Sleep Environment, Bedding Performance and a History of the Society of Sleep and Environments, Japan

ABSTRACT

The important characteristics of futons are heat retention, resilience, humidity transfer, weight, fit, durability etc. An outline of methods for testing and expressing these futon characteristics is presented, and the history of the Society of Sleep and Environments, Japan is described. Society of Study on the Regulation System in Biology, Symposium on Man-Thermal Environment System, Symposium on Human-Environment System, Symposium on sleep-environment, and International Conference on Human Environment System have been held later on in order.

Key words: futon, heat retention, resilience, humidity transfer, Society of Sleep and Environments, Japan

1. INTRODUCTION

The sleep environment is composed of factors including heat, light, sound, vibration, and air quality. With regard to heat, bedding (futons etc.) is designed to play an important role in creating a suitable environment for the sleeping body. Satisfactory sleep cannot normally be obtained unless the cold night air is excluded by bedding and a residential structure.

If we examine the body's thermoregulation during sleep, over the course of a night's sleep body temperature follows a circadian rhythm, falling as morning approaches, accompanied by a lowering of metabolic rate. On the other hand, peripheral arteries dilate raising the skin temperature of hands and feet. The environment inside the sleeping room varies according to geographical location and season, but normally the room temperature falls exponentially rather than at a uniform rate. Accordingly, heat emitted from the body passing through the bedding into the room varies with time in a very complex way that depends on the relationship between bodily changes and changes in room temperature. We need to use a variety of values to describe the heat retention performance required for bedding, depending on the type of sleep environment. These must be modified by local customs, and differences between individuals, genders and age groups. The values will also vary over time.

The problem lies in deciding what is a suitable environment for the sleeping body. This is not clearly defined, but it is commonly accepted as being an environment that guarantees a good night's sleep, allowing a person to adequately recover from mental and physical fatigue. To solve this problem we need to fully understand both the action of thermoregulation during sleep and the essential nature of fatigue.

The body frequently turns over during sleep to aid blood circulation and other functions. Insufficient turning can lead in extreme cases to bed sores. Bedding needs to be plump in order to relieve localized pressure on the skin, but if it does not possess enough resilience then more energy than necessary must be expended to turn the body during sleep. To cope with bodily movements during sleep, bedding must also be wide enough to provide a suitable draping effect.

We can see that the performance required for bedding is made up of multiple, complex factors. The important factors include heat retention, resilience, humidity transfer, weight, fit, and durability. These factors must all be studied for the whole set of bedding, from futon to blankets, in order to determine bedding performance.

Recognizing the many difficulties listed above, we see that it is essential to establish a testing

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methodology in order to clarify the performance requirements for futons .

The problem is that there are no evaluation methods for almost all the performance factors mentioned, and no measurements have been made. Because none of these factors are indicated on the product, consumers are able to base their choice of bedding only on looks, design and filling description. If we are to encourage the spread of good quality products, a performance evaluation indication is required to allow consumers themselves to make a comprehensively informed decision. A performance indication tag is especially important for items such as futons, which cannot be opened to look inside.

Bedding and bedrooms are the most important elements in the half our lives we spend sleeping. It is necessary to modernize the bedding industry through a scientific understanding of bedding and bedrooms, to enable the manufacture of bedding based on reliable data that can be sold with its performance clearly indicated. If we do not reform the current situation where consumers have no way to judge the performance of products, then the futon, which has long been a valued item, will fall victim to price cutting competition and end up in the worst possible situation as a cheap, poor quality product.

2. Research History

The futon was introduced a long time ago in the Muromachi era (late 14th to late 16th centuries), and became accepted throughout society with no real discussion of its properties. This changed in 1983, when the National Research Institutes established the Futon Standardization Survey Commission as an executive office for Zennichimen, the all-Japan association of cotton-filled bedding products. This commission not only standardized the conventional description of “nakawata” (the cotton filling of futons), it also concluded what factors relating to human physiological and psychological characteristics needed to be evaluated in finished futon products.

A nationwide survey was conducted to clarify the performance required for bedding. The interview-style survey targeted typical housewives in 4,200 homes from Hokkaido to Kyushu. There were divergences in the results, but, in descending order of desirability, the performance factors required for winter top futons were found to be heat retention, resilience, weight, humidity transfer, and fit, and for winter bottom futons to be heat retention, humidity transfer, resilience and durability.

The Yokohama National University Thermal Research Group developed methods for futon performance evaluation following the order of priority found in the survey results. They then completed work on (1) heat retention test apparatus, (2) resilience test apparatus, (3) drying machine for pretreating futons, (4) form measuring instrument (5) moisture transfer characteristic test apparatus, and (6) fatigue test apparatus, proposed a futon performance indication method and proceeded with an overall systematization of futon performance evaluation methods.

The optimal values for heat retention performance, etc., depend on environmental conditions in the bedroom such as temperature and humidity. To measure the relationship between bedding performance and a comfortable sleep environment, tests were performed in a climate-controlled room. Thermoregulation, brain waves and other physiological patterns during sleep, the temperature-humidity environment within bedding and the sleeping room environment were measured.

Sleep environments in actual homes depended on conditions differing from than those in the test room. These were not uniform and varied greatly according to season, region, type of house structure, use of heaters/coolers, etc. Analysis proved difficult in many cases, but real life studies identified many matters that were not found using the test room with its set conditions. It was essential to obtain a grasp of actual facts, and to conduct substantive research using typical real-world sleep environments. With the cooperation of large numbers of people, notably the members of Zennichimen, nationwide surveys were conducted to measure sleep environments in spring, summer, fall and winter. With the cooperation of the Tokyo Electric Power Company, a further survey measured sleep environments for the elderly throughout Japan, from Okinawa to Hokkaido.

Next, a comprehensive sleep environment survey method was established to give a complete grasp of body temperatures during sleep, bed and bedroom environments, and the external climate, and a method for expressing these values was proposed.

In use, the performance of a futon degrades over time. In order to make a realistic study of futon durability, a survey was conducted with the cooperation of the futon industry in which the performance degradation of various types of futons used in real-life conditions was measured.

From these results, the Bedding Performance Evaluation Standards Commission of the Japanese Society of Sleep Research prepared a set of bedding performance evaluation standards and a method for indicating futon performance. In addition, because an organization was required to evaluate performance tests on futons and other bedding, and to certify performance indications, the Sleep Environment Research Center was established.

It has been many years since futon performance evaluation research first began, but we have at last reached a conclusion.

This report is a summary of the research into evaluating futon performance conducted by the Yokohama National University at the request of the Japanese Society of Sleep Research and the All Japan Bedding Goods Association.

3. Futon Performance Evaluation Methods

3.1 Heat Retention Performance

Similar methods to those used for measuring heat retention performance in clothing can be considered: (1) testing in use by human subjects, (2) constant temperature method using heating elements, and (3) cooling method.

3.1.1 Usage Tests

This method seeks to establish the heat retention performance of bedding by measuring the skin temperature of the sleeping subject at various points, metabolic rate, amount of perspiration, temperature distribution through different layers of bedding, temperature distribution inside the bedroom, etc. The implementation of measurements for the various items, especially for measuring perspiration, is complex and difficult, but in the case of measuring heat retention performance it is permissible to use a low temperature environment in which perspiration does not occur. Moreover, even if the subject does not sleep and tests occur in the waking state, it is possible to observe the effect of factors such as posture and turning. However, the amount of heat radiated due to metabolic activity cannot be measured separately in the up and down directions, so this method can only be used for heat retention performance of the entire bedding set.

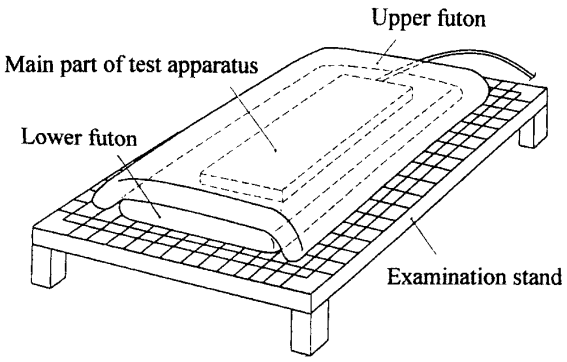


Fig.2 Futon heat retention performance test apparatus

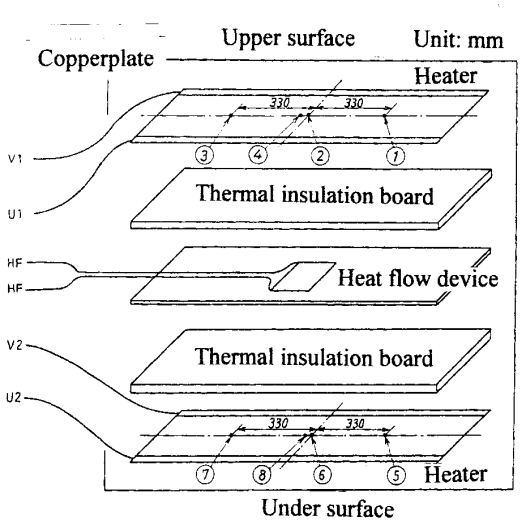


Fig.3 Main part of futon heat retention performance test apparatus (Patent)

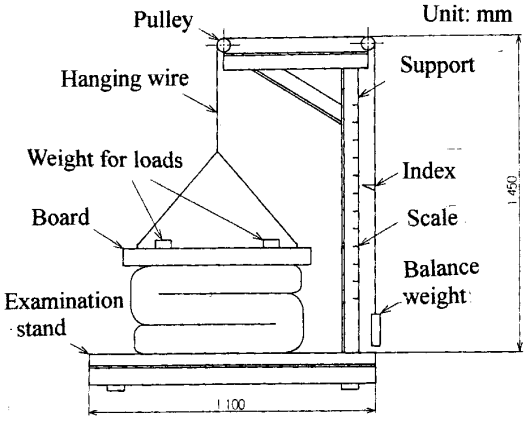


Fig.4 Resilience test apparatus for futon finished products

3.1.2 Cooling Method

The cooling method seeks to establish futon heat retention performance by inserting a heated object into the futon and measuring the time taken for

cooling. This method has the advantage of being relatively inexpensive to implement. When the object is a flat shape, heat flow meters placed on the upper and lower surfaces allow the top and bottom futons to be measured separately. If the futon is too thick in relation to the heat capacity of the test apparatus, the amount of heat accumulating within the futon will become larger than the amount passing through and the measurement accuracy as ability to intercept heat will fall radically.

3.1.3 Constant Temperature Method

To compensate for the disadvantages of the cooling method, this method includes a heating element supplying heat to control the surface temperature at a constant value.

3.1.4 Futon Heat Retention Performance Test Apparatus（Patent）

In order to improve the accuracy of the tests, separate heating elements were used for upper and lower sections of the bedding, with heat flow meters placed to measure of the amount of heat transferred internally and provide corrected values. The heating elements used were carbon heaters in sheet form, the surface covered by 0.1 mm thick copper sheet painted to form a black body. Sensors to regulate the surface temperature and safety equipment were included beneath the copper sheet, and a PID controller was used for the regulator to minimize temperature variations. Heating elements closer to the shape of the human body would have been ideal, but the flat shape was chosen for ease of handling and for cost, since it was commonly available.

This test apparatus had several advantages. (1) It allowed simultaneous upper and lower measurements, (2) it could show the heat retention performance of each of the various layers of bedding (futon, blanket, etc.) and (3) by using materials with small heat capacity, it allowed measurements to be made comparatively rapidly.

Measurements made using this heat retention test apparatus included the relationship between heat retention performance and the quality and amount of filling materials, the effect of the futon-cloth on heat retention, the effect of weight on the heat retention of the lower futon, and the effect of the ratio of moisture content included in the futon.

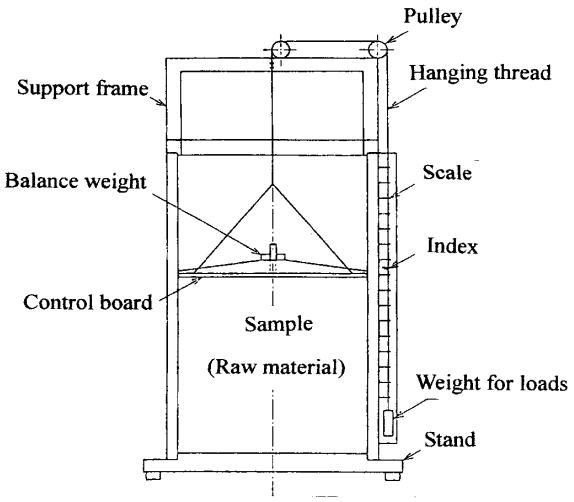


Fig.5 Resilience test apparatus for down (raw materials)

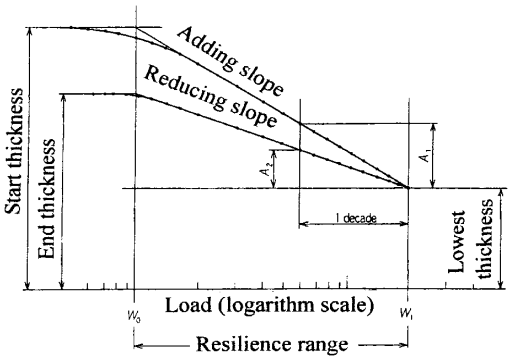


Fig.6 Resilience characteristics of futon

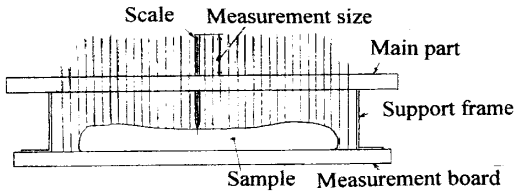


Fig.7 Form measurement instrument for futon finished products

This heat retention test apparatus was approved as a JIS standard.

3.2 Resilience

3.2.1 Futon Resilience

The results of the survey showed that there was a high level of demand for plumpness in bedding. This could be restated as a need for bedding that keeps its heat retention properties for a long period and which does not easily lose its thickness and become hard.

3.2.2 Resilience Test Apparatus for Futon Finished Products

Futons were folded in three or in four and lightly

restrained by a board that would not cause deformation (100 mm thick expanded polystyrene, etc.). A weight was then applied to determine the relation between compressive load and dimension (bulk). Weight was added up to about 30 kg. The weight was then reduced and the recovery process measured. Using a pulley with low frictional resistance to balance the restraining board, measurements could be made starting from zero weight.

3.2.3 Resilience Test Apparatus for Down (Raw Materials)

In the JIS-L1903 down bulk test, measurements are made using a greater compressive load than would be found under real-life conditions. This allows the quality of materials to be compared, but it is inadequate to evaluate the performance in real use by the consumer. For this reason, a resilience test apparatus was developed for down raw materials.

The measurement method used a 13 g restraining board (the lowest useable weight) and a set of standard weights (10 x 14 g). 30 g of down material were allowed to drop naturally into a 29 cm internal diameter cylindrical container. A restraining board was placed on top of the down and the weights were added one by one to determine the relation between compressive load and dimension (bulk). The recovery process was measured in the same way as before, using a pulley with low frictional resistance to balance the restraining board so measurements could be made starting from zero weight.

These resilience test methods were approved as JIS standards.

3.2.4 Special Resilience Characteristics of Fiber Aggregates

The measurement results for futon finished products, when shown on a semilogarithmic scale, reveal the existence of a range over which bulk and load weight have a linear relationship. Similar resilience characteristics were found for all kinds of materials: different varieties of down, cotton, wool and synthetic fiber. And the same results were obtained when testing the resilience of filling materials.

In normal spring materials, load weight and dimensions have a simple proportional relationship

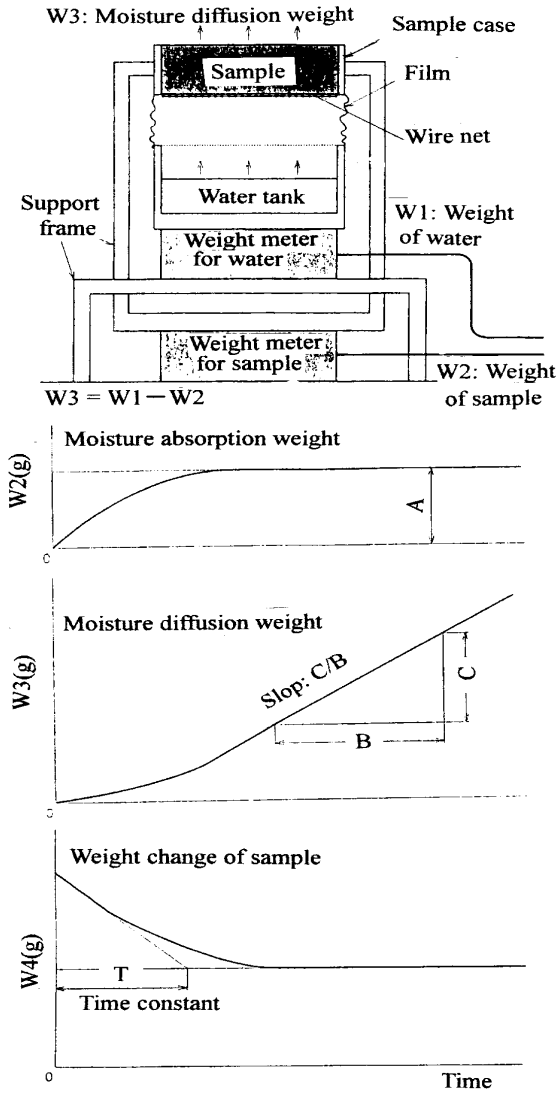


Fig.8 Moisture transfer characteristics
(Moisture transfer characteristics test apparatus from a top, futon absorbency, moisture diffusion and moisture permeability) (Patent)

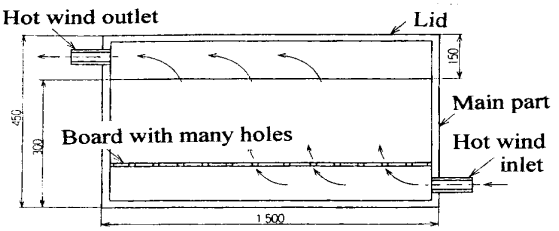


Fig.9 Futon humidification and drying apparatus
High-speed drier

called the spring constant, but these aggregates show fundamentally different characteristics. These special resilience characteristics can be seen as the normal features of fiber aggregates, and are thought to be due to the resilience of each fiber and to friction between fibers.

The range where bulk and load weight have a linear relationship was named the Fiber Aggregate Resilience Range. This range is important for bottom

futons, since if the futon is not within this range, the user can feel the floor through the bedding. It is desirable that bottom futons should be within this resilience range.

3.3 Form Measurement Instrument for Futon Finished Products

A finished futon product is laid on a flat board and a contact gauge is used to measure the distance (bulk) between the upper surface of the futon and the board at points sited on the futon approximately 30 mm transversely apart. This gives a description of the form of the futon's surface. In places such as where the futon's gussets cause gaps between the futon lower surface and the board, double sided tape is used to make the futon surface flush with the board for measurement. If the form of the entire futon is to be measured, measurements are made by repeating these measurement points in the longitudinal direction.

3.4 Moisture Transfer Characteristics

3.4.1 Futon Absorbency, Moisture Diffusion and Moisture Permeability

The absorbency and moisture diffusion properties of a futon appear to have a large impact on comfort during sleep. The human body emits about 100 cc of moisture during each night during sleep. Some of the moisture that evaporates from the skin in perspiration is absorbed by the futon, while some passes through the futon and is diffused into the surrounding atmosphere. If the futon's absorbency or moisture permeability (the ability of moisture to permeate through the futon) are poor, humidity will rise in the air in the vicinity of the skin. Perspiration will not evaporate, and instead will either remain on the skin or be absorbed by the futon directly as water droplets. If this happens, the thermoregulating functions of perspiration will be impeded and sleep will become uncomfortable.

Moisture that accumulates in the futon is normally released naturally, or more efficiently by drying in the sun or use of a dryer. However, in seasons or other circumstances where room humidity is high, the reverse can be observed in practice: the futon absorbs moisture during the day and is dried at night by the heat of the sleeping body.

When considering a futon's performance, we need to look at absorbency, moisture diffusion and

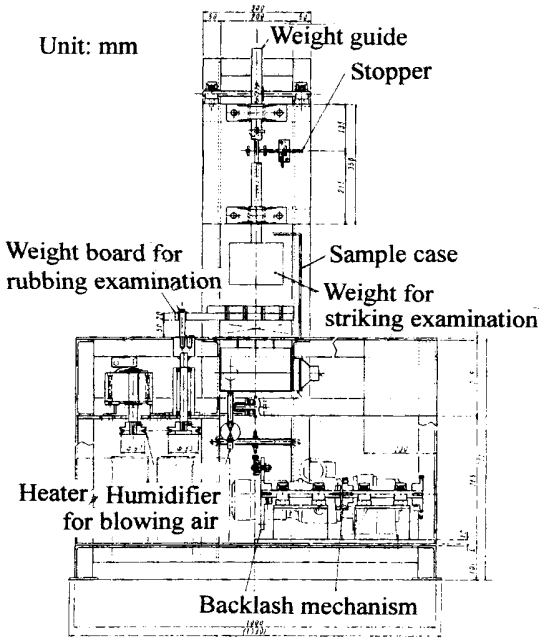
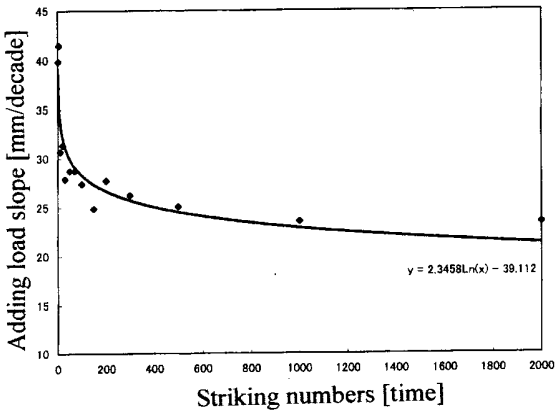


Fig.10 Futon durability test machine



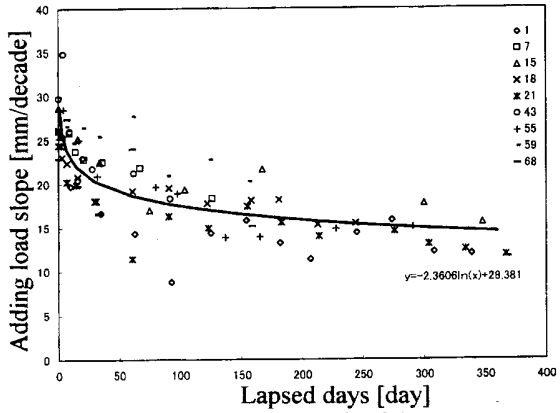


Fig.11 Comparison as result of durability test machine and futon durability usage survey

moisture permeability, and rather than looking just at static, unchanging characteristics, it is necessary to obtain a grasp of the dynamic characteristics to see how they change over time.

In a real-life sleep situation, this mass transfer of

moisture accompanies the transfer of heat, as described above, in a periodic phenomenon where moisture absorption, diffusion and permeation combine in a daily cycle. It is necessary to establish methods for evaluating absorbency, moisture diffusion and moisture permeability.

3.4.2 Futon Moisture Transfer Characteristics

Each kind of futon filler material has its own water saturation factor, and moisture within this range that is absorbed from the sleeping body or its surrounding air can be diffused by sun drying, etc. Moisture transferred and diffused from the sleeping body passes through the futon and is released into the air of the sleeping room. (1) The water saturation factor, or amount of moisture retained, can be found from the weight difference in the test room at equilibrium between the absolutely dry state and a standard state. (2) The transfer characteristics for absorbency and moisture diffusion can be found by examining the transition process from the absolutely dry state and the standard state or vice versa. However, because this transition process is greatly affected by the shape and surface conditions of the futon at the time of testing, the test method must be standardized. (3) The moisture permeability can be found by measuring the amount of moisture transferred through the futon, using the difference in humidity levels between the inside of the bedding and in the bed room.

Regarding the futon moisture transfer characteristics test method, a fundamental study is required to determine which characteristics to focus on - absorbency, moisture diffusion or moisture permeability - and whether to use a test method that examines all of them together, or to use a mix of methods. For the moisture permeability test method, two methods are available: to supply a determined amount of moisture to the inside of the bedding and to find the moisture permeability rate from the humidity difference between bed interior and bed room; or alternatively to control the humidity inside the bed to a constant amount and to find the moisture permeability rate from the amount of water required to achieve this.

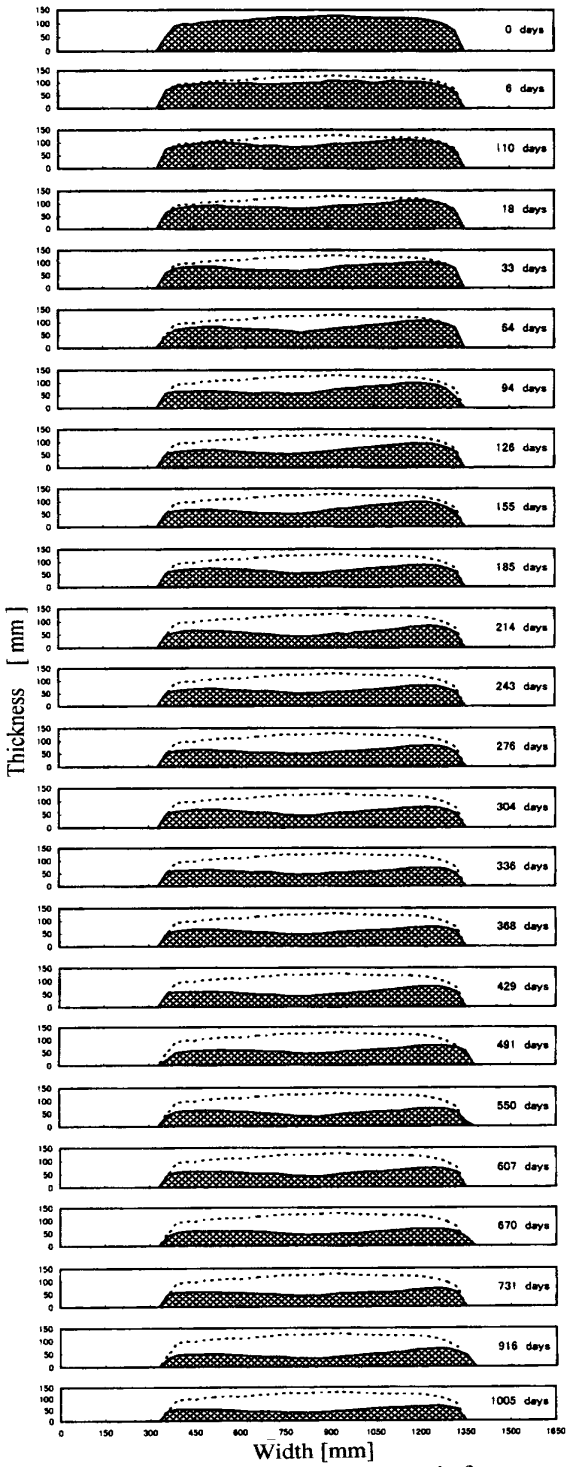


Fig.12 Change of futon fatigue in futon durability practical usage survey (Central part, Sample: Cotton)

3.4.3 Moisture Transfer Characteristics Test Apparatus（Patent）

The test apparatus developed used two precision weight meters to measure the amount of water supplied to the test materials and the amount absorbed by the test materials. Absorbency, moisture permeability and moisture diffusion could be measured separately. This futon moisture transfer characteristics test method was adopted as a JIS standard.

3.5 Futon Humidification and Drying Apparatus

In order to measure the futon absorbency and moisture diffusion performance, we must be able to adjust the proportion of moisture in the futon.

To enable this, a futon humidification and drying apparatus was constructed to allow the water content in the futon to be relatively easily adjusted. Futon performance is affected by the water content of the futon.

3.6 Futon Durability Test Method

3.6.1 Durability

As well as having basic performances such as retention, resilience, and water transfer characteristics at the time of its manufacture, a futon must also retain these performances over a fixed period. Users demand that a futon should have plumpness, in other words that it should not become thin and hard. Since there was no method for evaluating performance degradation and no surveys had been made to determine service life, futon manufacturers were in the past unable to answer consumer questions on this subject.

Moreover, since there was no way to determine performance degradation, many futons that had become virtually unusable were simply left in cupboards, taking up valuable storage space in crowded homes. An indication is needed, something like an expiry date, to allow the consumer to judge the appropriate period of use. A standard plan for the disposal or recycling of futons cannot be developed without data on futon degradation.

3.6.2 Futon Fatigue Test Apparatus

The method used to test durability involved measuring resilience and other performance for a new futon, using the fatigue test apparatus to degrade the futon's performance, and then measuring the difference to evaluate the performance degradation that occurred.

The fatigue applied to futons attempted to approximate real-life conditions of use though repeated drying and humidifying, and repeated application of compressive and crumpling loads.

Reduction in size of test materials to 20 x 20 cm allowed the test apparatus to be made smaller and easier to handle than the first prototype. Using this test apparatus revealed that the effect of crumpling was very significant.

Futon durability and the performance degradation process cannot be understood without a survey employing real-life usage. Accordingly, a project to survey futon durability in real-life usage was conduced with the cooperation of the bedding industry.

Matching the results obtained from the fatigue test apparatus with those from the real-life usage survey, the relation between number of tests and service life was obtained. This made it possible to use the data from the fatigue tests to estimate the service life of a futon.

Two test methods were decided upon: a complex test method in which striking, crumpling drying and humidifying were performed sequentially over time, taking into account real-life sleeping times; and a simple-to-use striking test method.

In Figure 15 one of the results from the futon durability usage survey shows large degradation during the initial period of use. In some cases, bulk falls to 50% over the first 6 months, and to 30% by the end of the first year of use. Looking at the initial period only, there are striking examples of consumers suffering from the choice of inferior products.

3.7 Bedding Layering, Weight and Fit

Futons are normally used together with layers of other bedding such as blankets. When selecting bedding, many consumers simply make their decision based on whether the futon is a good futon or the blanket is a good blanket.

In fact, the characteristics of futon and blanket should be considered for use layered together. When looked at like this, a thin blanket for example is more suitable for layering than a thick one, and it should be understood that a weight should be chosen that will act to increase the bulk of the futon. For the same heat retention, lighter, layered bedding can be selected; and for the same weight, bedding with layers giving high heat retention can be selected.

Blankets play an important role as shock-absorbing materials to assist the comfort and fit of futons. The fit of the futon itself is important, and this is evaluated using the futon drape measurement method. In the same procedure used to test drape performance of fabrics, a futon is placed on a 100 cm long, 30 cm diameter cylinder and number of folds produced is measured.

4. Futon Performance Indication

In addition to the futon performance factors described above, other items valuable to help consumers make purchase decisions include stowability, flame resistance, pattern and design.

The problem is that almost none of the above-mentioned performance factors have ever been measured. Because these factors are not indicated on the product, consumers are able to base their choice of bedding only on external looks, design and filling description. If we are to encourage the spread of really good quality products, a performance evaluation indication is required to allow consumers themselves to make a comprehensively informed decision. This comprehensive judgment need not be standardized; it can be left to the individual consumer to decide which items are important or not to their needs. It is important that manufacturers clearly indicate all these performances.

Homes, and especially bedrooms, are places where people recover from life's fatigue during sleep. It is vital to provide a scientific explanation of the performance of bedding and bedrooms, so important to the half of our lives we spend sleeping, and to base the manufacture and sale of bedding on this data.

Figures 14 and 15 show the performance evaluation standards for futons and the method used to indicate them.

5. History of Sleep Environment Societies

Human life cannot be separated into day life and night life. In sleep environment research, it is important to make a broad-based, integrated study of human-environment systems.

To grasp the essential problems related to humans and the environment, it is necessary to see the issue broadly as a system, and to strive to organize research results from many fields as a human-environment system. Close cooperation between researchers in all these fields is essential for the organic integration of these results.

The Society of Study on the Regulation System in Biology was set up to begin thermoregulation research. This led to the Symposium on Man-Thermal Environment System, the Conference on Human-Environment System, the International Conference on Human Environment System, and the Sleep Environment Symposium. The history of these symposiums will be outlined below.

5.1 Society of Study on the Regulation System in Biology, Symposium on Man-Thermal Environment System, Symposium on Human-Environment System, the International Conference on Human Environment System

Communications between medical and engineering science researchers provided conditions favoring cooperation between these fields to tackle questions on biological regulation systems, and this led to the establishment in April 1967 of the Society of Study on the Regulation System in Biology. The present author was in charge of its executive office, and choosing the human thermoregulation system as a research topic, began measuring the characteristics of that system. This thermoregulation system was attractive not only as a simple biological control information system, but also because it provided deeper insights into the basis of the human-thermal environment system, comprising elements as diverse and deeply related to human life as clothing, heating and cooling systems and housing environments.

The thermal environment has a fundamental relationship to all forms of life, including human, and therefore comprises an important part of the human-environment system. To achieve a correct understanding of the human-thermal environment system, it is important for researchers working in a wide range of different fields to cooperate closely in the investigation of the various issues involved. To this end, the first Symposium on Man-Thermal Environment System was held in August 1977 at the Society of Heating, Air-Conditioning and Sanitary Engineers of Japan. This Symposium has been held every year since, under the auspices of the Science Council of Japan.

Until now, basic physiological and psychological data have been accumulated on thermoregulation in ordinary persons, the aged, the disabled and children, and research studies have been conducted in residences, offices, factories, vehicles/transportation and traditional old private houses. The symposium has featured discussion of the issues involved in working in adverse environments such as fire fighting, in refrigerated warehouses and in high and low pressure environments; thermoregulation during

physical exercise; and issues relating to bedding and the sleep environment. These issues have been examined from many angles, including physiological, psychological, clothing, environmental and construction related approaches, to expand the range of physiological, psychological and environmental physical measurement methods available.

The symposium has served as a forum to deepen the exchange of information between researchers in medical science, physiology, human engineering, air conditioning and sanitary engineering, clothing hygiene, architecture, control engineering and heat transfer engineering, and between engineers in the housing, construction, textile, medical treatment, air conditioning system, control equipment, fire fighting and automobile industries. This has resulted in cooperative research between many diversified fields.

The symposium was intended to be a research community based on engineering and real-life problems, but thanks to the wide-ranging cooperation it achieved, it has become a truly interdisciplinary forum.

Since about 1990, the topics covered by the symposium have expanded from thermal environments to include issues such as room air quality, and it was considered whether to expand the focus to cover human-environment systems. It was thought that the time had come for interdisciplinary research going beyond narrow specialties, as indicated by the panel discussion at the 16th Symposium on Man-Thermal Environment System, which covered issues linking space, earth, city, architecture, clothing and human beings.

To indicate the broadening of its concerns from human-thermal to human-environment systems, the name of the symposium was changed to the Symposium on Human-Environment Systems, and it began attracting participants from an even wider range of fields. The symposium preparation committee was reorganized to become the Japanese Society of Human-Environment Systems, reflecting its comprehensive range of research interests.

To make this a truly interdisciplinary society, it was seen as necessary to provide an equal platform for all specialist fields, and the society expanded to admit researchers and engineers from all fields and also the general public.

The Japanese Society of Human-Environment System aims to act as an organic link for knowledge and technology in a wide range of fields related to human living environments, to systematize the human-environment system, to work toward the realization of living environments where people can live in health and comfort, and to contribute to improving the quality of human life. To achieve these goals, the society holds the Symposium on Human-Environment System, conducts factual investigative research related to the human-environment system, proposes research to improve this environment, holds classes and workshops, issues the society's Journal of the Human-Environment System and other publications, and engages in cooperative activities and exchanges with organizations and individual researchers, engineers and members of the public both domestically and internationally. Table 1 lists this history.

5.2 Society of Sleep and Environments (SSE)

The Society of Sleep and Environments (SSE) was established to specialize in research into sleeping environments.

Human life consists of alternating activity and rest. After any substantial activity, we need an adequate period of rest. It is very important that we conduct research into the nighttime sleep environment and bedding equivalent to that conducted into the daytime active environment and clothing. SSE held the first Sleep Environment Symposium in August 1985, aiming to provide a qualitative explanation of sleep and evaluate bedding performance. The success of this symposium led to its being repeated annually ever since.

Table 2 lists the work done on futon performance evaluation and performance indication. Figure 16 gives an outline of research into sleep environments.

Categories to be evaluated to allow the creation of a healthy, comfortable sleep environment include (1) bedding performance, (2) the physiology of human sleep, and (3) sleep environment, but we must not overlook the elements that link these together: (4) the human-bedding interface and (5) the human-sleeping room interface. Many issues must be studied to obtain a comprehensive grasp of (6) humans, bedding and bedroom as a system. Factors such as sleeping posture and pressure distribution are related to (4) the

human-bedding interface. It is important to clearly rank the issues being handled. (Figure 16)

To achieve the above objectives, SSE engages in the following activities:

1) Performance evaluation method and indication method

Setting up a standard performance evaluation method and deciding a labeling method for indicating performance that will be easy to use and acceptable to consumers.

2) System for testing, evaluating and labeling futons

Setting up a system for testing, evaluating and labeling futons.

3) Seminars, conferences, etc.

• Lectures and training in the use of heat retention test apparatus, resilience test apparatus, drying machine for pretreating futons, form measuring instrument, moisture transfer characteristic test apparatus, and fatigue test apparatus.

• Lectures and training in methods for measuring physiological and psychological states during sleep in an artificial climate chamber.

• Lectures and training in methods for studying actual sleep environments using environmental thermometers, etc.

• Lectures in cerebral physiology, thermoregulation during sleep, physiology of sleep disorders, physiology of bedsores, sleep in the elderly and ill, etc.

4) Producing an easily understandable manual on bedding performance, and ensuring it is distributed to stores selling bedding and bedclothes.

5) Establishing a recognized system of qualifications for bedding performance consultants, etc.

On Sept. 2, 2000, a sleep environment seminar on bedding performance evaluation was held that produced the first bedding performance consultants. In addition, a sleep environment mini workshop on understanding futons and sleep was held, which produced the first sleep environment coordinators. These graduates are now active in many areas, and the objective is to expand the training to produce technicians with Meister level proficiency.

6) In order to measure and evaluate the performance of futons and issue performance indication labels, the Sleep Environment Center was established. Facilities at the Center include futon heat retention test apparatus, resilience test apparatus, moisture transfer characteristic test apparatus, durability test apparatus, form measuring instruments, high-speed driers and environmental test chambers.

7) The Sleep Environment Center's activities include holding seminars and lectures on futon performance, certifying bedding performance consultants, conducting surveys, research and publication concerning sleep environments, and issuing the Journal of the Society of Sleep and Environments.

6. Conclusion

Research into human living environments becomes a science when it becomes capable of solving actual problems. Research into futon performance evaluation took many years to reach these conclusions.

We developed bedding performance test apparatus, made real-life surveys of bedding, and decided a method for indicating bedding performance. To spread acceptance of this system, sleep environment courses were held to produce bedding performance consultants and sleep environment coordinators. The Sleep Environment Center was established to measure and evaluate futon performance in order to cooperate with the members of the bedding industry in bedding development, etc.

I believe that we can contribute to a fundamental improvement of the bedding and bedclothes industry and an improvement in the quality of life for everyone.

The author has followed a common theme - humans and the environment - throughout all the executive positions, including president, that he has held in organizations that include the Society of Study on the Regulation System in Biology, the Symposium on Man-Thermal Environment System, the society of Human-Environment System, the International Conference on Human-Environment System, and the Society of Sleep and Environments. Thanks to the endorsement and support of a great number of people, I have been able to devote myself wholeheartedly to human-environment system researches, starting with biological control information systems like the human thermoregulation system, and going on to cover measuring instruments such as "vinyl gloves" and environmental thermometers, incubators, fire-fighting clothing, radioactivity protective clothing, cold resistant

lifesaving clothing, home environment surveys, transportation environment surveys, comprehensive surveys of office building environments, comprehensive nationwide surveys of home thermal environments, sleep environment surveys, and bedding performance evaluation. Looking back from the present, it seems a reckless decision to have leaped into such a huge field of study as the human-environment system, but thanks to that decision, I was exposed to an extraordinary variety of fields and had the good fortune to work with people of great ability in many disciplines. I humbly take this opportunity to express my gratitude to them all.

7. REFERENCES

Kawashima,Y.1993 :Characteristics of temperature regulation system in the human body, J. of Thermal Biology, Vol.18, No.5/6. pp307-323.

Kawashima,Y. et al 1993 :A study on body temperature regulation and residential thermal environments of the elderly – whole country survey of residential thermal environment and evaluation methods: RTE-index, J. of Thermal Biology, Vol.18, No.5/6. pp487-499.

Kawashima,Y., Y.Tochihara, S.Gotoh, M.Kaji, Y.Osada ed. 1993 :The Human-Environment System, Pergamon Press.

Note: Figure 1,13~16 and Table 1 ,2 will be shown at the conference. And they will be included in the http: //futon-center.com.

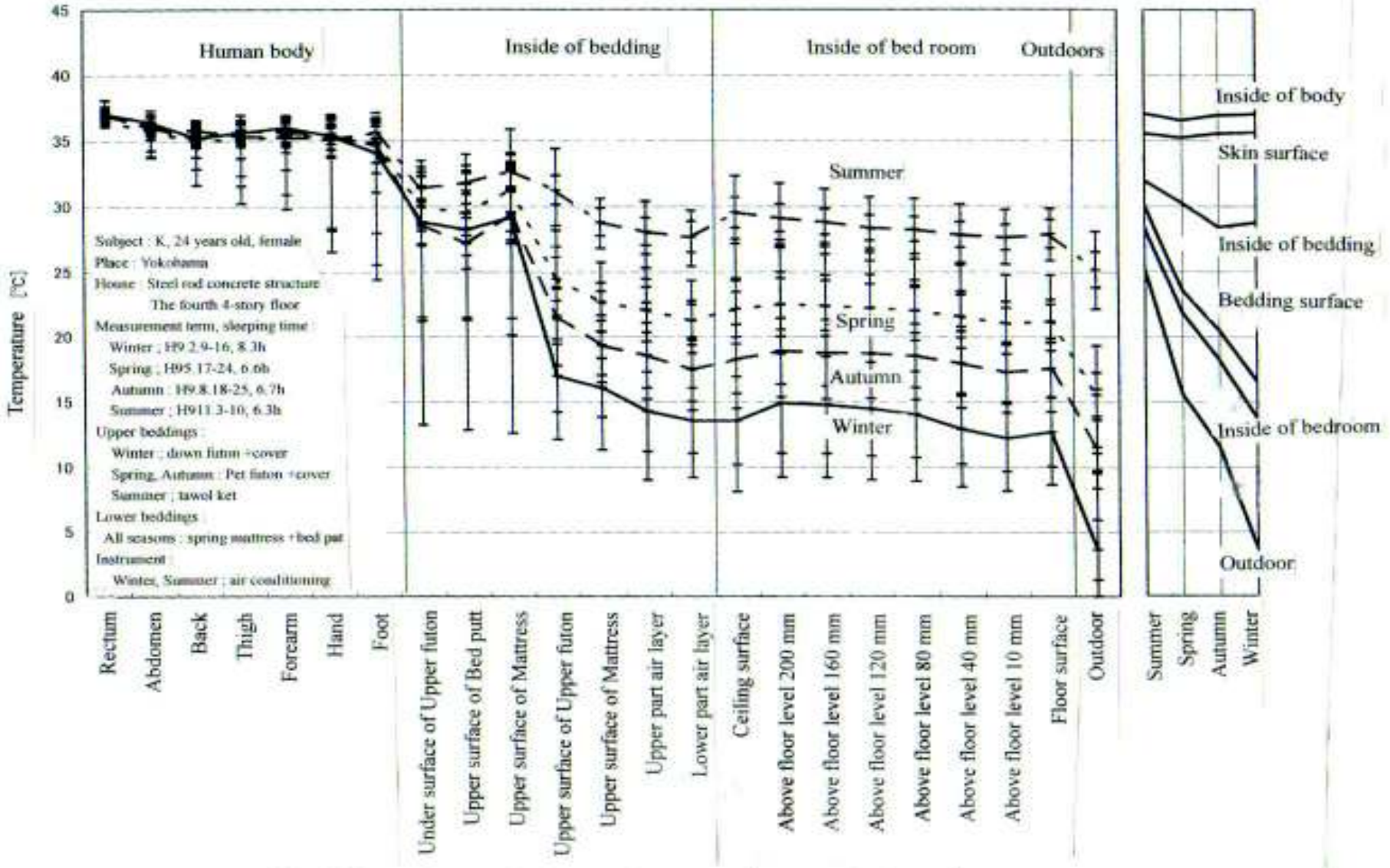


Fig.13 Investigation of sleep environment (seasonal change)

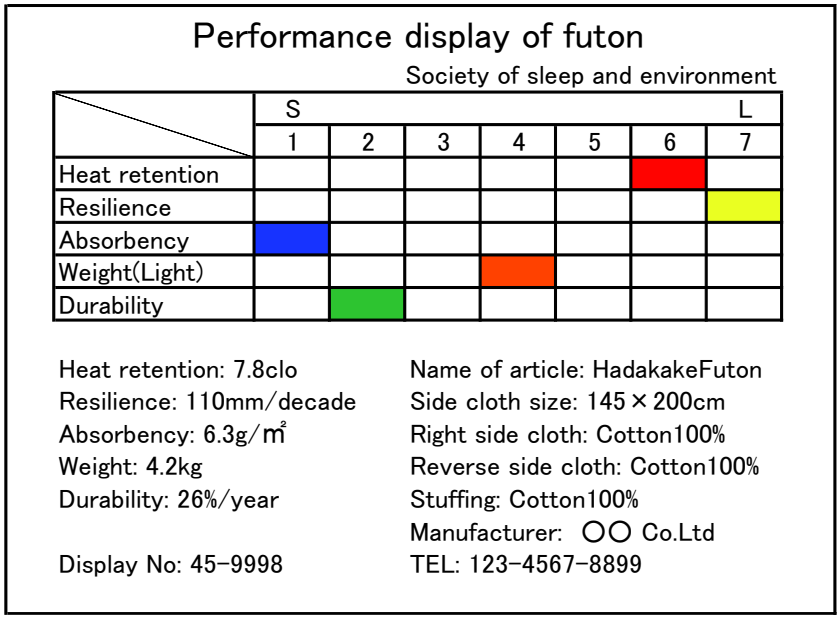


Fig.14 Performance display of futon

	S						L
	1	2	3	4	5	6	7
Heat retention [clo]	less than 1.5	not less than 1.5 less than 3.0	〃 3.0 〃 4.5	〃 4.5 〃 6	〃 6 〃 7.5	〃 7.5 〃 9	〃 9
Resilience [mm/decade]	less than 10	not less than 10 less than 20	〃 20 〃 30	〃 30 〃 40	〃 40 〃 50	〃 50 〃 60	〃 60
Absorbency [g/㎡]	less than 20	not less than 20 less than 40	〃 40 〃 60	〃 60 〃 80	〃 80 〃 100	〃 100 〃 120	〃 120
Weight(light) [kg]	not less than 6	not less than 5 less than 6	〃 4 〃 5	〃 3 〃 4	〃 2 〃 3	〃 1 〃 2	〃 1
Durability [%/year]	less than 20	not less than 20 less than 35	〃 35 〃 50	〃 50 〃 65	〃 65 〃 80	〃 80 〃 95	〃 95

Fig.15 Performance criteria of futon

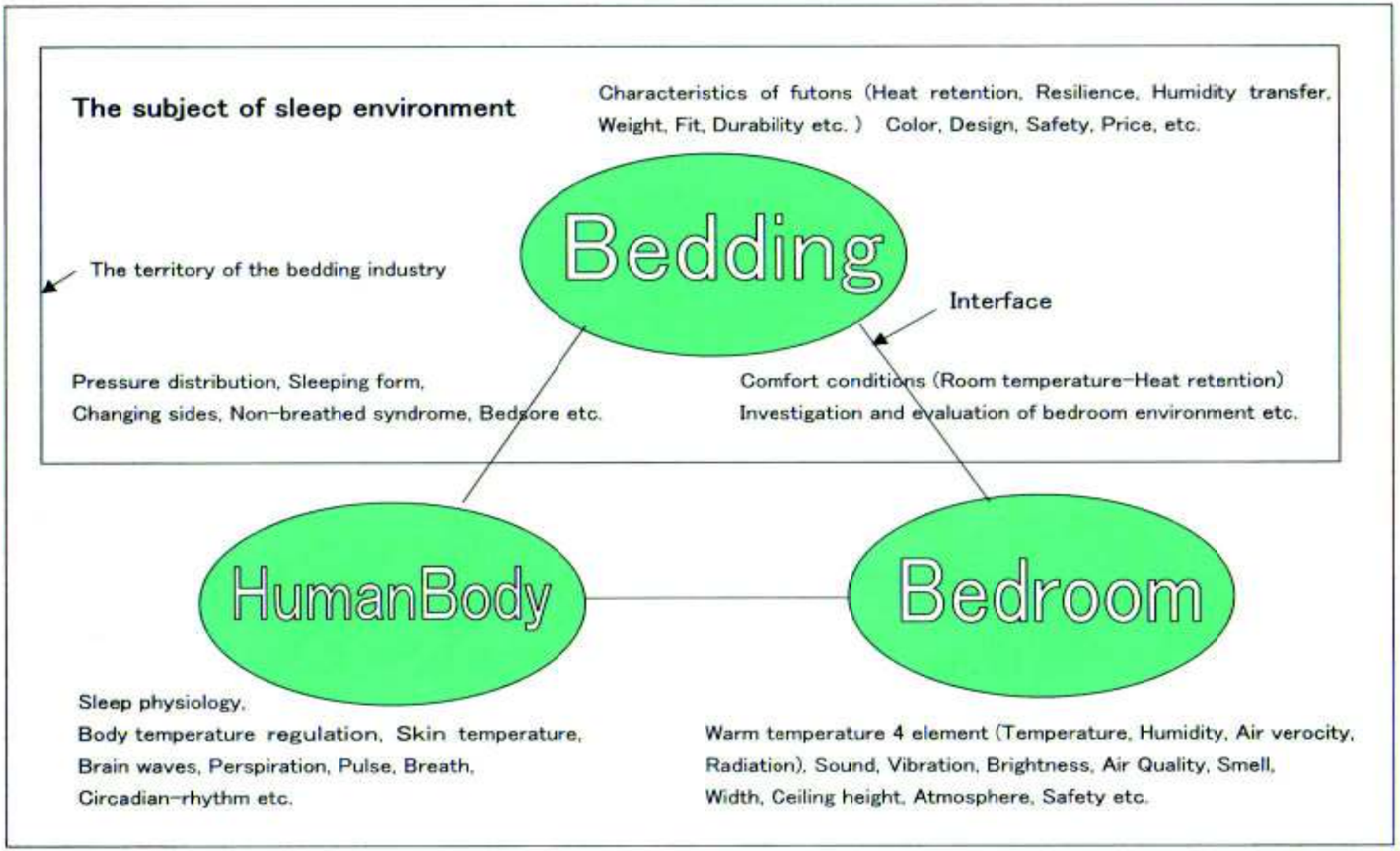


Fig.16 The subject of sleep environment

Table 1. The History of Society of Study on the Regulation System in Biology, Symposium on Man-Thermal Environment System, Symposium on Human-Environment System, the International Conference on Human Environment System, Symposium on Sleep Environment, and the Society of Sleep and Environments

No.	year	Human-Environment Systems	International Conference	Sleep-Environment Systems	Others
1	1967	Society of Study on the Regulation System in Biology			
2	1968	〃			
3	1969	〃			
4	1970	〃			
5	1971	〃			
6	1972	〃			
7	1973	〃			
8	1974	〃			
9	1975	〃			
10	1976	〃			
11	1977	1st Symposium on Man-Thermal Environment System			
12	1978	2nd 〃			
13	1979	3rd 〃			
14	1980	4th 〃			
15	1981	5th 〃			
16	1982	6th 〃			
17	1983	7th 〃			
18	1984	8th 〃			
19	1985	9th 〃		1st symposium on sleep-environment	Symposium on Evaluation of Residential Thermal Environment
20	1986	10th 〃		2nd 〃	
21	1987	11th 〃		3rd 〃	
22	1988	12th 〃		4th 〃	
23	1989	13th 〃		5th 〃	
24	1990	14th 〃		6th 〃	
25	1991	15th 〃	1st International Conference on Human Environment System	7th 〃	
26	1992	16th 〃		Society of Sleep and Environment System, Established. 8th symposium on sleep-environment	Celebration Symposium of International Conference on Human Environment System 1st Symposium on Thermal-Environment for Aged
27	1993	Society of Human-Environment System, Established. 17th Symposium on Human-Environment System		9th 〃	
28	1994	18th 〃		10th 〃	
29	1995	19th 〃		11th 〃	1st Symposium on Human-Environment and Calamity 2nd Symposium on Thermal-Environment for Aged
30	1996	20th 〃		12th 〃	2nd Symposium on Human-Environment and Calamity
31	1997			13th 〃	
32	1998		2nd International Conference on Human Environment System	14th 〃	1st Symposium on Indoor Air Quality 1st Symposium on Human-Environment in Vehicle
33	1999			15th 〃	
34	2000			16th 〃	
35	2001			17th 〃	
36	2002			18th 〃	
37	2003			19th 〃	
38	2004			20th 〃 21st 〃	
39	2005			22nd 〃	

1.The Sleep Environment Institute, Japan (Formaly Kawashima Labo., Division of Artificial Enviroument Systems, Graduate School of Engineering, Yokohama National University)

2.The author has followed a common theme - humans and the environment - throughout all the executive positions, including president, that he has held in organizations that include the Society of Study on the Regulation System in Biology, the Symposium on Man-Thermal Environment System, the society of the Human-Environment System, the International Conference on Human-Environment System , and the Society of Sleep and Environments.

Table 2 The History of Study on Futon Performance Evaluation Methds and The Society of sleep and Environments

No.	Year	Symposium, Conference etc	Futon Performance Evaluation	Projects	Seminares	Plans
1	1983	Futon Standardization Survey Commission				
2	1984	Nationwide survey of futon				
3	1985	1st symposium on sleep-environment				
4	1986	2nd symposium on sleep-environment				
5	1987	3rd symposium on sleep-environment	Futon Heat Retention Test Apparatus			
6	1988	4th symposium on sleep-environment				
7	1989	5th symposium on sleep-environment	Futon Resilience Test Apparatus			
8	1990	6th symposium on sleep-environment	Futon Durability Test Apparatus (Type No.1)			
9	1991	7th symposium on sleep-environment				
		1st ICHES				
10	1992	Society of sleep and environment,Established				
		8th symposium on sleep-environment				
11	1993	9th symposium on sleep-environment				
12	1994	10th symposium on sleep-environment	Moisture Transfer Characteristics Test Apparatus			
13	1995	11th symposium on sleep-environment	Futon Fatigue Test Apparatus			
14	1996	12th symposium on sleep-environment	Futon Heat Retention Test Apparatus (JIS)			
15	1997	13th symposium on sleep-environment				Sleep Environment Institute, Japan
16	1998	1st symposium on Futon Performance Evaluation	Futon Resilience Test Apparatus (JIS)	Project on durability in actual use		
		(14th symposium on sleep-environment	Moisture Transfer Characteristics Test Apparatus(JIS)			
		2nd ICHES				
17	1999	15th symposium on sleep-environment	Futon Performance Test Apparatus and displey methods	Project on durability in actual use		
18	2000	16th symposium on sleep-environment		Project on durability in actual use	1st seminare on sleep-environments	
					1st forum on sleep-environments	
					2nd forum on sleep-environments	
19	2001	17th symposium on sleep-environment	HomePage: Society and Sleep Environments	Project on durability in actual use	2nd seminare on sleep-environments	Project on comfort conditions in sleep
		Meeting for final report on survey of durability			3rd forum on sleep-environments	Project on pressure distribution and sleeping form
		(Project on durability in actual use)			1st mini seminare on sleep-environments	
					2nd mini seminare on sleep-environments	
20	2002	18th symposium on sleep-environment			3rd mini seminare on sleep-environments	
21	2003	19th symposium on sleep-environment	Sleep Environment Institute, Japan		3rd seminare on sleep-environments	Project on Durability test method of feather futon
					4th mini seminare on sleep-environments	
22	2004	20th symposium on sleep-environment			4th forum on sleep-environments	Project on Investigation and evaluation of bedroom environment
		21st symposium on sleep-environment			5th forum on sleep-environments	Project on measureing device of sleeping form on futon
					5th mini seminare on sleep-environments	
23	2005	22nd symposium on sleep-environment			6th forum on sleep-environments	
					6th mini seminare on sleep-environments	

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