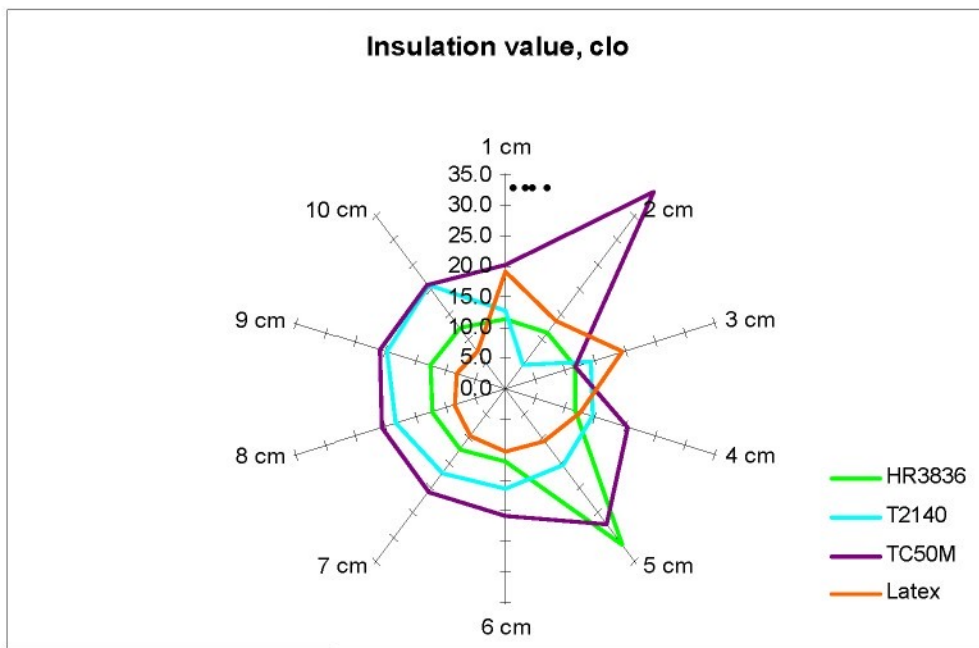


Figure 31: Insulation Value•

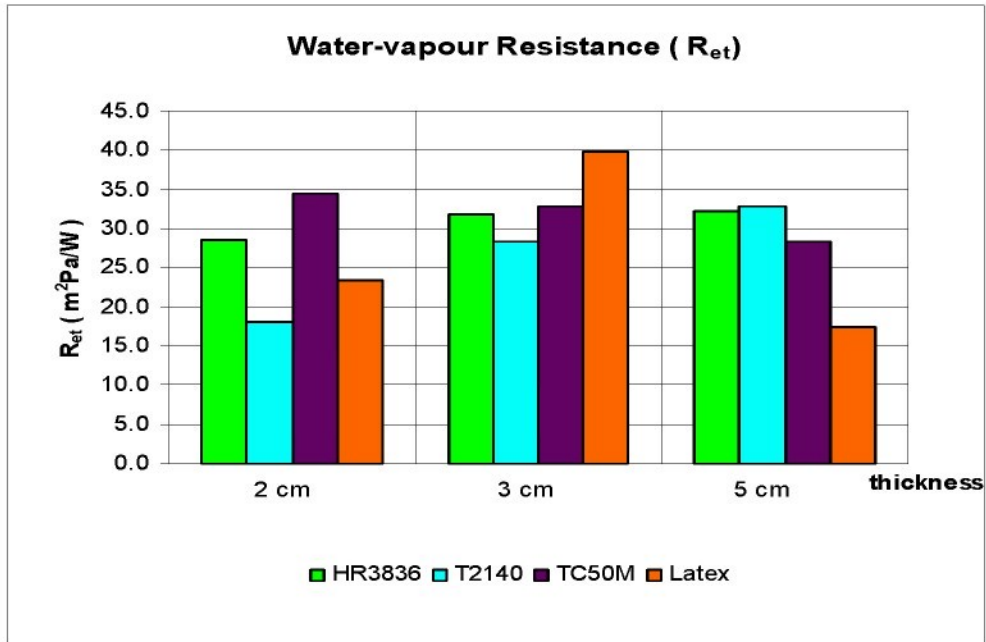


Figure 32: water vapour resistance R_{et} result of Mattress material (Human skin simulate)

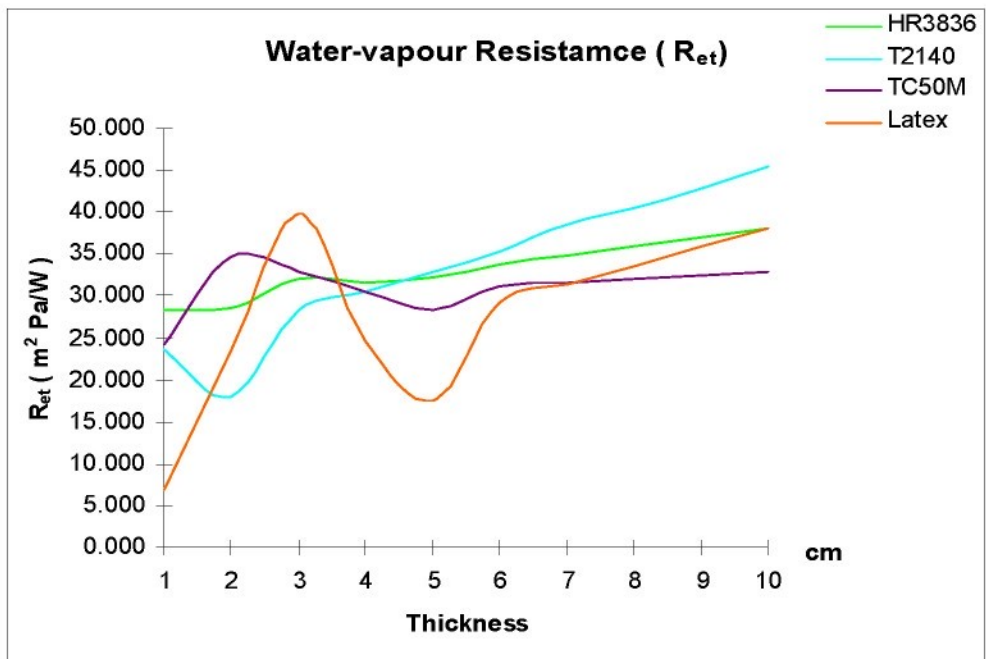


Figure 33: water vapour resistance R_{et} result of Mattress material average (Human skin simulate)

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In behavior Water –vapour Permeability characteristic with foam is low and bad insulate; these result forecast Water vapour Permeability were closed lines and low around $0.05 \text{ g / m}^2\text{h Pa}$. For normal day, we sleep long about 8 hours and stand body area is about 1.8 m^2 so that we can calculate Water-vapour Permeability in 8 hour with body area is around $0.5 - 0.6 \text{ g/ Pa}$ of this Mattress material.

For Calculate Heat loss Latex material was highest forecast value and a group PU- Foam (HR3836, T2140, and TC50M) a little difference values. (Shown in Figure 36) These mattress materials showed Thermal Comfort characteristics; Thermal Resistance and Water- vapour Resistance both values. Therefore we can found ration these value in Water –vapour Peameability Index (i_m).., that result material testing were low and not distance distribution values, that mean These Latex material many high value than other values maybe reason from difference hole in material (shown in Index Figure Latex material))

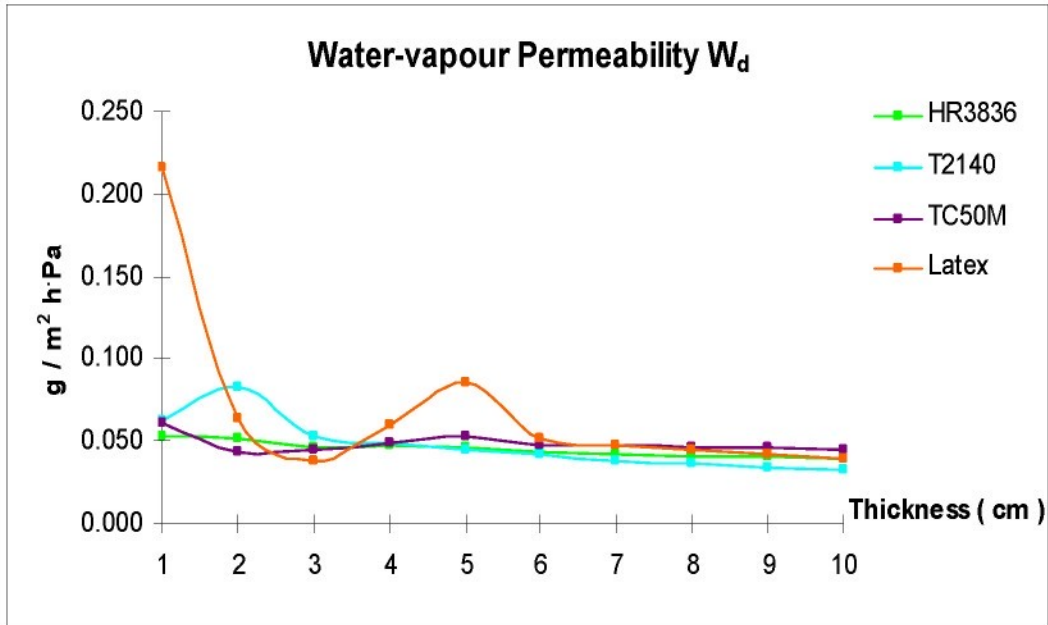


Figure 34: water vapour permeability W_d result of Mattress material

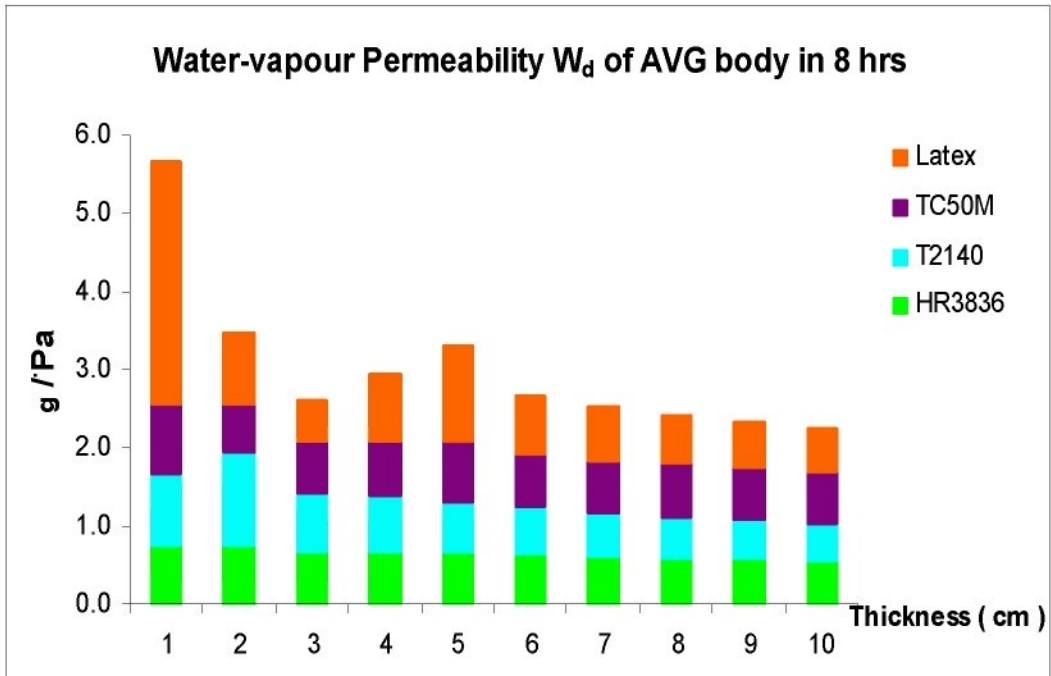


Figure 35: water vapour permeability W_d per average body surface area in 8 hours of Mattress material

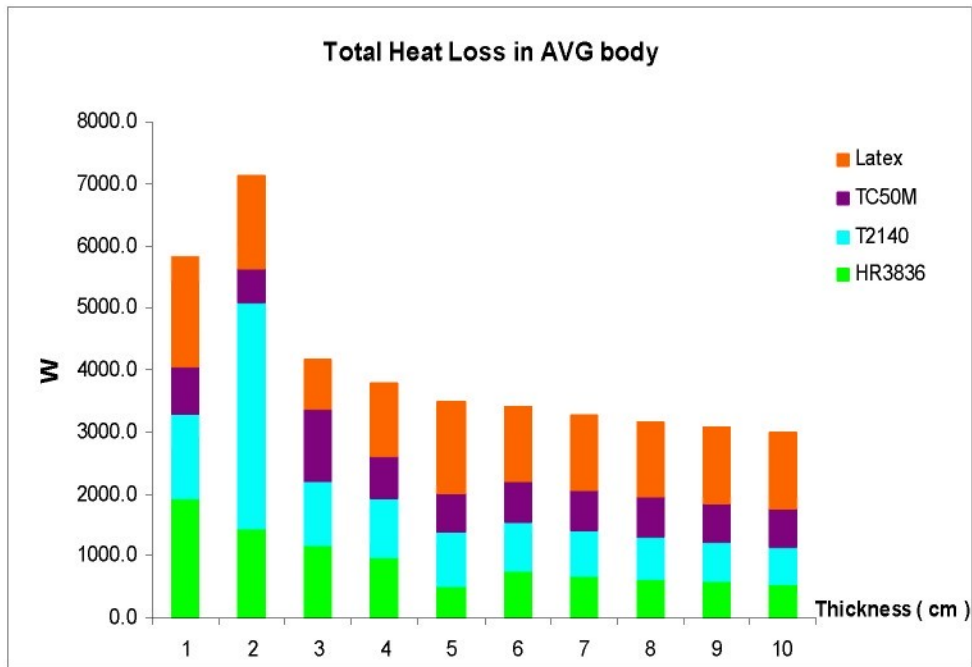


Figure 36: Heat Loss

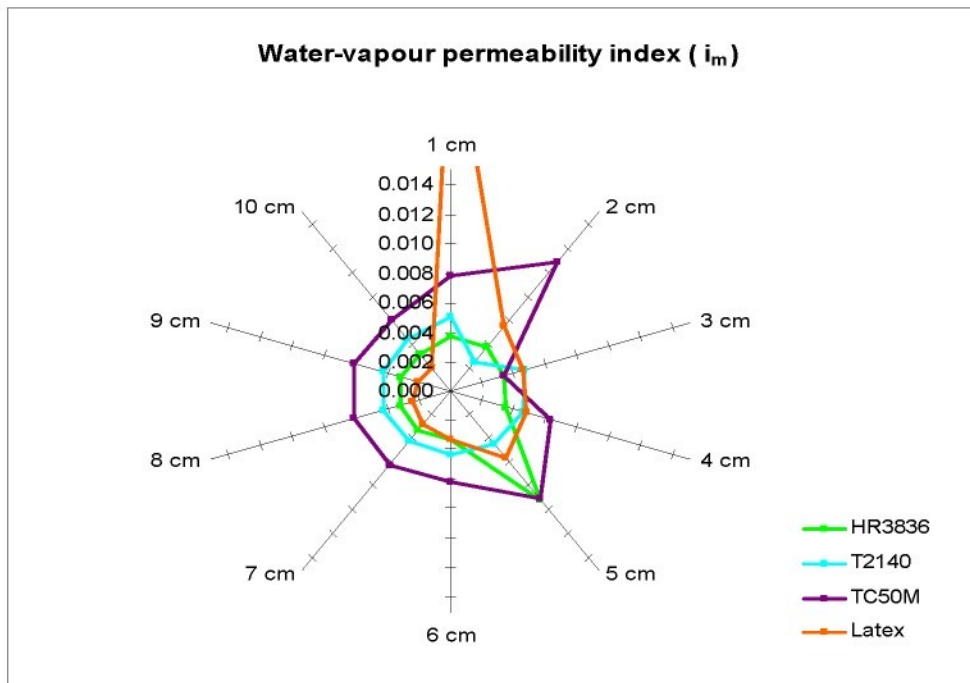


Figure 37: water-vapor permeability index

6.4 Conclusion

During sleep, moisture has to be transported to the environment in order to avoid a clammy feeling at the mattress surface, to avert mildew formation at the mattress bottom, and to prevent decubitus ulcers, since a moist skin is rough and therefore more sensitive to shear forces. One third of this moisture is emitted through breathing; the remaining two thirds are transmitted through the body surface and have to be absorbed by the mattress (25%) and the sheets, blanket, and head cushion (together 75%). As a result, (a) the fluid permeability of material is directly related to the fluid absorption capabilities of a sleep system and (b) the fluid transport from the human body to the environment (i.e., ventilation), which are the two main humidity – related physical characteristics of a sleep system,

Body temperature should stay constant during sleep. When heat insulation is too low, the body will cool off resulting in muscle stiffness and sleeping disorders; when heat insulation is too high, transpiration will increase, resulting in a too high relative humidity and, consequently, sleeping disturbances. Thus, heat insulation properties of materials, especially of those materials used for the core of mattress and for its top layer(s), are of prime importance when optimizing climate regulation. From this Human Skin Simulate Testing tell us, PU- Foam group keeps warmer than Latex mattress materials. (from Figure 36 Heat Loss) However if we would be long lie down is made uncomfortable too high warm temperature in surface body area. In conclusion, the Latex material is best, when you must long lie down on bed. On the other hand latex material is not high Water – vapour Permeability characteristic when compare with PU- Foam mattress material group. So that if somebody have problem too sweat or high moist in body area should be used TC50M because result from these testing was the best this characteristic

Today mattress design produces many combine material in mattress for support zone segment body; hard and soft part; user mattress and locality

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sleeping. In this Study latex mattress material gave good elastic characteristic and TC50M gave good slow recovery (elastic) soft when lie down on material .

The Finally conclusion this the study master thesis mattress material with Human Skin Simulate had problem control as surface material each difference thick and quantity of materials sample is not many per testing . Therefore many factor is made error data or not exactly forecast data in This study.