Using experience in design: a practical attempt to simplify the design process.

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USING EXPERIENCE IN DESIGN. A PRACTICAL ATTEMPT TO SIMPLIFY THE DESIGN PROCESS.

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Abstract: *It is proposed that the theoretical models of design management have now moved from being too shallow to being too complex. As a result, they are not being used.*

There needs to be a new approach that is simple to use, will capture particular experiential knowledge that exists within the organisation and also focus on the needs of the potential customers. Theoretical design management techniques were compared to those stages undertaken in this real design situation and those that were found to work are described. Also described is a simplified design management process that was found helpful in this particular situation

1. INTRODUCTION

It is proposed that the theoretical models and recommended activities in design management are now too complex and, thus, still impractical for the skilled practitioner to use. They do not account for experience in a particular field.

On the other hand, proposing 'fast-track' processes can also be 'dangerous'. The problem with a 'fast-track' process is that these can be written for one set of people and then used by a different set of people with different experience from that available within an organisation. This could result in the omission of important stages in the process.

There needs to be a new approach that must also be simple to use or it won't be used.

Theoretical design management techniques were tested in a real design situation and elements of a modified system that were found to work are described.

2. BACKGROUND

Design management may be defined as 'the organisation of the process for developing new products and services' [1](Hollins & Hollins 1999). Twelve years ago [2]Wikstrom & Erichsen (1990) presented the results of. a study of North Sea oil installations in which they concluded that none of the academic models of the design process worked in practice as they were all too shallow to be of practical use. Rohatynski [3](1990) deduced that it was the attempt to make these models universal that made them impractical.

Over these intervening years the understanding of design and it's management has grown. In the 1990's design management had a high profile. There are several British Standards that offer guidance in the process ([4], [5] BS 7000 Parts 2 and 3 and to a lesser extent, ISO 9000 – 2000 [6]) as well as several books ([7] Baxter 1995, [1] Hollins & Hollins 1999, [8] Ulrich & Eppinger 1995) that show the latest 'thinking' of this aspect of the product development process.

This author has been active in the development of these British Standards and in research and other publications that are supposed to advance our understanding of design management. Also this author has developed and implemented design management processes for organisations as part of consultancy. Some of these companies were later revisited to see how these processes were working. A typical comment was that the processes appeared to work all right. But on further questioning it was revealed that they were not always (sometimes rarely) used because they were difficult, often slow and this directly impinged on the product 'time to market'.

3. PROJECT

More recently this author has been involved, as a Non-Executive Director with a company called ‘Cool Logistics’ in the field of pharmaceutical distribution. The company supply shipping systems for the transportation of temperature sensitive products anywhere in the world. These temperatures, defined by the customers are, typically, +2 degrees C to 8 degrees Celsius.

The main method for cool distribution has been to package the pharmaceuticals into well insulated containers and keep the inside of the container cool through the use of ice packs. The company’s marketing edge has been in the testing of the systems and the certification.

This provides an assurance to customers that the product will remain within the 2-8 degrees Celsius that customers require over the specified period of days despite the variation in temperature outside of the container. This means that pharmaceuticals can be sent throughout the world with the confidence that the contents will arrive in good condition.

Of course, all this currently works well which is why the systems have remained, virtually unaltered for such a period. But there are drawbacks to the existing methods. Pharmaceutical distributors need to keep ice-packs frozen in a refrigerator until it is time for them to be used. Furthermore, during use, the ice-packs slowly melt. This causes no problem if the packages are delivered on time but if delayed in, say, customs, for a period of days the contents of the packages may become spoilt and need to be destroyed and replaced. The problem can be overcome with the use of refrigerated transportation but this is expensive, typically fifty per cent more than the price of non-refrigerated trucks and there is no reliable aircraft equivalent.

Although the methods adopted for testing and validation have become significantly more sophisticated, the products used in cool pharmaceutical distribution have remained, essentially, the same for the past twenty years - until now.

4. NANOCOOL

All this is about to change due to an exciting new product. The new product is called NANOCOOL and is a joint venture between Cool Logistics of Bedfordshire, England and Nanopore of New Mexico, America who are developing a revolutionary new form of ‘absorption cooling’. This product is still under development and is protected by world-wide patents. This involves cooling through vacuum absorption and is operated as follows:-

The cooling device is built into the lid of the insulated container. The cooling process is actuated by the press of a button on the pack and can provide up to several days of product cooling without the need for any form of electric power or precooling (as will be demonstrated in the conference presentation). The ongoing development is targeted towards the 48/72 hour devices.

After initiation of the NanoCooler, heat is transferred from the inside by evaporating modified water at low pressure; this evaporation takes place at low temperatures. The temperature inside the box falls and remains controlled until the evaporation process is complete and then the temperature begins again to climb. The cool part of the packet is on the inside of the insulated container whereas the heat is ducted away to outside the container. Temperature sensitive printing indicates that the system is operating correctly inside the container.

The device works thus. When the process is initiated through the pressing of the button modified water is released into the cooling ‘packet’. Molecules of this modified water are attracted to a modified food-safe absorbing material (the whole system also has the benefit of being food safe) and absorption causes this part of the packet to become cool. The temperature then rises in the absorbing material. This method of absorbing heat from the container is seven times more efficient than ice.

For products aimed at the 2-8 degree C. shipment range evaporation occurs at around +4 C. NanoCool technology is reactive to changes in ambient temperature. As the ambient temperature increases, the device ‘works harder’ and the cooling rate increases and steadies the product temperature.

Figure 1 shows a printout of the temperature inside the container as well as the ambient temperature. It can be seen that after initiation, the temperature inside the box falls and remains controlled until the absorption process is complete and then the temperature begins again to climb.

By altering the flow rate and the speed or amount of absorption it is possible to control the rate of temperature fall, the minimum temperature, and the time that the product is to remain cool. Thus, by fitting larger, smaller or even several NanoCoolers to an insulated container it is possible to extend or alter the cooling characteristics or even provide emergency ‘back up’ cooling.

In practice, the control of the absorption rate is critical. If this happens to slowly then the temperature drop is to little or to slow. If the absorption rate happens too fast then the cooling period will end before the required time.

5. PRODUCT ADVANTAGES

This following section will read like an advertisement for the product. This is necessary in order to demonstrate a different emphasis in the product development.

One of the main advantages of the NanoCooler is that it is much smaller and lighter than the equivalent icepack. The cooling device is about 75% the size and only 20% of the weight of its equivalent ice-pack required to do the same job. This means that a larger amount of pharmaceutical product can be put into the same sized box or a smaller container can be used for the same quantity of product to shipped. With a smaller container there is less surface area which has to be kept cool and, therefore, smaller NanoCoolers can be used, which means a reduction in courier costs.

As transport costs per unit volume (often by air freight) are one of the major costs in transporting pharmaceuticals, the overall saving in volume significantly reduces the overall transport costs. Savings will be better than 5%-15%.

There is also the saving through not having to pre-freeze ice-packs (which can take 48 hours) and then to keep them frozen. It is such sums that show that the NanoCooler can actually operate competitively on price compared with using ice-packs. Another advantage of the elimination of frozen ice packs, which makes the freezer redundant, is a saving in the space that it takes up in the warehouse. This means that a delivery company, such as Federal Express, can collect temperature sensitive products from their customers (such as blood samples for analysis) and the cooling process can be initiated just as the product is put into the box. Thus distributors can keep a supply of the NanoCoolers on the shelf and they will be ready at the press of a button to cool the product if and when it is needed. The devices have a shelf life of about twelve months.

6. PRODUCT DISADVANTAGES

There are also disadvantages of the NanoCool technology. With an icepack it is obvious if it is working but this is not the case with the NanoCooler. To offset this problem temperature sensitive paint is used that changes colour if the device has been correctly activated.

The NanoCooler must be actuated by an operator pressing a button and this could introduce human error. This operating button has been designed to be as simple as possible as well as being protected against accidental operation.

Furthermore, the product may be past it's 'use by' date and this will be printed on it. Of course, the device may have been incorrectly manufactured. Stringent quality assurance procedures are being introduced that conform to ISO 9000-2000.

The advantages of any product would be used in the promotion of the device. The disadvantages indicate where additional design work is required. It must be remembered the advantages and disadvantages of any new design are not of equal value when compared with what is already on the market. It may be that one disadvantage could destroy the entire potential for the product. Quite often, this is the likely selling price which is higher than the market will stand even taking into account the increased advantages of the new product.

Once again, this shows the importance in fully understanding the customer's needs and wants and the cost necessary to fulfil these needs and wants.

It should also be remembered that the cost of any new product will always be relatively high at the start of production and this will fall over time as markets grow to support batch and then mass production – if it is that type of product.

Initially, there will be capital expenditure on production equipment. The cost of the actual product development needs to be paid off. There will be high advertising and other promotion costs associated with the introduction of the new product to potential customers. And also, the company will be operating at the bottom of the learning curve and efficiencies will subsequently result as experience and output grows.

With the NanoCool it is being initially aimed at the small volume high value end of the market.

7. THE ENVIRONMENT

Links were also made to the whole life benefit for the company through the various stages of the design model [9](Bush & Sheldon 1993). One aspect of this was the prospect of developing the product so that the cooling system could be reversible. This could make it worthwhile arranging for the product to be returned to Cool Logistics and the company was prepared to supply a prepaid return label or even pay for the cost of the returns It is perhaps disappointing in this time of concern about the environment that market research has indicated that major customers are not likely to want the bother of returning the used NanoCoolers even if there is a financial incentive to do so. This indicates that perhaps much of the discussion emanating from the top of being a 'green' organisation has not permeated down to the 'doers' in these companies ([10] EMAS 1995, [11] BS 7750 1994).

8. SMART

Part of the development has been funded through a SMART Award from the UK Department of Trade and Industry. Interest has also been shown by the UK Design Council. They will be including the concept as one of their 'Innovation Stories' when the product is marketed in September 2002.

The NanoCool was demonstrated to some major potential customers and they are enthusiastic. Chris Gardener of APB (a pharmaceutical company) was at this event and has since written; 'We can see the potential for saving a lot of our distribution costs. And the sooner we can start using this system the better as far as we are concerned'. Clearly they see that this is a fundamental advance.

There will still be a market for the traditional ice-packs in pharmaceutical distribution systems for the foreseeable future and there may be cases where they are preferred. But there is no doubt that the NanoCool is an exciting new development that is likely to be the first choice in this and other cool distribution markets. This is one of the first of several exciting new products that are to be developed by Cool Logistics over the next couple of years.

9. RESULTS

The development of this product has provided the opportunity to 'test' some of the latest theoretical design management models and principles in a practical application to see if the theory is now practical. The main model that it was intended to use was from BS 7000 Part 2 (1977) [4]. In practice, no specific design model was followed although several informed the processes used.

Many of the existing doctrine regarding design management were found to hold true. This shows that we have progressed in our useful understanding and aid to the practitioner in recent years.

9.1. Stepped Specifications

One of the keys has been in the recent developments in our understanding of Product Design Specifications. The results also confirmed the effectiveness of the stepped approach for specification compilation. This can instil existing learning and experience into its compilation [12] [13] (Hurst & Hollins 1995, Hollins & Hurst 1995). With these, a small amount of information is identified and from this it is possible to make the decision as to whether it is worth making the investment to take the project to the next stage of product development. Thus the information grows in a series of steps. At any of these steps a decision may be taken to abandon the project, these are called 'bail-out points'. These are easier to use and go, some way, towards solving the problem.

In effect, this gives a front-end loading to product development and causes more projects to be (rightly) abandoned without much having been spent on them. The process is easier to use but there is a disadvantage. Although the overall time that a company may spend on the total number of design projects is reduced, as many more product ideas are abandoned at an early stage, the design team may spend more time on any one successful product developed through to market due to the increased number of assessed stages involved.

9. 2.Initial Parameters

Prescribing an initial set of parameters on which an organisation should base future developments did save a great deal of time as described in BS 7000 part 1 (1999) and Hollins & Hollins (1999) [14], [1]. In effect, it focused a potentially good product towards specified market niches that the company could usefully exploit. In this case it clearly showed the sequence of different markets that should be approached starting with the high value markets and down through to the low value high demand commodity markets. In this case the sequence of proposed whole life planning for market penetration has been planned for a period of five years. This was also similar to the mapping of both the length and width of the Innovation Highway [14] (BS 7000 part 1 1999).

9.3.Concurrency and Iteration

Another aspect that was prevalent throughout the design process was concurrency. The literature indicates that concurrency in developing new products tend to occur within certain stages of an overall design management process [15] (Hollins & Hollins 1991). That is, concurrency cannot (logically) occur in between, say, the market research stage and the detail stage of the design process. In this case the concurrency was far greater due to the high degree of iteration.

In practice, the design process of this highly innovative product was so iterative that aspects of all stages of the design process were occurring at the same time. It is believed that the degree of innovation involved in this project has meant that it has been necessary to undertake some planning of the later stages (selling and manufacturing) as early as the market research stage. Perhaps this finding just indicates that iteration is far more extensive and detailed than is generally acknowledged in the literature.

9.4. Innovation

It should be remembered that innovation can occur throughout the value chain [16] (Topalian & Hollins 1998) including the marketing end of the process and all such opportunities need to be confronted and resolved early in the process. This could also be considered as part of the concurrent engineering. In this case, the marketing side would not require a significant degree of innovation and so the existing knowledge that the directors held of the market could be used.

10. LATERAL THINKING

An interesting piece of Lateral Thinking [17] (de Bono 1993) was brought into play whilst developing the NanoCooler. When operating correctly the temperature curve drops to the required temperature and then stays flat until the process ends and then the temperature begins to rise as shown in figure 1.

Unfortunately, the level of this flat portion of the temperature curve is quite difficult to control at the required level of between 2-8 degrees Celsius. Quite often, when in use it would drift down to zero, which was initially considered unacceptable

The temperature at which the process settled is determined by the rate of flow of the absorbent liquid and, in theory, it would be possible to control this flow (and thus the temperature) by placing a flow control valve in the line. But this flow could be as little as 0.1 ml/min - very difficult to control with any accuracy at low cost.

Then during one of the many brainstorming sessions that occurred in all stages of this product development somebody mentioned that the ice packs currently used are arranged so that they do not cause the product to freeze.

But (as said) when freezing occurs in the NanoCooler, the system stops working and the temperature in the container will rise. This will cause the NanoCooler to unfreeze and the NanoCooler will begin to operate again. Therefore, it should be possible to control the freezing effect and to allow the temperature of the NanoCooler to 'saw-tooth' within controlled parameters. It has been pointed out to us that this saw-tooth effect is exactly the temperature output of a domestic fridge or freezer. This meant that the valving becomes unnecessary and the trick is to arrange controlled cooling to take place sufficiently far away from the product so that it would be maintained within the required temperature range.

This has an additional advantage over any attempts at controlling the flow rate through valves. The outside of the box may be exposed to any (unexpected) varying temperatures up to 40 degrees Celsius. Valving the flow could be matched to an anticipated outside temperature but this relies on the 'guess' at this temperature being correct. If the guess is wrong then the product could be exposed to temperatures outside of the accepted range and would be spoilt.

Using the controlled freezing means that the outside temperature of the container need not be predicted. If the NanoCooler is called upon to work 'harder' then freezing will be delayed and the cooling will work for a longer period of time. Conversely, if the temperature outside the container is cooler than anticipated, the NanoCooler will freeze in its 'safe' area and the cooling process will cease until the outside temperature again begins to rise.

The simple beauty of this control method is that it is both inexpensive and variable to outside conditions.

11. A NEW WAY USING EXPERIENCE?

As a result of our learning, an alternative, simplified, emphasis in design management for new product development is proposed, based on what was found to work in this particular product development. It is suggested that existing experience can be incorporated into the process through the identification of areas where development is actually needed.

In this example, although this was a new start-up company, the three directors have more than 30 years of experience in providing solutions to this market. We chose to channel our effort into particular known customer needs rather that spread our effort outside of chosen boundaries. The process builds on earlier work [15] (Hollins & Hollins 1991) and has to be kept simple for it to be acceptable to practitioners.

It is now accepted that the main reason for new product failure is market failure [18], [19] (Hollins & Pugh 1989, Cooper 1999). Bearing this in mind, the step was taken that planning a new product should be viewed mainly as an exercise in satisfying the market at all stages of the customer experience (at a profit). This means that customer needs throughout the life cycle of the new design should be paramount in it's design.

Research previously undertaken for the UK Department of Trade and Industry [16] (Topalian & Hollins 1998) had already shown that those successful companies that planned their new products well into the future (some up to more than ten years) did not tend to look specifically at new technology. They were more likely to adopt one of two strategies. Either they would identify likely new markets and then seek the technology that would satisfy that market (generally these are large organisations). Or they would find real potential markets that would use the technology that they had discovered and then 'aim' the development of that technology towards those markets (these tend to be small companies). This development followed the second of these strategies. What they did not do was assume that customers existed for any bright new technological idea. If this reasoning was already widely accepted today then products would not appear on the market with many features that we, the customers, neither want nor subsequently use.

It was anticipated that this development would be closely related to the company strategic plan. But although the strategic plan is important this plan did not allow for the serendipity in which this new high potential product came about. It was found that the product development programme tended to inform and alter the strategic plan. If this is a common occurrence it would appear that Product (and Service) development, especially in very small companies, leads the company strategy rather that following it. This is fundamentally different from most writing on strategic management. Further work is needed to identify if this is an isolated case or whether this is commonplace. If it is the latter then the importance of strategic design management has been understated in management literature. Furthermore, the common practice of considering strategic management without giving thought to product design may actually be wrong in all but large multi-product enterprises.

12. The process

The following outline of an experiential design process is proposed. Most of this will occur at the early stages (the first 15%) of the design process where the costs are low but 85% of the management decisions are made. Essentially, this would be undertaken at the market research and product design specification compilation stages.

1. Understand the existing products (competition) that serve the market you are trying to reach (some may be your own products). Beware of Levitt's (1961) marketing myopia [20] as this may indicate that the competition is likely to be wider than initially thought. Experienced product developers often know this competition if the new product is to meet their existing markets.

2. Then identify the advantages and disadvantages of the potential new product against that which already exists on the market. This stage is not new [15] (Hollins & Hollins 1991). Parametric Analysis can help here if it is a manufactured product [18] (Hollins & Pugh 1989). This tends to be less useful when appraising a service.

3. Specify the <u>minimum</u> performance standards in each case for the new product to be able to compete with the competition in every case. Some will not matter and some will be essential and this must also be indicated. The reasoning here is made on the realisation that people do not buy technology, they buy the benefits that can be derived from that technology [1] (Hollins & Hollins 1999).

4. As a result, it is also necessary to identify the technology that will provide this performance standard that customers require for the various design parameters. This stage is quite difficult in practice. Essentially, it means identifying the important aspects and then quantifying aspects of the product design specification, starting with the most important. It is putting numbers to the proposed design. Although experience helps, it needs to be confirmed by customers through market research.

5. Specify the <u>maximum</u> performance in each case that is required by the potential customers. Deming's (1986) [21] phrase that we should endeavour to 'delight the customer' is now common as a basis around which Total Quality programmes are built. Parasuraman, Zeithml and Berry (1988) [22] applied this thinking when developing their SERVQUAL and the gap analysis to demonstrate how to improve the quality of services. More recently Huda (1997) [23] has proposed that there is a service level beyond which customers do not require (or notice) a greater level of service at any point in time. Over time, expectations rise but this can be anticipated and accommodated within subsequent design improvements.

If it is accepted that there is a maximum (and therefore optimum) performance level for a service, then providing a product that exceeds these performance levels (usually at a higher development cost) is a waste of time, effort and money. This requires either well focused market research or a good understanding of the market that comes through experience (or both). Parallels can be drawn here with Quality Function Deployment, ([24] Hauser & Clausing 1988, [25] Akao Y. 1990) where the 'voice of the customer' defines the subsequent design work that is to be undertaken. In practice, what is being proposed here is less structured and is configured around the identified important elements in the product design specification.

6. Identify the unique selling propositions (or benefits) that the new product idea could provide,

over and above the competition, and identify if customers really want these Unique Selling Propositions (U.S.P.'s).

7. Identify the minimum standards/performance that the customers want from each of these U.S.P's. The effect of this is shown on figure 2.

8. Identify what needs to be done to compete in each (important) area - to reach the minimum standard. Some of these may be achieved by engineering design. Others may be achieved through the design of the service.

9. Develop each of these sectors using stepped specifications ([12] Hurst & Hollins 1995). Knowing the important design problems that must be solved will result in greater resources being devoted to them. If any one of these important features cannot be achieved then the project can be put on hold until a technical breakthrough is made (archived) or abandoned. In practice, most of these problems can be identified early in the process and thus do not appear after much time or money has been spent on the project.

The emphasis throughout is a focus on the market.
As can be seen, the ease in which a design team will be able to achieve the above depends a great deal on their experience and understanding of the product market. Less experience will indicate more work but those with experience will need less research. All this is easier for developments made for industrial markets as was the case here. In industrial markets the customers are usually fewer and more easily identified, some are larger and known to be more important and their requirements tend to be more clearly defined. Furthermore, purchases for industrial markets tend to be made in a more logical manner rather than by whim or impulse.

At first glance what is being proposed seems fairly obvious but it is not the way that many plan their new product development. It could be called Design Management by Objectives and mirrors aspects of Management By Objectives as first prescribed by Drucker in 1955 [26]. Particular objectives can be identified and the design team can concentrate on fulfilling these. Other areas are of less importance and, in some cases, can be ignored. Of course, all of this is highly iterative, more so than was expected, but most of this iteration will all take place before the detail stage of design, at the low cost end of design.

Communication has been identified by Andreassen as being a key difficulty in concurrent engineering. This was found not to be the case in this project as the company is sufficiently small to get all the project participants around a table. The project did benefit from having the active involvement from a director who acted as product champion (in both definitions of the term) [15], [27] (Hollins & Hollins 1991, BS 7000 Part 10 1995).

It was found to be advantageous to break down the project into those parts that were known to work from experience and the 'new parts' of the product (sub-innovations). Each could approached as a separate target and prototypes and testing developed to prove each of these sub-innovations in turn (whilst not losing sight of the 'whole').
The theory implies one concept stage in the design process but practice showed that many beneficial 'off-hand brainstorming sessions' ([28] Lockwood 2000) took place throughout the design process to 'sort out' small difficulties as they occurred. These concerned marketing and operations as well as design. This is a confirmation, in fact, an expansion of that proposed by Hollins & Hollins (1995) [29], that a design process consists of many concept stages within the overall design process. A gestation period was in-built into the brainstorming sessions by revisiting various themes after a period of a few days or weeks [4](BS 7000 Part 2 1997).

13. Conclusions

This paper has attempted to show which aspects of the theory were found to work and how other aspects needed modification to operate more effectively. The result of this research highlights a dilemma for academics proposing 'sophisticated' design management models. We academics have still some way to go in our research before we can be confident that our design management processes can be considered suitable for the practitioner, but we are getting there.

The spotlight was put on developing those areas that are particularly needed to make the product competitive. It also fully utilises the existing knowledge of the particular design team - which would be different in any new design project for a new market or new design team. Furthermore, it quickly shows if the potential product is achievable by focusing on specific design areas. This will encourage the necessary abandonment of potential failures early in the process.

The focus here is the product idea, the market, the competition, but not necessarily the company business plan.

In a large and established organisation with a large portfolio of products the strategy can lead and the products follow to fulfil that strategy. In 'micro' organisations, where there are fewer products, a new product could have a more fundamental effect on the entire organisation. This makes the product strategy lead the company strategy. This is fundamentally different from that stated in the strategy literature. This is, perhaps, the main finding of this paper.

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Function				
			X	
maximum customer performance required	______	______	______	______
	X			
		X		
Minimum customer performance required	______	______	______	______
				X
design parameter	1	2	3	4

Typical Performan[ce]
NanoCool™ cooler wit[h]

- 250 mm cube box with 2-8 ºC targ[et]
- No payload (worse case because o[f] thermal mass!)

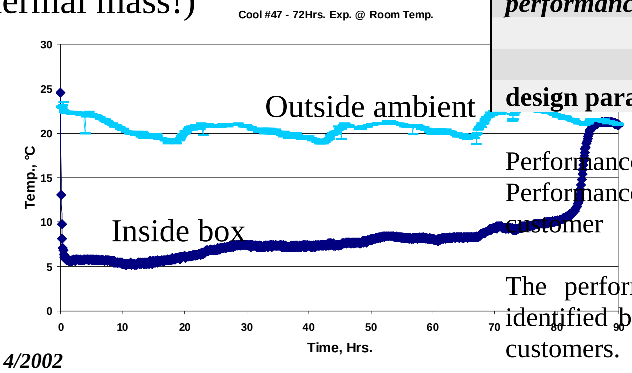

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Figure 1

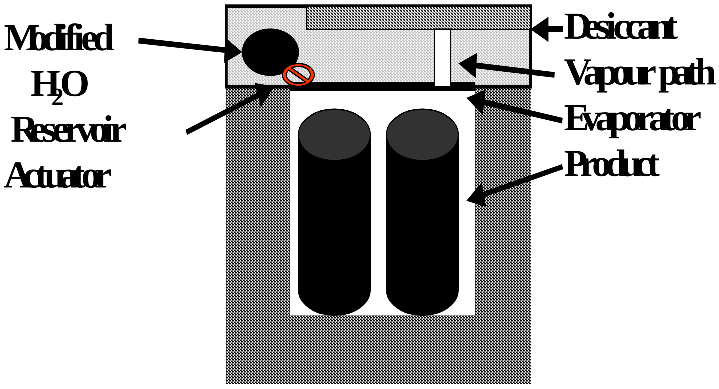
Performance function '3' over designed. Performance function '4' & '6' unacceptable to customer

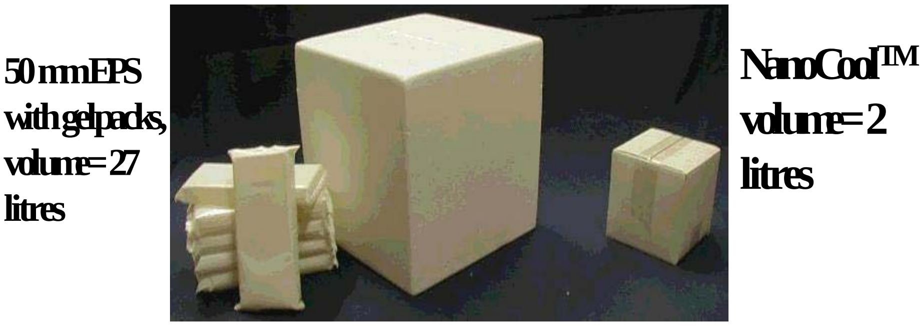
The performance that is required can only be identified by understanding the needs of potential customers.

Figure 2. Minimum or maximum standards/performance that the customers want from each U.S.P's.

Performance							

NanoCool™ in a "standard" box





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An example showing the NanoCool and the reduction in container size by using the new technology.