2 Problem identification

Here the processes necessary for the definition of a Product Design Specification (PDS) are detailed. As a prelude to writing the PDS much research must be carried out and much information gathered. This is a continual process and is described in Chapter 9. In this chapter the required contents of a PDS are explained and the format of a PDS illustrated by example. The writing of a PDS is the essential first step in every design project.

2.1 Introduction

If you were asked to design a corkscrew could you do it? Reference to Fig. 2.1, which illustrates many different types of corkscrew, probably convinces us that the answer to the question is yes. However, why are there so many fundamentally different types? How is it possible for different design teams to set out to design a corkscrew and end up with completely different devices?

In a little more detail the corkscrews illustrated in Fig. 2.1 are the plain corkscrew, with from left to right a double helix, lazy-tongs, the waiter's friend, a lever system and a screw pull. The double helix uses both left and right hand screws. One is inserted in the cork and the other forces the corkscrew against the neck of the bottle and removes the cork. The lazy-tongs illustrated provide a 4:1 mechanical advantage. Once the screw is inserted in the

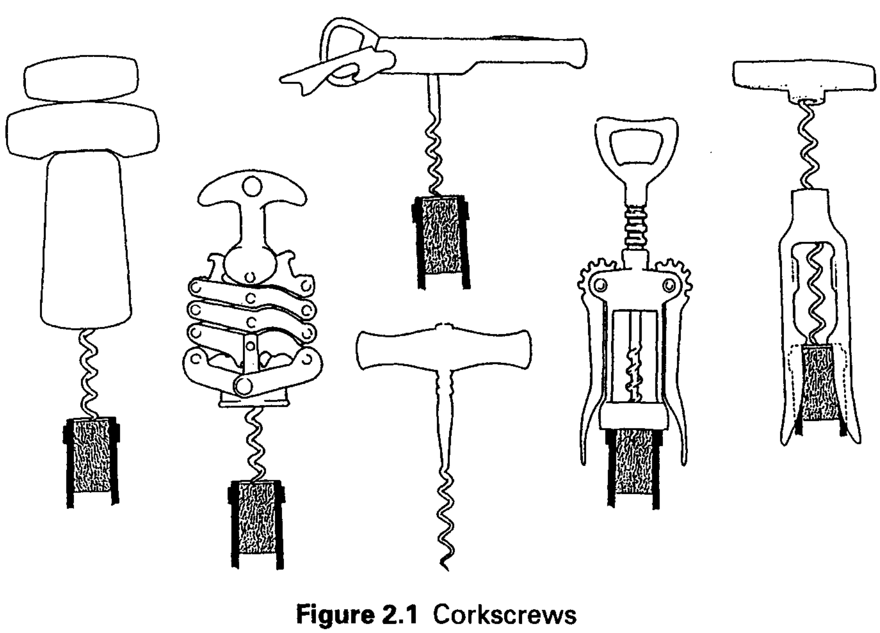


Figure 2.1 Corkscrews

cork the handle is pulled and travels four times the distance that the cork travels thus reducing the force required. The waiter's friend provides a mechanical leverage which is dependent on the length of the handle. When the screw is inserted in the lever system the levers rise. As they are pressed down the cork is extracted by pushing against the neck of the bottle. In the final device the screw is simply inserted in the cork and the turning continued. The cork 'climbs' the screw.

All of the devices described rely on the screw to be inserted in the cork. They differ in the mechanical advantage provided, in appearance, in complexity and in production cost. In order that a satisfactory product is designed the market need must be thoroughly researched and a technical specification reflecting customer requirements developed. In the case of a corkscrew constraints such as the mechanical advantage required, the appearance and the production (ex-works) cost must be specified.

In the solution of any design problem the design process begins with the defining of the boundaries within which a solution must be found. The project brief as presented to the design team is often incomplete. Hence, research often needs to be conducted and information sought before a full Product Design Specification (PDS) can be produced. Even if a full PDS is provided it is the duty of the designer to question the validity of that PDS.

This questioning approach can often make a customer alter their requirements. As an example consider the problem which was set as one of designing a corkscrew. If the original problem statement had been to design a device for removing a cork from a bottle then many more solutions are possible. Figure 2.2 illustrates two devices for removing corks which do not use a screw, the wiggle and twist extractor and an air pump. In application the two prongs of the wiggle and twist extractor are inserted between the walls of the bottle and the cork. By careful combination of pulling and twisting the cork is removed. The air pump employs a hollow needle which is pushed through the cork. Subsequent pumping action increases the pressure behind the cork and the cork is pushed out. Both of these valid devices were ruled out by the thoughtless problem statement which dictated that a screw be used.

As a final thought on this problem it is interesting to consider the problem statement as to remove wine from a bottle. More importantly, the new problem statement is as intended from the outset. If this is the intention then removing the cork may only be one category of solution! As further emphasis of the importance of a clear problem statement consider two wonderful engineering achievements.

The two photographs, Figs 2.3 and 2.4 show what was until April 1998 the longest single span suspension bridge in the world, the Humber bridge, and Concorde (the only supersonic airliner in the world) respectively. Both are elegant and simple in form and each is a

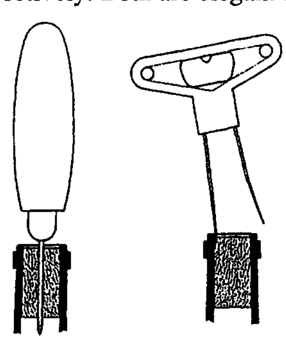


Figure 2.2 Cork extractors

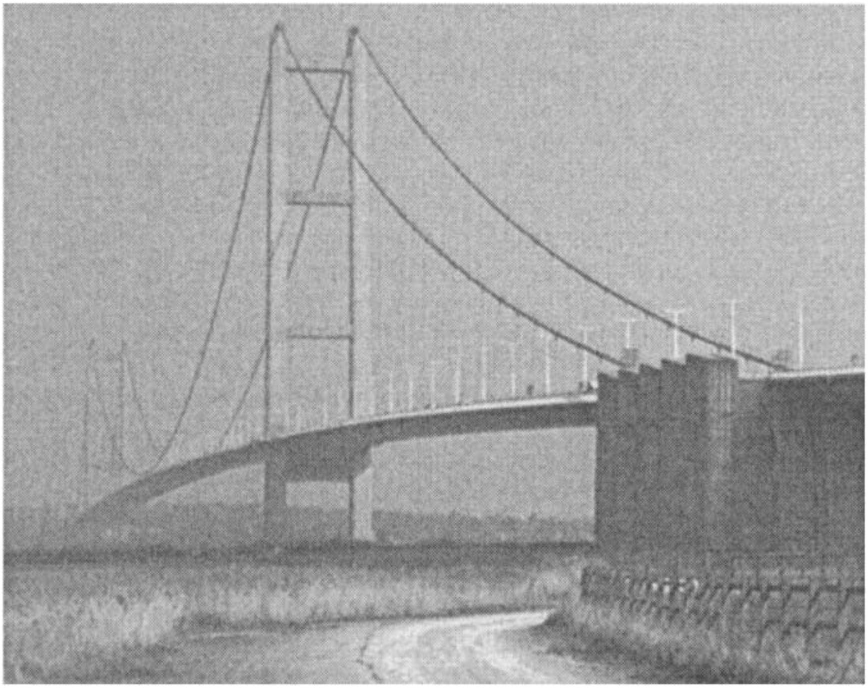


Figure 2.3 Humber Bridge (Reproduced by kind permission of The Humber Bridge Board)

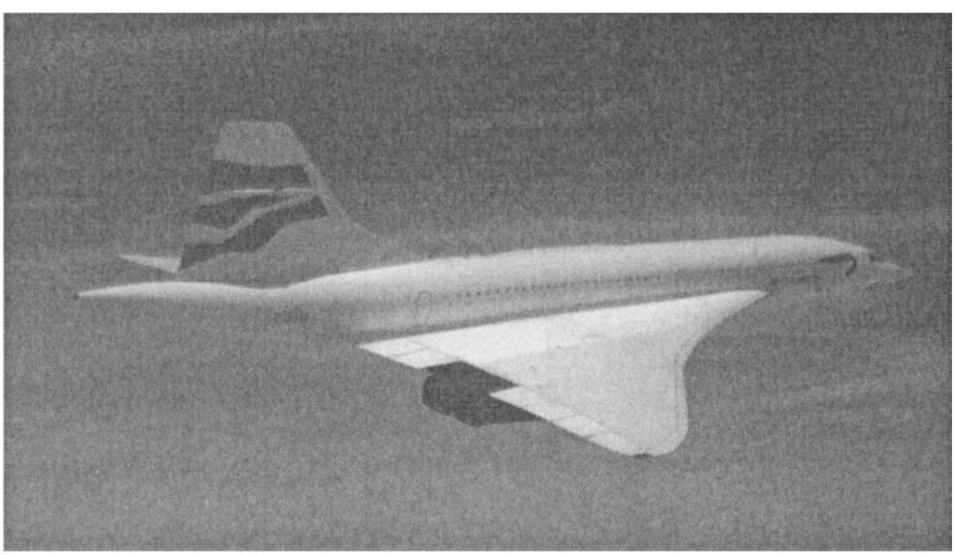


Figure 2.4 British Airways Concorde, the flagship of the world's civil aviation fleet (Reproduced with kind permission of British Airways)

magnificent feat of engineering which must be seen to be believed. However, neither has made a profit for their owners!

A first draft of a PDS must be developed before any attempt is made at generating solutions to a problem. This is an important discipline since so much time, effort and money can be wasted by providing a solution to the wrong problem.

Whilst it is desirable that a fully defined PDS be written before the design process starts it must be recognized that for many projects this proves impossible. The design process is iterative and the PDS must be regarded as a fluid document which will develop along with the design. This is indicated in Fig. 1.5 by means of the return arrows. The PDS is questioned at all stages and reference made to the customer as and when changes are suggested by the design team. However, the aim at the outset is to define the PDS as fully as possible.

It is extremely important that prospective customers are identified and that the language used in the PDS can be readily understood. Even within engineering each discipline, mechanical, electrical, electronic, civil and chemical, has evolved a specialist code not readily understood by other engineers. The customer may be involved in a totally different profession and yet must be able to understand fully the PDS.

It is the duty of the design team to verify that every function and constraint specified is relevant, correct and realistic. Consequently, it is essential that a thorough investigation of the problem is made by the designer before a solution is sought. For large, complex and diverse problems it is generally worthwhile breaking the project down into smaller, more manageable, sections.

In general there are two main tasks which have to be completed if a thorough identification of the problem is to be achieved:

(1) definition of the problem area;
(2) formulation of the exact problem.

The exact formulation of the problem involves the writing of a comprehensive PDS defining all the required *functions* which the solution must provide and all the *constraints* within which the solution must work. The information necessary for addressing these two tasks may be known or could be determined by calculation, by testing and by information search. Wherever possible a questioning approach should be employed and questions should be phrased in such a manner that a specific or numerate response is demanded. The information gathering process, which is a continual process, is explained in Chapter 9 and illustrated in Fig. 9.1. The information inputs required for the PDS are illustrated in Fig. 9.2.

2.2 PDS criteria

The main headings and criteria listed here and illustrated in Fig. 2.5 are intended to assist in the writing of the PDS. They are not to be regarded as an all embracing check-list which if followed blindly will completely define any PDS. Design projects are by their nature diverse and substantially different criteria are required from one project to the next. Nevertheless, the check-list will provide a good foundation upon which you, the student engineer can build. Once the project is begun you will find that many of the important criteria will suggest themselves. However, it is true that there is no substitute for experience and you should always be prepared, at any stage of the design process, to ask for help and guidance from experts such as component suppliers.

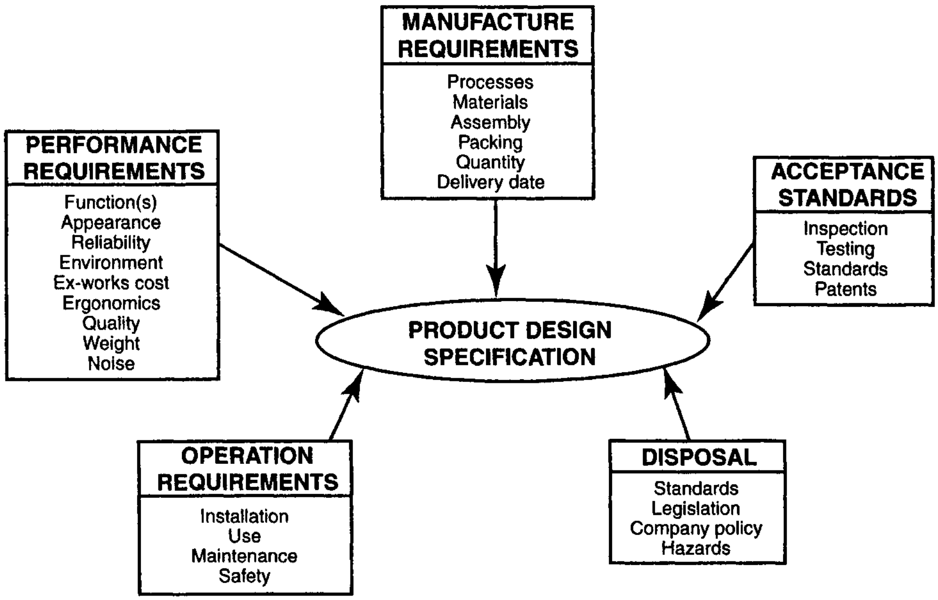


Figure 2.5 PDS criteria

The five main headings on Fig. 2.5, performance requirements, manufacture requirements, acceptance standards, disposal and operation requirements are now considered in detail.

Performance requirements

Function(s) There may only be a single main function which is to be provided by the product to be designed but this is unusual. More often than not multiple functions can be identified which can be divided into primary and secondary functions. These can vary in nature from mechanical, electrical, optical, thermal, magnetic and acoustic functions to name but a few. The primary function of an engine in a vehicle is to drive the wheels. Secondary functions, such as providing heating inside the vehicle and supporting alternators must also be listed.

Loading Loading can be divided into primary and consequential loading. Primary loads are due directly to the required function being provided. Shocks and vibration are generally consequent on the situation in which the product is used. Consequential loading is often very difficult to quantify without empirical data. Specified performance requirements should generally be met comfortably, with some performance to spare.

Aesthetics In some instances this is not important, particularly where the device or structure is not seen. However, for many consumer products or structures a pleasing elegant design is required and colour, shape, form and texture should be specified. All visible aspects must be in accordance with the nature of the product and reflect the corporate image of the company. Any statement in a specification which relates to the way a product will look is inevitably more qualitative than quantitative and should include analogy to qualities found in existing products or natural objects. It is possible to use techniques like golden section, which indicates that for aesthetic beauty any shape should be divided into two thirds and one third.

Reliability The required design life, taking due account of routine maintenance, must be specified. This is usually done by specifying the number of operating cycles rather than in units of time. Within this number of cycles an acceptable level (%) of random failures or breakdowns is also specified. Where high levels of life expectancy of components exist and it is known that those components will be employed in a controlled environment, such as in electronic circuits, it is common practice to specify the MTTF (Mean Time To Failure) and the MTBF (Mean Time Between Failures). Where reliability is critical, redundancy, either active or stand-by, should be specified. Reliability is inextricably linked with maintenance, even if a maintenance free product is envisaged.

Environmental conditions These include the temperature range, humidity range, pressure range, magnetic and chemical environmental conditions to which the product will be exposed. It is important to consider manufacture, store and transport environmental conditions along with the more obvious operating conditions. Also, any physical size restrictions should be specified. This is mainly dictated by the area available to the product when working but is often determined by considering transport and erection. The simplest form of expression for this constraint can be a diagram which forms an integral part of the PDS.

Ex-works cost Companies sell products for the maximum price the market will stand which often bears little relation to the cost of producing that product. Hence, the maximum cost specified in the PDS and which the design team must work to, should be the production (ex-works) cost and not the selling price.

Ergonomics (Human factors) If a product is intended for human use then account must be taken of the characteristics of those users. The design of the product and the tasks required of the product and the users must reflect their respective capabilities. The person/product interface, as identified in Fig. 2.6, must be carefully specified. Decisions are based on those functions which can be carried out by products and will vary as capabilities of machines increase. The functions carried out by the user are generally to sense a display, interpret it and make a decision and perform a controlling action.

The environment in which the product is to be operated should be specified carefully. For example, if noise levels are high then audible signals to which a user must respond may not be heard. Anthropometrics is the branch of ergonomics which deals with body measurements and it is normal to specify a user population who fall between the 5th and 95th percentile sizes in any particular respect. Any controls must operate in a logical or expected manner. Controls should be placed in easy reach of the operator.

Quality The quality of the product should meet market requirements and the quality of all components should be consistent. All workmanship must be in accordance with the best commercial practices. Robust design practices should be used where possible. All materials and components shall be new and free from defects.

Weight In some industries, such as aerospace, this is the most critical constraint. However, this is not always the case and weight is not always required to be a minimum. Generally in any product involving motion reduced weight is an advantage whereas a product where stability is critical may require weight to be a maximum. Minimum weight generally means less material which leads to reduced production costs and economic advantages.

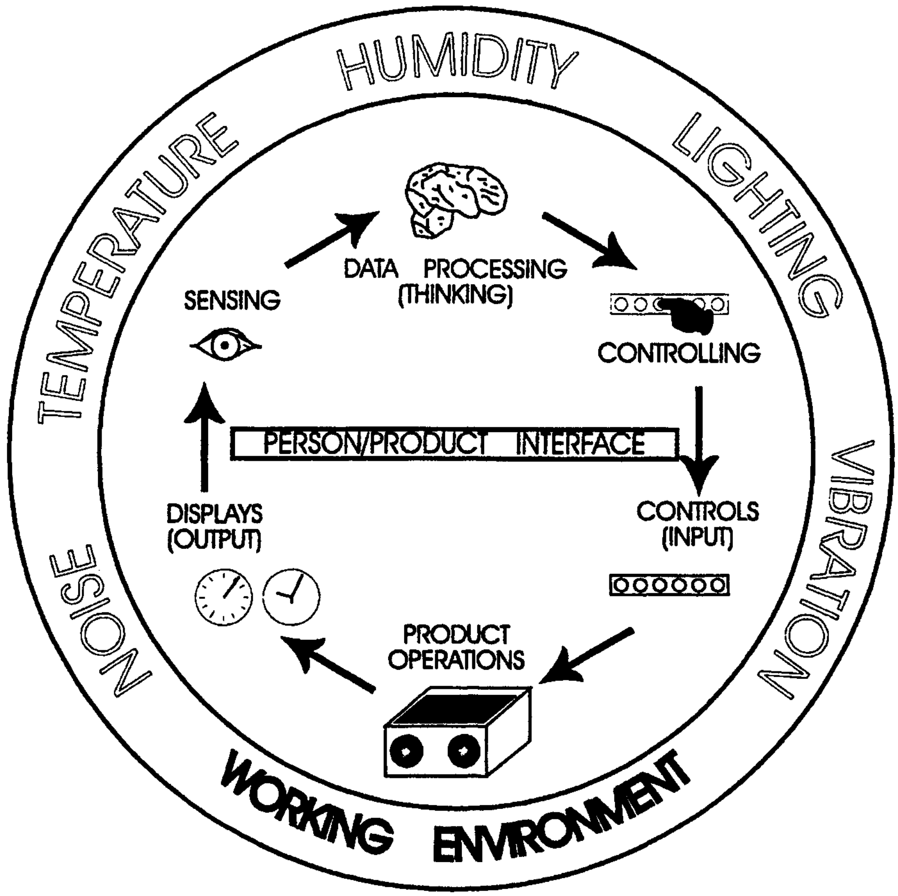


Figure 2.6 Person/product task division

Noise The upper limits of noise levels which can be emitted by the type of product being designed should be specified. Regulations differ from one country to the next so either the standard which applies in a particular country or the lowest maximum limit amongst those countries targeted for export must be specified. These standards represent the maximum level of noise which is acceptable but lower levels could be specified, for example, to gain competitive advantage.

Manufacture requirements

Processes The in-house manufacturing and forming facilities and the criteria under which external resources are sought should be specified. The required reliability of any source of supply and the required quality should be specified. Any special finishing processes which may be required should also be specified.

Materials Materials for both the product and its packaging must be considered and the criteria governing the selection of materials specified without constraining the design team unnecessarily. The many criteria which must be considered are corrosion and wear resistance, flammability, density, hardness, texture, colour, aesthetics and recyclability. There are also many regulations governing the use of hazardous materials which must be included in the specification if relevant.

Assembly The method of assembly should be specified; automatic, manual or assembly line. The rate of feed of components for assembly and time allowed are also important parameters. The specification should also contain statements with regard to the ease of disassembly.

Packing and shipment The maximum size and weight for convenient transportation must be specified. Shape can also be important since stacking products together can reduce transport costs substantially. Provision of suitable packing, lifting points and locking or clamping of delicate assemblies should be specified to prevent damage during transport. It may also be important to ensure large products can be disassembled and reassembled easily for transport. The cost of packing and shipment must be added to the ex-works cost to ensure that the product remains competitive wherever it is used.

Quantity The projected quantity of a product which will be sold can have a profound effect on the manufacturing methods and materials used. This must be specified as carefully as possible at the outset. This particularly influences the appropriate levels of tooling, with large quantities justifying expensive tooling.

Delivery date It is important that realistic timescales are set for each stage of the design and production process. This is particularly important when a delivery date has been agreed with a customer and costly penalties for late delivery are built into the contract. Hence, the date by which each stage of the process is to be completed must be specified at the outset. The PDS of a single complex system which is to be designed and produced to an agreed contract will state dates by which the design, manufacture, erection, testing, commissioning and hand over of the fully working installation are to be completed.

Acceptance standards

Inspection The degree of conformance to standards must be specified in accordance with relevant legislation and the objectives set in the PDS. The degree of conformance required to tolerances as stated within the rest of the specification must also be specified.

Testing The methods of verification for the product should be specified along with the timescales for carrying out the necessary tests. It is usual on completion that acceptance tests are carried out in the presence of the customer. Tests often include safety interlocks, load capabilities such as speed and power consumption and reliability. Specified means and forms of testing should comply with standards where they exist. The PDS should contain a policy statement on the level of testing, such as every product to be tested or an agreed level of sample testing.

Standards These may include national, international and company standards. There may also be many other rules, regulations and codes of practice which must be followed.

Patents Following a patent search it is important to state, and subsequently to ensure, that the design must not infringe any patents identified as being relevant. Patents are useful sources of information, particularly when you are beginning a new project with no previous experience in the particular field.

Disposal

Standards Individual country or international standards for disposal of products and materials must be listed in the PDS. The main implications should be stated. For example, most plastic materials used now must be identified during moulding of the component so that recycling and more importantly, reuse is made possible.

Legislation Any legislation governing the disposal of a product must be specified. Many governments are tightening their legislation with a view to ensuring recycling takes precedence over other methods of disposal, that manufacturers are responsible for accepting products from their last owners and that ease of dismantling and disposal are specified from the start. Also, legislation dictates that all materials used can be easily identified for subsequent recycling or disposal at the end of the life of the product. This must be specified.

Company policy Products which make less impact on the environment than similar products will have an increasing marketing advantage. They also afford a company significant advertising opportunities, which will also improve their competitive position. There are many ways of specifying this and only one is to specify increased life.

Hazards Any potential hazards that may cause difficulties at the end of a product's life should be identified and specified.

Operation requirements

Installation Where installation of a product is complex it should be specified. This is particularly important when small numbers of large devices are designed. The constraints should include construction, assembly, the time taken, provision of instructions and the skill levels required for installation.

Use The cost of ownership of a product, which should be minimized, is, in some cases, more important than the cost of initial purchase. Factors which influence this, such as the number of operators required, the skill level required from these operators, the cost of spares and the maximum tolerable energy consumption should be specified. Continuous, 24 hour a day, operation or the number of stop/starts in a relevant timescale should be specified. An alternative to dividing costs into separate categories is to specify a whole-life cost.

The power sources available should also be specified. These may include manual, gravitational, environmental, electrical, gas, water and internal combustion engines. Each should be specified exactly. For example, electrical power may be three-phase and 380–420 volts.

Maintenance A policy to minimize down time, simplify maintenance, ensure correct reassembly, provide easy access and provide interchangeable parts must be developed at the outset and specified. If there is to be any routine maintenance, service or overhauls

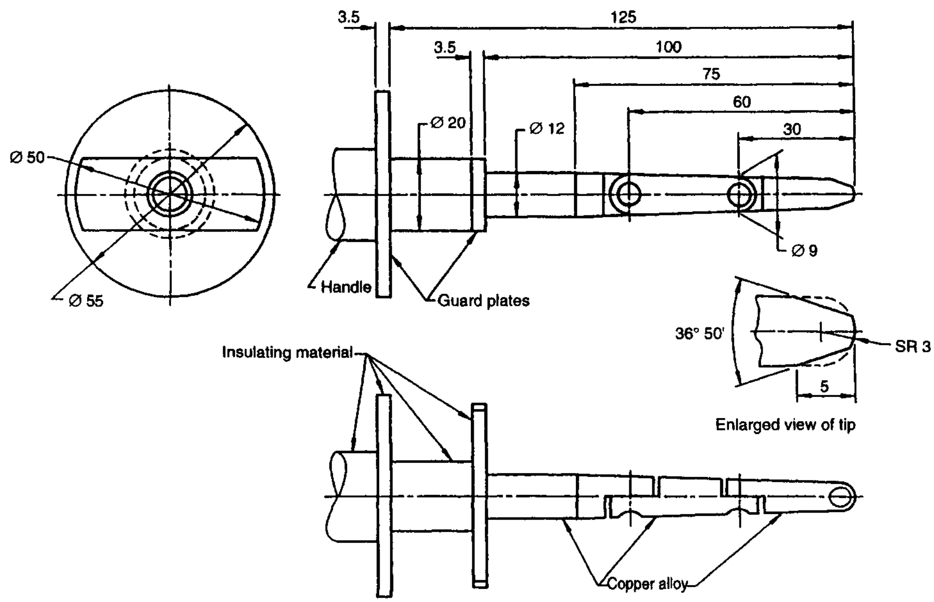


Figure 2.7 Test finger IV. From British Standard 3042:1971 (Extracts from BS 3042:1971 are reproduced with the permission of BSI under licence no. PD\1998 1956. Complete editions of the standards can be obtained by post from BSI Customer Services, 389 Chiswick High Road, London, W4 4AL)

the intervals and complexity of these should be specified. In order to simplify the maintenance procedure provision of special purpose tools and disassembly features should be specified if appropriate. The required skill levels of maintenance staff should also be specified. Guards should be easily removed. Levels of lubrication should be specified. An operation and maintenance manual must be supplied. Automatic lubrication should be considered.

Safety There are many standards, a great deal of legislation and codes of practice which refer to all safety aspects of products. These should be listed in the PDS. As an example consider Fig. 2.7, which is extracted from British Standard 3042 and shows test finger IV. This is one of a series of probing devices for checking protection against mechanical, electrical and thermal hazards. Where standards do not exist it is normal to specify fail safe design with no sharp edges and that electrical panel isolators must be interlocked with the door, for example. Where headroom over walkways is less than 2 m suitable warning notices and head shock absorbers should be provided. Guards should be specified to eliminate danger to individuals or equipment.

2.3 Content of a PDS

As described, much work is required before an agreed or final draft of a PDS is produced. The content of each PDS will differ from any other but the way in which the information is ordered should always be the same. The essential information gathering which must precede the definition of the PDS is detailed in Chapter 9. Assuming the necessary information is available, including the identification of customers and any similar previous specifications, the complete format of the specification should be as follows:

(a) *Identification:* Title, designation, authority, date
(b) *Issue number:* Publication history, previous related specifications

(a)

(b)

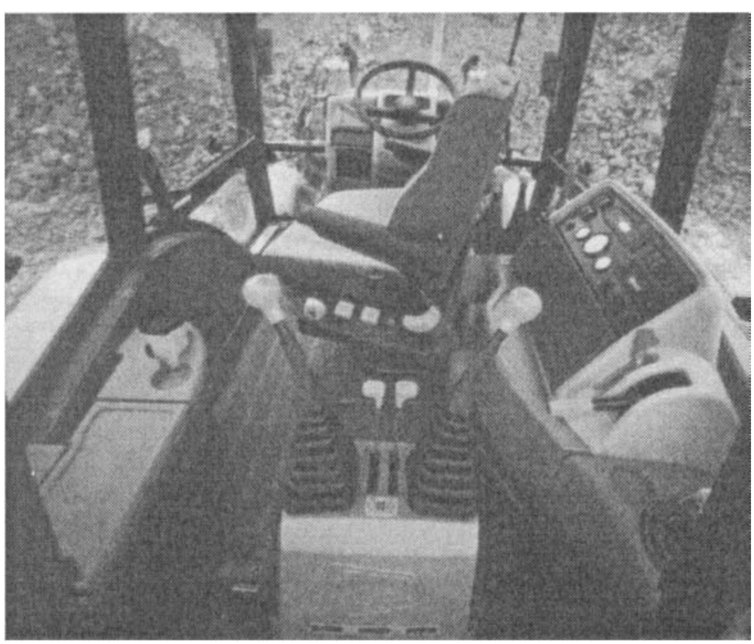


Figure 2.8 (a) and (b) Excavator loader (Reproduced with kind permission of JCB)

(c) *Contents list:*	Guide to layout
(d) *Foreword:*	Reason for and circumstances under which the PDS is prepared
(e) *Introduction:*	Statement of objectives
(f) *Scope:*	Inclusions, exclusions, ranges and limits
(g) *Definitions:*	Special terms used
(h) *Body of PDS:*	Performance requirements, manufacture requirements, acceptance standards, disposal and operation requirements
(i) *Appendices:*	Examples
(j) *Index:*	Cross references
(k) *References:*	To national, international, or internal specifications.

Not all of the sections which represent the full format are necessary in every case. For example, a foreword should only be included where it would assist the understanding of the PDS. Also, students will find the identification of issue numbers and authority fatuous on many occasions since they are only relevant when working within a company environment. However, just as it is important with detail drawings and components to identify unique identifying numbers so it is with specifications. You should therefore identify a PDS as fully as is possible in the circumstances.

2.4 Sample PDS

There are many specifications which run to multiple volumes and include such things as contractual and warranty agreements. It is not possible, nor desirable, to produce such a PDS here, so the example presented contains the level of detail considered appropriate for you as students to produce during your engineering course. The PDS is for a suspension mechanism to isolate the vibrations of an excavator loader, such as the one in the photographs in Fig. 2.8 (a) and (b), from the operator.

ISSUE: 3 PRODUCT DESIGN SPECIFICATION for REFERENCE NO.: PDS014 DATE: 17:06:98 UNDER SEAT SUSPENSION UNIT
RELATED SPECIFICATIONS:
ISSUING AUTHORITY:
CONTENTS:
FOREWORD: The photograph in Fig. 2.8 shows an excavator loader. Historically, prior to 1975, machines of this type did not have any suspension, other than that provided by the pneumatic tyres. Investigations into injuries sustained by operators of farm tractors and off highway construction vehicles, like the excavator loader, have revealed a high incidence of back trouble. These injuries are more marked in operators of farm tractors because of the need to observe attachments being towed at the rear of the machine. This means that the spinal column is twisted and the induced stresses are consequently higher.
INTRODUCTION: The objectives are: To design a suspension mechanism for the operator's seat. To design the mechanism in such a way that the position and orientation of the seat is fully adjustable. To design the mechanism so that driver vibrations are damped to within acceptable limits.
SCOPE: All machines, whether with a fully enclosed cab or a simple canopy, are to be provided with such a suspension mechanism.

DEFINITIONS:
PERFORMANCE REQUIREMENTS: The mechanism must allow full adjustment of the seat position. To comply with ISO 4253 these adjustments are rotate through 180 degrees in either direction, 80 mm up and down in the vertical plane and 150 mm front and back in the horizontal plane. Increments of adjustment must be less than 30 degrees and 25 mm respectively. The natural frequency of vibration of the combined seat and operator must be <2.5 Hz. Isolation criteria for class 3 seats as set by ISO 7096. The mechanism must still operate with the machine on a 30 degree slope in any direction. Suspension travel must be vertical and a maximum of 110 mm. Amplitudes must be limited under resonant conditions and step inputs. The temperature range during operation is between –10 and +50°C and whilst stored could drop to –30°C. The humidity will range from 0 to 80%. The suspension mechanism will also be subjected to rain, snow and heavy organic and mineral grime. The ex-works cost of the mechanism must be <£30. The target population of operators is to be restricted to people between the ages of 19 and 65. Sizes, weights and strengths are to be between the 5th and 95th percentiles. For example, adjustment must accommodate drivers in the weight range of 60 to 130 kg. The quality of the mechanism must be consistent with the rest of the machine. The required design life is 10 000 hours of operation. The required reliability is 90% over the 10 000 hours of operation. The appearance must be as rugged as the rest of the machine. The weight of the complete mechanism must be <50 kg. The maximum overall size is 0.5 × 0.5 × 0.5m. In the horizontal plane the mechanism must have a radius about the centre of rotation <300 mm. The mechanism must be capable of being fitted to the full range of seat bases and machine floors.
MANUFACTURE REQUIREMENTS: The machine will be assembled on a ten stage assembly line. The mechanism will be assembled prior to installation as far as is possible. Installation must take <20 minutes. The mechanism is to be manufactured and finished in-house. Any materials can be used as long as they comply with other statements in this specification. 6000 are to be produced each year.
ACCEPTANCE STANDARDS: In accordance with ISO 3776 anchorage points must be provided for seat belts which accept a pull load through the suspension of 5000 lbs. Every mechanism will be inspected prior to assembly in the machine. Accelerated cyclic tests of five fully loaded mechanisms are to be carried out to verify the reliability levels and fatigue strength. The mechanism must not conflict with existing patents.
DISPOSAL: The suspension mechanism must not contain any hazardous materials and all polymeric materials used must be clearly identified.
OPERATION REQUIREMENTS: Adjustment of the seat position or the level of damping must be easily carried out by the operator whilst in the sitting position in <30 seconds. Removal of the mechanism from the machine by one person must be possible in <30 minutes. The device is to be maintenance free for the life of the machine. Secure locking must be provided after adjustment. Seat movement and locking must be fail safe. It must not be possible for the operator to trap their fingers in the mechanism.

2.5 Principles

Specification principles

Definition With the agreement of the customer all important technical aspects of the future 'product' must be specified.

Information The specification must be informed by relevant and up-to-date information gathered from a wide variety of sources.

Function A clear statement of the function(s) the product is required to fulfil is the starting point of the specification.

Constraint The many aspects of the product which the customer and market surveys indicate are required must be quantified into statements that the engineering team can work towards.

Iteration At the outset the specification can only be regarded as a draft. As the project progresses more information will surface which will add to or contradict the original draft. This is normal and acceptable, as long as the 'customer' agrees to the changes.

2.6 Exercises

1. Write a detailed specification for a car which is to be used in towns.

2. Write a specification for a foot-pump to be designed for pumping up car tyres.

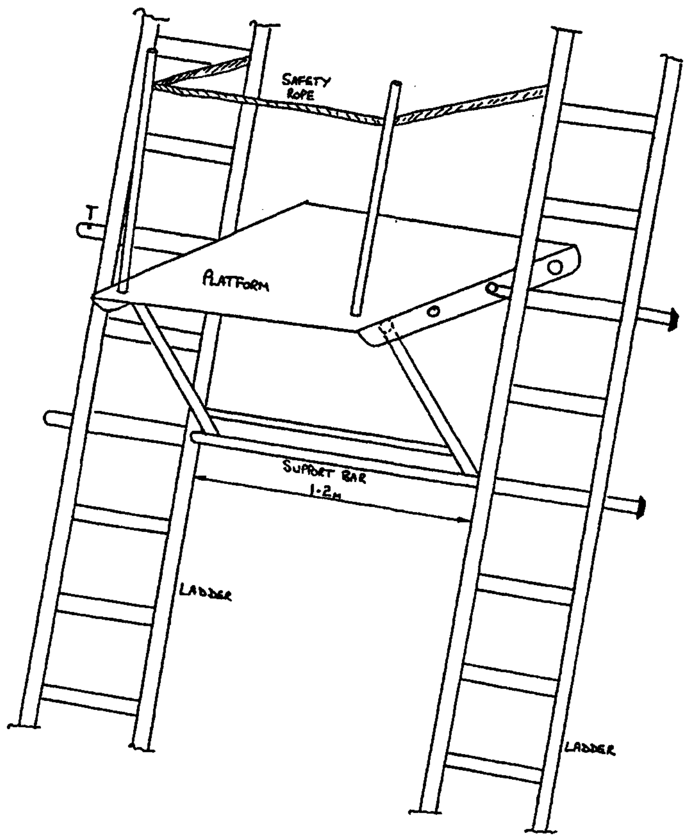
3. A market opportunity exists for a can opener which is operated by disabled people with only one hand. The device is to open the can in such a manner that the contents are not spilt or contaminated, the contents can be easily removed and no dangerous or jagged edges are left exposed. Write a specification for the device.

4. With the increasing popularity of the game of snooker, most UK towns and cities now have many snooker and pool halls. There is a substantial market for a device which will make the cleaning of the tables easier and quicker. The present cleaning procedure for a snooker table is as follows:

   (a) Brush debris out from under the cushion into the middle of the table.
   (b) Use hand brush and dustpan to remove debris, by brushing up the table to baulk.
   (c) Iron up the table to baulk.

   Write a specification for a combined vacuum cleaner and iron which would reduce the time taken in cleaning a snooker or pool table.

5. Shown in the sketch at the top of p. 30 is an idea for a working platform. The principle is to span two ladders with support bars pushed through the hollow rungs and to use these bars to support the platform. Write a specification for such a platform.



You can assume that the idea is sufficiently innovative to be patented. Would you recommend that a company produce such a device? Write a short report explaining your reasons for recommending continuation or rejection of the project.

6. Current multi-gyms found in health spas, leisure centres and gyms are extremely large, taking up a lot of space. A market survey has been conducted indicating a sizeable market for a similar device, if it were to be available for home use. The new design must incorporate all the basic movements offered by large multi-gyms, but be small enough to fit into a spare room or garage of a typical house. The movements offered should include shoulder press, chest press, leg raisers, leg/thigh extension, leg curl, latissimus pulldown, triceps pulldown and biceps curl.

   Produce a detail specification for a small multi-gym. You should assume that the specification will be passed to another designer who will not be able to ask for further information.

7. Due to increasing demand for high-speed public transport, particularly on the railways, the requirements for more precise rail-track performance became a necessity. This led to the introduction of longer rails and continuously welded tracks. Problems associated with track expansion were overcome by using sleepers at shorter spacings and clamping the rail to them. This causes compression stresses in the rails, but does not allow expansion.

During routine inspection of the rails it was discovered that uneven wear occurred and this was especially the case where the track was curved. The worn lengths had to be replaced, not necessarily with the full length of track. The procedure adopted involved flame-cutting the section out, replacing the section and then welding back together. Railtrack have identified a problem with these welds because they fatigue and crack after a short period of time. This is due mainly to the poor control of the cutting operation and not due to poor weld quality. Therefore, a portable 'Rail-Cutter' is required which could be used on site and track locations and be capable of cutting any rail section to such a high standard that no further attention of the rail ends is required.

Produce a detailed specification for such a 'Rail-Cutter', broken down into functions and constraints.

8. An ex-seagoing officer has had an idea which he claims would substantially reduce the cleaning time for the holds of large bulk carrying ships. The idea is a portable bilge strainer which would prevent solids entering the bilges and damaging the bilge pumps during cleaning. These solids can be anything from coal to grain and the current washing procedure is outlined below:

(a) Inspection of bilge, strums and roses prior to washing.
(b) Rough sweep of all accessible areas and removal of solids from hold prior to washing since the solids are much lighter when dry.
(c) Fit perforated grids over bilge well. Previous cargo and state of the hold will dictate the grade of fine netting, wire gauze or perforated sheet used.
(d) Use of pressure hoses capable of reaching all areas of the hold. Someone in charge with communications link to the bridge and engine room.
(e) Monitor amount of water in the hold and washing should cease if bilge stops pumping or cannot prevent water build up.
(f) Remove solids from base of hold and bilges. Clean and inspect the bilge.

Unfortunately, the theoretical procedure outlined is seldom, if ever, this straight forward. Invariably the pumping out procedure slows due to a combination of problems such as choked bilge cover plate or pump. One remedy is to remove the bilge cover plate but this allows solids to enter the bilge. The subsequent removal of solids from the bilge is a slow, awkward and unpleasant task as there is hardly room for one man to enter the bilge.

The aim is to prevent the necessity for the removal of the cover plate with all its associated problems. Basically the idea involves using a top hat shaped filter standing on the hold floor and covering the bilge well. The sizes of the bilge well openings vary from 450 mm diameter to 900 mm square with 100 mm radiused corners. Space available for the filter is restricted to a radius of 700 mm from the centre of the well. The thickness of the hold base is between 20 mm and 30 mm and can undulate by 100 mm. The depth of the bilge is 1.2 m. A typical hold is 20 m deep and contains 10 bilge wells. The maximum force imparted by a hose is 300 N and hosing down must take place in the open sea.

Write a specification for the bilge strainer based on the design brief outlined.