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Viscoelastic foam mattresses: marketing hype or molecular miracle?

By Liz White, UT Contributing Editor

In the last decade, a new type of flexible foam—commonly called 'viscoelastic' or 'slow' foam—has achieved a high profile in the mattress market.

Its marketing might lead you to believe that this is a magic material with quite amazing properties (see box, below).

But for once, the claims for the materials are not just marketing hype: as Paul Bergad, managing director of US mattress maker Bergad Inc. explained, "What excited us most [about viscoelastic foam] was that it had benefits as well as a story."

Tempur World

Slow to recover—and heat sensitive.

Anybody can promote a product well, Bergad said, but it is different when the product has major advantages over competing materials—as viscoelastic foams have in health features (see box right).

High damping

"A key feature of 'visco' foam is that it is lazy or slow, with high damping. One of its main characteristics is very low resilience, there is no spring in it," said Padraig Hackett, technical director at Irish foamer Kayfoam Woolfson, based in Dublin.

But by far the more important quality is the foam's temperature sensitivity, "this is the key active property of viscoelastic foam," Hackett added.

Slow recovery is an obvious feature, used in marketing the material. If you sink your hand into viscoelastic foam, it leaves an indentation which disappears only gradually (see pic).

"Conventional HR [high resilience] foams are two-dimensional (density and hardness can be varied); viscoelastic foams are four dimensional, with hardness, density, temperature and time effects," said Denis Hicks, slabstock technology manager with Huntsman Polyurethanes, based at Everberg in Belgium.

Most foam experts listed similar key properties: "The novelty is that it has very slow recovery characteristics and conforms to body shape." Most flexible foams are "more lively, highly resilient and bouncy," explained Stan Hager, research fellow in Bayer Corp.'s polyurethane division. Hager has been working on viscoelastic foams for some years now, with Union Carbide, Arco Chemical and Bayer.

Viscoelastic foams, "become more lively as you heat them up—they all have this to some degree or other," Hager said.

Jacob Boelskifte, quality and development manager at Dan-Foam A/S, described viscoelastic foam as a slow recovery, rather soft, but supportive foam, which is also temperature sensitive in its indentation hardness.

The low indentation hardness (IFD) of these foams allows the body to sink "rather deeply" into the foam, while still maintaining the firm feel of a good quality resilient foam, Boelskifte said.

Viscoelastic foam is formulated to give very rapidly, he said.

Hackett made similar points about design of wheelchair pads. Sophisticated pressure-mapping techniques are used to assess the problem, with the same aim—of keeping the maximum pressure below a critical point.

The principle for wheelchairs is the same as for beds—"to spread the load, to lower pressure at any given point," Hackett said.

Hicks added that viscoelastic foams are breathable, so they allow moisture to dissipate, which is good for arthritic conditions and for reducing skin irritation. They are also usually medicated so that they have antibacterial properties.

Other solutions to bed sores are generally more expensive, said Hackett, listing "active" mechanised beds, complex air beds, and highly sophisticated water beds, used in burns units.

Viscoelastic foam mattresses can also be used for burns units, to minimise pressure, Hicks said.

Sufferers from back and joint pain and restless sleepers may also gain relief using viscoelastic mattresses, the literature claims. The foam supports the whole body, while keeping the spine aligned (below). **UT**

Tempur World

Foam-tastic!

"Visco-Elastic Memory Foam is a revolutionary open cell space-age foam ... developed for NASA in the early 60s. So unique are its properties that it continually adjusts and moulds to the weight and shape of your body … it dramatically minimises pressure points, thus reducing tossing and turning, significantly improving circulation, noticeably reducing pain and discomfort associated with disruptive sleep."—US internet supplier Oh My Ach'n Back. (www.swedishfoam.com)

"The Future Is Here— … new space age technology … an extremely high density visco-elastic foam which moulds to every curve of the body… completely eliminates localised pressure … at the hips, arms, and shoulders [which] results in impaired circulation and numbness, stiffness or pain. you will experience tension-free sleep which is vital to good health."—Sleepyzzz, a US supplier of foam products made by Knoxville-Tennessee based Knox Foam Corp. **UT**

Medical benefits

"Within five years, every hospital mattress will be made out of visco foam," Hackett said. It has great benefit in stopping development of bedsores, saving nurses and carers a lot of hard work and time, he said.

Conventional HR foam mattresses cause pressure on specific parts of the body—shoulder blades, buttocks, heels. Viscoelastic foam acts more like a viscous material at these points, under the influence of heat from the body. So it softens and flows around these pressure points, Boelskifte said. This spreads the load over a much wider area, avoiding the pressure spikes that can cause decubitus ulcers, commonly known as bed sores, he explained.

Kayfoam data confirms this: compared with regular pressure reducing mattresses, viscoelastic foams give a far greater area of surface contact for a supine patient, with a contact area for the head, back, buttocks and feet of 1872cm^2 as opposed to 902cm^2, according to Kayfoam literature. This reduces average pressure to around 15 mmHg from nearly 30 mmHg with the regular product, the firm says.

Viscoelastic pads are also a bonus during surgery, because blood flow problems can occur when patients are immobilised, said Paul Bergad, managing director of US mattress maker Bergad Inc. Breakdown of tissue leading to ulcers can occur

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a certain low resilience and hardness at 20°C. If the temperature drops, the foam gets very hard, "like a piece of wood," Hackett said. "If you want to see if a piece of foam is genuinely viscoelastic, put it in the freezer, to see if it hardens," he commented. "Above about 30°C, the foam gets softer and this temperature dependence is the reason the foam is used in applications like hospital beds," he said.

With a standard flexible furniture foam, a hardness (IFD) of 20 at room temperature will be the same if the temperature is raised to 30°C or if it is dropped to 0°C, Hackett said. For normal flexible PU foam, across the ambient temperature range, IFD values are not temperature-dependent, he stressed.

"Typical furniture foam has, say, 65 percent resilience: you drop a steel ball bearing on it from a metre and it rebounds 65 cm," he commented

"On a piece of slow foam it will only rebound 2 cm," Hackett said, since, "visco foam is very low resilience, it is dead, with no bounce." A typical metal sprung bed base will give perhaps 95 cm rebound, he added.

Markets and marketing

"Slow foam opened up a new market for us," and it is big business for Kayfoam, said Hackett. But as a segment of the total flexible foam market, viscoelastic foam is very small, he added.

In a UK market of perhaps 50 kilotonnes a year, viscoelastic foam makes up perhaps 1000 tonnes or 2 percent, he estimates. It is a growing segment, he stressed, but "will always be a niche."

A lot of foam manufacturers are using viscoelastic foam in some shape or form, observed Alvaro Vaselli, vice president of marketing and sales with Foamex International. It is a unique way to differentiate products, he added.

Hager said the viscoelastic foam market has grown considerably in the US over the last 7 to 8 years. Tempur has raised the market size by its promotion of these materials and, "other producers have piggy-backed on this," he added.

In the US, Hager said, almost all the foamers are making viscoelastic material. Similarly in Europe, "All the major manufacturers are now making these materials," Hillier said.

Both Kayfoam and Dan-Foam feel the next major growth area for viscoelastic foam is domestic bedding.

On the domestic side, there are a lot of mattresses now available "with a top 2 or 3 inches of visco foam, giving a very comfortable, lazy feel," said Hackett.

Cost will be a limiting factor in this use, said Hackett, since viscoelastic foams are denser than conventional flexible foam and therefore use more material. Also, the speciality polyols and surfactants are more expensive.

Manufacturers typically use a 30 kg/m^3 density foam for normal mattresses but visco foams are perhaps twice the weight at 60 kg/m^3 density. Some manufacturers offer viscoelastic foam at around 85 kg/m^3.

Materials for VE foam

British Vita's viscoelastic foams "use a blend of polyols, one a high hydroxyl value polyol, this is kind of typical for most suppliers," said Ken Hillier, chief technologist with Middleton, Manchester-headquartered foam maker British Vita plc.

One approach is to "try to have two phases in the polyol, each with a different temperature response; depending on how well the phases are mixed and the nature of the transition, you can get fast or slow change and temperature response," said Hicks of Huntsman.

There are various routes to such polyols, "a lot of know-how, but, because there are many ways of doing this and there are a lot of patents, it takes a lot of care to avoid infringements," Hicks explained.

Foamers can use MDI (methylene diphenyl diisocyanate or TDI (toluene diisocyanate) Hicks added. MDI seems better than TDI on the production line, he said. It gives "taller blocks, good shape and very commercial properties," Hicks commented, adding that the fast cure of MDI systems is also of benefit

The Huntsman specialist added that, "control of foaming needs to be very precise, we stick it on the line and optimise it for them."

Dan-Foam uses a specially developed polyether polyol and TDI, and fine-tuned the recipes with silicone stabilisers to optimise processing in the early days, Boelskifte said. Foam index is normally below 100, he added.

Polymer systems for Dan-Foam's Tempur materials are basically the "same raw materials produced at different indexes," which is how the glass transition temperature is altered, Boelskifte said.

Dan-Foam uses very similar materials for moulded viscoelastic foam, with minor variations to cover higher moulding temperatures and to handle high pressure mixing, Boelskifte said. **UT**

A Scandinavian first

Tempur is a major global brand in viscoelastic foam products, and has led the field in marketing the material, according to most commentators. Tempur viscoelastic polyurethane foam products are made by 40-year- old Danish company Dan-Foam A/S, based in Aarup.

Originally a general-purpose flexible foam maker, Dan-Foam is now totally focussed on making products for Tempur World Inc. This organisation was set up in 2000 to market the products globally, following the high sales growth experienced in the last decade for Tempur products, Boelskifte said.

In 1989, when Dan-Foam was taken over by Fagerdala World Foams, of Varmdo, Sweden, it already had a recipe for viscoelastic foam—as originally developed in the US at NASA (the National Aeronautics and Space Administration). NASA had wanted a shock-absorbent and insulating foam for astronaut's suits. Slow foam has the shock-absorbency, but not the temperature protection, so, "was not suitable" for space suits, Boelskifte said.

But Dan-Foam had not yet developed successful mass production of the foam.

Former Dan-Foam chemist Åge Kristiansen spent the next two years developing a reproducible slabstock process for the

foam—and the firm has never looked back.

Fagerdala's major shareholders set up Tempur World to market the products, with Dan-Foam as its manufacturing subsidiary. The Danish unit now focusses solely on making slabstock and moulded viscoelastic foam, together with the HR foam used as a base in the mattresses.

Dan-Foam turns the foams into upholstery backing, mattresses and cushions, using its cutting and fabricating facilities.

Tempur World, which has all the distribution rights to the Tempur products, had a turnover last year of DKr 14000 million ($168 million), said Boelskifte. Average annual growth has been around 35 to 40 percent in recent years, he added.

Tempur World has doubled its foam production capacity with the completion in June 2001 of a 40 000-m^2 US foam production facility, in Duffield, Virginia. The Duffield plant (pictured above) will eventually employ over 200 people, and matches Dan-Foam's Aarup plant in size, facilities and capacity. Tempur decided to build the US plant because it already shipped over 40 percent of its production to the Americas. It made sense to make foam locally and avoid transporting the light but bulky material around the world.

Tempur products also sell well in the Far East and Dan Foam is considering setting up an Asian plant, although it is not close to a decision on this yet, Boelskifte said.

Dan-Foam's 85 kg/m^3 viscoelastic foam mattress tops are higher density than competitors' foams, Boelskifte claimed. Mechanical properties including durability and ageing are, "significantly better than competitors' materials, typically made at 55 kg/m density," he claimed

Tempur products are sold via a network of 22 daughter companies who sell to furniture shops, and through chiropractors and back specialists, and direct to the public.

The firm will design and make products for individual customers, it offers a personalised service, Boelskifte stressed.

In moulded foam, Tempur has developed the 'Tempur inside' concept to allow manufacturers, of chairs and recliners for example, to use the Tempur logo and to keep its brand prominent, Boelskifte said. **UT**

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Hillier said British Vita makes it, "in a range from 40 to 60 kg/m^3, depending on which factory it is made in."

Viscoelastic foam is expensive—"three to four times the cost of regular foam," said Bergad, raising the cost of the foam products the company supplies.

With DanFoam's Tempur mattresses, prices are competitive with those of a good quality spring mattress, Boelskifte said.

Other viscoelastic foam uses are in prostheses and medical devices: for example a viscoelastic foam layer can be used under Plaster of Paris for setting broken bones, and in neck braces, said Hackett.

They are also finding use in trolley pads in hospital accident and emergency units. Although patients are not generally supposed to stay on the trolleys for any length of time, they unfortunately do in some countries.

Bergad uses three layers for the wheelchair pads, soft, firm and a lot firmer, so that there is no bottoming out of the foam—quite a task with only a 3-inch foam layer, Bergad pointed out.

Visco foam will find its way into seating, but it is too expensive to be used at the mass end of the market, it will only be used for the top end of the range, for people able and willing to pay lots of money—$800 to $1400—for a sofa, Hackett said.

Dan-Foam does not sell foam, it only sells products. A relatively new area for the Danish foamer is moulded foam parts for office furniture and similar uses.

Hackett said another market for visco foams may be in musical chairs—orchestral seating. This is a specialised market, using purpose-designed seats, since many musicians must sit in specific ways in order to play their instruments, for example the cello. Orchestras travel with their own chairs, and comfort in sitting for long periods in one position is also a critical factor.

Foamex is also working on energy absorbing foams, some of which are viscoelastic materials, Vaselli said. Foamex's use of the variable pressure foaming (VPF) system, in combination with formulating expertise, means it can make novel energy-absorbing products "not available with conventional processes or urethanes," he added.

Energy absorbing foams are becoming more widely used in automotive and packaging applications, and the Foamex materials "will deliver benefits at equal or lower costs to existing plastics," used in this field, Vaselli claimed.

Real or pseudo effects?

There is a big debate as to what viscoelastic foam is, Hicks commented.

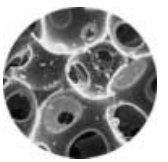
In simple terms, the foam is viscoelastic because it is made using a viscoelastic polymer, said Hillier.

While fiddling with the cell structure to leave vestigial cell walls can create similar initial behaviour, these are not true viscoelastic materials, which need a "good open cell structure," Hillier said.

But Hager said that, while viscoelastic foams, have open cells, "the windows are not necessarily wide open," and this increases the viscoelastic effect a little.

"You can achieve a pseudo-viscoelastic foam with a closed cell structure, but this is unlikely to be viscoelastic over any useful time period," Vaselli commented.

A foam with a lot of closed cells can seem 'slow,' because when crushed it takes time to recover, but this is just slowness in taking up air again, Hillier said.



Viscoelastic cell structure—Tempur

Hackett agreed: "some manufacturers do a little bit of a cheat," he said, by raising the number of closed cells, which can make a foam lazy. It is easy to pick these foams out, though, because it is difficult to draw air out of them, Hackett added. These feel like a lazy foam to the touch, but the temperature dependence is small, he said.

The temperature dependence occurs because the glass transition temperature (T_g) of the foam has been designed to be in the right region—about body temperature. Normal foam has too low a T_g and is also usually highly resilient rather than highly damping.

"We've designed formulations to raise the T_g to typically around 30°C," said Hackett, adding that T_g is a range, not a single value. For pressure-relieving mattresses the T_g needs to be between 15° and 30°C, he said.

One aspect of the technology is to try to make the T_g close to room temperature,

VE foam renews Bergad

"Viscoelastic foam has turned our business around," said Paul Bergad of mattress maker Bergad Inc. of Ford City, near Pittsburgh, Pennsylvania.

"Right now we primarily deal with viscoelastic products," he said, listing wheelchair cushions, surgical pads, medical and consumer mattresses, and even surgical pads for pets, among his firm's products.

Bergad set up the company to make cheap foam mattresses for children's bunks, inexpensive pads for furniture and similar items, he said.

In 1993, Bergad said, "I got my first glimpse of viscoelastic material... Then we started to restock the whole operation to use viscoelastic foam."

Bergad now turns over between $3.5 and $4 million a year, and employs 50 in its production unit, plus, "another army of sales people," Bergad said.

Growth has been high—exponential according to Bergad—with "this year one of the best to date," he added.

Bergad's 8-inch (20-cm) thick mattresses consist of a 5 inch base layer of conventional firm HR foam. Next is a 1½ inch layer of softer, less heat-sensitive viscoelastic foam and the top 1½ inches is a firmer, slightly more heat-sensitive viscoelastic type. **UT**

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and thus give slow recovery, Hager said.

"You want viscous damping, so you have to have glass relaxation over room temperature to do this," he added. But, "you don't want to leave an impression long-term, you want recovery."

Broadening of the glass transition peak reduces the temperature sensitivity, and Hager said another possibility is to have double peaks.

Slow, slow, quick-quick, slow

Some slow foams give a sudden hardness change with temperature, others a more gradual change, Hicks of Huntsman pointed out. This is the focus of another debate: whether the temperature sensitivity should be broad or narrow. US specialists say broader would be better.

Current viscoelastic foams can be too temperature sensitive, said Hager. This means they are not suitable for automotive seating, as they would be too hard in cold winter conditions. Also, in a non-heated hotel room, such mattress foam may become too hard, Hager said.

The chemical suppliers and foamers have put, "a lot of technology development into improving that," Hager said.

But Dan Foam sees the "very steep T_g," of its Tempur material as "one of the good things in a mattress application," Boelskifte said. "It maintains a rather rigid foam at low temperatures, then when the foam is heated by the body temperature, it shapes to the body and stabilises it," he commented.

US users seem to prefer a softer feel to their mattresses. It is a selling point in some regions for the foam to be firm, and only soften at body temperature, Vaselli said. But for the US market, Foamex, "wanted to have an initial feel which was more comfortable," he said. People "don't want the bed to change its feel from showroom to bedroom and over the year," Vaselli said. In Foamex's recent work it, "wanted to make the temperature range where the material is viscoelastic much broader," Vaselli explained.

Bergad also commented that if the user's house is cold, the mattress can feel firmer. The ideal material has to have a controlled temperature sensitivity; users "only want to sink to a certain point," some support is essential, he said. Softening between 70°F (21°C) and body temperature (36.8°C) is the right sort of range, Bergad said.

But DanFoam's Boelskifte pointed out that the majority of beds are used at ambient temperature in peoples' houses.

New from Foamex

Foamex International is using its newly developed proprietary VPF (variable pressure foaming) processing technology, in combination with internally developed formulations, to make a new line of viscoelastic foams. They are initially available in two high-density grades, said Alvaro Vaselli, vice president of marketing and sales with the Linwood, Pennsylvania, headquartered foam producer.

Alvaro Vaselli

Foamex is using a proprietary process and protected chemistry to give benefits never seen before in conventional viscoelastic foam, he claimed

The flexible foam maker has been working closely with some foam customers in the US on these materials, Vaselli said. It has had products available for two months now, and is just about to launch the new grades on the market, he added, in a 19 Nov telephone interview.

Foamex is aiming these foams at the medical and residential bedding markets, for mattresses and pillows. **UT**

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This temperature does not vary significantly in the developed world, since the advent of central heating and air conditioning, he pointed out.

In contrast to the US, users in the UK want firmer support, Vita's Hillier's said. "UK customers will probably be looking for a little harder foam than other markets want," he said.

Also the UK has much tighter flammability requirements than the rest of Europe. "A lot of our [British Vita's] material is sold into the UK market," he added. "So the material has to pass the UK flammability laws as well as doing the job of pressure relief," he said.

Irish foamer Kayfoam also makes its viscoelastic foam flame retardant. It claims to be the only company in the world that makes an 85 kg/m^3 density (5.5 pound) viscoelastic foam to the UK flame safety standards.

From hospital to home

Kaymed viscoelastic foam is the result of a $250 000-investment in R&D by Dublin, Ireland-based foamer Kayfoam Woolfson.

Far from relying on NASA, the company's researchers, led by Padraig Hackett, developed the material in response to the slowness of a PU foam toy—a 'doughy' nerf ball. These toys are, "slow" but not temperature sensitive. The research team had been experimenting with temperature-sensitive polymers and felt if they could combine slowness and temperature sensitivity it would create an pressure-reducing material—offering support with a flotation effect.

Kayfoam made the first sample in November 1997, named it 'Kaymed Visco,' and set up its Kaymed Division that same year.

"The pressure-reducing properties of the Kaymed products won approval through evaluations at ward level from carers and patients alike," according to the firm.

Kaymed has recently been awarded two major NHS contracts—from Cornwall NHS and Community Care of Northern Ireland. It has also licensed distributors and manufacturers worldwide.

The Kaymed range is endorsed by leading chiropractic associations and consultants, the firm claims.

Kayfoam Woolfson has been in business for more than 100 years and now employs over 400 people at six manufacturing locations—in Dublin, Cork and Kildare in Ireland, and Manchester, UK, with smaller component-manufacturing units in South Wales and Belfast.

Kaymed is also aiming at the US market with Federal Foam Technology and other strategic partners.

The firm has just launched a range of viscoelastic consumer products under the Impression name.The firm has used its Visco material for some years in its own range of King Koil beds for the UK and Irish market, but "it has taken some time for bedding companies to realise the potential of higher-end genuine Visco as a mattress interior," chairman Solomon Woolfson said.

Kayfoam Woolfson is also franchising its marketing approach and licensing the whole process to firms capable of meeting the exacting technical requirements. **UT**

Longevity also an issue in US

Bergad now has viscoelastic foam, "poured just for us." Previously, "we could not find the longevity which we needed," with foam from some of the major suppliers, Bergad said.

Medical mattresses are used in the, "worst situation ... when someone lies on it 24/7 (24 hours a day, 7 days a week)," and the material can suffer permanent set, Bergad explained.

Bergad's current foams, "are holding up extremely well," he said. They have been in medical use for over five years now and have shown less than 2 percent loss of height during this time, he said.

Foamers are addressing this aspect: "We know that a feature of some mattresses on the market is that they lose their viscoelasticity over time," Vaselli said. So a key objective of Foamex has been to make a foam with viscoelastic properties that do not deteriorate long term.

Hackett said the only factor he has seen which changes the viscoelastic nature of the foam is humidity. "If you raise the humidity to 100 percent, this affects the resilience, which also goes up, and the foam acts more like a normal foam. Also the temperature effect diminishes," he said.

Slow to develop slow foam

The viscoelastic foam concept was developed in the US around 25 years ago, said Vaselli. So why did it take so long to be commercialised?

One reason was that the foams are "not easy to make," said Hillier. Raw material suppliers—Shell, Dow, Bayer, Huntsman—will offer formulations, but using them on a production scale machine is not simple.

Vaselli made the same point: processing a quarter of a tonne of foam a minute on a commercial-scale production line is quite different to making some successfully in a laboratory.

Foam index (OH to NCO ratio) is important: higher index foams give "better processing, but too high and you lose viscoelasticity," Hillier commented.

The real advance in getting these foams into the marketplace was being able to mass-produce them reproducibly and control the performance, agreed Hager.

The foams have had a fairly narrow processing window, and machinery developments were a factor, said Hager, citing the use of high-pressure machines with a nucleating capability that gives highly uniform cell structure. Developments in computerised control have helped by raising repeatability, Hager said.

Another factor in the slowness of the development may have been that viscoelastic foam did not represent a "sizeable market" to the chemical suppliers, Hackett said.

Also, hospitals were "maybe a little slow in realising the potential of the foams," Hackett feels.

Both Kayfoam and British Vita had the added challenge of developing fire resistant visco foams to sell into the stringently regulated UK market. **UT**

Varying cell morphology

German PU systems supplier Elastogran is offering systems for moulded viscoelastic foam under the Cosypur name. These have adjustable cell morphology, using high molecular weight polyols and additives, said Peter Falke, a research chemist at BASF Schwarzheide GmbH. With perforated cell walls, a viscoelastic foam results, while totally open cells give a supersoft foam.

This makes it possible for the industry to make supersoft water-based foams using MDI, previously only possible with TDI, said Falke.

Cosypur is a very high hysteresis foam so it can absorb a lot of energy, the BASF specialist said. It acts like a shape memory foam, with the perforated cell walls behaving like a pump for the air in the cells.

The price of the material is comparable to that of conventional flexible foam systems, said Hans Schmidt, senior manager for CASE technical service with Elastogran GmbH, based in Olching, Germany.

One potential use for Cosypur is to make all-PU office seating. Rigid PU can be used for the structural parts, with Cosypur flexible foam and an integral skin PU cover.

Similar systems to make slabstock foam are available under the Elastoflex name, Schmidt said.

The system uses high molecular weight hydrophilic polyols and isocyanate prepolymers based on MDI, and special additives, used to control the phase separation of the ureas, Falke said. "To achieve a different cell morphology we use a different additive," he said. These materials are not temperature sensitive, this is not an issue, according to the Elastogran specialists. **UT**

Examining a moulded pillow are (l-r): Peter Falke, Heinz-Jürgen Schröder of Elastogran's CASE/flexible foams unit at Schwarzheide, and Lothar Baum, manager of the CASE/ flexible foams unit.