Mutual Consultants

SDS

SDS0902

Structured Design Scrutiny

SDS

"A structured approach for highlighting design weaknesses in all types of plant and equipment ***before*** *the design leaves the drawing board"*

Overview of Structured Design Scrutiny (SDS)

Definition

Structured Design Scrutiny (**SDS**) is an approach applied at the design stage for highlighting design weaknesses in all types of plant and equipment. It may be applied at the concept or detail-design stages to help ensure that design weaknesses are identified before the design "leaves the drawing board".

Supplier v User

Both the supplier of a piece of equipment and its ultimate user may have legitimately different business objectives - this can cause conflict both during and after the equipment has been supplied. The strength of **SDS** over traditional methods of design scrutiny lies in its systematic approach which provides easily-understood criteria for identifying deficiencies (which promotes “co-makership” between supplier and user, rather than 'conflict'). **SDS** gives the user an intimate knowledge of the asset from day one.

Application

On their own, the suppliers of the new equipment or plant cannot answer all the questions posed by **SDS** - neither can the ultimate users and maintainers. "Analysis Groups" are established to apply **SDS** and hence scrutinise the design before manufacture commences.

Approach

SDS systematically scrutinises the design of the equipment against several decision criteria, (usually relating to reliability, maintainability and supportability); other criteria may be included in the design scrutiny if required.

Mutual Consultants' Role

Mutual Consultants' role is to impart an understanding of **SDS** to clients and provide support and guidance in its application; our goal is for clients to become competent to apply **SDS** themselves.

Benefits

Applied correctly, **SDS** yields the following benefits:

- **Safety and the Environment** – the systematic review of safety implications of every critical failure
- **Performance** - an emphasis on the design of crucial equipment elements and the elimination of design weaknesses which would otherwise be undetected until the equipment is in use
- **Quality** - a better understanding of equipment and the clarification of equipment set-up requirements
- **Cost Effectiveness** - the prevention/elimination of design weaknesses and reduced life-cycle costs

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STRUCTURED DESIGN SCRUTINY

Structured Design Scrutiny (**SDS**) is an approach applied at the design stage for highlighting design weaknesses in all types of plant and equipment. It may be applied at the concept or detail-design stages to help ensure that design weaknesses are identified ***before*** the design "leaves the drawing board".

The process is normally applied when the detailed design is nearing completion but before manufacture commences. Depending on the nature of the equipment **SDS** may or may not be applied prior to prototype testing; however, it should always be completed before the final product goes into production or before major assembly/construction begins.

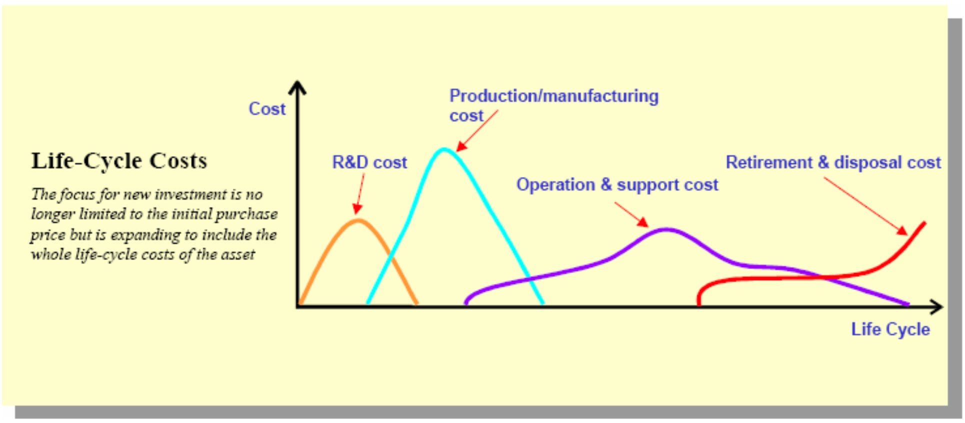
WHY SDS?

Traditionally the scrutiny of new designs has been either superficial or detailed to the point of paralysing delivery of the product. The objective of a Structured Design Scrutiny is to assist you to produce a design which meets the user's requirements for function (both initially and over an extended period of time), and is cost-effective to buy and operate.

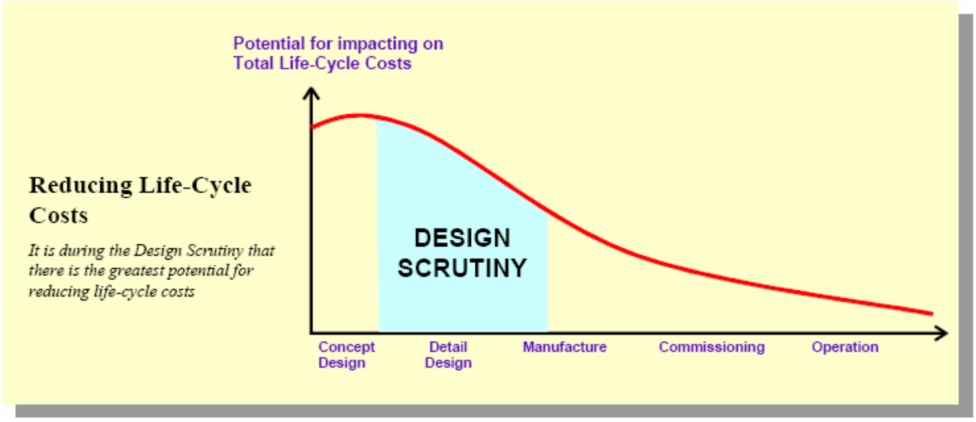
Life-Cycle Costs

All too often, when new equipment is purchased the emphasis is on the initial purchase or procurement costs. What is more, the success of the new-build project team is measured in their ability to deliver the equipment on time and to a price. Once this has been achieved, the equipment is handed over to the ultimate users and maintainers.

It is at this stage that the problems of operating costs and performance become apparent. The operations and maintenance managers are then faced with the (often impossible) tasks of increasing equipment reliability and availability whilst containing operating costs. This struggle may remain unresolved throughout the life-cycle of the asset and may even lead to its premature retirement.



During the life of the asset, however, maintenance and production managers have limited scope for enhancing machine performance. This is because the level of performance is "inherent" in the design of equipment and, little can be done to improve the situation without major investment; they can only hope to match the performance inherent in the design. What is even worse, this performance may be woefully short of expectations.



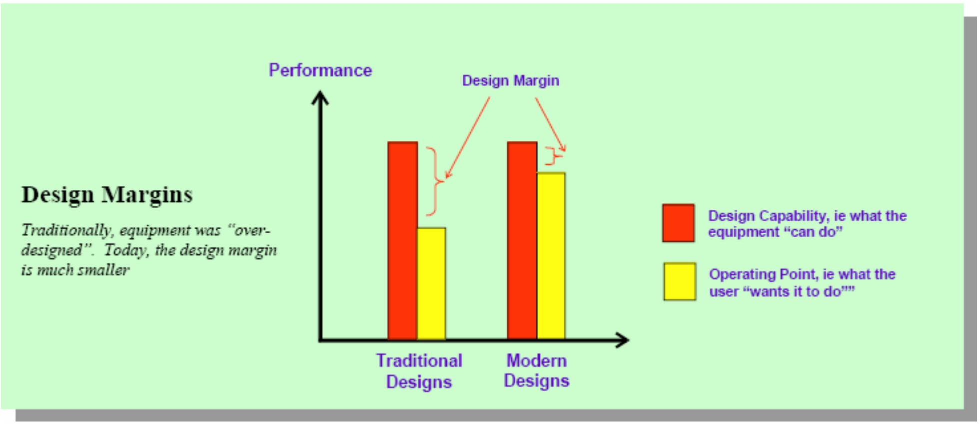
Increasingly, companies are recognising the shortcomings of a "buy-to-a-price" policy. As a result, the focus for new investment is no longer limited to the initial purchase price but is expanding to include the whole life-cycle costs of the asset.

The ultimate users and maintainers are now becoming involved at the design stage to ensure that the performance requirements are met whilst minimising the total life-cycle costs. The challenge for companies adopting this philosophy lies in finding ways to structure and control this involvement efficiently – hence the need for **SDS**.

Design Margins

Traditionally, equipment was "over-designed" - i.e., the margin between what the user of the equipment wants it to do and what it can do is comfortably large.

Today, such an approach is impractical as a result of the pressures created by designing to a price and the fact that equipment is increasingly operating close to technological limits. Modern equipment rarely has a generous margin of over-design. The net result is a greater risk that the equipment will not perform to expectations, leading to poor reliability and, ultimately, poor availability. Design scrutiny is, therefore, becoming an essential step in the process to ensure that the eventual design is "right first time" - i.e., ensuring that there is sufficient margin in the design for it to work from day one and to continue working.



Co-makership

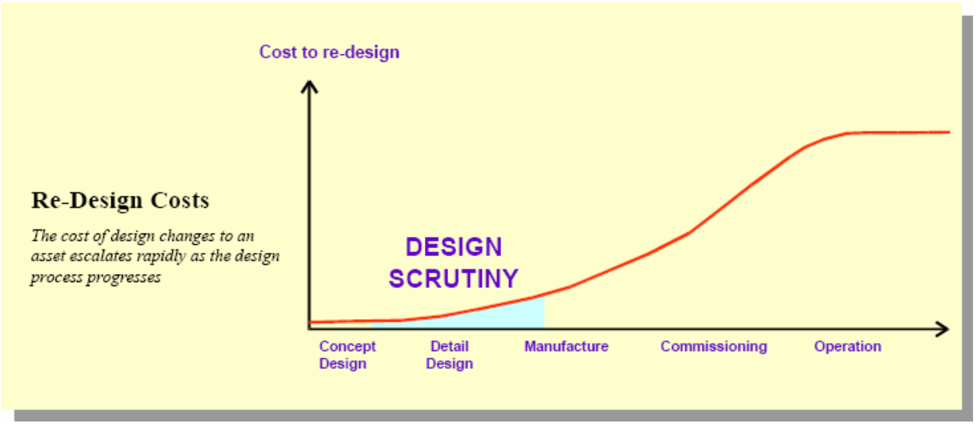
Skilled labour is becoming more difficult to recruit and retraining can be an expensive alternative. Hence, some industries are insisting that new equipment be operated and maintained by existing personnel (to avoid unforeseen costs). These demands can constrain the designers, particularly where proven modern technologies are ignored in favour of less efficient and more outdated solutions.

Much can be gained if the suppliers and designers of equipment and the ultimate users and maintainers are involved in the design process. The process is two-way, i.e. the design team can learn much from the experience of personnel who have worked and maintained existing (often similar) equipment and vice versa.

The requirement, therefore, is for a process which draws on the knowledge of the design team (without hindering the process) yet incorporates the inherent practical experience of the eventual users/maintainers. This involves ***co-makership*** between the supplier and the user.

The Financial Incentive

The cost of design changes to an asset escalates rapidly as the design process progresses. A modification may cost tens of pounds to do on the drawing board (or CAD screen), thousands of pounds to change during the development stage, tens of thousands of pounds to change on the production line and hundreds of thousands (or even millions) of pounds to change once the equipment is in use.



At best, shortcomings in the design will cost both parties dearly to rectify - the user suffering delays in achieving output with a corresponding loss of revenue - the supplier facing additional project costs and, possibly, claims for liquidated damages. At worst, the supplier may be bankrupted and the user left to pick up the rectification costs or live with the problems. Consequently, there is considerable financial incentive to both the supplier and the user to get the design ***right the first time***.

Conflicting Objectives

In summary, therefore, both the supplier of a piece of equipment and its ultimate user may have legitimately differing business objectives. The supplier will want to minimise manufacturing costs and meet production schedules and time constraints; after-sales support and income will also be a major consideration (e.g., technical support, monopolising the supply of spare parts, etc). The user, on the other hand, requires an asset which will dependably perform the functions required of it whilst minimising the initial purchase price and subsequent operating and maintenance costs.

Sometimes, these objectives may be in direct conflict but must be resolved by timely design reviews during the concept and detailed design stages.

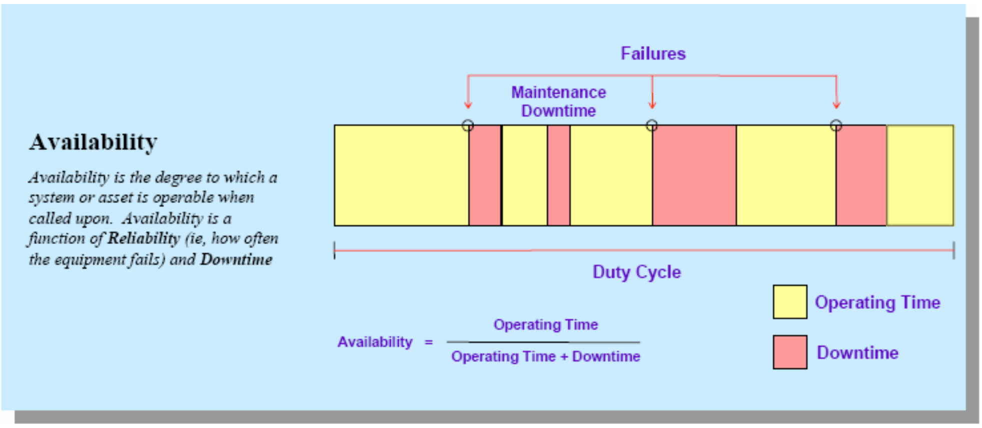
It is for these reasons that **SDS** was developed. Very briefly, it is a process which is applied at the design stage ***to help ensure that any piece of equipment meets the expectations of users, before it is too late***. It does so by systematically scrutinising the design of the equipment against several decision criteria, (usually relating to reliability, maintainability and supportability); other criteria (for example, manufacturability or diposability) may be included in the design scrutiny if required.

WHERE IS A DESIGN SCRUTINY FOCUSED?

When new equipment is designed the primary requirement is for the asset "to work on day one and go on working". **SDS** was originally conceived to address this requirement by focusing on the ***availability*** of plant and equipment.

Availability

Availability is a measure of the "ability of a piece of equipment or plant to perform (when required) its intended functions satisfactorily over a given period of time". In simple terms, it is the degree to which a piece of equipment is operable when called for. It is usually expressed as a percentage of time or as a probability (i.e., if a piece of equipment has 80% availability it can perform its intended function for eight hours out of every 10).



Availability is clearly a key aspect of the performance of a piece of equipment or plant. When it is not available, it is unable to carry out the functions for which it has been purchased (i.e., it is costing money but not earning any!). Availability is determined by two factors: ***reliability*** and ***downtime***.

Reliability

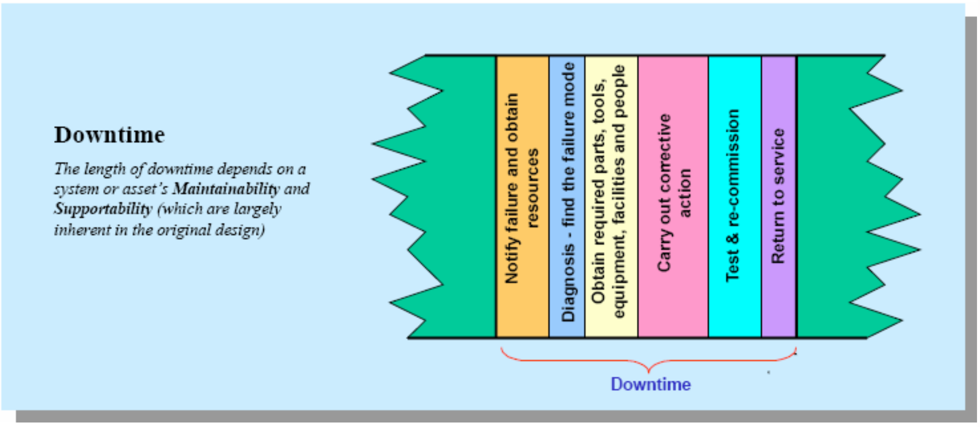
Reliability may be expressed as "the probability that a piece of equipment will perform its intended functions for a given period of time when used under specified operating conditions". In simple terms, it is a measure of "how often something fails". As with availability it is also expressed as a percentage, but that is where the similarity ends: for example, a light bulb may have 98% reliability over 1000 hours, meaning that if we started with 100 working light bulbs, 98 would still be functioning at the end of 1000 hours.

Another common way of expressing reliability is the frequency at which failures occur, or the time between each failure. This is normally referred to as the mean time between failure (MTBF). The MTBF is calculated by dividing the total operating time by the number of failures experienced; the better the reliability, the greater the MTBF.

The inherent level of reliability (i.e., the in-built level of reliability) of a piece of equipment or plant, is established when the equipment is designed and manufactured. In practice, no amount of maintenance will improve reliability beyond this point, as it is the design limit. This inherent level must be sufficiently high for the equipment to work satisfactorily and go on working - it is essential, therefore, to get this right ***at the design stage***.

When equipment fails it will often (but not always) affect the overall plant availability, having a direct adverse effect on operations.

Downtime



Downtime is the time during which a piece of equipment is unavailable for use after failure or during regular preventive maintenance. The length of downtime will depend upon several factors; these may be categorised under two broad headings: *Maintainability* and *Supportability*. Like reliability, both maintainability and supportability are largely inherent in the design of a piece of equipment.

Maintainability is the "ease" with which corrective, predictive and preventive maintenance tasks may be carried out. The better the level of maintainability, the easier it will be for maintenance and operating teams to carry out their maintenance tasks and, as a result, this will generally reduce downtime (i.e., increase availability) and improve repair quality.

Supportability is the degree to which a piece of equipment may be supported by the user organisation. In **SDS**, supportability relates mainly to the supply of the parts and materials required to maintain the piece of equipment; poor supportability can increase equipment downtime and maintenance costs. A typical instance is a machine being unavailable for use because it is awaiting the delivery of a spare part that is difficult to obtain.

Mean downtime (MDT) is the total downtime divided by the number of instances of downtime, e.g., if a machine has a total downtime of 10 hours from four instances, then the MDT is 2.5hrs.

Availability can therefore then be expressed as follows:

$$Availability = \frac{MTBF}{MTBF + MDT}$$

Consequently, availability can be improved by increasing the MTBF (i.e., improving reliability) and reducing MDT (i.e., improving maintainability and supportability).

Other Reasons for a Design Scrutiny

Whilst **SDS** was originally conceived to focus on asset availability, the approach can also address other issues.

For example manufacturability of the design can make the difference between a design that is a commercial success or otherwise. Environmental considerations are also becoming important, particularly with regard to the disposability of the asset at the end of its useful life. **SDS** may be used to address both of these issues at the design stage.

THE SDS APPROACH

SDS involves assessing the design against a series of criteria. These criteria may include (but are not limited to) reliability, maintainability and supportability of the ultimate design. These criteria are considered according to the operating context of the equipment being scrutinised and the needs of the ultimate user.

Numerical versus a Non-numerical Approach

The approach followed when assessing equipment availability and reliability at the design stage may be either numerical or non-numerical.

A numerical approach attempts to set numerical targets for an asset's availability and reliability at the outset and apportion availability and reliability targets to the individual components that make up the asset. The approach is very systematic and logical but in practice it only works if the numerical data is available or can be made available through testing. As a result, many industries have found that the numerical approach either proves to be a massive burden (in terms of cost, effort and time) during the design stage or an academic exercise in manipulating numbers (that often have little or no relevance to reality). Whilst the numerical approach is a sound approach in theory it has limited practical application, unless it is carried out correctly and is funded accordingly.

The non-numerical approach to considering availability and reliability aims to share with the design team the knowledge and practical experience of those who have worked with and maintained existing (often similar) equipment. The non numerical approach can achieve much for relatively little effort (compared with the numerical approach).

The objective of the non-numerical approach is to ensure that (as far as possible) the design is approached from a pragmatic engineering point of view, by scrutinising the design for common weaknesses; for example:

- Have steps been taken at the design stage to influence equipment reliability by using components that have proved themselves to be reliable in other situations?
- Has the design taken into account the practicalities of changing a component (in terms of tools, equipment and skills required)?
- Can a replacement component be sourced from more than one supplier in the event of a breakdown, etc?.

The non-numerical approach draws on the knowledge of the design team whilst incorporating the inherent practical experience of those who know the equipment best (such as maintainers, commissioning engineers and possibly users). It questions the design from an “engineering common sense” point of view (a process which designers sub-consciously follow to a limited degree) but in a structured way. **SDS** is a non-numerical approach to conducting a design scrutiny.

Overview

SDS is a process which scrutinises the design of the equipment against several decision criteria. The decision criteria are considered according to the operating context of the equipment being scrutinised and the needs of the ultimate user.

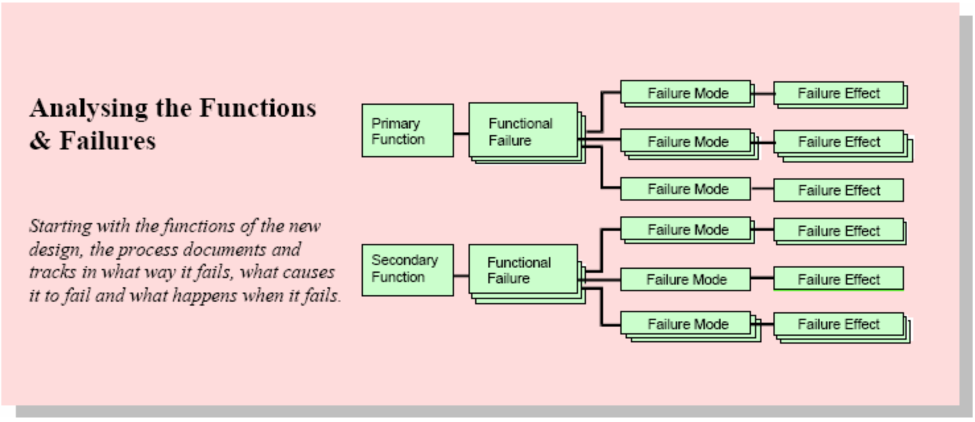
The approach entails asking the following questions about the equipment in its operating context

- Against which factors will the design be assessed?
- What are the functions of the equipment?
- In what ways can it fail?
- What causes it to fail?
- What happens when it fails?
- Does it matter if it fails?
- How can we influence how likely it is to fail?
- How readily can we rectify the failure?
- Where should the design be improved?

Briefly, these questions entail:

- *Prioritising the Decision Criteria against which the design will be assessed*: typically there are up to ten criteria each for reliability, maintainability and supportability (and other criteria such as manufacturability and disposability). If appropriate, weights are assigned to each of these criteria according to their relative importance to the ultimate users

- *Defining the Functions and required performance standards of the equipment in its operating context*: **SDS** places an emphasis on quantifying the performance standards that are needed. This stage of the process assesses the margin between what the equipment can do versus what the user ultimately wants it to do i.e., the design margin.
- *Establishing the Functional Failures which apply to each Function*: A Functional Failure is defined as the inability of an item or component to meet its desired standards of performance.
- *Determining the Failure Modes which cause each Functional Failure*: Failure Modes are the engineering reason why a component or item fails. **SDS** concentrates on identifying the cause of failure.
- *Recording the Failure Effects*: i.e., documenting what would happen if the Failure Mode occurs.



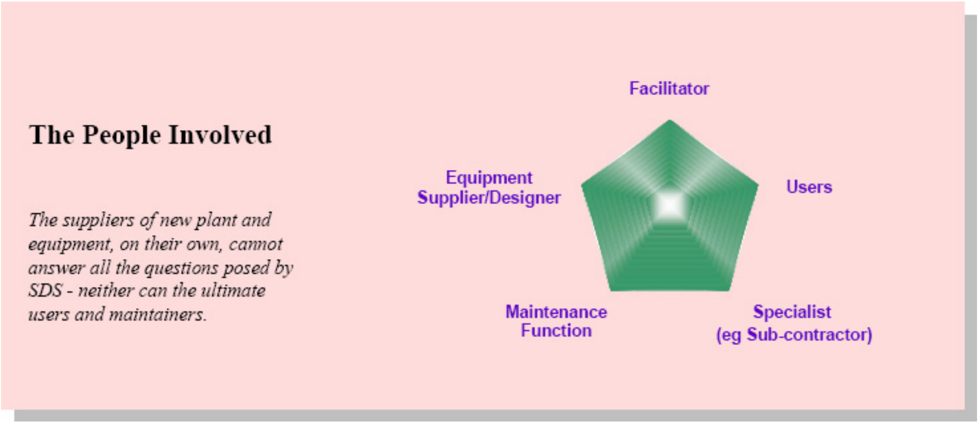
- *Assessing the consequences of failure*: Each failure mode is categorised according to the consequences of failure.
- *Identifying design weaknesses*: Each Failure Mode is then assessed against the prioritised and weighted decision criteria for Reliability, Maintainability and Supportability (and other categories if appropriate). The result is an individual and overall score for each of these elements which affect availability. The overall, weighted scores for each Failure Mode highlight areas of design deficiency against which corrective action may be evaluated.

A great strength of **SDS** is the way in which it provides simple and easily-understood criteria for identifying design deficiencies (if any). It also provides a means for prioritising the proposals for design changes according to the criteria against which the design is being assessed and the consequences of failure.

THE PEOPLE INVOLVED

The suppliers of the new plant or equipment, on their own, cannot answer all the questions posed by **SDS** - neither can the ultimate users and maintainers. Consequently, "Review Groups" are established to apply **SDS** and hence scrutinise the design before it is manufactured.

These groups should ideally include at least one person from the design team, one from the ultimate users of the equipment and one from the maintenance function. The seniority of the review group members (each of whom will require training) is less important than their desire to learn about the equipment under review and their respective knowledge and experience.



Each review group works under the guidance of a highly-trained specialist in **SDS**, known as a "facilitator". Their role is to ensure that the approach is applied correctly, that reasonable consensus is achieved by the group and that no significant equipment or component is overlooked. Immediately after each review has been completed, the senior managers with overall responsibility for the design (from both the supplier and ultimate user) should satisfy themselves that the **SDS** analysis has been carried out correctly and that the requisite action is taken.

WHAT SDS ACHIEVES

The objective of **SDS** is to assist users and designers to create the most cost-effective design which meets the user's requirements for function, reliability, maintainability and supportability (and other categories if appropriate). Its strength over traditional methods of design scrutiny lies in its systematic approach which provides easily-understood criteria for identifying deficiencies (without having to resort to exhaustive and often meaningless numerical analyses).

The applied discipline in using **SDS** will ensure that users accurately determine their needs and wants before the supplier sets about the manufacturing process. It will also force them to review the way in which they intend to operate and support an asset over its life-cycle.

In particular, **SDS** yields the following benefits:

Safety

Greater safety and environmental protection due to:

- consideration of the application of and need for protective devices
- the systematic review of safety implications of every critical failure
- the identification of failure modes whose prediction, prevention or correction creates safety or environmental hazards

Performance

Improved operating performance due to:

- improved availability by considering the criteria that influence how often an item fails and the time taken to correct any failures
- an emphasis on the design of crucial equipment elements
- the elimination of design weaknesses which would otherwise be undetected until the equipment is in use

Quality

Improved quality due to:

- a better understanding of equipment capacity and capability
- the clarification of equipment set-up specification and requirements
- the confirmation or redefinition of equipment-operating procedures

Cost Effectiveness

Greater cost effectiveness due to:

- the prevention or elimination of initial design weaknesses. Where the desired levels of reliability and availability cannot be attained at an acceptable cost, **SDS** will identify the areas where there has been a cost/performance trade-off
- clearer operating policies
- a better understanding of the equipment from day one
- reduced life-cycle costs by optimising the design on the drawing board
- the documentation of the knowledge held by suppliers, users and maintainers on each piece of equipment

Teamwork Better teamwork brought about by a co-makership approach to the design.

Other benefits to be gained from applying **SDS** include the identification of requirements for:

- predictive, preventive and corrective maintenance routines
- user drawings and manuals
- maintenance facilities, test equipment and tooling
- maintenance personnel skill and training
- consumable spare parts and storage
- systems support

The detailed analysis used by **SDS** will also give the user an intimate knowledge of the asset which would normally only come after extended periods of use - the advantage of **SDS** is that this knowledge is available from day one.

Motivation Greater motivation of individuals, particularly those involved in the review process. This gives improved understanding of the equipment in its operating context and wider “ownership” of the eventual design.

MUTUAL CONSULTANTS' ROLE

Our role is to impart an understanding of **SDS** to clients and provide support and guidance in its application; our goal is for clients to become competent to apply **SDS** themselves.

This is achieved via a combination of highly-developed training courses, on-site technical support, contract facilitation (if required) and the supply of purpose-written software.

The services we offer include:

- Highly developed RCM2 training courses
- On-site technical support
- Contract facilitation
- Supply of ***SDS*** software*

*The **SDS** software records the information collected and the decisions made during the **SDS** process. For further information about the software and its availability please click here.

If you would like further information please click here.

CONCLUSION

SDS pays for itself very quickly. When applied correctly, it helps to overcome the traditional problems which result from design weaknesses. It also transforms the relationship between supplier and user into one of co-makership rather than an adversarial one.

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