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TC S372 Product Environmental, Health and Safety Standards (Free Courseware)

香港公開大學
THE OPEN UNIVERSITY OF HONG KONG

Contents

Chapter 1 Product Categories and Life Cycle

1.1 Introduction

Welcome to this free courseware module, which is part of the OUHK course *TC S372 Product Environmental, Health and Safety Standards*. *TC S372* is a five-credit, higher-level course that is part of the BSc/Bsc (Hons) in Product Design, Testing and Certification programme degree programme at the OUHK.

TC S372, like most OUHK courses, is presented in the distance learning mode using print-based materials. The materials for this module have been specially adapted to make them more suitable for studying online.

Normal study units in OUHK courses contain study content, activities, self-tests, and assigned readings. This module retains most of these elements, so you can have a taste of what an OUHK course is like. In addition to this module's topics introducing the basic concept of product environmental, health and safety (EHS) performance, and on categorizing products and the product life cycle, the original unit also includes topics on product EHS performance, and standards and regulations.

This module provides you with the foundational knowledge you need to understand what 'products' are, and how they can be classified, designed, produced and disposed of in ways that best preserve and promote the integrity of the environment, and of human health and safety.

This module should take you about six hours to complete, including the time you will need to complete the activities and self-tests.

Good luck, and enjoy your study!

1.2 An introduction to product environmental, health and safety (EHS) performance

Living in a developed country, we use or come into close contact with hundreds or even thousands of products every day. These include common things such as your toothbrush, shoes, mobile phone, the dining utensils you used today, the highlighter you use for studying this course, and even the folder that holds the hard copy of this study unit.

But how much do you know about these items? It's likely they were mass-produced in different factories around the world, some even in places you have never heard of.

Obviously these are important questions. Imagine how you and the rest of society could be affected if the answer to any one of these questions is 'yes'! The following are real-life examples.

There can be serious consequences if new products are launched into the market without thorough consideration of their effects on the natural environment and human health. The article in the following is about nanosilver particles, which are becoming increasingly popular in consumer goods.

Reading

Shetler, G and Environmental Health News (2009) 'Fish kill: Nanosilver mutates fish embryos' (http://www.scientificamerican.com/article/nanotechnology-silver-nanoparticles-fish-malformation/), Scientific American, November 17.

According to the article, how might products with nanosilver affect the environment and our health?

Surely it would be in everyone's interest to prevent such unfortunate incidents from happening. Ensuring that a product is safe to use, is environmentally friendly, and poses the minimal threat human health can be a very complex task. Such achievements can only be possible via joint efforts in developing, maintaining, and cohering to product environmental, health and safety (EHS) performance standards.

1.2.1 Activity 1

As a consumer, have you ever asked the following questions about the products you frequently use:

- Are they safe to use?
- Will they cause any harm to the environment during their usage or upon disposal?
- Will they cause any adverse effects on your (or others') health?

1.2.2 Activity 2

Visit the following YouTube links and watch the videos, which illustrate how problematic product designs can lead to deadly threats.

- This video (https://www.youtube.com/watch?v=Mb_sv8Wjnn0) is about exploding notebook batteries.
- This video (https://www.youtube.com/watch?v=dnFp2yLBnNQ) is about badly-designed car accelerator pedals.

1.3 Categorizing products

Imagine that you are a product designer, manufacturer or exporter. Among the numerous EHS standards around the world, how would you know which ones your products should comply with? Just as products are divided into categories, product standards are also grouped according to their nature and applications. Knowing how products are categorized will make life much easier, particularly when you need to identify the relevant standards.

Depending on the intention and area of application, the approaches to categorizing products may differ. For example, the product groupings for safety standards are different from those for product environmental compliance. This section gives you an overall idea by presenting some examples of product categorization, and ends with some remarks on the types of product this course will focus on.

Before continuing, let's see what 'product' means. According to ISO 9000 (http://www.iso.org/iso/iso_9000), which is a series of standards for quality management and quality assurance, a 'product' is defined as 'the result of activities or processes'. A product can be tangible (like a cup) or intangible (like transportation services), or a combination of both.

The following are the four generic product categories listed in ISO 9000:

- services
- software
- hardware
- processed materials.

Some products may combine several categories. For example, a car combines hardware (e.g. a steering wheel), software (e.g. braking control algorithms), and processed materials (e.g. lubricants). Whether a combined product belongs to a category depends on the dominant element.

The ISO 9000 series only applies to quality management systems (QMS), and does not actually apply to the products themselves.

The RoHS (Restriction of Hazardous Substances) directive, which has been adopted by the European Union (EU), suggests another approach to categorizing products. This directive is about the restriction on the use of certain hazardous substances in electrical and electronic equipment. As you can see in Table 1.1, the directive identifies 11 categories, some of which are exempted from compliance.

Category	Description
1	Large household appliances: refrigerators, washers, stoves, air conditioners
2	Small household appliances: vacuum cleaners, hair dryers, coffee makers, irons
3	IT and communications equipment: computers, printers, copiers, phones
4	Consumer equipment: TVs, DVD players, stereos, video cameras
5	Lighting: lamps, lighting fixtures, light bulbs
6	Electrical and electronic tools: drills, saws, nail guns, sprayers, lathes, trimmers, blowers
7	Toys, leisure and sports equipment: video games, electric trains, treadmills
8	Medical devices and equipment
9	Control and monitoring equipment
10	Automatic dispensers: vending machines, ATM machines
11	Other electrical and electronic products not covered by any other categories

Table 1.1: RoHS2 product categories

We can also look at how products with CE Markings are grouped. The CE Marking is the manufacturer's self-declaration symbol on the product that indicates the product's conformity with the health and safety requirements of the relevant European directives. If you look at the titles and nature of these directives, you will find that products are generally divided into 20 groups, as listed in Table 1.2.

Appliances burning gaseous fuels	Medical devices
Cableway installations to carry persons	Active implantable medical devices
Low voltage equipment	*In vitro* diagnostic medical devices
Construction products	Non-automatic weighing instruments
Equipment and protective systems for use in potentially explosive atmospheres	Radio equipment and telecommunications terminal equipment
Explosives for civil uses	Personal protective equipment
Hot water boilers	Simple pressure vessels
Lift	Pressure equipment
Machinery	Recreational craft
Measuring instruments	Toys

Table 1.2: Product groups for CE Marking

It is also possible to group products from an environmental perspective. For example, in the EU's Ecodesign Directive (http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/index_en.htm), which provides a framework for improving the environmental performance of energy related products (ERP) through ecodesign, the initial working plan suggests a list of 10 product groups which were considered to be a priority for implementation in 2009 to 2011. The groups are listed in Table 1.3.

Air-conditioning and ventilation systems
Electric and fossil-fuelled heating equipment

Table 1.3: EU Ecodesign Directive — product groups considered priority for implementing measures in 2009–2011

Food-preparing equipment
Industrial and laboratory furnaces and ovens
Machine tools
Network, data processing and data storing equipment
Refrigerating and freezing equipment
Sound and imaging equipment
Transformers
Water-using equipment

Table 1.3: EU Ecodesign Directive — product groups considered priority for implementing measures in 2009–2011

1.3.1 Activity 3

Visit this YouTube link (http://www.youtube.com/watch?v=oq1Zi_V4KyE) and watch the video, which gives a general overview of ISO 9001.

1.3.2 Consumer products

A large portion of our lives revolves around consumer products. According to the United States' *Consumer Product Safety Act (CPSA) (http://www.herc.org/library/cpsa.pdf)* and the *Consumer Product Safety Improvement Act (CPSIA) (http://www.gpo.gov/fdsys/pkg/BILLS-110hr4040enr/pdf/BILLS-110hr4040enr.pdf)*, the term 'consumer product' means:

> . . . ..any article, or component part thereof, produced or distributed (i) for sale to a consumer for use in or around a permanent or temporary household or residence, a school, in recreation, or otherwise, or (ii) for the personal use, consumption or enjoyment of a consumer in or around a permanent or temporary household or residence, a school, in recreation, or otherwise... (US Congress 1972 (United States Congress (1972) Consumer Product Safety Act, Public Law 92–573, codified at 15 USC, para. 2051–89.))

In layman's terms, a consumer product is something that you normally expect to be obtained by an individual for household, recreational or sports purposes. However, as you will see in the next reading, there are exceptions. For this reason, the Consumer Product Safety Commission (CPSC) (http://www.cpsc.gov) does not have jurisdiction over all consumer products.

If we view products from this perspective, the categorization approach is very different from those mentioned earlier in this unit.

Items that do not fall under the scope of commercial products in CPSA are food, drugs, cosmetics, medical devices, tobacco products, firearms and ammunition, motor vehicles, pesticides, aircraft, boats, and fixed-site amusement rides. Of course there are regulations for these items in the United States, but they are dealt with by other federal agencies such as the Food and Drug Administration (FDA) (http://www.fda.gov/) and the Environmental Protection Agency (EPA) (http://www.epa.gov/).

Activity 5 (Page 7) shows you how consumer products are categorized by the CPSC.

In fact, the CPSC regulates over 15,000 types of consumer products! It would be impossible to study each category. Nevertheless, we can focus on the groups which are of prime concern nowadays and those which we, as consumers, use frequently.

As you can see, there are numerous approaches to categorizing products, and numerous categories for each approach.

1.3.3 Activity 4

Scroll down to Section 3(a)(5) on page 5 of the the United States Consumer Product Safety Commission's (2008) Consumer Product Safety Act (http://www.cpsc.gov/PageFiles/111466/cpsa.pdf).

Can you name some items which are considered as consumer products, and some which are not?

1.3.4 Activity 5

Visit the website of the US CPSC (http://www.cpsc.gov/en/Regulations-Laws--Standards/Regulations-Mandatory-Standards--Bans/Regulated-Products/). It gives a table that lists out product types for which the CPSC has issued mandatory standards. Have a look at the titles. Scroll down the page to view the list of standards. Pay particular attention to Toys/Children's Products.

You should see a list of very specific standards for things like pacifiers and marbles.

1.3.5 Self-test 1

According to the CPSA, which of the following items are considered to be consumer products? For each item not considered to be a consumer product, give a reason why it is not:

- Shoes
- Cigarettes
- Apples
- Electric kettle
- Blood pressure meter
- Merry-go-round
- BB gun
- Lipstick
- Two-seat sports car
- Pesticide

1.3.5.1 Self-test 1 - Feedback

Items (a) shoes, (d) electric kettle, and (g) BB gun are considered to be consumer products by the CPSA.

The rest are not consumer products because they appear in the exceptions list: (b) cigarettes (tobacco products); (c) apples (food); (e) blood pressure meter (medical device); (f) merry-go-round (fixed-site amusement ride); (h) lipstick (cosmetics); (i) two-seat sports car (motor vehicle); (j) pesticide (pesticide).

1.4 The product life cycle

Have you wondered where the products you use come from, or what happens to them after you throw them away? Actually, products go through life cycles, just as living organisms are born, age and die.

Life-cycle thinking is a fundamental concept that enables a holistic approach to the planning, implementation and evaluation of a product's EHS performance, and its compliance with standards. The term 'product life cycle' refers to the phases of a product life — from planning to disposal.

If you search for this term on the Internet, you will find that other disciplines also refer to it, but with different meanings. For example, in the context of business management, 'product life cycle' usually refers to the stages of a product's market performance (i.e. how a product is introduced into the market), followed by growth,

maturity, saturation and eventually a decline in sales. This type of 'product life cycle' is not our intended area of study, so be careful not to get this concept mixed up. We will refer to 'product life cycle' only in the engineering context.

For example, the sales of mobile phones are now mainly driven by replacement sales. How often do you change your phone?

The following article talks about the product life cycle of a mobile phone.

Reading

Environmental Literacy Council (2002) 'The Environmental Literacy Council — Cell phone life cycle' (http://enviroliteracy.org/article.php/1119.php).

1.4.1 Activity 6

Visit this YouTube link (http://www.youtube.com/watch?v=CVa4GBze3tU) and watch the short video that talks about the life cycle of the Toyota Prius.

The video emphasizes the environmental friendliness of the car.

1.4.2 Product life cycle overview: from idea to disposal

The 'product life cycle' generally refers to the stages from idea to disposal of a product. As you can see in Table 1.4, it comprises six phases.

Click this link to watch the video:
http://www.opentextbooks.org.hk/system/files/resource/10/10234/10248/media/Product%20life%20cycle%20overview%20from%20idea%20to%20disposal.mp4

1. Product planning	In the first stage, product planning, customer needs, business trends, and market competition are analysed, and a

Table 1.4: The product life cycle

	team is formed to plan the product requirements, and to set timelines for its upcoming design, development, validation and production.
2. Design & development	The design and development phase comprises the preparation of detailed product specifications to meet the requirements already set. The concept design is then worked out, including necessary subsystems. This is followed by a detailed design for the product, and the selection of materials and components. Note that this is an essentially iterative task.
3. Verification & validation	Two major steps occur in verification and validation phase. First, a small number of product prototypes are built for design verification testing. If all criteria are met, pilot production may be initiated. If not, then the product must be redesigned. The second step is product validation testing, aimed at validating the production process itself. That is, it must be shown that the quality of the product wont be degraded when the production process runs at full capacity.
4. Production	If the product's design and production process have been validated, then full-scale production can begin. Note there may still be the need for testing end products at this stage before they are sent to customers.
5. Field deployment	As the name suggests, the field deployment stage is characterized by the product going out 'into the field' as customers use it. This phase involves marketing, and sales and technical support. The product's actual field performance may also need to be monitored, and improvements can still be made at this stage

Table 1.4: The product life cycle

6. Disposal	Disposal occurs at the end of a product's life cycle, I.e. when, for whatever reason, it's no longer worth using or repairing. In some cases, the manufacturer may still need to provide support at this stage in terms of disposing of, dismantling, or recycling the products.

Table 1.4: The product life cycle

The breakdown of the product life cycle into six phases is actually a traditional and limited view that was originally developed for manufacturers. But as product environmental, health and safety (EHS) issues are becoming increasingly important and in the public interest, the structure of the product life cycle has evolved into variants that provide more comprehensive coverage of other elements and parties, such as consumers, government, and recyclers. You'll see an example in Activity 7 (Page 12).

As you can see, recent product life cycle models are more comprehensive. Many have been and are being developed in the context of Design for Environment (DfE). Note that DfE actually encompasses three areas:

- design for environmental processing and manufacturing
- design for environmental packaging
- design for disposal, reuse or recycling.

The next reading explains this, along with industrial ecology, which emphasizes the product's interaction with the ecosystem at each phase of its life cycle. It also introduces the product-system concept — considering the product and its life cycle as a whole system that encompasses its environmental, social and technological context.

Reading

Read the first part of the article at the following website. Stop at the heading 'Life cycle approach to design: Methods and techniques'.

Giudice, F (2006) 'Life cycle concept' in 'Product design for the environment: Concepts' (http://www.productdesignenvironment.info/concepts3.htm).

In summary, the complete product life cycle comprises:

1. need recognition;
2. design and development;
3. resource extraction/sourcing;
4. material processing;
5. production/manufacturing;
6. packaging and transportation;

7. use/utilization; and
8. reuse/recycle/disposal.

Figure 1.1 gives an overall picture.

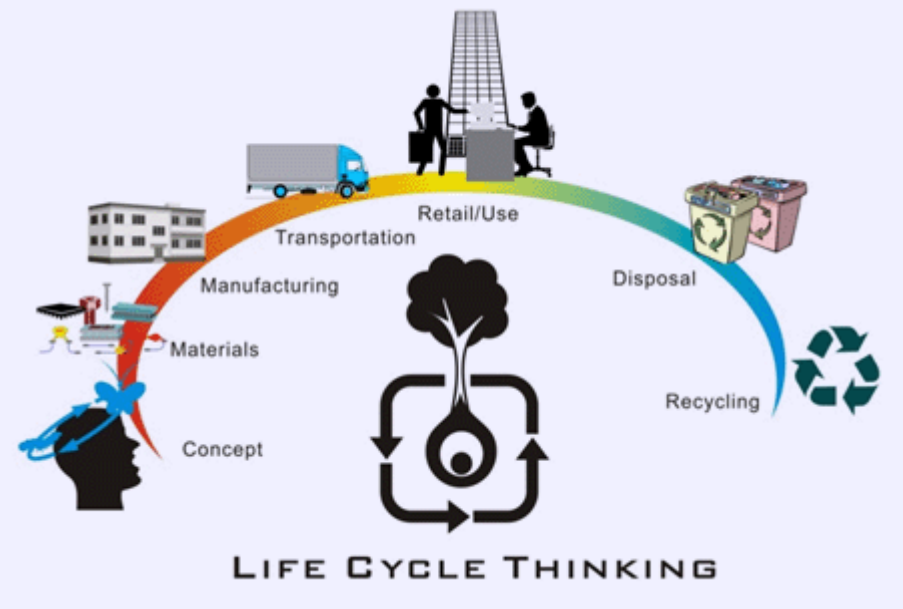


Fig. 1.1: Phases of the product life cycle from a DfE point-of-view

Source: http://www.dlinkgreen.com/greensupplychainmanagement.asp

By now it should be evident to you that a complete life cycle approach is advantageous. Life cycle thinking facilitates the making of environmentally-responsible products that span 'cradle-to-cradle' lives as opposed to 'cradle-to-grave' lives. This approach is also applicable in developing products with consideration for human health impacts and user safety. The idea is to integrate as many relevant measures as possible at each phase.

1.4.3 Activity 7

This pamphlet (http://www.epa.gov/osw/education/pdfs/life-cell.pdf) from the US Environmental Protection Agency (EPA) gives an interesting overview (with cartoons) of the life cycle of a mobile phone (note that mobile phones are usually called 'cell phones' in the USA). After reading it, attempt the exercises on page 2 of the pamphlet.

Pay particular attention to the six life cycle phases and the cell phone parts that have their own life cycles.

1.4.4 Activity 8

Visit this YouTube link (http://www.youtube.com/watch?v=gLBE5QAYXp8) and watch a video titled the 'Story of stuff'.

Remember that people may have different perspectives on product life cycles. Although this video has a strong political viewpoint, it actually gives a comprehensive overview of how a product-system interacts with the rest of the world in various realms: society, culture, economy, environment, etc.

1.4.5 Activity 9

Visit this YouTube link (http://www.youtube.com/watch?v=A-y0Q9uE0MM) and watch the short animation that takes you through the complete life cycle of a mobile phone.

Compare this video to the 'Story of stuff (http://www.youtube.com/watch?v=gLBE5QAYXp8)' video in Activity 8 (Page 13).

It's likely you noted that this video has a more positive message. Note how the materials and chemicals are analysed and assessed at the earlier phases of the cycle. The ending in fact is ideal — all materials that comprise the chair are sorted and recycled after usage. Good DfE practice should aim for such a beautiful ending.

1.5 Life cycle assessment and management

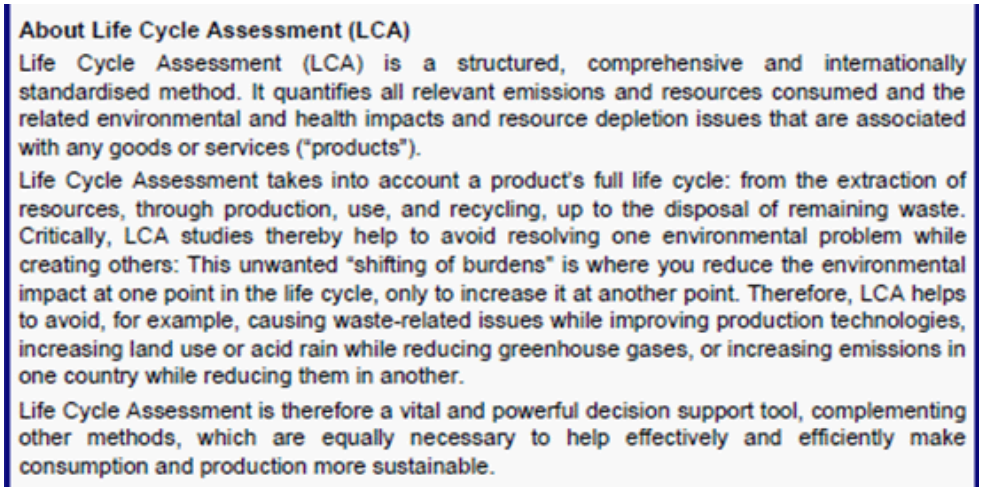
Life cycle management (LCM) refers to the process of managing the entire product life cycle from idea to disposal. According to Grieves (2006), it is:

> . . . . an integrated, information-driven approach comprised of people, processes/practices, and technology to all aspects of a product's life, from its design through manufacture, deployment and maintenance — culminating in the product's removal from service and final disposal. By trading product information for wasted time, energy, and material across the entire organization and into the supply chain, PLM drives the next generation of lean thinking (Grieves 2006 (Grieves, M (2006) Product Life cycle Management: Driving the Next Generation of Lean Thinking, New York: McGraw-Hill.), 39).

Among the various tools in LCM is life cycle assessment (LCA), which is a method for identifying and evaluating the environmental impacts of a product over its entire life cycle.

Read the excerpt from the European Commission's International Reference Life Cycle Data System (ILCD) Handbook, which gives a general introduction to LCA.

About Life Cycle Assessment (LCA)



About Life Cycle Assessment (LCA)

Life Cycle Assessment (LCA) is a structured, comprehensive and internationally standardised method. It quantifies all relevant emissions and resources consumed and the related environmental and health impacts and resource depletion issues that are associated with any goods or services ("products").

Life Cycle Assessment takes into account a product's full life cycle: from the extraction of resources, through production, use, and recycling, up to the disposal of remaining waste. Critically, LCA studies thereby help to avoid resolving one environmental problem while creating others: This unwanted "shifting of burdens" is where you reduce the environmental impact at one point in the life cycle, only to increase it at another point. Therefore, LCA helps to avoid, for example, causing waste-related issues while improving production technologies, increasing land use or acid rain while reducing greenhouse gases, or increasing emissions in one country while reducing them in another.

Life Cycle Assessment is therefore a vital and powerful decision support tool, complementing other methods, which are equally necessary to help effectively and efficiently make consumption and production more sustainable.

From European Commission, Joint Research Centre (2010) *International Reference Life Cycle Data System (ILCD) Handbook: General Guide for Life Cycle Assessment — Detailed Guidance (EUR 24708 EN – 2010)* (*http://lct.jrc.ec.europa.eu/pdf-directory/ILCD-Handbook-General-guide-for-LCA-DETAIL-online-12March2010.pdf*), 'Executive summary', 4.

Read the complete article at the following website (http://www.greenoptions.com/a/life-cycle-assessments).

Reading

Green Options, using material from Wikipedia (2012) 'Life-cycle assessments' (http://www.greenoptions.com/a/life-cycle-assessments).

As mentioned in the reading, an advantage of LCA is that it allows us to compare the environmental performance of products, and then to come up with decisions that lead to the least substantial environmental impacts.

You can see that many major businesses now recognize the advantages of LCA and are willing to spend substantial resources in implementing it.

The following two cases studies deal with 3M and ABB Ltd.

Reading

Read the following two case studies:

- Green Business Centre (2011) 'Life cycle approach' (http://www.greenbusinesscentre.com/msg/lca.html); and
- 'Life cycle assessment of large AC motors' (http://www.greenbusinesscentre.com/msg/lca2.html).

The definition of LCA is constantly evolving, and different companies of course implement it differently. Nevertheless, standards/frameworks (e.g. ISO 14040) have been developed for companies to follow and implement their LCA systematically. Recent LCM and LCA developments are taking into consideration not only environmental impacts, but also product safety and health issues.

You should now be ready to tackle the Self-test 2 (Page 15) for this section.

1.5.1 Activity 10

Visit this YouTube link (https://www.youtube.com/watch?v=ZlJ3HKXSdhc) and watch the short video. It is about the life cycle assessment and the ecodesign of cars.

1.5.2 Self-test 2

1. List the phases of a complete product life cycle.
2. What is product life cycle assessment?
3. Give some end-of-life options for notebook computers. Briefly discuss the pros and cons of each option.

1.5.2.1 Self-test 2 feedback

1.
    - Need recognition
    - Design and development
    - Resource extraction/sourcing
    - Material processing
    - Production/manufacturing
    - Packaging and transportation
    - Use/utilization Reuse/recycle/disposal
2. Holistic and systematic approach for identifying and evaluating the safety performance, as well as the environmental and health impacts of a product over its entire life cycle.
    - *Reuse*: Via organizations and programmes, or given to people in need.
    - *Recycle: Some electronics parts can be recycled; some notebooks are refurbished and sold.*
    - *Disposal: Send to landfills or incinerators; there is a problem with hazardous material polluting environment.*

1.6 References

Grieves, M (2006) Product Life cycle Management: Driving the Next Generation of Lean Thinking, New York: McGraw-Hill.

United States Congress (1972) *Consumer Product Safety Act*, Public Law 92–573, codified at 15 USC, para. 2051–89.