Design for life (and beyond)

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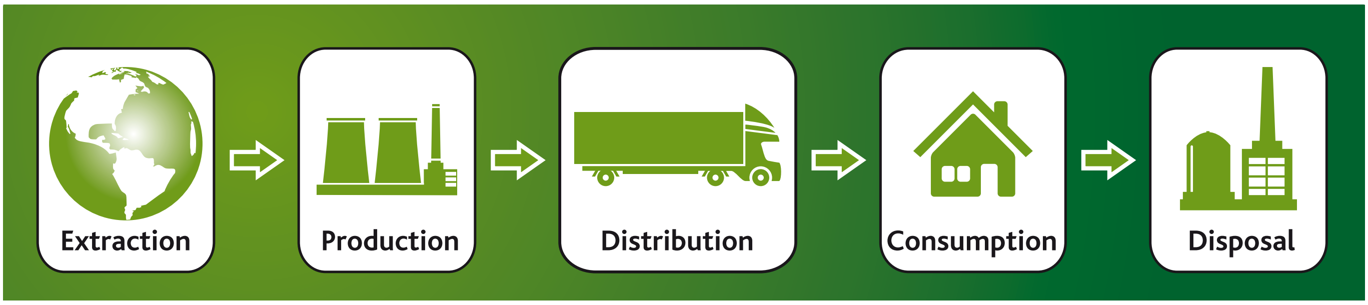


Figure 1: Conventional production – adapted from Leonard (2005)[2]

Figure 2: Closed loop production – adapted from Leonard (2005)[2]

Legislative pressures and consumer awareness are driving businesses to develop sustainable product design strategies[1]. End-of-Life (EoL) processing and design for the environment will therefore be of increasing interest. Designers have been aware of production issues for many years. However, design for disassembly and EoL processing are not so well established or understood. There is a need for practical advice and information about the implications of design decisions and material choices.

This article explores the use of sustainable design standards in the product development process, from both an environmental and economic perspective, with a particular focus on BS 8887-1 (2006) 'Design for Manufacture, Assembly, Disassembly and End-of-life processing (MADE)'.

To gain insights into the application of BS 8887-1, with a focus on sustainability, industry practitioners, who are active in new product development, were approached. More than 60 people with responsibility for design and development, including production, quality and drafting, were involved.

A case for less consumption

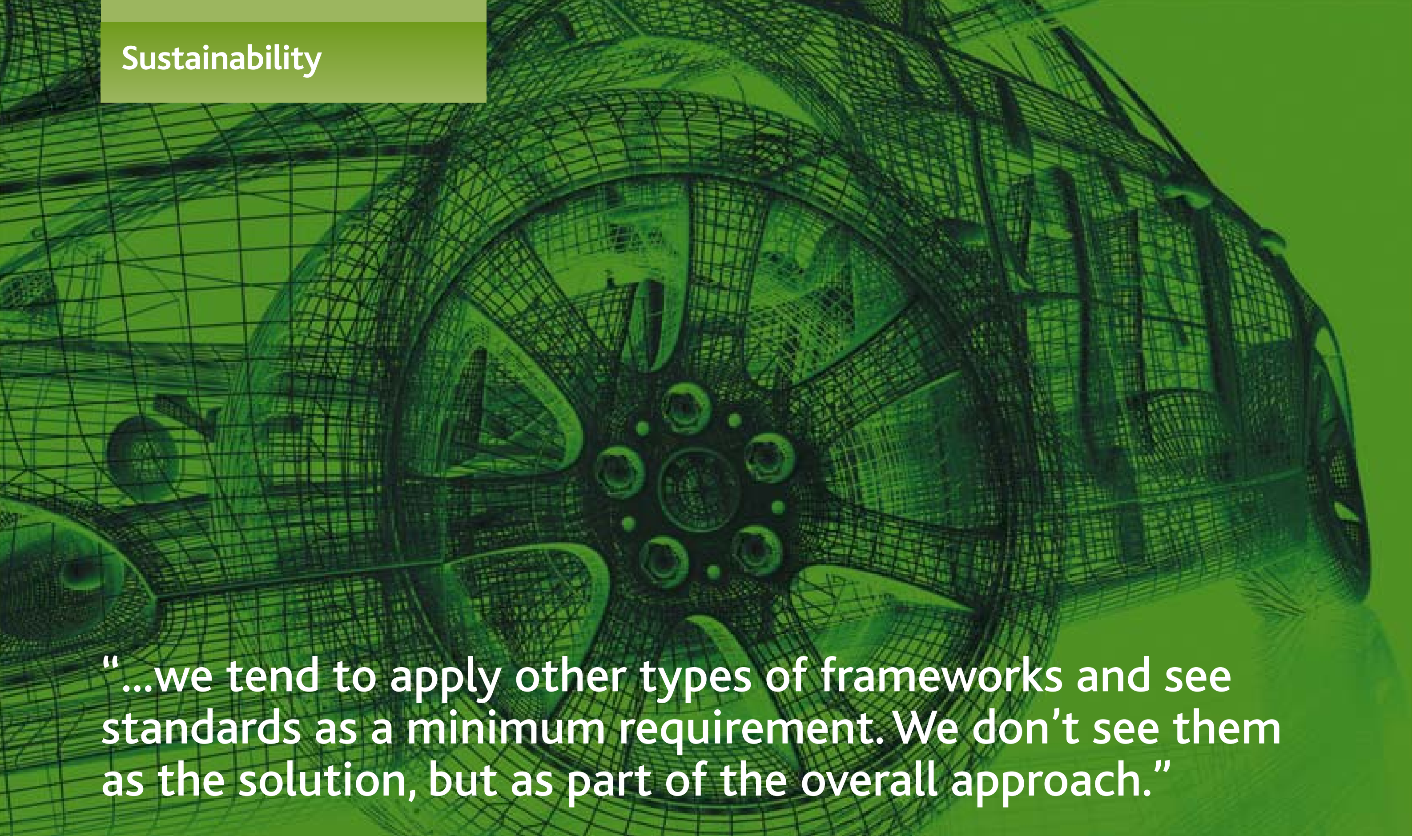
During the conventional product life-cycle, materials move through a sequence of extraction, production, distribution, consumption and finally disposal. This is known as the 'materials economy' and is represented in figure 1. It is a linear system that cannot be supported indefinitely[2].

A company making high tech equipment commented: "If we can stop putting stuff into the ground it is better for everybody. It saves more minerals from being excavated and also stops any possible contamination from landfill sites. This is very important for future generations." In the past 30 years, one-third of the planet's resources have been consumed[3]. Product designers should consider not only the production and transformation processes, assembly and technical aspects of manufacture, but also the consumption of water, energy, the origins of raw materials, as well as the residues generated and their disposal[4].

An R&D manager responsible for new product development said: "In the research and development department there is a big motivation to be greener. I think scientists generally are aware of environmental issues, and most of them are supportive... If you can get through life consuming less, that has to be a good thing. Most scientists are logical enough to see the clear case that it is always better to use less if you can."

Sustainable design refers to an approach that minimises environmental impacts, reduces production costs and gives companies a competitive differential in the market. Currently, about 60% of products are no longer in use six months after they are purchased[5]. Closed loop production, as illustrated in figure 2, has obvious environmental benefits and can deliver significant cost savings. Such systems maintain the economic and consumer benefit of industry while minimising the requirement for virgin material and the disposal of waste.

A leading authority on civil engineering explained: "In the long term, sustainable design is vital... I have had the argument with manufacturers that sustainable design is going to cost more and therefore increase prices, which has led to a fear that they would lose their market. I have explained that 'if everybody carries on the way you



"...we tend to apply other types of frameworks and see standards as a minimum requirement. We don't see them as the solution, but as part of the overall approach."

are going, the market, and the people you are trying to sell to, is going to start dying because the world is going to be piling up with rubbish.' Their response? 'Oh, that's in 20 years' time and for the government to do something about.' Only a few companies and a few organisations understand the message and the reasoning, are actually going to do anything about it and are willing to accept it. They grab BS 8887-1 with both hands saying 'this is great, this is the sort of information we need and can we have more of it!'"

Even if EoL product does not have an immediate financial value, there can be other advantages to take-back schemes. An engineering manager responsible for railway track equipment acknowledged: "If we want to do effective product development for the next generation, it is necessary to know what is going wrong with the product currently being made. The value of returned product is in determining the reason for failure."

Key stages

New product development begins with the 'market' because if there is no demand for a product or the service that it provides, then it cannot be a commercial success.

In the second stage, a 'specification' detailing design engineering requirements and product attributes, is written. These requirements would be established through market research. Relevant standards and legislation to be complied with are also stipulated. For manufacturers supplying to industry, specification requirements often come from their customers, as highlighted in an interview with a marine engineering company: "Anything that is supplied as a bespoke service will be dictated by the customer. Sometimes it is necessary to go back to various international customers and explain why certain stipulations can't be complied with because the legislation in the country of origin is slightly different. Normally, a company would dictate that we work to whichever standard is the highest."

The specification is used as a reference for 'concept design'. Drawings and models of the most promising concepts are evaluated with the client or members of the target market audience before moving forward to 'detail design'. "A clear fixed picture of the specification is developed so there will be certainty about what it is that we are supposed to be delivering. The project will then move to 'specific design', where it will be fleshed out in its final form. It is at this point that standards are often applied and health and safety requirements met." At the detailed design stage the chosen concept is optimised for 'manufacture'. The danger is that when substantial changes are made to a design late in the process, they tend to be very costly and should be avoided if possible.

The design output is the technical product specification (TPS), which drives the manufacturing activity. Production engineers are limited in how much they can improve a product by the position they occupy within the development process. A quality consultant said: "It all starts with design. By the time a product goes to manufacture the impacts are a given, they are set. With design for EoL and recyclability, or any other environmental impacts, the manufacturer will be stuck with them."

The last stage is 'sales'. Money and profit is fed back into the system from customers, thus providing income for the retailers, distributors, manufacturers, designers and investors. Design and manufacture are integral functions of the highly interdependent national and global economy. Today the process should not end there, producers of manufactured goods must also plan EoL product strategies.

Information is power

In part, the challenge of sustainable design is in capturing in writing, the information pertinent to all user requirements and product attributes.

The representation of the design process in figure 3 illustrates information transfer down through each stage to the next. It also shows inputs from multiple sources entering the process as required. In addition to the information flows represented, ideas and problems encountered are fed back to earlier functions, so that designs can be updated and improved in light of experience with previous models. This was highlighted by a company making sewage treatment equipment. "Staff can easily go from the factory to the design office to report difficulties such as the product being too difficult to put together or modify. Meetings are held regularly with company service engineers from all over the country. They report directly on problems with the products operating in the field. Such problems might include difficulties taking equipment apart or things that don't work. There is very close cooperation between design, production and the end-user. The design manager also regularly takes the opportunity to accompany the salesmen and service engineers and visit end-users. Comments from the various concerned parties are addressed in the design of future products."

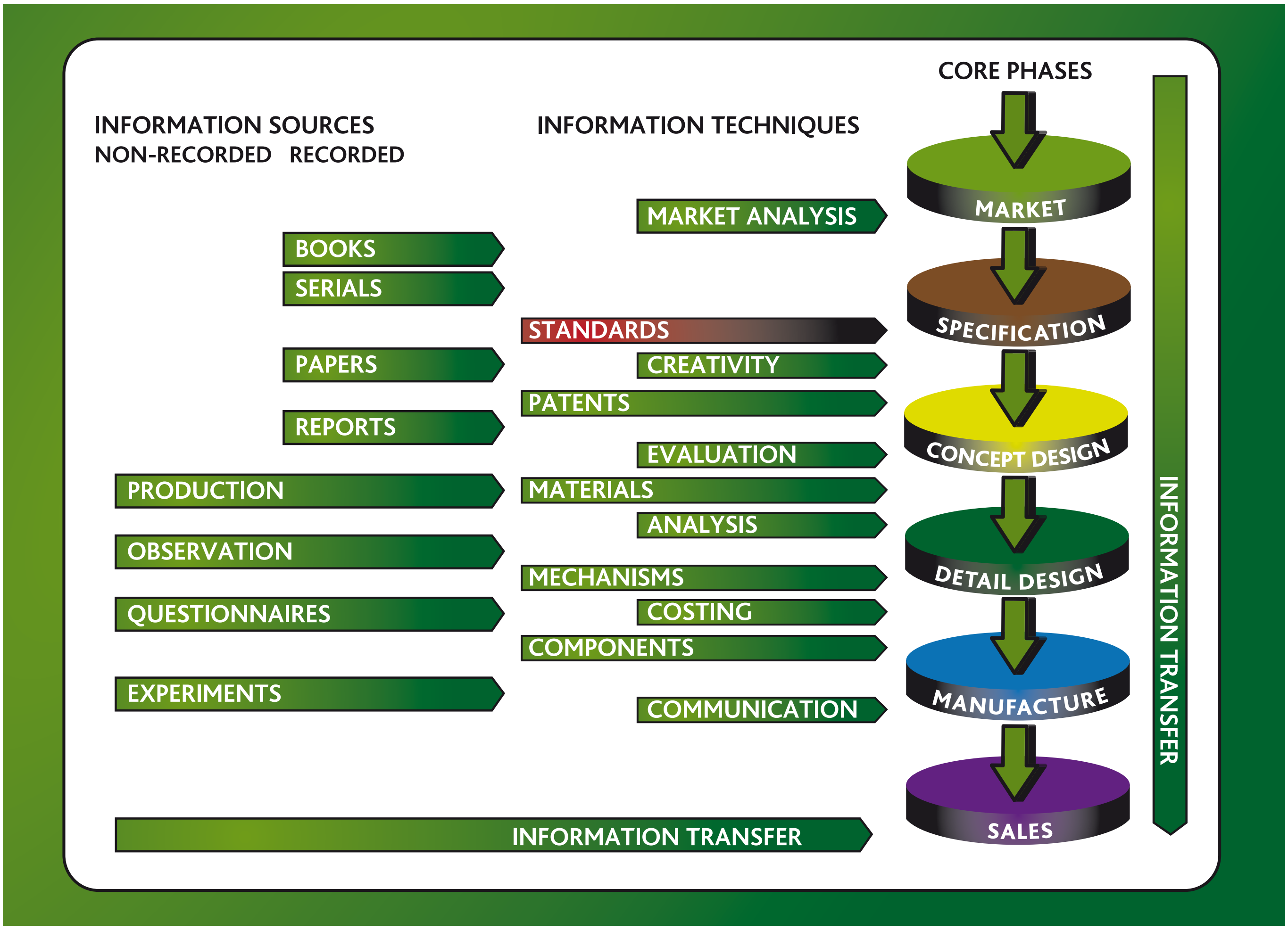
In another example of information transfer, a boiler engineer explained: "One of the parts of BS 8887-1 was used with the sales department who were requesting some new product development work. The senior design engineer asked for information relating to the product brief in order to fully understand it. The requested information was based on a list from Section 5: design brief (Table 1 on page 6 of BS 8887-1). This included market need, opportunity, price, potential for ongoing development and time scale, thus covering all of the 'parameters for consideration in the preparation of a design brief'. Effort is made to identify opportunities and consumer needs through user involvement, so users help design the products."

The challenge of information transfer can be problematic and expensive when late changes occur. The following opinion was typical: "It can be frustrating that once the design process has started and an accurate technical specification has been arrived at, the design requirements may change following the first iteration of a product. Very often other demands will grow out of that. One of the things that the company suffers from is the people who work in the sales department and many of the customers are ignorant of the engineering possibilities. Design tends to be a fairly organic process and it needs to remain flexible right up to the prototyping stage. Frequently there will be changes, sometimes fundamental changes, in the components of a specification right up to the point where the first production prototypes are built and field trialled with customers. Often there will be feedback from that because there were unforeseen issues."

The bottom line

EoL processing is starting to gain recognition. However, the financial implications of adopting such processes can be an obstacle when the activity is not profitable, as commented on by an auto parts firm: "A good product should not die because it can't be recycled. In some instances recycling could cost as much as the product itself." From the perspective of a designer concerned with environmental impact, BS 8887-1 Annex C is especially useful as it can be directly applied to product development and appears almost as a checklist. However one interviewee commented: "The recommendations in Annex C should be considered alongside the requirements relating to performance, commercial viability

Figure 3: Design activity model – adapted from Rhodes and Smith, (1987)[6] in Pugh, (1990)[7]



The MADE Concept

In the UK, the main manufacturing standard is BS 8887-1 (2006), which has its origins in PD 6470 (1975). This standard was entitled 'The Management of Design for Economic Production'.

The TDW/4/7 committee of the British Standards Institution (BSI) decided to take a holistic view of design. The new standard has an equal emphasis on each stage of the product life-cycle, including production and what happens after use. The result is BS 8887 'Design for Manufacture, Assembly, Disassembly and End-of-life processing (MADE)'. As BS 8887-1 is 'Part 1' of the series, it is the entry standard or foundation from which others follow.

BS 8887 did not start as a sustainable design standard. It is concerned with the way in which documentation produced by designers, using BS 8888, is used. The standard was originally developed to support manufacture. It was intended to help with the conversion of design output into physical products. It soon became clear that it was also necessary to consider product life-cycle planning. This necessity led to the inclusion of eco-design, disassembly and EoL considerations.

BS 8887 is a highly authoritative source of information that supports the emerging industrial trend towards sustainable production. More EoL processing and product life-cycle planning standards and additional specific standards, directly applicable to various industries and product groups, will expand the series.

and health and safety given in the body of the standard. It is for the designer and/or relevant design collaborators to decide on the relative priority to be given to issues once they have been considered."

The standard is not a prescriptive set of requirements against which a product can be certified as compliant, but highlights the design and planning issues that must be addressed to support sustainability. A firm manufacturing disability aids commented: "As much as possible is recycled. The number of parts that can't be reused is kept as small as possible for disposal. Much of this is based around the fact that it costs money to dispose of electronic products. It makes sense to reduce the cost of disposal."

The BS 8887-1 'Best Practice Sequence of Events' features several differences from the model shown in figure 3, but most notably now contains 'life-cycle considerations, including end-of-life processing' and 'design for assembly and disassembly'. This requirement for design for disassembly was sometimes unintentionally achieved through design for assembly: "In terms of companies applying it, I think many of them are doing it as part of the design process they go through, sometimes without recognising it, because they are designing for assembly. Obviously, the links between that and disassembly and remanufacture are strong."

However, there are differences between design for assembly and design for disassembly. Just because something is designed to be simple to put together, it doesn't necessarily mean that it can come apart easily. One company working with lasers had designed their product for assembly, but had definitely not designed it for disassembly. They did not want their product to be reverse-engineered and taken apart for security reasons. Their solution was to encase the technology in resin.

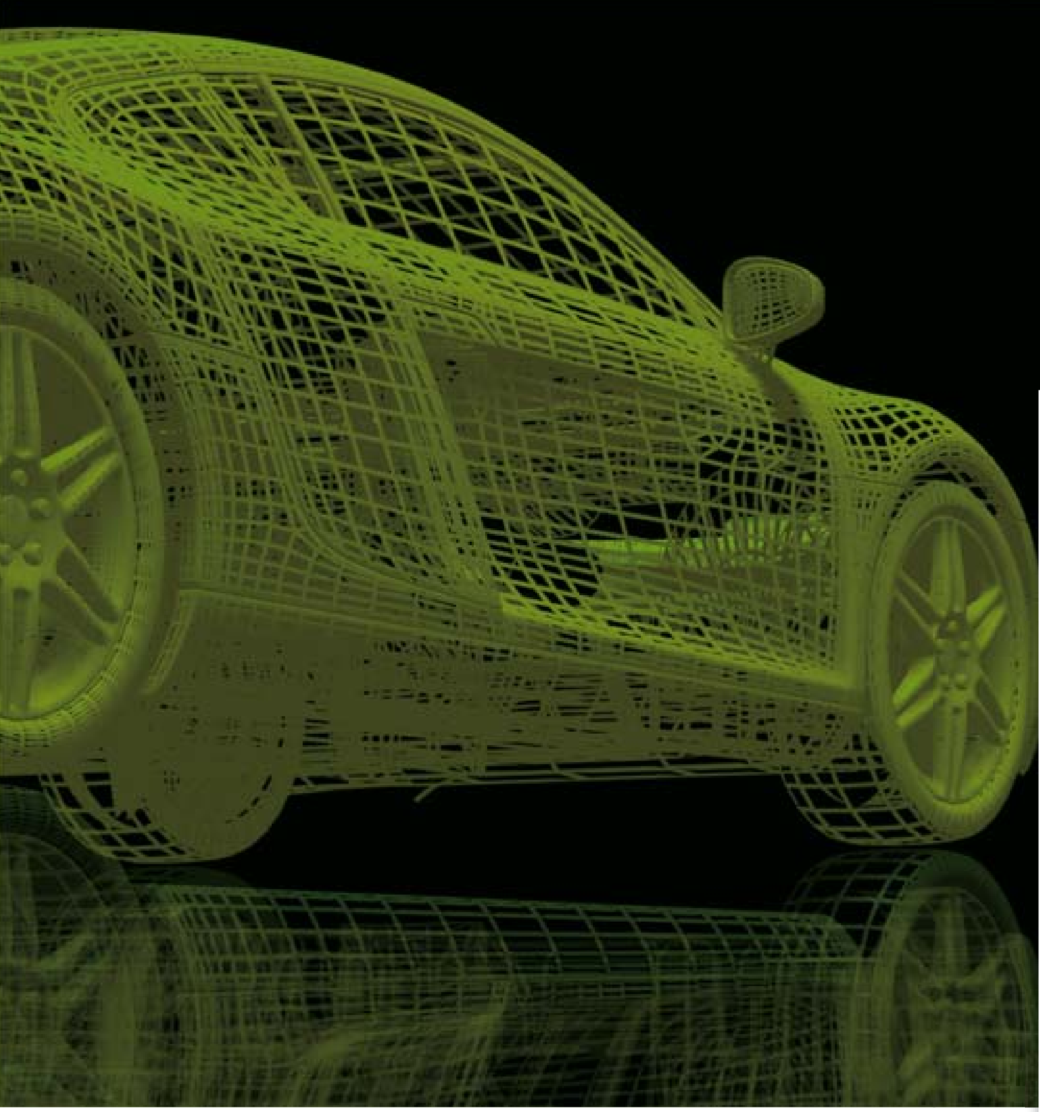
It is widely recognised that it is in the early stages of product development where sustainability can be most effectively addressed. Under BS 8887-1, a 'MADE team' is required for the development of the design brief. Collaboration between representatives of the various disciplines is not uncommon in commercial design. Early stage inclusion of people with expertise in product 'take-back facilitation' and 'environment' within the MADE team, should greatly improve the EoL value of the product being planned.

Around 70-80% of a product's features, manufacturing methods and costs are determined during the early stages of the design process[8]. There was unanimous agreement among those interviewed that the beginning of the design process is the optimal time to apply life-cycle planning. One technical product developer commented: "In reviewing the standard, I have been through each of the sections to tie it in with what we do and, if necessary, I have changed what we do to help fall in line with that, as long as it doesn't contradict anything that we are already trying to do

for other standards. The interesting thing for us is the EoL information because of the End-of-Life Vehicles Directive. In trying to comply with that... it's good to have it at the front end as well."

Not all of the Standard's users were motivated by its sustainable design content. In an interview with a construction firm specialising in building support systems, it transpired that BS 8887-1 was part of a batch of standards bought to assist with product optimisation for manufacture. Financial considerations still dominate decision-making during the design process: "The goal is to value analyse each item beginning with those with the highest volume of sales and ask 'can we reduce the cost?' or with the larger products 'can we improve the efficiency and reduce the cost?' If the weight of a casting can be reduced by 10%, the cost will be reduced by almost 10%."

Standards are written by consensus; they could be regarded as statements of basic requirements to be exceeded: "The standard can be part of the process, but we tend to apply other types of frameworks and see standards as a minimum requirement. We don't see them as the solution, but as part



of the overall approach." Section 13 of the standard, which sets out documentation requirements for design, manufacturing and EoL, has proved valuable, as one participant commented: "BS 8887-1 has been helpful in... creating a set of documents... with recommended methodologies and processes including design brief, specification, technical documents, market, materials and through the whole range of recommended documentation."

Proper documentation and a full audit trail were also important to some environmentally aware commercial customers: "The company is currently looking at more environmentally friendly ways of producing electronics. This is an ongoing process as designs are updated. This is not only for internal purposes, but is being driven by customers. More and more customers are requiring us to find out where the components have come from and to see the audit trail."

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The BS 8887 series supports industry in its inevitable transition through the development of lower impact products and into closed loop production. The interviews with industrial practitioners reveal how BS 8887-1 is already being used within their established design process and is proving commercially advantageous. Implementation requires both knowledge and judgment on the part of designers and support from management, as well as extended scope of operations to include end-of-life product recovery.

I would like to take this opportunity to thank all those who have contributed to my research by making themselves available for interviews. ***Alexander Plant.***

Information

This article is based on a research paper entitled *Design for Manufacture and Sustainability in New Product Development* written by Alexander VC Plant, David J Harrison, Brian J Griffiths and Rebecca De Coster, School of Engineering and Design, Brunel University. It was first published by the Institute for Manufacturing in the proceedings of the Cambridge International Manufacturing Symposium 2010 – ISBN 978-1-902546-90-2.

If anyone would like to make a contribution to the future development of BS 8887, they are invited to contact the TDW/4/7 committee by emailing Brian.Griffiths@brunel.ac.uk.

Any queries or comments relating to this paper should be directed to Alexander.Plant@brunel.ac.uk.

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