“GREEN” DESIGN

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The amended Law Concerning Rational Use of Energy was enforced on April 1999 and the Specified Household Appliance Recycling Law will come into effect on April 2001 (both in Japan) in an effort to create a sustainable society in the face of worsening global environmental problems. Although conventional product design has focused on quality, cost, and lead time, manufacturers such as Yokogawa are required to include the environmental impact factor in the design. Hence, manufacturers must assess their product design so as to minimize the environmental impact of the product throughout its life-cycle from purchase of the materials and parts, through manufacturing and distribution, to use and disposal. This paper introduces Yokogawa’s design guideline, design criteria, and assessment tools for assessing product designs and developing environmentally friendly products. An example result of a “green” design and the practices of self-declared environmental labeling are also given.

INTRODUCTION

Environmental friendliness (E) must be assessed in today’s product design in addition to the conventional design considerations of quality (Q), cost (C), and lead time (D). Hence, the product design system must be urgently restructured in order to minimize the environmental impact of a product throughout its life-cycle from purchase of the materials and parts, through manufacturing and distribution, to use and disposal.

DESIGN CRITERIA AND DESIGN SUPPORT TOOLS FOR ENVIRONMENTALLY FRIENDLY PRODUCTS

In 1997, we began enhancing the guidelines and standards for engineers by including information on how to engineer and design environmentally friendly products as well as how to assess them. We have now issued the design criteria and assessment standards for environmentally friendly product design as shown in Figure 1.

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Environmentally Friendly Product Design Guideline

This guideline was drawn up in order to define mandatory rules regarding environmentally friendly product design. The intention is not to hamper miniaturization, which has long been one objective when designing a product, since it helps reduce the impact on the environment, but rather to take into account the disposal of products. The design aspects stipulated in this guideline include:

- Design of long-life products
- Design of energy-efficient products
- Design of resource-efficient products
- Selection of materials and parts
- Recycling and disposal design
- Selection of machining and assembly methods

Environmental Assessment Standard for Product Design

This standard defines the criteria for assessing the environmental impact of each product designed according to the aforesaid Environmentally Friendly Product Design Guideline, to ensure that the design considers reduction of environmental impact and that the design targets are set from the early stages of product design. The progress of the series of assessments to be performed in accordance with the following rules stipulated by this standard is recorded in the Product Design Assessment Record Form shown in Table 1:

(1) Stages of assessments: Initial design review, intermediate

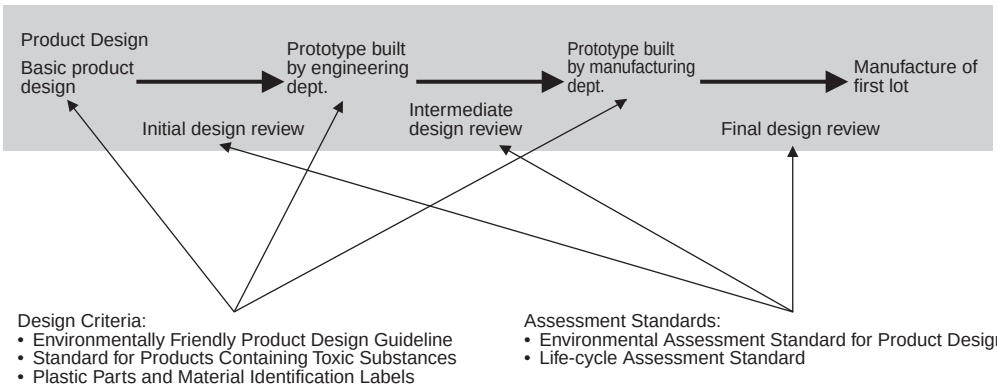

Figure 1 Design Criteria and Assessment Standards for Environmentally Friendly Product Design

design review, and final design review

(2) Assessment items: 29 items including salvageability and recyclability, resource efficiency, energy efficiency, long-term usability, ease of recovery and transport, safety, environmental integrity, information disclosure, and packing

(3) Assessment standards: Awards each item 0 to 4 points depending on the degree of reduction or improvement.

- 4 points: Reduced or improved by 30%
- 3 points: Reduced or improved by 15%
- 2 points: Reduced or improved by 5%
- 1 point: No reduction or improvement from the previous model but legal requirements are met.
- 0 point: No reduction or improvement from the previous model and legal requirements are not met.

(4) Pass/fail criteria:

- Pass: No item is evaluated as 0 point, or the total number of points is greater than that of the previous model.
- Fail: One or more items are evaluated as 0 point, or the total number of points is equal to or less than that of the previous model.

We set an overall reduction of 25 percent from Yokogawa's previous model as the guideline for improvement, and our aim is to incorporate this reduction in the environmental impact in designs.

Table 1 Product Design Assessment Record Form

Initial Design Stage		Intermediate Design Stage		Final Design Stage	
Drawn by		Drawn by		Drawn by	
Checked by		Checked by		Checked by	
Approved by		Approved by		Approved by	

Model Developed: CS 3000 Console **Earlier Model:** A1H21C (CS Console)

Category			Assessed Item	Previous Model	Model Developed			Appraisal			Appraisal (%)			Remarks
					Initial	Mid	Final	Initial	Mid	Final	Initial	Mid	Final	
1	Salvageability	1	Assembly lead-time	h	h	h	h							
		2	Disassembly lead-time (Parts made of different materials must be separated into mono materials.)	h	h	h	h							
		3	Use of recycled materials											
		4	Indications of materials for resin parts	Provided / Not provided	Provided / Not provided	Provided / Not provided	Provided / Not provided							
		5	Use of composite materials which cannot be decomposed											
		6	Number of types of materials used											
		7	Use of NiCd cells and indication of use											
		8	Gross area of PCBs	mm^2	mm^2	mm^2	mm^2							
2	Resource efficiency	1	Mass (kg)	kg	kg	kg	kg							
		2	Dimensions (m) and volume (liters)	_ x _ x _, L	_ x _ x _, L	_ x _ x _, L	_ x _ x _, L							
		3	Reduction of number of parts											
3	Energy efficiency	1	Reduction of running power consumption (can be normalized in proportion to comparison of functions)	W	W	W	W							
4	Long-term use	1	Provisions in structure to allow upgrade, such as modular structure											
		2	Easy-to-repair and easy-to-maintain structure											
5	Ease of transport and recovery	1	Provision of traveling wheels and/or handles for transport	Made / Not made	Made / Not made	Made / Not made	Made / Not made							
6	Safety and environmental integrity	1	Toxic											
		2	Explosive											
		3	Hazard when disassembling or decomposing											
		4	Safety of personnel from burns											
		5	Possibility of removal of battery cells and LCD	Possible / Impossible	Possible / Impossible	Possible / Impossible	Possible / Impossible							
		6	Environmental integrity (use of contaminants not allowed)	No / Some contaminants used	No / Some contaminants used	No / Some contaminants used	No / Some contaminants used							
7	Disclosure of information	1	Explicit instructions for treatment upon disposal											
		2	Explicit instructions for treatment (decomposing procedure) to recovery company											
8	Packing	1	Total mass of packing materials (packing box + cushioning materials, in kg)	kg	kg	kg	kg							
		2	Package volume (liters)	L	L	L	L							
		3	Use of staples and the like	Yes / No	Yes / No	Yes / No	Yes / No							
		4	Amount of styrene foam used (g)	g	g	g	g							
		5	Presence of cementing of cushioning material and cardboard (regarded as impossible-to-decompose if cemented)	Yes / No	Yes / No	Yes / No	Yes / No							
		6	Use of other packing materials such as pulp mold											
Total Appraisal				Number of items =	29									
								0	0	0				
								Improvement rate (%)						

Note 1: Compare with a competitor's equivalent if there is no previous model of Yokogawa.

Note 2: For the appraisals, show the calculation results (calculated for each function) as a percentage, together with the points.

Points	Criteria
4	Environmental measures are taken sufficiently. (30%)
3	Environmental measures are not sufficient but have been improved. (15%)
2	Environmental measures have been slightly improved. (5%)
1	Environmental measures at the same level as for the previous model are taken, and the legal requirements are met.
0	Legal requirements are not met.

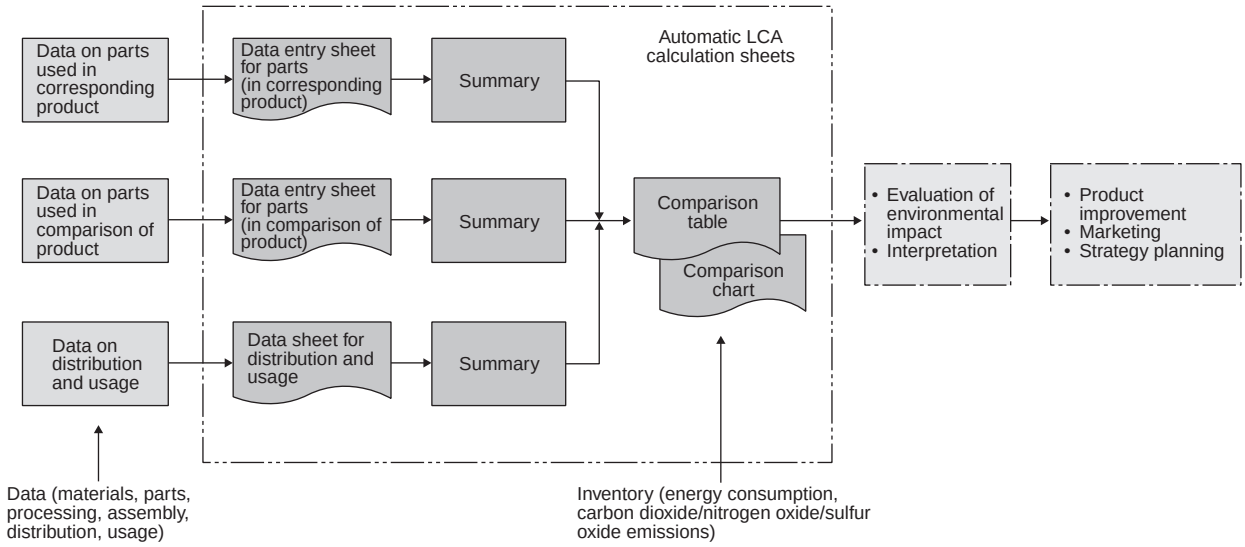

Figure 2 Configuration of Life-cycle Assessment Tool

Standard for Products Containing Toxic Substances

Regarding the need to take environmental protection into account also when selecting parts and materials when designing a product, the Standard for Products Containing Toxic Substances stipulates the use of toxic substances contained in products including packing materials. This standard categorizes toxic substances into prohibited substances and reduced-usage substances, and controls their usage.

Based on this standard, the currently used parts were researched and databases for eco-material selection were built. Each engineer is required, when assessing each product based on the Product Design Assessment Record Form, to check with these databases whether any of the parts for the product contain a prohibited substance that affects the environment.

Life-cycle Assessment Standard

A life-cycle assessment, or LCA for short, is a method to comprehensively evaluate the impact of a specific product on the environment throughout the life-cycle of the product, from material purchase, through manufacture and distribution, to use and disposal. We have developed an LCA tool for assessing a product quantitatively on a micro level in terms of energy consumption and carbon dioxide emissions. For the database, this tool uses NIRE-LCA from the Institute of Resources and Environment Technology in Japan. Figure 2 shows the configuration of the LCA tool, and Figure 3 an example of a comparison chart created using the LCA tool.

AN EXAMPLE OF THE BENEFITS OF GREEN DESIGN[1]

The OR100 oscillographic recorder is an example of an environmentally friendly product that resulted from implementing the green design systematically from the early stages of development. Figure 4 compares the appearances of the OR100 and the previous model, the ORP1200. First, an environmental assessment was performed for the ORP1200 and identified high environmental impacts in many aspects including the power consumption, mass, and hard-to-recycle parts. The detailed design policy was then drawn up, taking these problems into account. As a result: (1) the power consumption was reduced by approximately 80 percent by lowering the circuit voltage and

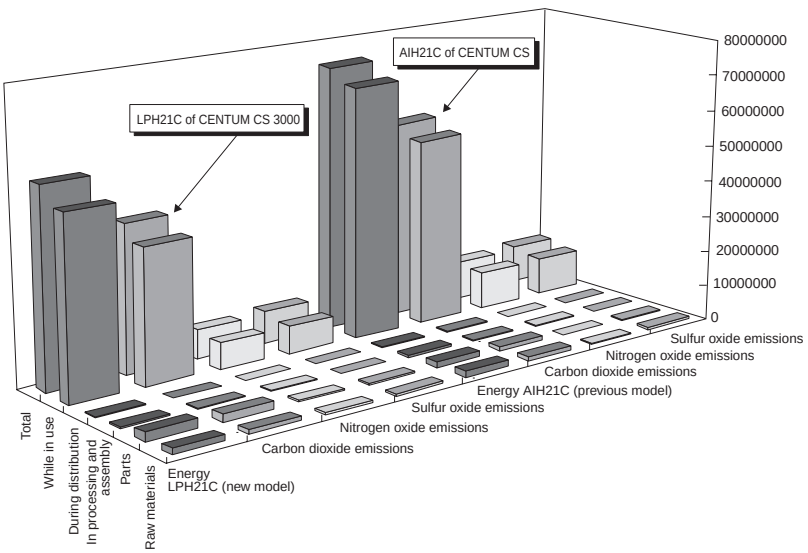

Figure 3 Example of Comparison Chart using LCA Tool

Figure 4 ORP1200 (previous model, left) versus OR100 (right)

Figure 5 Yokogawa's Eco-label

using application-specific ICs; (2) the mass and volume were each cut by 80 percent or more by using a three-dimensional CAD package for optimum structural design and by changing pressed and shaved parts to molded single-piece parts and employing gas-injection molding to create a thin but rigid casing; (3) the recyclability and ease of disassembly were improved by 76 percent by abolishing the press-fitting, gluing, swaging, and riveting of parts, use of insertion parts, and conductive coating.

ECO-LABELING

We have drawn up authorization criteria and rules of practice for the Type II self-declared environmental labeling schemes stipulated by ISO 14021[(2)] as of 1999. The authorization criteria allow the eco-label to be attached to only those products that:

- Have been designed in accordance with the Environmentally Friendly Product Design Guideline;
- Meet the Environmental Assessment Standard for Product Design; AND
- Are judged as taking greater account of environmental impact than Yokogawa's previous model or a competitor's equivalent.

Figure 5 shows Yokogawa's eco-label, which symbolizes a leaf and a panel meter, which was the main product of Yokogawa when it was established. The environmental data of the corresponding product, including the improved points and an advocacy that deserves special mention, are shown beneath this label. To date, authorization has been given to seven models: DX100/200 DAQSTATIONs, DL7100 digital oscilloscope, PZ4000 power analyzer, DL1540C/CL digital oscilloscopes, and MV100 data logger. This achievement is described on a website that is open to the public. The eco-label is also printed on promotional documents in order to promote "green" purchasing.

CONCLUSION

In the twenty-first century, manufacturers will be required to take actions toward reverse logistics, namely, to promote recovery, recycling, and disposal of products, in order to create a more sustainable society. Although there are few social controls applicable to Yokogawa's products at present, we remain committed to developing environmentally friendly products with reference to the controls that apply to household electrical appliances and the like. ◆

REFERENCES

(1) Yamamoto, Ryoichi. Strategic Environmental Operations – 100 Best Eco-design Practices, Diamond Inc. in Japan (1999)

(2) ISO 14021: Environmental Labels and Declarations – Self-declared Environmental Claims (Type II environmental labeling) (1999)