



**RP 50-1**

# **GUIDE TO THE APPLICATION OF CRITICALITY RATINGS**

**May 1993**

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| <b>BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |      |                                     |                 |     |      |         |             |       |  |  |  |
| Doc. No. <b>RP 50-1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |      | Issue Date<br>Latest Amendment Date | <b>May 1993</b> |     |      |         |             |       |  |  |  |
| Document Title<br><div style="text-align: center;"> <b>GUIDE TO THE APPLICATION OF<br/>CRITICALITY RATINGS</b> </div> <div style="text-align: center;">(Replaces BP Engineering Code of Practice)</div>                                                                                                                                                                                                                                                                                                                                                                       |      |                                     |                 |     |      |         |             |       |  |  |  |
| <b>APPLICABILITY</b><br>Regional Applicability: <b>International</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                                     |                 |     |      |         |             |       |  |  |  |
| <b>SCOPE AND PURPOSE</b><br><br>This Recommended Practice provides a conceptual guide to the establishment of engineering priorities throughout the life of an asset. It is intended as a management document, which aims to stimulate a methodical and consistent approach, rather than to offer prescriptive instructions for applying Criticality Ratings. Illustrative models which can be used at specific stages of the operational life cycle are referenced to assist in this task, and can be obtained from the Custodian of this Recommended Practice, if required. |      |                                     |                 |     |      |         |             |       |  |  |  |
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| <b>CUSTODIAN</b> (See Quarterly Status List for Contact)<br><div style="text-align: center;"><b>Quality Management Group, ESS</b></div>                                                                                                                                                                                                                                                                                                                                                                                                                                       |      |                                     |                 |     |      |         |             |       |  |  |  |
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## FOREWORD

### Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the General Foreword sets out the philosophy of the RPSEs. Other documents in the Introductory volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

### Value of this Recommended Practice

This Recommended Practice has been prepared to offer a basic philosophy for the consistent application of Criticality Rating, throughout the life of an asset. Its intent is to ensure that a methodical approach to establishing priorities is adopted for all Engineering activity. This will assist the appropriate allocation of scarce resources, whilst ensuring that equipment integrity, Company revenue and operational safety are not compromised.

### Application

Text in italics is commentary. Commentary provides background information which supports the approach proposed in the Recommended Practice, and may offer alternative sources of information.

The responsibility to ensure compliance with legislation and other statutory requirements, lies with the user. The user should adapt or supplement this document to ensure compliance in specific applications.

### Changes from Previous Edition

BP CP 53 was developed as a guide to the application of the ISO 9000 series of International Quality System standards. The Yellow Page Supplement included a guide to application of criticality ratings. The use of the ISO 9000 series of standards is now mature, therefore the BP guide to ISO 9000 is withdrawn, and this new document is an update of the former Yellow Page Supplement.

### Feedback and Further Information

Users are encouraged to feed back any comments or experiences in the application of RPSEs, to assist in the process of continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status Lists for contacts.



## 1. INTRODUCTION

"The Core of Management is the Art of Mobilising and putting together the Intellectual Resources of All Employees, in the Service of the Firm."

K. Matsushita - 1979

The quotation above encapsulates the intention of this document; not to define any prescribed methodology, but to encourage the adoption of a consistent methodical approach to setting engineering priorities, by increased networking across disciplines throughout asset life. Engineering, in this context, is the design, procurement, fabrication, installation, commissioning, operation and maintenance of an asset and the management of these functions.

*There are individual Criticality Rating models listed in Section 5 of this Recommended Practice.*

A Criticality Rating is evolved by evaluating the combined effect of the likelihood of failure, and its consequence i.e. financial, safety or environmental risk to a project or modification, their development and operation. This document proposes guidelines for a rating procedure which is applicable to, among others:

- management processes for project development and asset operation
- plant maintenance and operating practices
- equipment selection
- fluid systems

Its scope encompasses project and operations management, process systems and equipment.

*In order that the document is appropriate for all phases of BP Group engineering activities, the principles contained within it must be part of a general philosophy relevant to an asset's life cycle.*

The philosophy assists the identification, management and control of risk. This applies to Health, Safety and the Environment, to the Group's investment and production returns, and in all engineering areas of the Group's activities.

*It is particularly valid in the context of the strategic shift which now allocates increased accountability to external suppliers undertaking traditional BP roles.*

A considerable amount of valuable work has been undertaken within the BP Group to provide Criticality Rating guidelines for specific disciplines and phases in an asset's operational life cycle.

The generic principles described in this document are drawn from these guidelines.



Criticality Rating will not provide a direct solution to any engineering problems in any phase of project or operational life. It is intended to supply quantitative input to the engineering decision making process.

*The rating process is dynamic. The results obtained at each stage of the asset life cycle may feed into the next stage. Changes in operational requirements may alter the inputs to the rating process, as may the results of inspection activity. Criticality Rating should be an iterative exercise, and may be revisited regularly throughout asset life. Modifications and refinements can be undertaken at each stage of the asset life cycle, as a result of feedback from other stages.*

This document does not attempt to replace or simplify available existing techniques which are considered appropriate by specific businesses.

The primary purpose of the document is to consolidate the work in existing guidelines and build them into a readily understood and uniform conceptual approach to the assessment and analysis of Criticality.

*For some years criticality rating models have been available which enable procurement Quality Assurance activities to reflect the importance of equipment in terms of the risks associated with failure. In recent years models have also been developed which enable similar focusing of engineering activities, in particular for pressure systems, inspection planning, piping system engineering and latterly for maintenance planning.*

*It has recently been recognised that the concept of criticality rating has a wide range of application throughout the life cycle of an asset and for specific items of equipment. An important tool in planning and management of engineering activity and expenditure, criticality rating enables assessment of relative risk.*

*With this in mind it was concluded that a generic document describing the principles of criticality rating was needed, to which existing detailed procedures could be linked, and which would provide the basis for development of any other required procedures.*

*It is important that users should develop their own procedures for specific applications, so as to achieve full understanding of the concepts involved.*

*The power of criticality rating models lies not so much in the ability to generate a comforting set of numbers, rather in the focus that is brought to key areas of management, design and items of process systems and equipment with the possibilities for teams to achieve consistent, ongoing understanding of what is important, and what is not.*

## **2. OBJECTIVES**

The essential requirements of a Criticality Rating procedure are that it must be:-

- (i) Straightforward, universal and effective.
- (ii) Sufficiently flexible to be appropriate to all aspects of production systems, equipment and management processes in engineering.



- (iii) Capable of future enhancement without a requirement to repeat the analysis process from the beginning.
- (iv) Adaptable to computerisation.
- (v) Able to incorporate the experience available from the BP Group and allow transfer of information within it.
- (vi) The focus for the approach to engineering practice for the whole life of an operation.

The principles in this document are structured to apply to the following definition of an operational life cycle:

(1) CONCEPT

Every engineering proposal can be assessed in terms of the criticality of the processes involved and the equipment required for them.

(2) DEVELOPMENT

Sub systems within the proposal can be assessed in terms of their process and management applications. This will encompass the long term health, safety and environmental effects and the investment considerations for the proposal.

(3) PROCUREMENT

Equipment included within a project or modification can be assessed for its specific criticality and the optimum quality standards determined.

(4) CONSTRUCTION

Areas and systems can be assessed for their risk impact on completion, investment and future operation.

(5) OPERATION

The assessment of all systems, sub-systems, equipment and spares may be required. This should encompass modification, inspection and integrity, maintenance and operating activities. It should also consider the optimisation and/or minimisation of these activities, and the economic impact of equipment replacement.



### 3. METHOD AND PROCEDURES

It should be stressed that to obtain an acceptable level of objectivity in any method of Criticality Rating, the involvement of engineers from several disciplines and areas of activity is recommended.

*As a fundamental aim is to define engineering priorities methodically, any attempt to reduce subjective bias is valuable.*

#### 3.1 Criticality Definitions

Criticality Rating as described in Section 1 relates to systems, sub-systems, or the components within those systems.

The evaluation process may be used to select the appropriate design, procurement, construction, commissioning and operational strategy for all engineering systems and related items of equipment.

This process may have a different objective for different stages of the asset life cycle.

*For example, the inputs to (and hence outputs of) criticality rating during the procurement stage will differ from those during the operating stage.*

Risks are analysed in terms of two criteria: a) health, safety and environmental impact, and b) economic effect. The results of these analyses will frequently differ and conflict. A separate analysis for each criterion is therefore recommended.

*The 'unit' of risk is determined by the dimension of consequence. For economic effect a monetary value will result. When Health, Safety and Environmental consequences are considered there has traditionally been a reluctance to measure them in cost terms and high, medium or low type measures are often assigned.*

An additional factor, described as the hidden consequence, may also be included in the analysis. Whilst failure may have no direct impact on health, safety, environment or cost, there may be an impact which occurs when a secondary failure follows. Examples of this are monitoring or protective systems, such as fire alarms or gas detection.

#### 3.2 Criticality - General Principles

The analysis procedure evaluates the system, sub-system and equipment item in terms of safety and economy. This enables those items which are non-critical, due to their insignificant failure consequences, to be objectively identified.

Those systems or equipment items whose failure consequences are significant, and where serious risks to health, safety and environment, or where unacceptable economic impact will result, can be afforded a high level of engineering attention. Procedures for management,

design, procurement, inspection and operations may then be clearly defined and followed.

Systems or equipment items which are critical may be further analysed in terms of their sub-systems or components.

*Priorities can thus be set such that management and engineering effort is focused accordingly.*

The methods of evaluation have been developed to produce the most efficient return on engineering activity.

They also permit the same methodology to be applied irrespective of the quality or quantity of data available to the evaluator and engineer. If specific quantified data is not available, then qualified judgement may be applied. High, medium or low impact is selected, based on experience, or comparable information from other similar systems or equipment types. A schematic representation of the approach is illustrated in Fig. 1.

### **3.3 Criticality Rating Procedure**

*The use of a criticality rating method does not replace any other requirements for health, safety and environmental assessment, or statutory activities. The procedure assists in the identification of critical systems or equipment, but allows modification of engineering controls and procedures only in areas where individual engineering discretion is permissible.*

#### **3.3.1 Use of the Procedure**

A spreadsheet for initial definition is included, see Fig. 2. This may assist in identifying the areas for further analysis or increased priority.

##### **(a) Define and list all Systems or Main Equipment Items**

The system or equipment items and their boundaries should be defined and listed. For established or operational areas, drawings may be used to ensure that all equipment is identified and considered. The separating boundaries and interfaces should be clearly specified. Where the systems are documented in other locations, procedures or computer packages, there should be consistency with the definitions and descriptions already adopted.

For new designs or proposals, a uniform and logical approach to the separation of main systems and equipment items should be adopted and recorded.

For practical evaluation purposes, a complete system may be too large and complex for comprehensive analysis. It may, for the purposes of assessing criticality for procurement, be

appropriate to consider individual main equipment items without the need for further segregation into components.

The analysis of Sub-system criticality can be performed using a specific methodology, relevant to the stage in the asset life cycle of the engineering activity.

e.g. Quantitative Risk Analysis (QRA) may be used early in equipment/asset life-cycles to help establish criticalities.

The general Sub-system criticality rating method is illustrated diagrammatically in Fig. 3.

(b) Comments and Clarification

Having defined the system to be analysed, it is useful to include additional comments which assist in explaining its nature or function. These may contain information regarding the complexity of the process in which the system is involved, or methods by which failure in the system may be overcome.

(c) Mode of Failure and effects of Failure

Further clarification of the likely mode of failure, and its effects, is essential in the subsequent evaluation of the consequence classification below.

### 3.3.2 Evaluation of Failure Consequence

One or more of the following classifications should be allocated to the sub-system or equipment item to indicate the nature of the failure consequences:

S - Safety/Environmental

This classification applies to those sub-systems or equipment whose failure will result in a direct risk to personnel or the environment. It is also applicable to systems which are designed to mitigate the effects of serious failures (e.g. lifeboats).

H - Hidden

This classification applies when failure does not result in immediate consequences but a further failure must occur before consequences are apparent. For sub-systems or equipment in this category, the consequence of further failure should be considered, and the H classification prefixed by that of the further failure. (A monitoring or protection system, such as a Fire Alarm, will be classified as SH, for example).

## E - Economic

Failure of the sub-system or equipment item will have an impact on revenue or investment return.

The rate at which this impact may become significant should also be considered.

*It may help to consider where the failure will result in immediate economic loss, where a loss will occur after a delay, as may be expected with a storage vessel, and where the economic loss is hidden, or dependent on a knock-on effect. The last case would be relevant where stand-by units are available. The economic impact will not become apparent until failure of the stand-by occurs.*

## N - None

Failure results in none of the consequences defined above.

### 3.3.3 Assessing the Costs

This evaluation is to assist in the preliminary rating of the system or equipment item, in any phase of the asset life cycle.

An estimate of the economic consequence of loss of the system or equipment item, during operation, should first be recorded.

An evaluation of the actual cost of the engineering activity, at the specific stage of the asset life, may then be added.

Completion of this general spreadsheet then allows more detailed analysis to be performed where appropriate.

## 4. ANALYSIS

The systematic approach to criticality analysis may be assisted by the use of an appropriate computer package, adapted for the specific application. This could take the form of a proprietary spreadsheet or database program.

### 4.1 Categorisation

The sub-systems or equipment items should now be sorted according to Consequence of Failure classification.

The Safety categories may be sorted by engineering activity cost.

*Sorting by the cost of the engineering activity allows a further analysis to be made of systems and equipment which consume the greatest amount of resources. A diesel fire water pump whose failure consequence is unequivocally safety related appears as a critical item on the second sort because of its typical maintenance costs.*



*The engineering activity encompasses design calculations, inspection techniques and maintenance and spares requirements.*

The economic category may be sorted on the basis of the level of economic impact, and the timescale in which it is likely to occur.

Those in the 'N' category of failure consequence are sorted by engineering activity cost.

*An item with an 'N' failure consequence may be re-assessed according to the typical cost of engineering - maintenance, inspection, design - associated with it. It may then be reappraised to establish whether this engineering is justified.*

The category defined with a critical safety classification requires the maximum engineering effort and procedural definition. All items in this category may be further analysed at sub-system and component level.

Categories with economic impact will be sorted on the basis of that impact. The upper items can be further analysed at sub-system and component level. The lower, may merit reduced engineering activity and priority.

Those sub-systems and equipment items which are classified as having no consequent safety or economic failure implications will be afforded the level of engineering activity proportional to the cost of performing that activity. For example, it is unlikely that any sub-system or equipment item in this category will merit the use of advanced engineering analysis techniques or extensive inspection procedures.

## **4.2 Individual Rating Methods**

In order to carry out a full assessment on critical sub-systems or equipment items, the adoption of a model worksheet or checking plan appropriate to the stage of the asset life, is recommended.

*The Figures in this Recommended Practice give examples of models which may be applied at individual stages. Instructions for the use of these models are available through the custodian.*

Completion of this analysis will enable the appropriate strategy to be applied to the engineering activity.

## **5. CRITICALITY**

*It is strongly recommended that although these models are useful as examples, maximum benefit will be gained from use of the criticality concept if users think through their own requirements, bearing in mind the principles outlined in this account, in order to develop a model and systems which cater for their own needs.*

The following models available from the BP businesses have been developed for use in specific applications.



*Copies are available through the Custodian of this Recommended Practice.*

## **5.1 Equipment**

1. BP Chemicals Ltd. - [QSP/QAS/002](#) "The Setting of Criticality Ratings" by P.F. Scarlett
2. BP Exploration Ltd., Kinneil Terminal Expansion Project - "Criticality Ratings and Quality Programmes".
3. BP Exploration Ltd., Pipelines Project Group - [402/CPOM/Q/71615](#) "Criticality Ratings".
4. BPE Andrew Project - "Guide to Criticality Ratings".
5. BP Engineering Ltd., (for ADGAS Liquefaction Co. Ltd.) [DAS/A3/PE/154](#) "Criticality Rating of Equipment applying QA Requirements".
6. BP Group Recommended Practice [RP 42-1](#) - Piping Systems.

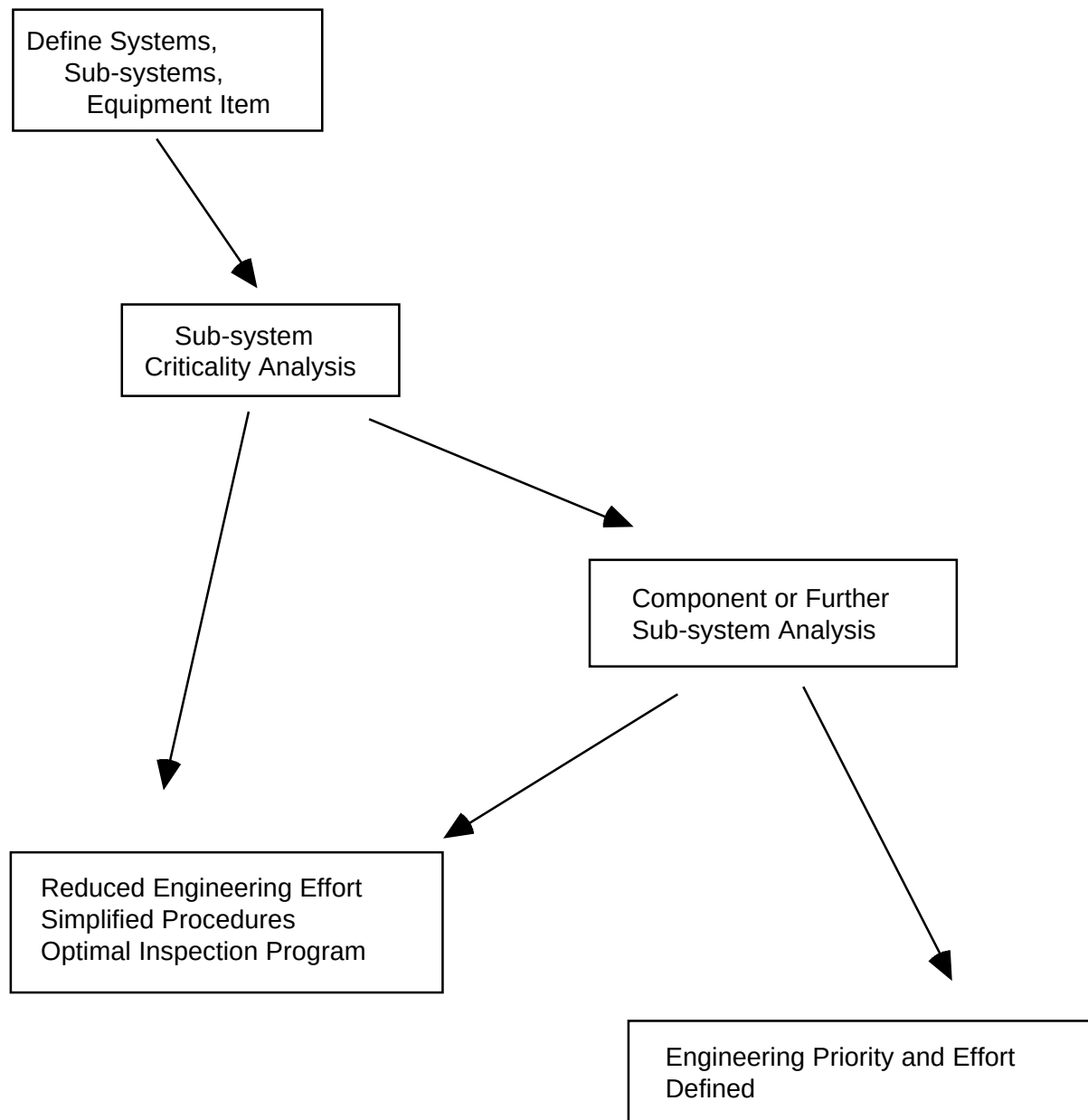
## **5.2 Process Systems**

1. BP Chemicals Ltd., - [QSP/QAS/002](#) "The Setting of Criticality Ratings" by P.F. Scarlett.
2. BP Oil Grangemouth Refinery Ltd. - "HF Alkylation Unit: Criticality Assessment"
3. BP Chemicals Ltd Baglan Bay -"Ethanol Plant Criticality Assessment"

## **5.3 Operations**

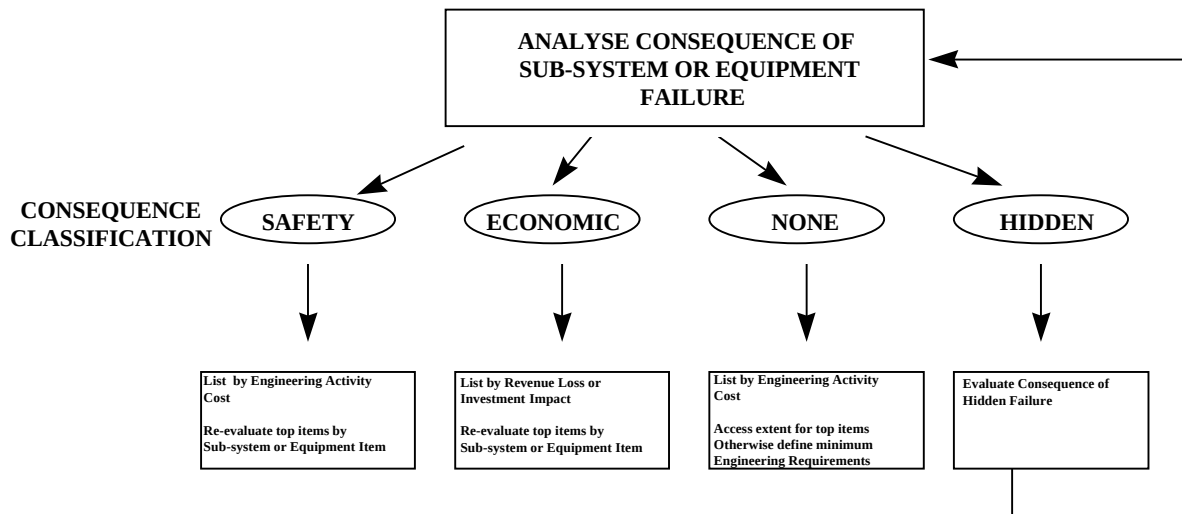
1. BP Exploration UK Ltd., Operations - "Asset Criticality Analysis Guidelines" by P.J. McCrory.
2. BP Exploration UK Operations - "New Fields Division Maintenance Guide" by S. Pearson.
3. BP Chemicals Ltd. - [QSP/QAS/002](#) "The Setting of Criticality Ratings" by P.F. Scarlett.
4. BP Exploration Ltd., Kinneil Terminal Expansion Project "Criticality Ratings and Quality Programmes".





**FIGURE 1**  
**OVERVIEW OF CRITICALITY ANALYSIS SYSTEM**





**FIGURE 3**

**SUB-SYSTEM CRITICALITY RATING METHOD**