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A REVIEW OF THE STATE OF KNOWLEDGE AND OF CURRENT PRACTICE IN SELECTION TECHNIQUES FOR PROCESS OPERATORS

Jeremy C Williams and Sally E Taylor

DNV Technica Ltd
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The objective of this report was the study and appraisal of selection techniques for process control operators. This included establishing the current use of techniques and industry practice in the selection of process operators. Evidence of the utilisation of practices was collected by interviewing, and from this it was established that process operator selection, although principled, is not very systematic. The report describes also the basic technology of selection methods, via information gained from published literature and consultants, including the construction of selection procedures and test instruments, and how these are evaluated, particularly with respect to their reliability and validity. Consideration is given to the transferability of techniques and knowledge that could be applicable to process control. Finally, recommendations have been made for the use of selection techniques for process control operators, based on good current practice.

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GLOSSARY OF TERMS

The following glossary of terms has been compiled from the Standards for Educational and Psychological Testing, produced by the American Educational Research Association (1985). Items selected for inclusion are those which are used in the present report. This glossary may, therefore be used when reading this report.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Ability Test</td>
<td>A test that measures the current performance or estimates future performance of a person in some defined domain of cognitive, psychomotor or physical functioning.</td>
</tr>
<tr>
<td>Aptitude Test</td>
<td>A test that estimates future performance on other tasks not necessarily having evident similarity to the test tasks. Aptitude tests are often aimed at indicating an individual's readiness to learn or to develop proficiency in some particular area if education or training is provided. Aptitude tests sometimes do not differ in form or substance from achievement tests, but may differ in use and interpretation.</td>
</tr>
<tr>
<td>Achievement Test</td>
<td>A test that measures the extent to which a person commands a certain body of information or possesses a certain skill, usually in a field where training or instruction has been received.</td>
</tr>
<tr>
<td>Assessment Procedure</td>
<td>Any method used to measure characteristics of people, programs, or objects.</td>
</tr>
<tr>
<td>Battery</td>
<td>A set of tests standardised on the same population, so that norm-referenced scores on the several tests can be compared or used in combination for decision making.</td>
</tr>
<tr>
<td>Cognitive Ability Test</td>
<td>A test which assesses the processes underlying thinking and decision making (cf Traditional Psychometric Test).</td>
</tr>
<tr>
<td>Concurrent Criterion</td>
<td>Evidence of criterion related validity in which predictor and criterion information are obtained at approximately the same time.</td>
</tr>
<tr>
<td>Related Evidence of Validity</td>
<td>Evidence that supports a proposed construct interpretation of scores on a test based on theoretical implications associated with the construct label.</td>
</tr>
<tr>
<td>Content-Related Evidence of Validity</td>
<td>Evidence that shows the extent to which the content domain of</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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</tr>
<tr>
<td>Evidence of Validity</td>
<td>A test is appropriate relative to its intended purpose. Such evidence is used to establish that the test includes a representative or critical sample of the relevant content domain and that it excludes content outside that domain. In employment selection testing, the content domain consists of task, knowledge, skills and abilities associated with a job.</td>
</tr>
<tr>
<td>Criterion</td>
<td>An indicator of the accepted value of outcome performance, such as grade-point average, productivity rate, accident rate, performance rate, absenteeism rate, reject rate and so forth. It is usually a standard against which a predictive measure is evaluated.</td>
</tr>
<tr>
<td>Criterion-Related</td>
<td>Evidence that shows the extent to which scores on a test are related to a criterion measure.</td>
</tr>
<tr>
<td>Discrimination</td>
<td>The ability of a test or a test item to differentiate among individuals by measuring the extent to which the individuals display the attribute that is being measured by that test or item.</td>
</tr>
<tr>
<td>Documentation</td>
<td>The body of literature (e.g. test manuals, manual supplements, research reports, publications etc.) made available to support test use.</td>
</tr>
<tr>
<td>Factor</td>
<td>In measurement theory, a derived hypothetical dimension that accounts for part of the intercorrelations among tests. Strictly, the term refers to a mathematical dimension constructed by a factor analysis, but it is also commonly used to denote the psychological construct associated with the dimension, for example, an attribute such as verbal ability (verbal factor) or numerical ability (numerical factor).</td>
</tr>
<tr>
<td>Factor Analysis</td>
<td>Any of several methods of analysing the intercorrelations or covariances among variables, which are fewer in number than the original variables. It indicates how much of the variation in each original measure can be accounted for by each of the hypothetical factors.</td>
</tr>
<tr>
<td>False Negative</td>
<td>In selection, an error in which a person is predicted to fail, but would have succeeded if selected. Alternatively, classifying someone incorrectly as being in a lower group.</td>
</tr>
<tr>
<td>False Positive</td>
<td>In selection, an error in which a person is predicted to succeed, but would have failed if selected. Alternatively, classifying someone incorrectly as being in a higher group.</td>
</tr>
<tr>
<td>Inventory</td>
<td>A questionnaire or checklist, usually in the form of a self-report, that elicits information about an individual. Inventories are not tests in the strict sense: they are most often concerned with personality characteristics, interests, attitudes, preferences, personal problems, motivation, and so forth.</td>
</tr>
<tr>
<td>Item Analysis</td>
<td>The process of assessing certain characteristics of test items, usually the difficulty value, the discriminating power, and sometimes, the correlation with an external criterion.</td>
</tr>
<tr>
<td>Term</td>
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</tr>
<tr>
<td>Job Analysis</td>
<td>Any of several methods of identifying the tasks performed on a job or the knowledge, skills and abilities required to perform that job.</td>
</tr>
<tr>
<td>Norms</td>
<td>Statistics or tabular data that summarise the test performance of specified groups, such as test takers of various ages or grades. Norms are often assumed to represent some larger population, such as test takers throughout the country.</td>
</tr>
<tr>
<td>Personality Inventory</td>
<td>An inventory that measures one or more characteristics that are regarded as psychological attributes or interpersonal skills.</td>
</tr>
<tr>
<td>Predictor</td>
<td>A measurable characteristic that predicts criterion performance such as scores on a test, evidence of previous performance, and judgments of interviewers, panels, or raters.</td>
</tr>
<tr>
<td>Profile</td>
<td>A graphic representation of an individual's scores (or their relative magnitudes) on several tests that employ a single standard scale.</td>
</tr>
<tr>
<td>Psychometric</td>
<td>Pertaining to the measurement of psychological characteristics such as abilities, aptitudes, achievement, personality traits, skill, and knowledge.</td>
</tr>
<tr>
<td>Raw Score</td>
<td>The unadjusted score on a test, usually determined by counting the number of correct answers, but sometimes determined by subtracting a fraction of the wrong answers from the number of correct answers.</td>
</tr>
<tr>
<td>Reliability</td>
<td>The degree to which test scores are consistent, dependable, or repeatable, that is, the degree to which they are free of errors of measurement.</td>
</tr>
<tr>
<td>Reliability Coefficient</td>
<td>A coefficient of correlation between two administrations of a test. The conditions of administration may involve variation in test forms, raters or scorers, or passages of time. These and other changes give rise to qualifying adjectives being used to describe the particular coefficient e.g. parallel form reliability, rater reliability, test retest reliability etc.</td>
</tr>
<tr>
<td>Restriction of Range</td>
<td>A situation in which, because of sampling restrictions, the variability of data in the sample is less than the variability in the population of interest.</td>
</tr>
<tr>
<td>Score</td>
<td>Any specific number resulting from the assessment of an individual; a generic term applied for convenience to such diverse measures as a test scores, estimates of latent variables, production counts, absence records, course grades, ratings, and so forth.</td>
</tr>
<tr>
<td>Screening Test</td>
<td>A test that is used to make broad categorisations as a first step in selection decisions or diagnostic processes.</td>
</tr>
<tr>
<td>Selection Decision</td>
<td>A two-alternative classification in which rejection is one possible assignment or treatment.</td>
</tr>
<tr>
<td>Split-half</td>
<td>An internal analysis coefficient obtained by using half the items.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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</tr>
<tr>
<td>Reliability Coefficient</td>
<td>To the test to yield one score and the other half of the items to yield a second, independent score. The correlation between the scores on these two half-tests, stepped up via the Spearman-Brown Formula, provides an estimate of the alternate-form reliability of the total test.</td>
</tr>
<tr>
<td>Standard Score</td>
<td>A score that describes the location of a person's score within a set of scores in terms of its distance from the mean in standard deviation units.</td>
</tr>
<tr>
<td>Test-retest Coefficient</td>
<td>A reliability coefficient obtained by administering the same test a second time to the same group after a time interval and correlating the two sets of scores.</td>
</tr>
<tr>
<td>Traditional Psychometric Test</td>
<td>A test of psychometric measurements (see Psychometric) which is based on the notion that a unified score can be used to describe a psychological factor such as intelligence or innate ability (cf. Cognitive Ability Test).</td>
</tr>
<tr>
<td>Validation</td>
<td>The process of investigation by which the degree of validity of a proposed test interpretation can be evaluated</td>
</tr>
<tr>
<td>Validity</td>
<td>The degree to which a certain inference from a test is appropriate or meaningful.</td>
</tr>
<tr>
<td>Validity Coefficient</td>
<td>A coefficient of correlation that shows the strength of the relation between predictor and criterion.</td>
</tr>
<tr>
<td>Validity Generalisation</td>
<td>Applying validity evidence in one or more situations to other similar situations on the basis of simultaneous estimation, meta-analysis, or synthetic validation arguments. This is achieved by controlling or compensating for situational factors that would otherwise lower the test validity, the concept is often pursued by arguing the points of similarity between jobs which might otherwise go unremarked.</td>
</tr>
<tr>
<td>Variable</td>
<td>A quantity that may take on any one of a specified set of values.</td>
</tr>
<tr>
<td>Variance</td>
<td>A measure of variability; the average squared deviation from the mean; the square of the standard deviation.</td>
</tr>
<tr>
<td>Weighted scoring</td>
<td>Scoring in which the number of points awarded for a correct (or diagnostically relevant) response is not the same for all items. In some cases, the scoring formula awards more points for one response to an item that for another.</td>
</tr>
</tbody>
</table>
A STUDY AND APPRAISAL OF SELECTION TECHNIQUES FOR PROCESS CONTROL OPERATIONS

EXECUTIVE SUMMARY

The following broad objectives of the study are given in bold print followed by summarised methods of enquiry, findings and observations made. Forward references to relevant sections of the main report are also given.

1. To establish the current use of techniques and industry practice in the selection of process operators.

Evidence of how good practices are utilised was collected by interviewing representatives of selected process control companies who were known to have some experience with selection procedures and techniques. This is discussed in Section 7 of the report.

This sample was not intended to be representative. This course of action was adopted to concentrate resources on those companies who could contribute positively to creating a data base of best current use of techniques and principles.

It was established that the current use of techniques and industry practice regarding process operator selection is sporadic, including the use of psychometric tests and interviews. It was apparent that most of the companies interviewed followed a systematic procedure in selection, in which they took reasonable care at various phases of the recruitment and selection process. Even so, there were some common deficiencies. In particular, there was no evidence of systematic measurement of the performance of operators in the tasks for which they were recruited and, hence, no systematic validation of selection methods. Selection methods, therefore, remained largely subjective and accepted on trust rather than on the basis of any objective evidence of their worth.

2. To provide an overview of selection techniques and tests both as reported in the literature and as used by psychological consultants or consulting organisations.

The report describes the basic technology of selection methods, including the construction of selection procedures and test instruments and how these are evaluated, particularly with respect to reliability and validity (Section 2). Section 4 outlines the main issues for development in this area. Section 6 reviews published literature on practices in process operator selection.
Further information concerning potentially good practice in process operator selection was sought by an examination of the practices of consultants working in this area.

Following approaches to a number of consultants, limited evidence of activity in this area was found and, hence, little first hand experience of application of selection techniques to process operator selection could be recorded. This is described in Section 8 of the Report. In discussion with the companies able to comment, and through a review of the literature of the research concerned with process operator selection, reviewed in Section 6, it became apparent that the common techniques adopted in the process industries included standard personnel selection methods. The problems of formally validating selection methods in a practical way were generally acknowledged as relatively intractable. Such methods as were employed entailed activities such as collecting and weighing up diverse evidence concerning the outcome of the selection decision, rather than a formal statistical validation procedure.

The use of interviews was found to be almost universal, despite the lack of evidence to demonstrate their worth. Psychological tests were used frequently, even though they are not formally validated. The prime use of psychological tests tended to be for reducing a pool of applicants to a size manageable for subsequent interviewing, rather than for making a final selection decision.

3. To consider validation issues and to explore the extent to which validated process operator selection techniques are available. Also to suggest possible approaches to validation given the difficulties of rigorous validation in this context.

The report discusses the formal requirements of validating selection methods in Section 2 and current developments in methods in Section 4. However, it is clear that there are limitations regarding the extent to which such formal methods may be applied with confidence in view of the constraints imposed by the nature of tasks and the organisation of work in the process industries, as discussed in Section 3.

One major problem highlighted was associated with the common failure to measure job performance reliably. Steps should be taken to improve these practices in companies. These may include objective methods entailing job sampling and simulation. They may also include subjective assessments made by managers and supervisors supported by a suitable framework to help make these judgements. These recommendations are discussed in Section 13.

Another major problem concerns the issue of computing validity coefficients, bearing in mind the constraints imposed by the operating context in the process industries where predictor measures may be collected for a substantial number of job applicants, but criterion measures may only be available for a very small number.
Whether psychometric techniques developed to overcome these range restriction biases are suitable for overcoming the extreme biases in typical process control contexts, is a question that needs to be addressed by psychometric research to establish the extent to which conventional validation methods can sensibly be employed. Similarly, the extent to which validity data from different contexts may be pooled to establish useful validity coefficients for specific process control selection needs to be addressed. These are issues suggested for further psychometric research in Section 14.

4. To consider comparable industrial work settings with a view to the transference of techniques and knowledge that could be applicable to process control.

Section 9 of the report considers tasks in similar contexts, to determine whether proven selection methods used elsewhere may be adopted in the process control context in the UK.

A problem here is establishing, with confidence, the extent to which other contexts are comparable to process control. A rigorous analytic approach, examining tasks, organisational contexts and safety considerations, would be required to show how task elements in one occupational setting provide justification for comparison with a task in another setting. To do this thoroughly would entail substantial resources. Unless it is done thoroughly, the relevance of one context to another may always be questioned. In the absence of this rigorous approach, similarity of contexts was judged according to face validity. Thus, comparisons were sought with, for example, military installations and nuclear installations overseas.

Other problems concerned gaining access to information regarding those tasks which seemed to be similar or receiving responses to requests for information. One consequence of this was that information from foreign nuclear utilities was very slow in materialising. Another consequence was that contacts made with organisations were often not able to supply information on relevant tasks.

In view of these problems, the results from this section are insubstantial. However, generally they support the conclusions described in 2 and 3 above.

5. To provide recommendations for the use of selection techniques for process control operators.

Recommendations for the use of selection techniques for process operators are made in Part 4 of the Report. These recommendations are in the form of broad suggestions for improving practice, rather than in a form for immediate dissemination to practitioners in industry.
Section 11 outlines the general approach to selection evident in the good companies visited and endorsed by the consultants interviewed - as discussed in Section 8. This appears to represent good practice and is recommended as a framework both to prescribe methods for companies and for reviewing the effort made by companies. There was no strong evidence for the adoption of any particular selection instruments rather than any other within each stage, although each company utilised a range of standardised psychometric tests - typically, verbal, numeric and spatial ability; sometimes with consideration given to aspects of personality - and interviews.

While there was no hard evidence to support the use of interviews as a selection instrument, it was apparent that they were used for other purposes, including gaining the commitment of line personnel to the selection process. Therefore the inclusion of an interview within a selection procedure can be justifiable, even though it may not contribute to the validity of selection methods.

It is felt that companies would benefit from being encouraged to adopt this outline framework, as it stands. Apart from starting to make their selection procedures more effective, they would then be operating within a framework to which further recommendations and innovations could be added. Furthermore, the absence of such a systematic approach would be indicative of a company who were failing to take adequate steps regarding their selection processes.

Section 12 discusses the issues involved in identifying suitable predictors and outlines a practical approach, which could be developed to aid this process, which uses a functional model of process control tasks for use by a manager concerned with selection to diagnose the selection requirements of particular process plant jobs. Development of this kind of decision aid would give companies assistance in choosing appropriate selection methods according to their particular pattern of requirements.

Section 13 considers the largely neglected area of criterion measurement. No evidence was found of the use of systematic measures of job performance in a form suited to making judgements about the adequacy of selection methods. Without such measures a rigorous approach to selection cannot be pursued and formal validation of selection methods must be ruled out.

Section 14 discusses the issue of demonstrating validity, highlighting the problems already discussed in 3 above. It is suggested that, while further work to establish practical solutions to computing validity coefficients may be justified, there cannot be too much confidence in achieving a solution in view of the methodological problems to be overcome.

Section 15 discusses the cognitive approach to selection testing which may offer a satisfactory way of dealing with this general question, but it is emphasised that practical benefits from this approach have yet to be demonstrated.
PART I: INTRODUCTION

Outline

This section discusses the relevance of selection in industry and the process industries in particular. It then sets out the organisation of the report.
1. SECTION 1: SELECTION IN PROCESS CONTROL

1.1 Introduction

Personnel selection entails making judgements about people applying for positions in organisations. These judgements are typically made by interviewing applicants, inspecting application forms and references, and conducting psychological tests. On the basis of these judgements, predictions are made regarding the likelihood of applicants’ matching the organisation’s needs. Through effective selection a company would hope to improve productivity and safety, optimise training, and reduce costs associated with staff turnover. Effective selection depends upon the care taken to make the initial judgment of the applicant, i.e. the predictor, and the care taken in measuring the relevant performance on the job, i.e. the criterion. The validity of the predictor rests with how accurately it predicts eventual job performance, i.e. the criterion. Good selection practices hinge on these three aspects - measuring predictors, measuring criteria and measuring validity. These three aspects, understandably, feature centrally in this report and it is to these that we shall return at its conclusion.

This report is concerned with establishing what companies could reasonably be expected to do to improve their selection practices, given the current state of knowledge of selection methods and research into selection methods. The report is based on evidence collected through discussion with a number of experts and reviewing various aspects of the literature on selection methods. The study undertaken was small in comparison with the number of people who could have been interviewed and the technical issues that might have been scrutinised in depth. None-the-less, because the pattern that emerges in even this small study is consistent, the authors consider that the conclusions drawn are representative and fair; a more extensive examination of these issues would be unlikely to change the conclusions substantially.

1.2 The Importance of Selection

Selection processes are a necessity if only to reduce the often large pool of applicants applying for a particular job, to the small number of people to be recruited by an organisation. In one case that we shall discuss later, for example, an applicant pool numbering around 3000 had to be whittled down to around 6 job placements. In any group of people, some are more suited to specific jobs than others and so a sensible selection process needs to be followed with the aim of identifying people who, if not the very best, are at least among the best. While it is naive to hope to select the very best, good selection processes should end up with a selection of the most able people from the recruitment pool.
There is a danger in placing too much reliance upon selection. While there are, undoubtedly, individual differences between applicants that might be exploited in selecting better people for jobs, the potential of selection should not be overstated. In any selection process, in any context, selection aims to increase a success rate; it is never claimed to be 100% accurate. Furthermore, overstating the potential of selection detracts from the need to deal with other more fundamental aspects of design for human performance. When people are appointed to jobs, they are given training, then placed in a particular work context. This context is defined in terms of the events presented to the operator by the process under control, the way in which information and control opportunities are made available, the way in which the operator is supported through job-aids or colleagues, the way in which the operator has to communicate and collaborate with colleagues, the shift-pattern that is followed, and the way in which operators are remunerated and generally managed. It is naive to overstate the potential of selection. This naive view may arise, not from genuine conviction, but from managerial expediency - selection is often seen as a cheaper and less disruptive mechanism for addressing performance weaknesses, than dealing with human factors issues. Rectifying a poor display, for example, is expensive in terms of purchasing new equipment, scrapping old equipment and inevitable down-time. It can also be embarrassing to a manager or engineer responsible for installing an inadequate system. It is often more acceptable to attribute poor performance to the quality of staff, than the job design and interface.

This naive view has been deliberately exaggerated and based on impressions gained by the authors' experience in dealing with human factors issues in the process industries over some years. It must be stressed that the view was not formulated in the field study, discussed in Section 7, where the people interviewed, who had been chosen for their expertise and experience in selection, all demonstrated a realistic view of the potential for selection alongside other means for improving performance. Indeed, it was not the purpose of the present study to examine general attitudes of this kind across the process industries, but the viewpoint has been raised in this introduction to emphasise that judgements about the importance and potential of selection are often influenced by expectations rather than a more realistic appraisal of their potential.

While selection methods occupy a central place in occupational psychology, they have not featured prominently in research into human factors of process control as will be demonstrated in Section 6. In process control, far more attention has been paid to issues of operator-system interface design, operator support and training. Certainly, the interest that human factors researchers appear to have shown in the selection issue does not reflect the importance attached to it in industry. One can only speculate about the reasons for this. Perhaps human factors researchers genuinely feel that selection has little significance in comparison to other aspects - they are probably right in reducing the emphasis on selection. A more likely reason for the apparent disinterest in process operator selection as a topic for research is that it is very difficult to study.
To conduct sensible research into selection entails operating on a far more complex scale than the controlled studies that are permissible when considering many other human factors issues. Many of the reasons why research into process operator selection is an unattractive prospect are the same as why it is so difficult to carry out defensible selection processes in reality. These problems are described in Section 3.

Despite the relative lack of research activity, the importance of selection as a component in process control is tacitly accepted. People bring to their work situations, operating knowledge and information processing strategies for dealing with problems. Training is one way to assist this, but selection, too, must form part of the story. Often we must rely on people possessing knowledge and information processing strategies that pre-date their training, and so selection is warranted. Indeed, existing knowledge and information processing strategies are important to enable training to take place. Furthermore, the relevance of different forms of knowledge and information processing strategies can only be judged in conjunction with the information provided to the operator and the work-loads experienced. So, the individual capabilities of the operator are crucial to a proper understanding of performance. A proper conclusion is that the knowledge, strategies and abilities that a new operator needs to bring to an operating situation should be appreciated when interfaces and other aspects of work are designed. This is a counsel for perfection, one which all human factors specialists would subscribe to, yet one which few acknowledge when they actually carry out their work.

It is acknowledged as important, but its proper place within the context of supporting operators is not fully understood or exploited by people in industry or in research. Indeed, methods for selection of process operators, which are both entirely satisfactory and practicable, do not exist. This is a view that will be argued in this report.

1.3 Organisation of the Report

Following this introduction, the report is organised in 4 further parts, each main part being set out in a series of sections.

PART II : METHODOLOGICAL ISSUES

This will deal with questions of how selection methods are constructed.

SECTION 2 : CENTRAL THEMES IN PERSONNEL SELECTION:

This considers the range of concepts and techniques that have been developed to deal with questions of selection. Amongst researchers and professional designers of selection instruments there is a general consensus regarding how selection should be approached. Briefly, the process entails:
• analysing the jobs for which selection is being devised;
• identifying job characteristics which cannot be established through training;
• choosing selection methods which, hopefully, will predict these characteristics and;
• validating these selection methods by correlating them with measures of job-performance.

Invariably, these methods require large numbers of people to be tested and their job-performance measured. The discussion is based on examination of a number of texts and reviews. The value of the recommendations from these sources rests with the extent to which they can sensibly be applied in real contexts. In the process control context, for example, there are serious questions concerning whether these approaches are, indeed, applicable.

SECTION 3: CONSTRaining FACTORS IN PROCESS CONTROL COMPANIES:

This considers the characteristics of process control environments. It will be shown that the real constraints imposed on selection methods by process technology, the numbers of people employed and the ways in which work is organised, prevent the ideal methods, outlined in Section 2, from being applied with any rigour.

SECTION 4: DEVELOPMENTS IN METHODOLOGY:

This reviews more recent research on selection methodology to determine whether there are any major issues currently under examination which could overcome the difficulties discussed in Section 3. A number of techniques are discussed, some of which would purport to deal with the major problems presented by process control environments. For example, there are methods which would aim to control for selection biases and cater for small sample sizes by combining data from different sources.

SECTION 5: METHODOLOGICAL ISSUES - CONCLUSIONS:

This section brings together the major conclusions from Part II. A major conclusion is that many of the current recommended practices in the selection literature cannot be applied with much confidence to the process control context. However, some techniques may warrant further investigation as a basis for improved practice in the future.
PART III: EXISTING PRACTICES IN SELECTION

Part III sets out to examine what is currently being done regarding selection in the process industries. It seeks evidence from a variety of sources, including literature dealing with interventions in the process industries and interviews with practitioners and other experts in selection.

SECTION 6: EVIDENCE OF EFFECTIVE PROCESS OPERATOR SELECTION PRACTICES FROM PUBLISHED LITERATURE

This considers the published literature concerned with operator selection in the process industries. Literature in this field consists mainly of policy documents stating selection criteria with little in the way of empirical studies demonstrating practical selection methods in action. A major reason for this dearth of empirical research is due to the methodological problems of carrying out this work (as discussed in Section 3). It is noticeable that the one extensive study identified which was concerned with developing a process operator selection method in the power industry is fraught with precisely the same sorts of methodological problems described in Section 3, severely limiting the conclusions that can be drawn from it with confidence.

SECTION 7: PRACTICES IN COMPANIES:

This considers actual practice in companies in the process industries. The information in this section was established by conducting relatively informal face-to-face interviews with people concerned with the administration of selection procedures in companies employing process operators. The groups concerned were very small in number and in no sense representative. The purpose of this small survey was not to establish a representative picture of selection practices in the industry. This would have been beyond the resources of the project and not consistent with its purpose. Rather, this small survey aimed to establish the sorts of possibilities that could be realistically entertained by companies commercially sensitive. To this end, discussions were held with a handful of representative companies who had been recommended as being experienced in the field of systematic process control selection. The general outcome of this survey was that nothing startling was being done in industry regarding selection. Practitioners were generally well informed and understood the limitations of what they were doing. They were distinguished by clearly recognising the planning and lead-time that was involved in selection, then being as careful and as systematic as they could be at all stages of the selection process.

SECTION 8: APPROACHES ADOPTED BY CONSULTANTS:

This section reports discussions held with a number of consultants concerned with the application of selection methods to industry. It outlines a telephone survey, which was somewhat unsuccessful in eliciting useful information about selection, but which was quite illuminating in failing to find consultants with any declared experience in the selection of process operators.
To supplement the weak outcome of the telephone survey, effort was made to locate consultants with actual experience. This confirmed the findings in Section 7. It emerged that consultants had no magic formulae for process operator selection and did not adopt particularly sophisticated techniques; they simply followed a process of planning in good time, followed by careful execution of each stage in their selection process.

SECTION 9: APPROACHES ADOPTED IN OTHER CONTEXTS:

The main reason why conventional selection procedures are difficult to apply in the process industries is because the industrial context constrains the application of these methods. This was discussed in section 3. It was felt useful to examine other real contexts to determine whether solutions had been established that which could conceivably be adapted to the process industries. Other contexts included military situations and foreign nuclear utilities. Unfortunately this work was not very revealing. The military contexts were not seen as being particularly applicable in view of the vastly different recruitment and placement patterns. Information obtained from foreign nuclear utilities was too sparse to be of major benefit.

SECTION 10: EXISTING PRACTICES IN SELECTION - CONCLUSIONS:

Two major conclusions are drawn from these sections. First, there are no surprises in the methods adopted; nobody seems to have developed methods for overcoming the problems cited in part II. Second, both the company practitioners and consultants adopted a similar systematic approach, characterised by planning and careful execution of the stages in the selection process. Moreover, there appears to be a consensus regarding the stages that should be followed in selection.

PART IV: AREAS FOR IMPROVED PRACTICE

Part IV reviews previous sections and sets out where attention could be focused to improve practice in selection processes. These areas include: recommendations involving the current state of the art, which could be put into practice in companies now; suggestions for developing techniques to supplement existing practices.

SECTION 11: A PRINCIPLED APPROACH TO SELECTION:

This section lists the stages in the selection process, identified in Section 10 and suggests that it may be regarded as a principled approach to selection that can be adopted usefully in other process control contexts. Companies seriously concerned with the quality of their selection decisions could be encouraged to adopt such a systematic approach; inspecting bodies concerned to locate evidence of good selection practices could seek evidence that selection procedures adopted by a particular company comply with this general pattern.
SECTION 12: IDENTIFICATION OF TRAINING CRITERIA - OUTLINE OF A FUNCTIONAL MODEL:

One of the major problems outlined in section 3 is that individual plants impose different patterns of requirements on their operators.

This effectively prevents extensive standardisation exercises, which are the hallmark of most psychometric methods. It also makes it impossible to generalise easily about general selection criteria for process operators.

In order to deal with this sort of problem, Section 12 sets out a functional model of process control activities, from which process control operator skills for a particular application can more easily be discerned. The model is useful in both highlighting specific attributes required to undertake specific activities and in drawing attention to those features of a task concerned with workload. It is suggested that a tool of this sort could help company personnel identify their selection criteria.

SECTION 13: MEASUREMENT OF JOB PERFORMANCE

Another major weakness which limits any serious attempt to validate selection methods is the absence of effective methods to measure job performance. This issue is discussed in Section 13 and suggestions are made in order to overcome this problem.

SECTION 14: MEASURING VALIDITY:

Despite problems in measurement, validation remains the basic means of demonstrating the adequacy of a selection method - this effectively means correlating a predictor score with a criterion score. In the absence of appropriate methods for computing such a value, selection practitioners must still make some judgement about validity, albeit subjectively - otherwise there is no justification for adopting the selection methods in question. However, objective methods should still be sought. Section 14 considers problems that remain in establishing such objective methods and considers the benefits of further investigation into validation techniques.

SECTION 15: COGNITIVE APPROACHES TO SELECTION:

In view of the various problems identified with validity measurement, the potential for a cognitive approach to developing selection method is considered.

PART V: CONCLUSIONS

Part V sets out and discusses the main conclusions from the report.
PART II: METHODOLOGICAL ISSUES

Outline

Section 2 of the report considers the basic principles that have been established in occupational selection methods.

Section 3 then considers how their application is constrained within the process industries.

Section 4 considers whether problems highlighted in Section 3 can be overcome by more recent developments in research.

The general conclusion drawn from Part II is that the characteristics of process control situations, that is the nature of the work and the patterns of recruitment by companies, mean that the straightforward application of personnel selection methodologies are unlikely to yield results in which much confidence can be placed. Substantial research effort continues to be made to overcome many of the problems of selection methodologies, but few of these seem likely to solve the basic problems of process operator selection.
SECTION 2: CENTRAL THEMES IN PERSONNEL SELECTION

This section is concerned with the range of concepts and issues which relate to selection methods. In addition to setting out the scope of issues involved, it is also intended to provide some basic definitions applicable to later stages in the report.

2.1 Basis of the Review

There are a number of general reviews of the issues associated with selection methods in industry and these should be referred to for further information on any issue of interest. Among the many accessible overviews those by Drent and Alegra (1987) and Osburn (1987) are particularly recommended. Drent and Alegra offer a good overview of the main concepts in the area. Osburn’s review is rather more technical, but contains useful indications of important trends. The work of Rust and Golombok (1989), provides an excellent account of the range of issues involved in this field and also serves to show how durable many of the main ideas in selection are; while specific areas are under constant review and development, the main framework of selection methodologies and the central questions involved remain quite stable. There are several comprehensive texts in occupational psychology which also contain worthwhile accounts of these processes. (e.g Blum and Naylor 1986).

There are a number of specialist texts providing more detailed accounts of issues involved, also often containing a greater range of illustrations of specific selection methods, including samples of occupational selection tests. These texts include those by Cronbach (1984) and Anastasi (1982). While these texts should mainly be referred to by people wishing to consider the issues in some depth, it is worth pointing out that the illustrative information, and some of the practical advice they contain, is invaluable. Many other texts would serve equally in providing a more detailed account of these issues for the reader.

The discussion that follows in this section is a distillation of central ideas culled from these various sources. Most of the points discussed here are consensus views which can be referred to in most of the general texts cited so far. Therefore, reference to specific texts will not be made unless they contain a specific view-point. The descriptions provided of the various selection issues are necessarily simpler than some of the descriptions offered in the various texts. Further reference to items of specific interest, therefore, is strongly recommended.
2.2 **The Scope of Selection Methods**

Selection procedures entail a range of activities designed to reduce a pool of applicants for a job to the number required by the organisation. These activities include:

- advertising for applicants;
- screening people who have responded to the advert;
- giving aptitude tests and other exercises;
- conducting interviews;
- vetting references.

Each of these can, in principle, help in the selection process.

2.3 **A Range of Personnel Decisions**

Selection processes are used to help make a range of different personnel decisions including:

- choosing people for their suitability for training for a specified post;
- choosing people who possess skills suited to a specified post;
- choosing people who possess personality attributes appropriate to the demands of a specified job;
- choosing people for advancement within the company;
- assigning a number of people to duties within the organisation to ensure available talents serve the organisation in the best possible way.

Selection methods will be adapted and combined to suit the purposes of the recruiting company.

2.4 **Filtering**

A common aim of selection in the process industry is to filter a pool of applicants for an advertised post until a suitable number of people for special attention is obtained. Process control jobs are often relatively well paid and so there are a large number of applicants for a few jobs.
The cost of extensive interviews for large numbers of people is prohibitive. On the other hand selecting the wrong people may increase the probability of accidents and error and its attendant costs, while the right people may be capable of avoiding or minimising problems and optimising plant performance. Therefore, successive stages of the recruitment process serve to filter out the appropriate less likely candidates.

A recruitment process moves through a number of stages from advertisement to appointment. Each stage requires 'measurements' to be made of applicants which are then used to reject them or allow them to proceed further. The aim is to reject those people who are clearly unsuitable and keep in the pool those people who are worth considering further. In economic terms, the aim is to reject as many unsuitable people as possible by the cheapest means available and only use more expensive selection methods for a few people for whom it is justified. Typically the applicant pool is reduced by screening of application forms, then further reduced by administering psychological tests, then further reduced by time-consuming and potentially costly interview sessions to make the final decision. The aim is to avoid rejecting good people prematurely. Whether or not this approach works depends largely on the methods used at each stage and the manner in which they are administered. The adequacy of different methods is the major issue being dealt with in this review.

2.5 Basic Ideas

There are several ideas basic to all aspects of measurement and selection. These will be discussed generally here, then considered further at various later stages in the report.

2.5.1 Measurement

Any selection decision entails assessing how well an applicant carries out various activities such as completing tests, answering questions in an interview etc. This amounts to measuring some aspect of the applicant's performance of the activity to infer some characteristic of ability or personality. It is however important to clarify the difference between personality and ability. Ability can be considered as dealing with the question of whether a person can do the job/task, whereas personality relates to the nature of the individual as a person.

In selection measurement processes it is believed that the distinct properties of ability and personality should be assessed as separate dimensions.

One author's view (Smith, 1989) is that the characteristics which an operator in a high risk occupation requires may be categorised into the following groups:

a) perceptual ability
b) mental ability
c) physical ability;
d) emotional stability.
Perceptual, mental and physical ability relies heavily on the correct physical and cognitive functioning of the body. Perceptual ability requires the demonstration of a basic level of acuity and a substantial level of performance. Mental ability relies upon a person's skill in interpreting correctly the signals he or she receives from the environment and then choosing correctly among the available responses. Effective performance can be influenced by intelligence. Training and experience can improve fault diagnosis and problem solving ability. Emotional stability supplements the specific personality requirements that may be thought necessary for persons in high risk jobs.

The personality qualities needed by these persons are that whilst being sufficiently sensitive to appreciate dangers they should not be so sensitive that they are overwhelmed by the emotions they may experience in a crisis. Temperament forms part of an individual's personality. Four main factors are thought necessary in hazardous industries. These are:

a) moderate extraversion;
b) low anxiety;
c) toughness, poise;
d) moderate independence.

The difficulties of making effective measurements is at the heart of the difficulties associated with selection. Any selection activity entails some measuring instrument being used to enable a facet of the applicant's behaviour to be converted into a score which can then be used in subsequent decisions. This can be the case, even where a manager merely chats to an applicant and selects or rejects on the basis of an impression made. The informal interview is a measuring instrument, gaining the impression is the process of measurement and assigning the applicant to an 'accept' or 'reject' category amounts to the score. The notion of measurement is at the heart of all discussion of selection methods, since it is the quality of such measurement that will determine or demonstrate the accuracy of a selection method. Issues of measurement are discussed in greater detail by Cronbach (1984).

2.5.2 Predictors and Criterion Measures

The measurements made when people are being recruited are used to predict whether or not a person will be worth employing, and so they are typically referred to as 'predictors'. Measurements made of people carrying out jobs are called 'criterion' measures. In essence, selection methods are methods of measurement used to predict people who will do well in the job, which means they will score high on the job criterion measures.
2.5.3 The Trait Approach versus the Functional Approach to Mental Measurement

Two different approaches to mental measurement are the trait approach and the functional approach. The trait approach sets out to measure psychological dimensions, for example, various aspects of personality and intelligence. As a result of such a test, we may assign a general attribute to the person taking the test, such as 'high spatial ability' or 'extrovert'. In the functional approach, tests are used primarily to make decisions, without undue concern for what they might be regarded as measuring - the person may be judged a good risk for employment or a poor one. Functional tests are essentially empirical in that the extent to which they discriminate rests with the extent to which they have been shown to predict job performance. Blinkhorn, and Johnson, (1990), have found little evidence relating personality test scores and measures of success at work. Personality tests have several inherent difficulties, the first problem being in the detail of construction leading to poor psychometric properties and the second being the scarcity of well conducted validity studies and the use of discredited theoretical approaches to the structure of personality. Using the trait approach in personnel selection is rather indirect; we need to look at the demands of a job, infer the traits that would be appropriate, measure the applicant against these traits, then combine the traits and validate the weighted measure against job performance. An advantage of functional tests in relation to making personnel decisions, is that it is more direct; there is little concern for attributing different psychological values to each applicant. Further discussion on the trait/function distinction is given by Rust and Golombok (1989).

2.5.4 Reliability

A key feature of any measurement instrument is the extent to which it is robust and makes the same measurements of a particular object, even though conditions of measurement might change. A good analogy is a ruler. If we use a fabric tape measure to measure a window for a roller-blind we may be faced with a problem. The measure has to be accurate, yet the tape measure sags and must therefore be pulled tight. It may stretch with continued use and ultimately may not measure consistently. Furthermore, different people may tolerate different amounts of sag. Clearly a fabric tape measure is far less consistent than a rigid ruler for this purpose. A rigid ruler would enable a more consistent result from different users than would a fabric tape-measure. This consistency between using the measuring instrument on different occasions is called reliability. Making reliable mental measurements is far from easy, and so a great deal of attention must be paid to the issue of reliability.

First, effort should go into maximising reliability; second, effort should go into measuring reliability to demonstrate that the measures adopted are truly satisfactory test instruments. Typically, reliability is maximised by appropriate construction of the test, and by its careful administration.
Reliability is typically measured by correlating test performance by the same people on two different occasions (known as 'test-retest' reliability) or by correlating half of the items in a test with the other half (known as 'split half' reliability).

These two forms of reliability are used to determine the extent to which a specific measuring instrument measures the same thing consistently. A third form of reliability is 'inter-rater' reliability. This would be used to measure the extent to which, say, different interviewers rate specific interviewees.

2.5.5 Validity

A selection method is said to be valid if it effectively measures what it purports to measure. Thus a trait measure is valid if it distinguishes between people in accordance with the trait in question - for example, the ability to cope with stress (a trait which some would say is important for process operators to possess) using such a measure, people regarded as extroverts score higher on extraversion scores than do introverts. A functional measure is valid if the decisions we make when using the test turn out to be the right ones - for example, if the test is used to select people, those people selected prove to be satisfactory. Ultimately, the functionality of a selection method must be demonstrated if its worth is to be proven in an occupational setting. However, there are many problems associated with measuring functional validity in occupational settings, especially in the process industries. These will be dealt with in section 3. One outcome of the problems associated with functional measures in process operator selection is that trait measures may take on greater importance. That is, in view of the problems in demonstrating a functional validity which clearly shows the benefits of a selection method in terms of its prediction of job or criterion scores, we may be forced to adopt methods where we seek to identify traits necessary for the job, then use trait measures as selection methods without formally checking whether they predict job measures. There are a number of technical issues associated with validity, some of which will be dealt with later. One issue that will be dealt with now concerns the various forms that validity can take.

Face validity: This concerns the acceptability of the form of the selection method. If the recipient of the selection method does not see it as valid, then it may not be taken seriously. A related issue in occupational settings is that selection methods must also meet with the approval of line management. If a line manager does not see the relevance of a selection method provided by a personnel department, then it may not be acceptable. For example, a manager may assume that a selection method must measure an aspect of mechanical reasoning. If such measurement is not obvious, then the manager’s support may not be forthcoming. If the line manager is required to participate in, say, an interview panel, then his or her commitment is necessary. Face validity is a two-edged sword; it is possible that undue effort is required to meet face validity, even where it is not strictly necessary in making effective personnel decisions. Face validity is a subjective estimation by a selection method designer. It does not entail any formal methods of measurement.
Content validity: This is concerned with the extent to which selection procedures sample a domain of useful job behaviours. For example, if a job entails numerical reasoning or verbal communication, these should feature in the selection method adopted. It is generally accepted that occupational selection methods should have high content validity, and content validity should feature in considerations for process control selection.

Establishing content validity depends upon the use of task and job analysis methods and the functional approach discussed in Section 12 offers a potentially practicable approach to this issue, reflecting the idiosyncrasies of the process industries. One practical problem concerns distinguishing those aspects of performance that are best developed through training or are best facilitated by human factors design - briefly, the question is, should we constrain who we recruit by a selection method if some aspect of the workplace could be redesigned to enable a wider range of people to do the job?

Predictive validity: Predictive validity or criterion-related validity of a selection method is a measure of the extent to which performance of the job may be predicted from a score obtained in a selection method. Ideally, predictive validity is demonstrated statistically by correlating predictor performance with some job-related criterion measure and is therefore the ideal method for validating functional selection methods. This is the tightest way of demonstrating the validity of a selection method, since it is objective. However, there are a number of serious problems that would have to be overcome to achieve this. A major one is concerned with potential problems associated with measuring job performance. Predictive validity is, therefore, something we would like to achieve in process control selection, but is something we probably are unable ever to achieve in this context. These problems will be discussed further in section 13.

Construct validity: This is the main form of validity for trait related measures and entails making an independent assessment of some construct, say, reasoning ability, and correlating this with the selection method being developed. Construct validity is unlikely to feature as an important concept in the development of company-based selection methods, but it could feature where an effort is made to develop new selection methods for process control skills generally.

Concurrent validity: This is the extent to which a new selection measure correlates with existing measures. Concurrent validity would have practical value if it were shown, for example, that an inexpensively-administered selection method, say a test, correlates highly with a more expensive selection procedure, say an interview panel.

2.5.6 Limits to Validity

There are some classic problems that impose limits to validity. In its most objective form, predictive validity is measured in terms of a correlation coefficient, linking a predictor score to a criterion score.
If the basic scores used in predictor and criterion measurement are unreliable, then any validation measure will have limited value, since the scores that have contributed to the correlation are likely to change on a subsequent occasion. Therefore, a selection method cannot be valid if its constituent measures are unreliable. This becomes a major problem in process control tasks where the problems of reliably measuring job performance are huge.

A second major problem is that related to errors of measurement induced by rejecting a large number of applicants by a selection method, who are then unable (by definition) to provide data for researchers to determine a criterion measure.

In some of the company case-histories we describe in section 7 for example, informants reported pools of applicants numbering up to 3000, then the testing of a group of around 250, to fill as few as 6 places. Thus, test data is available for 250 people, but only 6 of these could also provide criterion data. We know which of 6 people recruited had failed to come up to scratch, but not how many of those rejected would have proven satisfactory. In any process control context, the number of people available for computing a validation score are likely to be too small for a meaningful correlation coefficient to be calculated; and this tiny group is also completely biased by the recruitment process that has been undertaken.

A third major problem concerns the fact that time elapses between selection and predictor measurement on the job. A validity coefficient based on concurrent or criterion-related validity will mean that the social, educational and economic climate within which the predictor was measured is unlikely to apply to the new recruitment population, (the "shelf life" problem).

2.5.7 Task Analysis

Task analysis and job analysis methods feature strongly in approaches to personnel selection. Selection should be based on a proper appraisal of job needs, for example, the need to select for a robust ability to deal with multiple task demands and rapidly changing events. Part of this requirement is concerned with making sure that the selection method is appropriate to the job for which selection is being made. Another important part, however, is concerned with whether selection is the appropriate method for obtaining the desired level of skill for the job.

There are many forms of task analysis, including person-oriented approaches such as the Position Analysis Questionnaire (McCormick et al 1969) where the analyst categorises jobs according to their features and identifies the characteristics of job holders.

Alternatively, there are functional approaches which explore the functional requirements of jobs. There is no simple answer to which approach is best. Functional approaches are more suited to establishing how job skills link to functional needs and, therefore, where alternatives to selection might be considered.
Person-oriented approaches however may be more useful in rapidly identifying the personal attributes of applicants. The application of these various approaches is often subjective; this is not necessarily a bad thing but practice should be explored to offer guidelines for their application.

2.6 Selection Methods

Most of the discussion so far has been concerned with the notion of selection measures, and explicit reference to the form of measure has been avoided where possible. There are some major types of selection measure commonly adopted, in particular, psychometric tests, interviews and selection exercises. These will now be discussed in turn. The basic concepts discussed above apply, in principle, to each of these. For example, we should be as concerned with the reliability of interviews as we are with reliability of formal psychometric tests.

2.6.1 Interviews

A favoured method of personnel selection is the personnel interview. Interviews are often adopted because they seem easy to prepare and appear to have face validity. Many managers think they are good judges of personality, and ability of from interviews alone. Interviews formally constitute selection instruments and should be subject to the same scrutiny as any other selection method. For example, we should enquire about the reliability of the interview - would the same judgement be made, for example, on different occasions and by different interviewers? We should also consider validity - are the judgements made appropriate in predicting job success? Unless this is done we cannot make any judgements about whether the interview is useful and predictive. Herriot (1987) offers some practical advice on the issues of using interviews in personnel decisions, as do many of the texts on occupational psychology. There has been some useful recent research in this area that will be discussed in Section 4. A general conclusion is that selection interviews which are not conducted with care and stringency are almost certainly useless as job predictors.

Interviews can have another function that is not normally reported in the literature, but which is described by an informant during one of the company visits described in section 7. Line personnel are brought in to interview job applicants, not necessarily because they are good at interviewing, but because this may eventually commit them to the people selected.

Managers may make more effort to develop staff in whom they have a personal stake, rather than people who are simply handed over to them to supervise.
2.6.2 **Exercises**

Another common selection method is the selection exercise. Such exercises are essentially simulations of a crucial part of the job. They feature increasingly in management selection exercises, and may include in-tray activities or various discussion activities. They tend not to be used at the level of operator selection but there is no reason why this should be so. Formal appraisal of these methods is sparse and of little relevance to the present review. It is probably fair to say, that if such methods are adopted, they should be adopted with care in order to promote reliability and validity. Unless this is done, they will probably be of limited predictive value.

2.6.3 **Biographical Information**

A further method of selection is to use biographical information often gleaned from application forms, references or specially designed forms, administered at interview. Age, background, job history, for example, can all be used to eliminate people who would be unsuited to a post. Previous experience of shift-work, for example, could be useful to know when appointing someone to a job which may entail shift working.

Age and family commitment may be a good indicator of steadiness in a job where the company hopes to build up a reliable workforce. There is, of course, a danger of abusing or mis-using such information. Sometimes unjustifiable preferences are followed, causing the elimination of people who would otherwise be excellent candidates. Sometimes these preconceptions amount to prejudice and could result in legal action. Biographical information should, therefore, be used with extreme care.

2.6.4 **Psychometric Tests**

Psychometric tests are carefully constructed tasks, administered under controlled conditions in order to measure individual traits. They are usually pencil and paper tasks, though sometimes special equipment is used, for example in peg-board or assembly tests. Microcomputers are increasingly being used to present tasks and automate scoring (e.g. Bartram and Dale, 1982). Psychometric tests are common components of selection methods because they are convenient to administer, often to large numbers of people. They also provide a measure that can be said to be objective and which needs no further interpretation by the tester. They are therefore useful in that they can be said to be free from bias (although the freedom from bias of tests is always a contentious point). A major feature of a properly developed psychometric test is that it is a reliable measure, and this would suggest that it might be robust when adopted in novel situations.

The development of a psychometric test is a specialist undertaking. The technicalities of test development do not need to be understood in any detail by a person whose sole concern is personnel selection in a company context, but their principles and assumptions are important.
It is important to understand something of the way in which tests are developed in order to ensure that a test to be adopted has been developed to a satisfactory standard.

2.6.5 Description of a Psychometric Test

Analysis of traits: A psychometric test is developed to measure some specified trait. Some analytical activity is undertaken to determine what traits should be measured. This may be a rational appraisal of traits needed in a particular area, or it may be the result of an extensive data collection activity and statistical analysis, for example, Fleischmann (1973) has published many studies, using the technique of factor analysis, designed to identify the main traits that account for the differences in performance between people carrying out a range of different tasks. Factor analysis is a common technique used in psychometric research in trait identification for test development and is the basis for many of the theories of intelligence. A simple account is given in Rust and Golombek (1989).

Item Analysis: The test will have undergone a process where test items have been carefully selected according to rigorous statistical procedures. The purpose of this is to ensure that items are selected for inclusion in the test that will reliably and sensitively discriminate between different people who might take the test - there is no point in having lots of items that measure all people in the same way.

Test Versions: Several equivalent versions of the test will have been developed to reduce the chances that a test taker will have seen that test version before, along with a carefully specified procedure for administering the test.

Instructions: Test instructions will include whether the test should be administered individually or in groups: these will cover the conditions in which the test must be carried out: the instructions that should be read out to the people taking the test, the time limit for the test, and the scoring method that must be adopted. The importance of following test procedures closely is to ensure that the test is administered in standard conditions, thereby promoting the test's reliability.

Reliability and validity: Steps will have been taken to measure reliability and validity of the test forms.

Standardisation: In many tests, procedures will have been followed to standardise the test scores.

These are statistical procedures whereby the test scores can be adjusted to be normally distributed and presented so that an individual score can be seen in relation to the population at large, rather than on some apparently arbitrary scale where its meaning is obscure. For example I.Q. test raw scores are adjusted so that the population mean is 100. This means that it is easy to see whether an individual score is above or below average.
Norms: As the test is used by more and more groups, it is possible to publish norms, indicating the mean scores for specific groups within the population. This enables a person wishing to select a test for a particular group to choose one for which norms have been developed for a similar occupational group. At this point, the tester will have a good idea of the scores to expect from applicants who will be successful at the job. Fuller details of producing psychometric tests are provided in the texts cited (e.g. Cronbach, 1984; and Anastasi, 1982).

2.6.6 Test Batteries

A common form of selection method is the test inventory. These may consist of several tests designed to measure various aspects of performance, e.g. mechanical ability, spatial ability, verbal reasoning etc. Such inventories may be used as convenient ways of considering different facets of behaviour, or they may be used to establish performance profiles, where the relationship between different scores is critical rather than the absolute value of those scores.

Test batteries are usually used to assess ability but they can also be used to good effect to assess personality traits. Personality inventories attempt to measure various personality dimensions, providing the option of matching observed personality profiles to desired characteristics of operators. For example, a stable, introverted person may be sought to carry out the duties of a process operator.

2.6.7 Choosing an Occupational Test

Fletcher (1989) provides a detailed understanding on all matters concerning psychological testing. The first formal intelligence testing was developed more than 80 years ago. Psychometric testing however has seen a period of explosive growth in the past 10 years. Fletcher describes a psychological test as "a procedure for the evaluation of psychological functioning. The distinction is sometimes made between tests of maximum performance and tests of habitual performance: the former refers to tests of intellectual ability, and the latter to performance measures."

An effective psychological test possesses the following attributes;

Reliability: This requires the test to be consistent in the results it produces. Obviously this relies on the provision that the test is measuring a stable aspect of the person. If a test is found to be unreliable then it cannot be valid.
Validity:-

This is the most rudimentary attribute of a good test and is essentially the extent to which it purports to measure the specified attribute. However there are several types of validity; face validity, external or criterion validity, concurrent validity, all of which are explained in detail in section 2.5.5 of this report.

Objective Scoring:-

The test is scored, either by hand or machine, according to an answer key. The feelings and the judgement of the person doing the scoring do not affect the outcome.

Standardised Administration:-

Every candidate must be given the same instructions and presentation.

Appropriate Norms:-

The score that an individual acquires on a test is only valid when looked at, against the spread of scores obtained by a relevant comparison group.

There are several arguments that could prevent one from using such measures, such as technical complexity and the possibility of using alternative selection methods. However, evidence indicates that psychometric tests are superior methods in predicting work performance especially, when judged against assessment techniques of comparable cost, availability and flexibility.

Tests are most often used in shortlisting, as a part of the main selection procedure, which can save money and identify at an early stage those candidates who have little chance of success. Candidates may of course feel alienated at seemingly being rejected on test results alone, but this is a necessary risk.

Caution also has to be exercised when using an arbitrary cut-off point, below which candidates are rejected, as the organisation may be depriving itself of people who more than compensate for some limitations, and promise excellence in other areas. Assessment of senior managers before a final hiring decision is made upon the completion of a battery of tests may be important. It can also be used as a tool in individual career development, or else in team building.

More than 5,000 psychometric tests are available to the public today. However, as many of the marketed tests are of little proven value, it is important that specialist advice be sought before embarking on any particular use of a test, in order to be certain that it fits the organisation's needs. The first thing a company should look for is the test's worth, which basically relies on reliability and validity.

The manual that accompanies the test should present data on both of these. Reliability will normally be expressed as a figure ranging from 0 to +1, with 0 indicating no reliability at all, and +1, perfection.
An ability test that has a reliability coefficient of 0.75 or above is generally acceptable. Personality measures however are more subject to variation, and a reliability of 0.65 might be acceptable. The test manual should apply appropriate normative information to facilitate the interpretation of the test scores. The test must be acceptable to the candidates that sit the test. This should take the form of:

- appearing professional;
- candidates should be able to see the relevance of the test;
- being clear and not upsetting to the candidate.

It is possible to do a great deal of psychometric testing without employing consultants, apart from the initial phase of becoming trained in testing to the standards required by the test producers. To obtain the kind of expertise that is needed, it is recommended that organisations employ charted occupational psychologists who also have a current practising certificate. Independent advice would be best sought from consultants who are not aligned to any major test producer, in order to prevent bias. Consultants can offer assistance to organisations that wish to produce a company wide assessment strategy, or in running validation studies to check that the selection tests are doing their job properly.

A wide range of tests under different categories, together with important information associated with their technical suitability is available through various commercial agencies. Anastasi (1982), includes a suggested outline for test evaluation. This includes appraising test information under 6 headings:

- General information: such as test title, authors, timings, costs.
- Brief Description of Purpose and Nature of Test: test type, target population, type of content, sub-tests involved, item scores.
- Practical Evaluation: design of booklets, ease of use, quality of content, attractiveness, durability.
- Technical information: norms, reliability, validity.
- Reviewers’ comments.
- Summary Information: strengths and weaknesses.

It is vital that anyone concerned with making such selections is conversant with the features that need to be considered, and they should therefore make use of books such as these, or else attend a course on the relevant subject matter.

2.6.8 Licensing

There is often a limit imposed by the test manufacturer regarding who is qualified to administer the test. For some tests, requirements relate to qualifications in psychology, for example, graduate status or membership of a professional organisation. For other tests, it is necessary to obtain a licence from the manufacturer. Obtaining a licence may entail attending a short course. The need for qualifications to administer tests is based mainly on a perceived need to ensure that proper procedures are respected, for if they are not, then the reliability of the test will almost certainly be jeopardised. However, some of the motivation for licensing is to preserve commercial interests which is quite fair since such tests are very expensive to develop. In such cases, it is illegal to administer tests without a licence.
SECTION 3: CONSTRAINING FACTORS IN PROCESS CONTROL COMPANIES

3.1 Introduction

Section 2 sets out the range of issues that constitute a foundation for selection methods. The ideas presented are well established and generally accepted. Despite this acceptance within occupational psychology, the ideas may be thought of as statistical rather than psychological, depending, as they do, on models of decision theory, rather than theories of psychology. By this is meant that techniques are justified as valid selection methods according to the extent to which they are shown to facilitate appropriate selection decisions, rather than depending on a rigorous psychological analysis. Most simply stated, a selection method is said to be valid if it correlates highly with a criterion concerning performance of the task for which the selection is being made. This is logically sound. However, making such measurements depends upon adequate data being collected about criterion performance, as well as predictor measurement, so that proper statistical measures can then be computed.

Despite the general commitment to selection methods in principle that are made by the people involved in selection, many industrial contexts do not permit the collection of data in a manner that would be required for proper validity measurement. Indeed, the process control environment is a particularly extreme case of this, such that the straightforward application of selection methodologies can be assumed impossible. This section will describe the features of process control contexts which contribute to these problems.

3.2 Recruitment Patterns

3.2.1 Capital intensive/low labour environments

Investment in the process industries is mainly in equipment utilising, where possible, automated control. This is often for reasons of safety and/or productivity, and means that there are relatively few process operators employed thereby, contributing to the problems of collecting data for a selection validation exercise.

3.2.2 Well Paid Responsible Jobs

A consequence of the capital equipment nature of the process industries, allied to the potential for profit, and the consequences of mistakes is, that the relatively few people who are employed in these industries are well paid. Since these jobs are often in industrial areas where other employment prospects have been under-developed, there is considerable competition for jobs.
Companies advertising jobs attract large numbers of applicants to recruit a handful of operators. This means that they must adopt some selection criteria in order to reduce the recruitment pool. This process severely jeopardises the acceptability of any subsequent validation exercise, since there is no way the suitability of applicants already rejected can be assessed for proper validation measurement.

3.3 Idiosyncratic Features of Process Plants

3.3.1 Plant and Process Design

A feature of many of the process industries is that individual plants have novel designs. Different companies operate in a limited area of the market, often exploiting unique plant features to give themselves a commercial edge. Furthermore, process control technology changes so rapidly that similar plants can be controlled differently, creating different task demands on operators, from time to time.

A major aspect of task demand in this sense is the balance between activities. Some plants require manual activity to a far higher degree than other plants, where decision-making may be more important. Plant reliability, which may be a consequence of the nature of process and product and control philosophy, will vary, thereby influencing operating demands. The power generation industry is probably one of the few areas where consistency of plant design can be expected. Even here, different generations and technology of plant and equipment can affect the reliability of a plant quite considerably. The extent to which plants differ, affects the justification for generalising validity data from one system to another, or pooling the data from various systems in order to increase sample sizes in order to facilitate validity measurement.

3.3.2 Varying man-machine interface philosophies

Plants vary in accordance with their man-machine interface philosophies. The cognitive demands of operating with older forms of display may be different from those of operating with newer computer based display systems. Different plants operate with different shutdown philosophies, in some cases requiring operatives to anticipate problems and avert shutdown by diagnosis and rectification, while other plants rely on automatic shutdown procedures. These choices may well be rational ones in the different circumstances, reflecting the respective hazards of different processes, or they may simply reflect different degrees of caution by respective managements. Whatever the motive, the consequence is different cognitive demands on the operators, which call into question the justification of pooling data from different plants.
3.3.3 Variations in Manning Plant

In addition to the technical bases for variation between plants, different management philosophies assign different sets of responsibilities to operatives.

Allocation of responsibilities: Different companies have different expectations of operators. Sometimes, operators may be restricted to manual activities, calling on senior colleagues, possibly graduates, to carry out diagnostic tasks. In other situations, operators themselves are expected to deal with problems as best they can. There may be no differences regarding educational qualification of the two groups, merely a managerial preference. Again, this suggests that the different situations need to be treated differently.

Work and team organisation: Different companies organise their operating staff very differently. Some companies prefer a hierarchical organisation where there is strict demarcation of responsibility between different plant areas, and problems are handed up the line. Other companies prefer operators to adopt a wider set of responsibilities.

Our purpose here is not to comment on the adequacy of these variations in employment patterns, but to point out that because they exist, the opportunity to legitimately pool data from various sources may be reduced.

3.3.4 Variations in Personnel Systems

A further set of variations concern personnel practices.

Varying aiding/training provision: Companies vary enormously in the ways in which they support and train operators. These issues are not independent of the task demands placed on the operators. Thus, a well trained operator in a well supported and well designed environment may achieve far more than another operator in another company who demonstrated similar qualification and aptitude at the time of appointment. It may be wrong to consider selection independently of other factors to support performance. More pertinent to this argument may be the fact that selection methods which are predictive in one context may not be predictive in another, where training and support are more effectively designed.

Appraisal systems: Companies vary in the extent to which they appraise staff. Hence, they will not be consistent in the extent to which they will judge operators to be poor or effective. Many companies do not really undertake anything that could be described as constituting a formal appraisal of operators. Again, it is difficult to see how data from different sources may be meaningfully pooled.
3.4 Problems with Criterion Measurement

One obvious reason for poor or inconsistent appraisal, as discussed in Section 3.3.4, is that there are no obvious satisfactory methods for appraisal. This means there is no satisfactory criterion measurement, without which there is no basis for formal validity measures.

3.4.1 Infrequency and Irregularity of Events

Many situations with which operators must cope are rare, or at least occur irregularly. There is no way to infer a measure of competence from actual performance at the job, simply because a representative set of events with which the operator must demonstrate competence cannot be guaranteed to occur.

3.4.2 A Problem with Simulation

Artificially representing situations using simulation offers a partial solution to this problem, but there are several reservations in accepting such performance measures as being representative. A major problem is that people cannot be guaranteed to perform the same way in a simulation as under the real stresses of a real situation. This could, of course, meant further investigation.

3.4.3 The Problem of Inferring Competence from Performance

A further difficulty is that there are few totally reliable measures of cognitive performance that can be applied. We may judge whether operators make the right choices in given circumstances, but we cannot be certain that they have tackled the task in a way they would enable us to be confident that they could deal with similar but different circumstances - they may have been lucky and encountered a familiar situation, or even guessed. Without more valid criterion measures, we cannot therefore validate, such selection methods.

3.5 Conclusions

This review of the characteristics of the organisation of work in the process industries, judged against the ideas concerning selection methodologies set out in Section 2, suggests that putting selection methods into practice in the process industries is far from straightforward.

There are three major problems. First, the numbers of people typically rejected for any job substantially exceeds the numbers of people accepted, such that the feasibility of applying validation methods is called into question.
Secondly, even though people in different companies may be called process operators, the variations in technology and work organisation raise questions concerning whether they can be treated in the same way. Thus, the extent to which findings from one context apply to another must be questioned, as must the legitimacy of pooling information to increase sample sizes to improve validity measures.

Thirdly, the nature of the work creates major difficulties in validly measuring job performance. The absence of any such methods means that selection methods cannot be formally validated.
SECTION 4: DEVELOPMENTS IN METHODOLOGY

4.1 Introduction

This section will consider main themes in the literature concerned with personnel selection which would appear to have relevance to the problems of selecting process operators. In particular, it is important to determine which techniques exist that would aim to overcome the difficulties outlined in Section 3.

The amount of research literature devoted to the area of personnel selection is vast, much of it examining details of methodology, including a wide range of statistical issues. It has to be said that much of this literature has little relevance to the practical question of selecting process control operators. It is conceivable that if some of the central problems in selection for process control operators could be solved, then some of these issues could profitably be revisited. The present review has therefore been rather selective. For comprehensive reviews of developments in the selection field, the reader is referred to the series of review articles appearing in the "Annual Review of Psychology". Since 1979, these have included papers by Carroll and Maxwell (1979), Dunnette (1979), Guion and Gibson (1988), Hakel (1986) Tenopyr and Oeltjen. (1982) and Zedeck and Cascio (1984). Added to this is the review by Osburn (1987). All of these were consulted for the present review. The major journals reporting work in selection have been examined from 1970 to the present. These are listed in Appendix 2.

The main themes that emerged that may be of possible relevance to process control, which will be examined in turn, are:

- Validity and validation
- Job analysis
- Job performance measurement
- Validity Generalisation
- Interviewing
- Cognitive tests
- Computerised Testing
- Trainability Testing
4.2 Validity and Validation

Apart from several statistical issues concerning validity, there has been a general move away from the notion that validity should be seen as a collection of separate measures. Dunnette (1979) argues that there is a serious danger of over simplification where test users place too much emphasis on deciding what type of validity should be considered in which context (e.g. content validity, predictive validity etc) instead of specifying what inferences they wish to draw from test results. Campbell (1976) spends considerable effort in describing the many types of evidence that may be brought to bear in working out the meanings that may be attached to scores. Similarly, Guion (1976) emphasises that the central concern with selection is hypothesis testing; it is suggested, for example that formal compliance with over simplified decision criteria is misplaced.

These views are emphasized here because, while there still remain major problems with formally measuring predictive validity in the process control environment (which remains the acid test of the adequacy of selection procedures), experts clearly recognise the practicalities of needing to make decisions. Presumably this implies that considering all sources of validity will substantially improve the selection decisions made. Those responsible for selection in the process industries should make every effort, therefore, to consider every conceivable form of validity in order to optimise the selection predictions made. A problem might be that making such judgements and balancing the available evidence is a job for experts who have extensive experience of such decision making activities. Do people in the process industries who are responsible for process operator selection have sufficient experience to deal with these issues effectively?

A related issue, discussed later in Section 4.5 is validity generalisation. This is an issue concerned with collecting validity data from a range of sources in order to overcome many of the practical difficulties associated with validity measurement.

4.3 Job analysis

Most of the work on job analysis methods associated with the selection literature has been concerned with the development and application of inventories/questionnaires designed to reveal the characteristics of the job and the traits that holders of specific job types would be expected to have. Prominent is the work by McCormick and co-workers on the Position Analysis Questionnaire (PAQ) (e.g. McCormick, De Nisi and Shaw, 1977). There is an Anglicised version by Sparrow et al (1982) and a number of similar instruments. Such approaches require the analyst to collect information on a wide range of topics, resulting in profiles of personal attributes for which selection methods can be proposed.

Sparrow et al’s paper provides a useful outline of the procedures involved in the exercise of generating profiles for a particular job type; in their case they consider that of a "setter".
In principle, such tools would be very useful for people responsible for selection in a process control context. However, the idiosyncrasies of process control jobs, as described in Section 3 severely limits the extent to which information on process operators can be generalised. Furthermore, these generalised checklist approaches are unlikely to be sensitive to the particular characteristics of plants, such as hazards or plant reliability. Alternatively, functional approaches to task analysis which may match the characteristics of the plant and process more precisely, such as hierarchical task analysis (Duncan, 1974) do not attempt to provide definitive statements about selection criteria and require expert judgements (guesses) to be made about suitable selection criteria. Both approaches have their strengths and weaknesses. There would be benefit in combining these approaches, so that the specific needs of a particular plant could be modelled as a prerequisite to identifying the traits sought for the task. The approach outlined in Section 12 goes some way towards this.

Dunnette (1979) lists several problems remaining to be dealt with regarding job analysis methods for selection:-

a) How should the analyst carry out proper sampling of the total job domain?

b) What methods exist for estimating accurately the relative importance, complexity, difficulty, etc of job elements?

c) How should job element estimates of complexity be meaningfully linked with personal attribute estimates?

d) What are the appropriate statistical criteria for determining job dimensions and relative similarities/differences between jobs?

e) What are the appropriate roles of experts in describing jobs, in judging performance qualifications for those jobs, and in determining the relative degree of congruence between job dimensions and attribute measures?

f) Should one utilize task-oriented or worker-oriented checklists?

g) How can one assure fairness for all persons in the application of job checklist methodology?

This clear listing highlights many of the problems associated with selecting process operators. Regardless of the problems associated with job analysis, it should be noted that during the 1980's all American nuclear utilities were required to develop both job and task analysis for 12 process control job categories, including process control operators. In addition, considerable information about job and task analysis methodologies and specific job and task analyses for process control operators are available through the US NRC (Nuclear Regulatory Commission) and INPO (Institute of Nuclear Power Operations). This information was developed for training purposes, and it is not known whether this same information is being used for process control
personnel selection. It is obvious that such information would be useful for determining selection criteria.

4.4 Criterion measurement

A major theme is, quite naturally, concerned with job performance measures. These need to be reliable, in that different analysts would make the same judgements as each other from the same evidence and the same judgements as themselves on different occasions. Job performance measures also need to be valid, in that these judgements should correspond to the facets of performance that are valued by management in making systems safe and productive. If job performance measures are not reliable and valid, then any validation of predictors that makes use of them will be suspect. There is a general consensus in the literature that measuring job performance is difficult. Certainly in the process industries, this is a major problem in formally validating selection methods. There has been precious little research tackling the problems of job performance measurement to make any inroads into the problems of measuring process control tasks. However, every nuclear utility in the United States has developed job performance measures for each of 12 process control job areas, including senior reactor operators and reactor operators. Generic job performance measures information is also available through the US NRC and INPO. It should be noted that the development of job performance measures in the US was carried out by training departments for the development of training programs. It is not known whether this information is also used for selection purposes. Job performance measures information is comprehensive and is worthy of review from anyone interested in job performance measures for process control operators or those with an interest in job performance measures methodology.

Dunnette and Borman (1979) describe a number of research studies on aspects of rater training, that is how to improve the performance of people concerned with making job-ratings. One general approach is the development of specific rating instruments more formally to structure the rating process, for example, behaviourally anchored rating scales (e.g. Smith and Kendall, 1963). The benefit of such scales is not generally proven. Another general approach is the training of raters, for example Latham et al (1975) designed a workshop to show raters common errors in rating.

They claimed reduction of rating errors and that these benefits were maintained for several months. However, again, results from such studies are not very persuasive. Guion and Gibson (1988), have questioned the value of spending time on trying to improve rating performance.

4.5 Validity generalisation

The issue of validity generalisation has emerged as a major theme in the selection research literature over the past ten years or so, deriving from the work of Schmidt and associates (e.g. Schmidt et al., 1979). The basic argument underlying validity
generalisation is that validity scores for particular jobs are low due to a number of situational features which introduce error into measurement. If these features can be controlled, or compensated for, then validation scores would be "truer" and certainly larger.

Those features that reduce validity estimates and which, need to be corrected for to establish "true" validities include: small samples in validation exercises; poor reliabilities of criterion measures; a restriction of the range of people tested on both predictor and criterion measures.

The validity generalisation argument is that investigators should not rely on single studies to establish the validity of a particular selection method, but rather take evidence from other studies in similar contexts to correct for various features. This entails a computational effort to revise the estimate made from the data collected in a specific company using data collected elsewhere. The idea seems attractive in principle, though not all experts agree with the power of the notion. In their review, Guion and Gibson (1988) cite supporting evidence for the benefits of validity generalisation, but also several papers that are critical of the approach.

Published criticisms notwithstanding, there are a number of problems in translating these ideas easily into the process industries. First, range restrictions in these industries are immense in view of the need to select so few people from a substantial pool of applicants. Secondly, the variations of types of process plant and the different ways they are organised make generalisation very difficult to envisage. To exploit the idea of validity generalisation, one needs to develop methods by which the similarity between jobs can be argued. Thirdly, before we can generalise them, we have to have validities to generalise (see Section 14.1). Before we can have validities to generalise, we need job criterion measurement to be undertaken - it rarely, if ever, is undertaken. There is certainly no evidence of valid and reliable criterion measurement being undertaken - and poor reliabilities of criterion measures are cited as one of the reasons why such validities are poor. Whether validity generalisation methods may be applied in these extremes is a technical question that warrants far more detailed examination than has been possible within the present review.

4.6 Interviewing

Interviews enjoy a patchy position in the literature. There is a general consensus that interviews are not a very valid selection tool, yet because managers still retain implicit faith in interviews, researchers continue to explore aspects of interviewing behaviour. Osburn (1987) describes a number of studies which reflect the inadequacy of the interview as a selection method. Generally interviews are shown to have both low validity and low reliability.

Dunnette (1972) for example, reports low validities of interviews, 0.3 for clerical jobs and 0.4 for testing and quality control jobs. Hunter and Hunter (1984) reported a
validity of 0.4 for predicting supervisory success from interviews. Guion and Gibson (1988) are generally very sceptical about the value of interviews, quoting Hanson and Balesteri-Spero (1985),

"... all too often, the person more polished in job-seeking techniques, particularly those used in the interview process, is the one hired, even though he or she may not be the best candidate for the position".

However, all is not lost and several studies report measures to tighten up interviewing procedures to improve poor validity and reliability measures. What can be concluded, though, is that selection interviews which are not conducted with care and stringency are almost certainly useless as job predictors. Schmitt (1976), reviewing interviewing, makes the following suggestions for good interviewing practice:-

a) decide what the purpose of the interview is to be
b) know the job requirements of the job to be filled
c) recognise the public relations implications of the interview
d) allow the applicant time to talk
e) be aware of the need to avoid bias in interviewing persons of different race, sex, beliefs.

This work clearly has relevance for process control where the selection interview is still generally favoured. The weaknesses of job-interviews should be accepted and this should reinforce the requirement for companies to follow good practice in training and preparing interviewers for their task.

4.7 Tests of Cognitive Ability

It was stated above that there is a general consensus, following validity generalisation studies, that tests of cognitive ability are useful predictors of job performance. There are some developments concerning cognitive testing, critical of the traditional psychometric approach (see also Section 15). For example, Hakel (1986) concludes that

"cognitive ability tests are related to many job performance criteria"

but points out that we lack strong theoretical accounts of how these cognitive abilities affect performance. We still rely on the traditional psychometric approach of factor analysis and other psychometric tools, to infer the factors that are assumed to cause observed variations in performance.

An obvious problem with psychometric approaches is that we have to collect data
from lots of sources to derive anything meaningful. This results in losing sight of the specific nature of any plant’s requirements. An alternative approach to traditional psychometric methods is described by Hunt (1983).

"Mental behaviour should be explained by identifying the processes involved in problem solving, rather than by producing abstract descriptions of the outcomes of thinking. In other words, intelligence should be defined in terms of individual differences in cognitive acts, rather than in terms of a person’s position determined by an abstract set of factors".

Thus, we would identify the cognitive demands to be placed on operators in accordance with operational demands. Hunt follows a central cognitive psychology line arguing that individual differences should reflect differences in how people represent problems, their strategies for solving problems and elementary cognitive operations. The approach is reviewed by Carroll (1979).

Hunt has reservations as to whether this approach will lead to better predictors of cognitive ability, whereas Hakel believes the area shows some promise. The general theme of examining cognitive processes as a basis for examining individual differences has been developed by several writers. Sternberg, a leading exponent of the approach, has edited a collection of readings by leaders in the field (Sternberg 1985). There is much promise but, as yet, nothing of practical benefit to help the practitioner in industry. A similar comment has to be made regarding Ronning et al’s (1987) collection of contributions on the same topic. Both collections bring together contributions by seminal figures in the field, so the approach is receiving some weighty attention.

Despite the lack of practical benefits to date, it is possible that this sort of approach will best meet the idiosyncrasies of process control. This would enable us to match a task requirement to the psychological characteristics that appear necessary for carrying out complex tasks. But how this might be done remains firmly in the future. In the meantime, Hakel and Hunt’s dismissal of psychometric methods has to be viewed with extreme caution. Despite their limitations, psychometric methods have been shown to be beneficial in many occupational contexts, while the cognitive approach they advocate has yet to get off the ground.

4.8 Computerised Testing

Hakel (1986) describes a number of instances of computerised testing. It seems that more effort has gone into computerising tests or presenting on the computer tests that were hitherto presented on paper. The computer is used for automatic scoring and a number of other statistical analytic purposes. However, there does not seem to be much use of computers to measure more interactive tasks. A notable exception is the work by Bartram and Dale (1982) in their MicroPat Program.
This measures a number of dynamic skills for selecting helicopter pilots. A further development of computerised testing will be the application of artificial intelligence, to adapt tasks to individual people being tested and to draw richer inferences from richer sets of recorded data. So far, no developments of this kind have been noted in the literature; when they emerge, it is likely to be from cognitive psychology rather than from the traditional psychometric researchers. It is conceivable that this approach to dynamic testing, allied with developments in the analysis of cognitive skills, will provide a useful basis for predicting process control skills.

4.9 Trainability Testing

Trainability testing arose in the 1970s as an alternative approach to selection testing, but it does not seem to enjoy much continued attention. In principle, it is an attractive notion that would have application in the process industries. Smith and Downs (1975) describe trainability assessments as

"... a practical interview which takes the form of an instruction period followed by a test on what has been demonstrated".

Thus it measures how well a person can master a small representation of the job for which he or she has applied. It is an attractive notion, since, in principle it involves developing a test specific to the needs of a particular job. The technique appears to have been successful in a number of applications but, due to a substantial amount of work in preparing for a test and the fact that the approach relies heavily on practical rather than obviously cognitive skills, the technique has not been adopted. Also the test has not been reviewed in the literature to any appreciable extent. It would be interesting to see effort devoted to developing such an approach for a process control task.

Clearly, there is a functional distinction between training and performance, so it cannot be assumed that trainability testing is geared to selecting the best operators. The trainability aspects of trainability testing is interesting in the process control field for two reasons. First, the costs of training in process control can be high - it is worth recruiting people who will minimise such costs, by reducing training times or reducing failure rates. Second, it is quite likely that the ability to master a cognitive skill, such as many process control tasks require, correlates highly with the ability to plan actions to deal with unfamiliar events.

4.10 Conclusions

While there continues to be a great amount of research into selection methods, little of it appears to deal with the problems posed by selecting process operators. Most of the standard issues and methods outlined in Section 2 are still being explored.
One research theme which would appear to deal with the problems of validation of selection methods in the process industry is that of validity generalisation. There remains controversy regarding its general worth, yet since it sets out to consider how weak validity measures might be strengthened, it must be taken seriously.

A related problem remains that of criterion measurement. There have been no developments in this area which help with the issues of job performance measurement in the process industries. This problem is fundamental, since, until we have established sound ways of measuring job performance in the process industries, no progress can be made in formal exercises in measuring validity.

One fears that the approaches to criterion measurement traditionally adopted in the selection field are far too narrow and that researchers have ignored some of the human factors approaches that might emerge from application of other task analysis methods and work-load assessment.

The research on interviewing is, on the one hand quite pessimistic, but on the other hand it seems to point the direction in which much practical selection advice should be applied. The main message of practical worth that comes out of the interviewing research is that we should exercise care in the procedures followed in order to optimise reliability and validity. This general point seems to be at the heart of the validity generalisation argument too.

It is also at the heart of the need to follow test procedures carefully. Essentially, we may conclude that, as in science, care in observation improves the reliability of measure. This, in turn, contributes to improving validity in view of the essential link between reliability and validity.

So, we can argue that people in the process industries would benefit from exercising care at all stages in their selection processes. Indeed, this sort of care is that which distinguishes those companies who appear most expert in their selection procedures, discussed in section 7.

In view of the problems associated with measuring job performance, and the allied problems of validating selection methods, we cannot rely on the psychometric methods, discussed in section 2, to produce valid selection methods for process operators. Maybe the cognitive science approaches to selection will offer new methods where it is possible to link cognitive models of operator behaviour to proven tests of cognitive ability. As yet, however, this approach has not yielded any practical outcomes. Computerised testing, however, might provide the opportunity to carry out more dynamic and more valid tests of this kind, possibly incorporating some of the practical notions of trainability tests.
SECTION 5: METHODOLOGICAL ISSUES - CONCLUSIONS

To conclude Part II, we bring together major conclusions from Sections 2, 3 and 4.

Section 2 outlined an extensive literature from occupational psychology concerned with selection methods. A particular feature was that selection methods must be both reliable, i.e. provide consistent measurement, and valid, i.e. accurately measure the feature which is designed to be measured. A number of ideal methods have been developed over the years, suggesting that a mature technology is now waiting to be exploited.

However, addressing the question of whether the technical and organisational aspects of the process industries permitted the ideas to be adopted with confidence, Section 3 cast serious doubts over whether the technology of personnel selection can be applied with confidence to process control. This conclusion followed discussion of the personnel requirements of process plants, the factors which prompt substantial task variations between plants and the technical difficulties of formally measuring job performance.

Section 4 considered recent research into selection methods to determine whether the problems raised in Section 3 could be overcome. With regard to the problems of formally measuring job performance, little progress has been made. This progress has been concerned, not with the establishment of formal objective methods, but with the training of people who set out to rate operator performance. Whether progress can be made in the process industries in this respect is not obvious.

With regard to the problems of formally validating selection methods (the problems of measuring job performance notwithstanding), there has been considerable activity in the area of validity generalisation. This purports to improve validation measures by removing the variation in scores due to local features and pooling data from several contexts. In principle this would be an asset for the process industries, since validity generalisation techniques are supposed to overcome many of the weaknesses that arise from inadequate sample sizes, but these approaches are not without their critics. Furthermore, it is far from clear whether the sources of variation of contexts in the process industries enable data to be compared legitimately. There are supporters and detractors of these methods. Further examination of this issue, addressing the particular circumstances of the process industries' may be justified, provided attention is also paid to the criterion measurement issue.

Two further pragmatic conclusions may be drawn. First, the validity generalisation research, whilst accepting the comments above, points to the importance of general measures of cognitive ability as good general performance predictors. Bearing in mind the cognitive nature of many process control tasks, this finding is worth accepting. The second pragmatic suggestion is that care in the development and administration of selection methods may enhance their reliability.
Even though we may be unable to measure formally the validity of selection methods, it can be argued that care should always be adopted, in any case, as it will enhance the consistency of application of selection measures and lead to a sounder basis for making subjective judgments.

A final comment is worth making regarding the interest in new approaches to cognitive testing. There is an interest in assessing the cognitive demands of tasks to predict the qualities that should be sought. These approaches aim to be more analytical than the psychometric approaches adopted so far, and may avoid the methodological problems inherent in traditional approaches to psychological testing. However, to date, this approach does not seem to have yielded any practical benefits.

The general conclusion to be drawn from Part II, therefore, is that the characteristics of process control situations, that is the nature of the work and the patterns of recruitment by companies, mean that the straightforward application of personnel selection methodologies are unlikely to yield results in which much confidence can be placed. Substantial research effort continues to be made to overcome many of the problems of selection methodologies, but few of these seem likely to solve the basic problems of process operator selection in industry.

In view of these conclusions, Part III will now consider what steps are taken in practice to deal with problems of process operator selection.
PART III : EXISTING PRACTICES IN SELECTION

Outline

Following the discussion of methodological issues in Part II, which argued the difficulties of meeting the formal requirements of selection methods in the selection of process operators, the review in this Part of the report turns to examining actual experience with the selection of process operators.

Section 6 discusses published accounts of projects concerned with process operator selection. It is immediately obvious that relevant research into the topic of process operator selection is very sparse indeed. Most available material is simply concerned with policy and practice, offering no empirical evidence to support the design of selection methods. Even if such research were impeccable, we would be forced to ask whether data gathered from studies in the United States are applicable to operatives of different sorts of plants in the United Kingdom.

A different sort of information is available from observing actual practice in companies regarding their selection procedures. To this end, three small studies were undertaken. The first, discussed in Section 7, is concerned with how managers concerned with the recruitment and selection of process operators carry out their duties. The second small survey was to consider the approaches adopted by consultants. This is described in Section 8. A third study set out to consider other contexts, including military situations and foreign nuclear utilities. From these studies a consensus approach emerges, which relies more on care and planning selection, rather than on the infallibility of psychological methods. This is discussed in Section 9.
SECTION 6: EVIDENCE OF EFFECTIVE PROCESS OPERATOR SELECTION PRACTICES FROM PUBLISHED LITERATURE

The main aim of Part III of this report is to try identify what has been done in practice to deal with the issue of process operator selection, and what might be recommended to enhance practice in companies. One theme is to consider whether there have been any published accounts of good practice, where proven ideas may then be disseminated more widely. Examining published literature should provide the best index of what is technically feasible in overcoming the problems inherent in selection for process control skills. Of prime concern, is literature which indicates how selection criteria can be related to job performance and, hence, the extent to which different selection methods have been shown to be valid. To this end a search was made of a number of professional journals, as listed in Appendix 2. In addition, other available reports, especially those dealing with work in the nuclear industries, were considered. Very few studies of interest were found, and even these failed to provide wholly satisfactory information.

6.1 Availability of Literature on Process Operator Selection Techniques

The apparent dearth of information is not just a finding from this review. Dunnette et al (1982) reviewed the literature in industrial and organisational psychology with a view to locating studies of process plant operators. The bulk of the material they found was concerned with general information about job activities, responsibilities, knowledge etc and not specifically with the issue of selection methods and their validity. Dunnette et al were concerned with establishing a selection method for power plant operators and so this general information was of relevance to their study. Indeed, there is substantial literature concerning human factors of process control which could, in principle, be relevant to any effort to devise new selection methods. However, this is not relevant to the present context where our concern is to establish what practices exist, rather than to devise our own. Similarly, Smith (1989), in considering selection in high-risk and stressful occupations, makes no mention of the process operator.

Of the few studies identified, that by Dunnette et al deserves greatest attention. Other studies will be dealt with more briefly. Dunnette et al’s study deserves attention for a number of reasons:

- it is by far the most ambitious and well researched study available for examination;
- it is specifically concerned with power plant operators i.e. process operators;
• it is a wide-ranging study, conducted in over 70 companies, dealing with a number of different job types, well over 1000 job titles and a sample size of over 3000 operators;

• it demonstrates the application of a full range of techniques in selection method development;

• it supports some useful general conclusions about selecting process plant operators;

• it makes dramatic claims for the financial benefits of selection, in particular claiming an annual gain of $800,000,000 for the companies participating should they adopt the procedures recommended.

Despite these promising characteristics, the study is notable in that its methods may be broadly criticised as it fails to overcome many of the potential problems described in Section 3. Unfortunately, therefore, its substantial claims must be treated with caution.


It is worth reflecting on the contractual arrangements behind this project, since work on this scale could never be undertaken on behalf of one organisation. It is important to recognise that Dunnette’s team were concerned to demonstrate that general selection methods and criteria would emerge from the study. The project was funded by the Edison Electric Institute, an industry association in the USA representing approximately 220 utilities, with 70 of these companies participating in the actual study. The study had three goals:

1. to identify the exact job activities performed by operators in different kinds of power plants and in different types of jobs;

2. to discover which abilities and other personnel characteristics are required for doing these job activities successfully; and

3. to develop valid measures of these abilities and personal characteristics for use in identifying applicants with high potential for success in power plant operator jobs.

The research project entailed four phases:

1. learning about the operator’s job and its requirements;

2. developing ways to measure both required characteristics and job performance;
3. trying out preliminary measures of the required abilities and personal characteristics on a sample of operators to learn how well the measures work;

4. combining the best measures of required abilities into a test battery for use in predicting performance in various types of operator performance.

Thus the aims are clear and the phases of the project represent a thorough approach to dealing with the issues. With this strategy, allied to the obvious resources the project commanded, and the technical competence of the researchers, we may assume that the best possible practices will be followed. We can follow the project by considering each of the 4 phases in turn.

6.2.1 Learning about the operator’s job and its requirements

To do this the investigators examined literature to identify job analysis studies undertaken by occupational psychologists in order to understand the structure of process control jobs, and cognitive psychology literature to establish different forms of information processing. They then linked these two types of information to establish an information processing model of electric power plant operator requisite knowledge, skills, abilities, and other characteristics. That is, the investigators had established how different cognitive skills etc related to standard types of job element. This is shown in figure 6.1.

The next stage was to develop analyses of specific operator jobs to be studied such that similarities and differences between the operating jobs in the study could be characterised. Two approaches were adopted. These were the Position Analysis Questionnaire (PAQ), developed by McCormick et al (1969) and the Plant Operator Task List (POTL).
### SECTION III: JOB PERFORMANCE CATEGORIES (Continued)

#### A. SYSTEM COMPREHENSION

Knowledgeable about plant equipment, plant processes, and plant operating procedures. Possesses complete knowledge of relationships between all types of plant equipment and their functions in generating electrical energy. Knowledgeable about operating characteristics of overall system and how all parts of the system fit together.

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<tbody>
<tr>
<td><strong>BELOW STANDARD</strong></td>
<td><strong>FULLY ADEQUATE</strong></td>
<td><strong>SUPERIOR</strong></td>
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<tr>
<td>- Takes wrong actions because of inadequate knowledge.</td>
<td>- Takes actions quickly without needing to search procedures manuals.</td>
<td>- Takes actions unique to special circumstances.</td>
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<td>- Delays actions that are covered by standard procedures.</td>
<td>- Takes actions without needing to rely on others to know what to do.</td>
<td>- Takes actions requiring knowledge not covered by standard operating procedures.</td>
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</table>

**Examples Illustrating BELOW STANDARD**
- Operator returned to unit three by throwing emergency manual switch. Smith knew that situation had been the same for the last three days.
- Operator put the load running in load manual to load manual switch. Smith knew that the load was down at 4:00 AM.
- Operator put a new load running in manual switch. Smith knew that the load was down at 4:00 AM.

**Examples Illustrating FULLY ADEQUATE**
- Operator returned to unit three by throwing emergency manual switch. Smith knew that situation had been the same for the last three days.
- Operator put the load running in load manual to load manual switch. Smith knew that the load was down at 4:00 AM.
- Operator put a new load running in manual switch. Smith knew that the load was down at 4:00 AM.

**Examples Illustrating SUPERIOR**
- Operator returned to unit three by throwing emergency manual switch. Smith knew that situation had been the same for the last three days.
- Operator put the load running in load manual to load manual switch. Smith knew that the load was down at 4:00 AM.
- Operator put a new load running in manual switch. Smith knew that the load was down at 4:00 AM.

#### B. RESPONSE TO CRITICAL, HIGH RISK, AND/OR EMERGENCY SITUATIONS

Operates equipment correctly during critical times and/or high risk situations. Diagnoses causes of emergency malfunctions under severe time pressure and high risk. Correctly assesses criticality of situation by considering effects on entire system. Takes appropriate action to maintain system or to return system to normal operating conditions.

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<tbody>
<tr>
<td><strong>BELOW STANDARD</strong></td>
<td><strong>FULLY ADEQUATE</strong></td>
<td><strong>SUPERIOR</strong></td>
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<tr>
<td>- Response is fluttered and confused.</td>
<td>- Knows and follows standard procedures in response to critical situations.</td>
<td>- Actions are immediate and show cool and insightful thinking.</td>
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</tr>
<tr>
<td>- Forgets or ignores important system parameters or procedures.</td>
<td>- Knows when cause cannot be learned quickly and takes necessary action to save equipment.</td>
<td>- Takes steps to learn cause of malfunction and assesse criticality of situation.</td>
<td></td>
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<tr>
<td>- Reacts before learning cause of malfunction.</td>
<td></td>
<td>- Takes quick action to correct situation or shut down system to prevent serious consequences.</td>
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<tr>
<td>- Depends on others to take over.</td>
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</table>

**Examples Illustrating BELOW STANDARD**
- Operator responded to unit two by throwing emergency manual switch. Operator knew that situation would get worse.
- Operator put a new load running in manual switch. Operator knew that the load was down at 4:00 AM.
- Operator put a new load running in manual switch. Operator knew that the load was down at 4:00 AM.

**Examples Illustrating FULLY ADEQUATE**
- Operator responded to unit two by throwing emergency manual switch. Operator knew that situation would get worse.
- Operator put a new load running in manual switch. Operator knew that the load was down at 4:00 AM.
- Operator put a new load running in manual switch. Operator knew that the load was down at 4:00 AM.

**Examples Illustrating SUPERIOR**
- Operator responded to unit two by throwing emergency manual switch. Operator knew that situation would get worse.
- Operator put a new load running in manual switch. Operator knew that the load was down at 4:00 AM.
- Operator put a new load running in manual switch. Operator knew that the load was down at 4:00 AM.
The results of these analyses were used to identify which selection instruments should be included in the study. Some of the personnel attributes identified were:

**Cognitive skills and abilities:**
- Numerical ability
- Verbal ability
- Memory
- Information processing and alertness
- Speed of perception
- Spatial visualisation
- Analytical reasoning
- Fluency of ideas
- Mechanical comprehension
- System comprehension
- Attentional selectivity

**Occupational interests:**
- Scientific/investigative
- Technical/practical/engineering

**Physical skills:**
- Manual dexterity
- Body coordination

**Proficiencies:**
- Twelfth grade reading ability
- Ability to read drawings/blueprints
- Ability to follow sequences
- Reading gauges

**Temperament/personality:**
- Emotional stability
- Ability to cope with stress
- Interpersonal/leadership/sociability
- Conscientiousness
- Acceptance of authority and structure
- Ability to sustain boredom

The investigators also held a series of 'Emotional stability workshops' to identify what they felt were the main dimensions of emotional stability pertinent to tasks in this environment. Six basic dimensions were derived from this part of the study:

1. Hostility towards authority (such as refusal to work).

2. Irresponsibility and impulsiveness (horseplay, failure to comply with regulations).
3. Defensive incompetence (extreme reluctance to carry out work due to lack of knowledge accompanied by covering up one's own incompetence).

4. Psychopathology (including incapacitating emotional reactions such as "freezing"....).

5. Compulsive incompetence (extreme/compulsive attention to detail, refusal to share information with others).

6. Substance abuse (excessive/inappropriate use of alcohol or other drugs).

Criticism of this stage of the project could be levelled at the appropriateness of the task and job analysis techniques used. This criticism may be somewhat churlish in that the list of potential cognitive and emotional aspects identified are unlikely to be bettered. However, we do know that other techniques of task analysis are likely to be more thorough than the combination of PAQ and POTL which was adopted. The PAQ and POTL techniques identify activities and duties in a broad sense without offering a detailed modelling of how various activities interact to achieve the overall operator performance. This has two practical implications. First, general terms such as "vigilance", "monitoring", "speed of perception" and reasoning can mean very different things in very different contexts but may be used equally by different respondents. Second, skills entailed in planning activities may not be represented adequately, where an analysis method relies upon listing constituent activities, as in the present case. Third, the nature of operator-plant interface, operator support and training may be quite different in different utilities and so the cognitive skills inherent in the various elements identified may be different. Fourth, the consequences of error in the various activities may vary from situation to situation and so the relative importance of the various elements is not the same.

However, while a more thorough type of analysis would be necessary in any other sort of human factors intervention, it can always be argued that in a selection exercise, task analysis serves merely to develop hypotheses for test methods to be considered during subsequent statistical analysis. Thus, at the end of the day the strength of the elements identified at this first stage will have been demonstrated formally. Arguably, though, the validity of the methods selected would be stronger if they had been identified through a more thorough method of task analysis, reflecting the idiosyncrasies of the particular plants operating policies and procedures, such as hierarchical task analysis (Duncan, 1974).

6.2.2 Developing ways to measure both required/characteristics and job performance

This stage entailed two major activities. First, the investigators had to identify methods which would measure the personal characteristics identified during the first stage. Second, they had to select a method for measuring job competence. Thus, the two components of subsequent criterion computation will have been selected.
6.2.2.1 Measures of personal characteristics

To identify potential tests, the investigators followed a common procedure, advocated by Cronbach (1984) and Anastasi (1982), who scanned literature on published tests to identify tests which would cover the elements identified from the job analyses. This entailed collecting the following information on each test:

a) Test title
b) Time for test administration
c) Definition of the construct measured
d) Test reliability
e) Validity information
f) A copy of the test
g) A copy of the test manual
h) Reviews from the current Buros Mental Measurement Yearbook

The published cognitive measures they selected are listed in Table 6.1. They then need to develop some tests of their own to cover facets which could not be covered by the published tests. These are listed in Table 6.2
<table>
<thead>
<tr>
<th></th>
<th>Published cognitive measures selected for consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Map Memory Test. Educational Testing Service, 1975. Construct: Measures ability to remember or recall details observed moments earlier-Visual Memory. Contains two sections with 12 items each. Time: In both sections subjects are given three minutes to examine a page of maps and then three minutes to respond to questions asked about the maps.</td>
</tr>
<tr>
<td>4</td>
<td>Building Memory Test. Educational Testing Service, 1975. Construct: Measures ability to remember the position of things observed on a street map-Visual Memory. Contains 12 memory items. Time: Subjects are given four minutes to examine street map, another four minutes to answer questions about the location of various objects without looking back at the map.</td>
</tr>
<tr>
<td>6</td>
<td>Employee Aptitude Survey, Test 1 - Verbal Comprehension Form A Revised, by G Grimsley, F.L. Ruch, N.D. Warren, &amp; J.A. Ford, Psychological Services, Inc., 1956. Construct: Measures the ability to understand words and ideas associated with them; to use words in thinking and communication-Verbal Ability. Contains 30 items. Time: 5 minutes.</td>
</tr>
</tbody>
</table>


12. Flanagan Industrial Tests - Assembly - Form AA, by John C. Flanagan, Science Research Associates, 1960. Construct: Measures the ability to see how an object would look when put together according to instructions, without having an actual model to work with; ability to visualize the appearance of an object from a number of separate parts-Spatial Visualization. Contains 20 items. Time: 10 minutes.


<table>
<thead>
<tr>
<th>Test</th>
<th>Construct</th>
</tr>
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<tbody>
<tr>
<td>EEI mechanical concepts test</td>
<td>Mechanical Comprehension</td>
</tr>
<tr>
<td>EEI systems understanding test</td>
<td>Understanding the overall system;</td>
</tr>
<tr>
<td></td>
<td>reasoning, Memory, ideational fluency</td>
</tr>
<tr>
<td>EEI follow directions test</td>
<td>Ability to follow instructions</td>
</tr>
<tr>
<td>EEI Mathematical Usage test</td>
<td>numerical reasoning &amp; Mathematical Formulation</td>
</tr>
<tr>
<td>EEI Numerical ability test</td>
<td>Numerical Ability</td>
</tr>
<tr>
<td>EEI Reading and comprehension test</td>
<td>Reading ability</td>
</tr>
<tr>
<td>EEI Tables &amp; Graphs test</td>
<td>Perceptual Speed and accuracy</td>
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</table>
For the non-cognitive measures, the investigators sought personality inventories to cover the constructs they had identified during the job-analysis phase of their investigation.

**Table 6.3**

<table>
<thead>
<tr>
<th>Responsibility (+)</th>
<th>Artistic Interest (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership Orientation (+)</td>
<td>Forbearance (-)</td>
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<tr>
<td>Conscientiousness (+)</td>
<td>Social Dependency (-)</td>
</tr>
<tr>
<td>Practical Interests (+)</td>
<td>Achievement Orientation (+)</td>
</tr>
<tr>
<td>Freedom from Anxiety (+)</td>
<td>Extreme Extroversion (-)</td>
</tr>
<tr>
<td>Scientific Interests (+)</td>
<td>Self Control (+)</td>
</tr>
<tr>
<td>Acceptance of Routine (+)</td>
<td>Absorptive Intensity (-)</td>
</tr>
<tr>
<td>Social Competence (+)</td>
<td>Playfulness (Horseplay) (-)</td>
</tr>
<tr>
<td>Willingness to Accept Authority (+)</td>
<td>Risk Orientation (-)</td>
</tr>
<tr>
<td>Confidence (+)</td>
<td>Adjustment to Shift Work (+)</td>
</tr>
<tr>
<td>Emotional Stability (+)</td>
<td>Psychopathy (-)</td>
</tr>
<tr>
<td>Social Closeness (-)</td>
<td>Freedom from Life Changes (+)</td>
</tr>
<tr>
<td>Impulsiveness (-)</td>
<td>Defensiveness (-)</td>
</tr>
</tbody>
</table>

The + or - signs in brackets signifies whether positive or negative values of these measures were of interest.

Armed with this mass of tests the investigators conducted a series of workshops with people who were coordinating the work in the companies to select what would go in the final battery. In all 19 tests were included in the final battery, as listed in Table 6.4 (page 59) to measure 26 constructs as listed in Table 6.3 (above).

It is worth recognising that the activity of selecting different sorts of selection methods as candidates for a test battery of this sort, is a subjective activity and in no sense an objective procedure. This is in no way critical as this is the only approach that can be adopted, but it is worth bearing in mind that people designing selection methods cannot rely on 'mechanical' methods to select candidate selection methods. They must utilise care and experience and trust that they have made a good selection. The problem is, that should they fail to make an appropriate selection at this stage, they may have chosen tests which are unlikely to correlate well with any job criterion measure adopted.

6.2.2.2 Measuring job competence

The investigators sought to establish measurement of job competence by asking the supervisors of operators in the study to complete, for each operator reporting to them, seven performance appraisal scales and also to rate the relative importance of each performance category in carrying out the overall job. The job importance scale was listed as a necessary component at the job analysis phase.

However, it was found that supervisor's responses on this scale were unreliable and so this data was discarded from inclusion in the later analysis. The seven performance
appraisal scales, however, proved reliable and were, therefore, adopted as job competence measures.

The seven scales considered for assessing each operator were:

A. System comprehension;
B. Response to critical, high risk, and/or emergency situations;
C. Maintaining standard operations;
D. Administrative record keeping;
E. Informing others;
F. Relationships with co-workers;
G. Coping with Job circumstances.

For each of these a detailed proforma was prepared to help the supervisor achieve a reliable rating. An illustration is given in Figure 6.1 (page 49). This example is for system comprehension. The supervisor had to rate the operator on a 9-point scale. The illustration shows how the supervisor was helped in this process. The data collected in this fashion served as data for the job criterion measures in the validity coefficients to be computed later.

These measures can be fairly criticised. There is no evidence that they are measures of performance. They are subjective judgements made by supervisors. The scales and their supporting information are well constructed and are likely to lead to reliable performance by raters, but are these scales valid? Measures such as performance ratings are adopted because reliable or direct measures are either difficult or impossible to obtain. In view of the irregular patterns of work demands in the process industries and the infrequent or rare opportunities to sample performance of all critical facets of a task (as discussed in Section 3), it would be impossible to utilize fair measures of any individual performance based on observation of actual skill. A possibility would appear to be to put people in simulated environments. This enables some control to be exercised over the different events with which the operator must cope, but it is not possible or realistic to simulate all of the crucial characteristics of the job, such as actual stress and genuine tedium. Indeed, elsewhere, Dunnette had considered and rejected the simulation option:

"An attempt by PDRI (Personnel Decisions Research Institute) to employ data recorded automatically in control room simulators as a criterion proved unsuccessful, apparently because the resulting metrics were not readily translatable into meaningful dimensions of operator performance". Dunnette in NUREG/CR-2833 (1982)

The steps taken by Dunnette et al (1982) to provide such a clear rating procedure, meant that ratings were reliable, but to show they were also valid would have meant demonstrating a strong correlation of these ratings with some job criterion score - but this is impossible to attain for the reasons which have prevented it from being used
to compute the validity coefficient. We are relying on impressions formed by supervisors. It is unlikely that supervisors have seen all of their operators performing in the whole range of situations. All supervisors can do in these circumstances is guess how a particular person would respond according to some stereotyped view held about the operator in question or operators in general. It is possible that an articulate operator may impress with the clarity with which incidents are discussed and so may be rated highly. If this were the case, it would not then be surprising that "verbal fluency" is identified as a predictor of operator competence. In conclusion, no categorical evidence is offered to show that Dunnette et al’s measures are valid job measures.

6.2.2.3. Trying out preliminary measures of the required abilities and personal characteristics on a sample of operators to learn how well the measure work

The study describes the sampling procedures adopted and the administration of the tests. These are clearly carefully done. From the data, the investigators examined how scores could be accounted for by a small number of factors. Twenty-one tests, as used in this study, would be impractical as a basis for routine personnel selection. A standard procedure in these circumstances is to carry out a factor analysis to identify a smaller number of factors capable of distinguishing between participating subjects, just as effectively as the full test battery. The results of the factor analysis are illustrated in Table 6.4 (page 59).
Table 6.4

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factor</th>
<th>Factor</th>
<th>Factor</th>
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<tbody>
<tr>
<td>FTI Test - Assembly</td>
<td>68</td>
<td></td>
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<tr>
<td>EAS Test 5 - Space Visualization</td>
<td>66</td>
<td></td>
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<tr>
<td>Mental Rotations Test</td>
<td>62</td>
<td></td>
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<tr>
<td>EAS Test 3 - Visual Pursuit</td>
<td>61</td>
<td></td>
<td></td>
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<tr>
<td>Group Embedded Figures Test</td>
<td>60</td>
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<tr>
<td>EEI Mechanical Concepts Test</td>
<td>58</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>EAS Test 1 - Verbal Comprehension</td>
<td>85</td>
<td></td>
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</tr>
<tr>
<td>IQ Estimate</td>
<td>77</td>
<td>40</td>
<td></td>
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<tr>
<td>Word Grouping Test</td>
<td>60</td>
<td></td>
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<tr>
<td>Reading Comprehension</td>
<td>44</td>
<td>59</td>
<td>41</td>
</tr>
<tr>
<td>Verbal Reasoning</td>
<td>54</td>
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<tr>
<td>English Reading Test</td>
<td>50</td>
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<td>45</td>
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<tr>
<td>Numerical Ability Test</td>
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<td>68</td>
<td></td>
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<tr>
<td>Mathematical Usage Test</td>
<td>40</td>
<td>61</td>
<td>38</td>
</tr>
<tr>
<td>Tables and Graphs Test</td>
<td>50</td>
<td></td>
<td>56</td>
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<tr>
<td>Numerical Reasoning</td>
<td>37</td>
<td>49</td>
<td>41</td>
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<tr>
<td>Follow Directions Test</td>
<td>48</td>
<td>35</td>
<td>49</td>
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<tr>
<td>Locations Test</td>
<td>43</td>
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<td>45</td>
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<tr>
<td>Systems Understanding Test</td>
<td>40</td>
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</tbody>
</table>

**Relative factor loadings for cognitive measures**

Table 6.4 (above) shows the way in which the different test scores are accounted for by four main factors. The numbers in the Table indicate the relative weightings of the identified factors. By inspecting these, the investigators are able to suggest general names for the factors in accordance with the loadings on the tests. For example, the first four tests are all accounted for in terms of one factor and these tests are all concerned with spatial operations.

I  spatial factor  
II verbal factor  
III numerical factor  
IV an inductive reasoning factor

The investigators noted that no factor concerned with 'perceptual speed' and accuracy' emerged, hence, this would not be a characteristic worth looking for during selection. This suggests that the control of a process plant is a cognitive task dependent upon reasoning rather than entailing any strong perceptual-motor elements.

It is also clear from the Table 6.3 that several tests seem to measure the same thing, for example, it does not really matter what specific test is used to measure the numerical or verbal factor, provided a reliable test of the particular kind is included in a test battery.
In the same general way the aspects of personality tested, led to the identification of six factors:

I  Confidence and overall effectiveness
II  Self control and stability
III  Active adolescence
IV  Responsibility and academic achievement
V  Friendliness and social closeness
VI  Order and structure

The main conclusion from this exercise was that the variations between process operators are accounted for by four cognitive factors and six personality factors. Thus a prediction measure based on these ten factors would be just as satisfactory in distinguishing between operators, for the purpose of selection, as the original substantial battery of tests employed and, clearly, much more convenient to administer. This general approach to isolating informative factors is a classic illustration of selection method construction.

6.2.2.4 Combining the best measures of required abilities into a test battery for use in predicting performance

The final stage of the study entailed establishing how these predictors successfully predicted job performance. Briefly, this entailed choosing an appropriate subset of predictor instruments (i.e. sufficient to obtain scores for each factor), then correlating this score for each operator with the job criterion score described above. The investigators also employed validity generalisation techniques to strengthen their validity measures.

As a final gesture, the investigators attempted to demonstrate the financial benefits of adopting the methods they advocated, using the decision theoretic approaches developed by Cronbach and Gleser (1965). They make substantial claims, but these depend upon the validity of the criterion measures adopted, and we have argued that these measures are not satisfactory.

The extent to which this practice was satisfactory prompts the major criticism of the study. It has already been argued that the job criterion scores adopted had not been satisfactorily validated against actual performance. It is difficult to suggest what else the investigators could have done. The fact remains that the measures they obtained may be questioned.

A second major problem is the standard difficulty of drawing inferences about a selection procedure from measures obtained exclusively from people who had already been judged as suitable for the organisation, many of whom had benefitted from training and the opportunity to become acquainted with the culture of the organisation. The selection methods suggested by the study are to be employed to select suitable operators from the larger population of applicants.
Yet no data has been gathered concerning how well people rejected by existing methods would have fared in these tests. It is possible that undesirable people would have done well on the criteria established through the study.

It is doubtful whether the investigators could have adopted a more rigorous procedure than the one they did. However, their procedure is subject to question. They have not provided a methodologically tight solution to the problem of selecting process operators.

A conclusion was that prospective operators should be measured on the factors identified, using tests where available, and other screening methods where formal tests are not available, then the people who score best on this composite should be selected. We cannot accept these conclusions without reservations in view of the criticisms made. However, they seem plausible on a content validity argument and they provide the best evidence we can obtain for appropriate tests for selecting process operators.

6.3 Other Studies

The remaining studies examined had very little of substance to add to that of Dunnette et al.

6.3.1 The Validity of Educational Qualifications (a study by Melber & Saari, 1985)

Melber & Saari (1985) looked at the validity of qualifications requirements for nuclear power plant operations shift crew positions by examining studies which attempted to assess the relationship between education and performance amongst NPP personnel (NUREG/CR-2534, 1982; NUREG/CR-3123, 1982; NUREG/CR-1750, 1981; Dunnette et al, 1982). Using a number of performance measures (e.g. speed/accuracy on a simulator; supervisor ratings) none of the studies found any significant relationship with education. This does not necessarily mean that education has no effect on performance. One of the problems of this criterion related validity testing was that the variability in educational backgrounds was small. Indeed, Dunnette et al's study, discussed above, isolated a factor which included academic achievement.

However, these same studies found some significant relationships between experience and performance. The general indication was that job experience in the general area of the job of interest is not positively related to job performance (in fact it may be negatively related to it), while experience in the specific job is. The results were consistent with those found for air traffic controllers.

Because of the problems of criterion related validity assessment, such as those inherent in Dunnette et al's study as discussed earlier, Melber & Saari (1985) looked at content validity. With content validity, a job analysis serves as a basis for comparing the content of a job with the content of a qualification. If the qualification is found to be representative of the job content then it is content valid.
One problem here is that any evaluation, being a subjective judgmental one, relies upon the expertise of the judges. Similar concerns were voiced in Section 6.2 above concerning Dunnette et al's (1982) study, although Dunnette et al went on to attempt to establish criterion related validity rather than relying on content validity. Another concern is the comprehensiveness of the job analysis.

The more comprehensive a description, the less likely it is that special qualifications requirements will be omitted. For example, the job analysis for reactor and senior reactor operators, describes 700 tasks and 40,000 knowledge elements. On the other hand, comprehensive analysis of this size is difficult to manage and costly to develop.

Melber and Saari reviewed 11 reports which made specific recommendations regarding minimum education and experience qualifications of the shift crew at NPPs. All the studies used experts from the nuclear or related industries. However, only three studies had the experts use a job analysis and only one also provided the experts with a detailed description of possible qualifications. All of the studies that evaluated the reactor operator position concluded that a high school education was sufficient.

6.3.2 Selection in the Petroleum Refining Industry (Dunnette, 1972)

Another major study by Dunnette (1972) undertook an investigation of selection studies relevant to the petroleum refining industry. The study indicated that job knowledge and job tryout measures, where used, have been relatively good predictors. For maintenance jobs and operating and processing jobs, mechanical ability tests have also been favourable. For operating and processing jobs general intelligence tests were also favourable.

In general, educational level and interview information were found to have very poor records for predicting job effectiveness, although the interview had a relatively higher validity for clerical jobs.

In examining the distributions of validity coefficients according to job categories and criteria of effectiveness it is evident that these coefficients are usually positive and higher for maintenance and clerical jobs than operating and processing jobs, as shown in Table 6.5 (page 63). Dunnette argues that this is because of the poor definition of operating and processing jobs therefore lumping together employees carrying out quite different tasks. Again, for operating and processing jobs many investigators failed to study job functions carefully enough to group employees according to similar functions.
### Table 6.5: Validity Coefficients from Dunnette (1972)

<table>
<thead>
<tr>
<th>MEASURE</th>
<th>Median Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating and Processing</strong></td>
<td></td>
</tr>
<tr>
<td>Job tryout measures</td>
<td>0.32</td>
</tr>
<tr>
<td>General intelligence tests</td>
<td>0.32</td>
</tr>
<tr>
<td>Mechanical ability tests</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td></td>
</tr>
<tr>
<td>Job knowledge measures</td>
<td>0.43</td>
</tr>
<tr>
<td>Mechanical ability tests</td>
<td>0.38</td>
</tr>
<tr>
<td>Reading tests</td>
<td>0.38</td>
</tr>
<tr>
<td>Job tryout measures</td>
<td>0.36</td>
</tr>
<tr>
<td>Quantitative tests</td>
<td>0.35</td>
</tr>
<tr>
<td>Biographical inventories</td>
<td>0.34</td>
</tr>
<tr>
<td>Chemistry knowledge</td>
<td>0.30</td>
</tr>
<tr>
<td>Verbal tests</td>
<td>0.29</td>
</tr>
<tr>
<td>Spatial aptitude tests</td>
<td>0.25</td>
</tr>
<tr>
<td>Motor skill measures</td>
<td>0.22</td>
</tr>
<tr>
<td>General intelligence tests</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Clerical</strong></td>
<td></td>
</tr>
<tr>
<td>Job knowledge measures</td>
<td>0.40</td>
</tr>
<tr>
<td>Job tryout measures</td>
<td>0.39</td>
</tr>
<tr>
<td>Interview ratings</td>
<td>0.30</td>
</tr>
<tr>
<td>Interest inventories</td>
<td>0.23</td>
</tr>
<tr>
<td>Verbal tests</td>
<td>0.22</td>
</tr>
<tr>
<td>Motor skill measures</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Testing and Quality Control</strong></td>
<td></td>
</tr>
<tr>
<td>Reading tests</td>
<td>0.34</td>
</tr>
<tr>
<td>Chemistry knowledge</td>
<td>0.32</td>
</tr>
<tr>
<td>Biographical inventories</td>
<td>0.27</td>
</tr>
<tr>
<td>General intelligence tests</td>
<td>0.24</td>
</tr>
</tbody>
</table>
Furthermore, the problems remain of using validity co-efficients based solely on those people employed, as a basis for predicting the success of job applicants. Dunnette et al's later 1982 study, discussed at length above, thus made great effort to define jobs more carefully and exploit validity generalisation techniques to eliminate local factors serving to depress validity coefficients.

Despite the limited published material on selection in the chemical industries, Dunnette's (1972) study is able to draw some important but, tentative, observations for operating and processing jobs:

1. Most predictor instruments have positive validities
2. Educational level and interest inventories are the poorest predictors
3. Job tryout measures, general intelligence tests and mechanical ability tests are the best predictors (median validities of 0.32, 0.32, 0.20 respectively)
4. The Bennett Mechanical Comprehension test has a high criterion validity coefficient (median of 0.43)
5. Training performance is better predicted than on the job performance
6. Validity coefficients for operating and processing jobs are generally lower than for maintenance or clerical jobs

6.3.3 Policies in the Selection of Nuclear Power Plant Operators

A number of publications from various countries have been concerned with issues of policy concerning qualifications in the selection of process plant operators. The existence of such documents is understandable, since companies or regulatory authorities have had a need to make public pronouncements concerning qualifications, especially following incidents in nuclear power plants, such as Three Mile Island.

The level of education process control operator candidates have received is often considered to be one of the main factors in the early stages of selection. A certain standard of education is necessary for fulfilling the requirements of the job. This, of course, conflicts with Dunnette's (1972) findings, as described above, showing education to be a poor predictor. Clearly, the reliance on educational attainment is an example of face validity in action. In practice, utilities have to recruit their personnel with whatever educational background they have acquired at the level corresponding to the educational qualification requirements of the job, and then provide training and experience. The entry qualification requirements can therefore be varied somewhat to accommodate the qualifications of the available personnel. A discussion of different educational preferences is not relevant to the present review, and so these studies will not be discussed. The issue will be raised in Section 9.
6.3.4 Individual Assessment

There is little to review regarding the choice of techniques to be used in individual assessment. Personal history, interviews and selection tests, have all been suggested as being beneficial, but this discussion adds nothing to the general description of these approaches such as those described in Section 2.

6.4 Concluding Remarks

The literature relating to the selection of eligible personnel for process control jobs is very sparse. On the whole, one must conclude that this is not a well researched area and that most of the selection practices adopted in companies are made on the basis of assumptions/experience rather than hard empirical evidence.

Dunnette et al.'s (1982) study was discussed at length because it is by far the most extensive, accomplished, and relevant study to the present review. It demonstrates the stages that are gone through in a thorough selection exercise. It also shows the effort and costs involved in such a study.

However, it also illustrates the methodological problems facing this sort of study in demonstrating categorically that a particular selection method is valid. In particular, the study demonstrates problems in:

- The adequacy of job and task analysis methods in necessarily identifying all aspects of performance. Thorough analysis of all tasks involved would take a great amount of time, but would be necessary to show all the skills entailed and the relative importance of various aspects of the task.

- The adequacy of job criterion measurement. Subjective assessment of performance of complex tasks is unlikely to reflect validly how well an operator is really likely to perform.

- The failure to collect both predictor and criterion data from people rejected at recruitment. It is not easy to be confident that the data from successful operators will be usefully predictive when a wider sample is under consideration in a real recruitment exercise.

It has been emphasised before in this report that these problems are an inherent feature of selection in process control and that no obvious solutions exist. One of the problems in any comprehensive study of criterion validity is that it must take place over several years in order to relate initial screening methods to subsequent performance.
In addition, differences in availability of eligible trainees may mean different population samples in terms of skills knowledge and background. The implication is that validity studies must be specific to the current status of a country, location and organisation in terms of both the characteristics of the pool of potential employees and the technical and operating characteristics of the plant. For this reason, individual selection method studies applied by specific organisations do not enable us to generalise validity coefficients, although they can demonstrate the general manner in which selection should be practised (see Section 7). The main conclusion from this Section is that we have found no sophisticated techniques lurking in the background which would categorically solve the methodological problems of process operator selection.

In spite of these criticisms, the research discussed provides the best information we can obtain to apply to future process operator selection activities. While we must accept the various findings with caution, the studies reviewed suggest the following:

- that educational qualifications are not necessarily predictive for process operator jobs;

- that a selection procedure should aim to choose the best people available by using spatial, verbal, numerical and reasoning tests;

- that interviews, screening and personality profiles should be used to identify personal characteristics, such as: confidence; self control and stability; responsibility; social closeness.
SECTION 7: PRACTICES IN COMPANIES

7.1 Introduction

A central theme in this report has been the fact that the variations in process plants, as discussed in Section 3, mean that findings from studies such as those described in Section 6, must be generalised with extreme caution. It is clear that many people in companies share these views and Section 6 showed that there is no generally accepted wisdom in the published literature which can be applied with confidence in companies to establish incontrovertible validity coefficients. Companies usually see the task of undertaking operator selection as one which they must tailor to their own needs. We know that some companies are poor in the way in which they carry out process operator selection, while other companies may be commended. It is possible that commendable companies utilise techniques that may have not found their way into general practice. It is often the case that good personnel practices do not translate into issues of general research interest and are therefore not published. It would be a mistake to miss this source of information. We may, therefore ask the following questions:

- Are there any special techniques adopted by companies that would commend themselves to other companies?

- Are commendable companies better by simply exercising more care in what they do?

To investigate these questions, it was appropriate to hold discussions with representatives of companies who were judged to be effective in their selection practices. It is important to emphasise that this study was not intended to be a survey of practices in the process industries; this would have entailed considering a large sample of companies, which would have been far beyond the resources of the present project and peripheral to the purpose of the project.

Eight companies were selected for the study. They were recommended for inclusion by various agencies. Interviews were arranged with key personnel responsible for selection from these companies. A schedule of questions was prepared to ensure that all required issues were covered systematically. The questions were used as a checklist to guide discussion and ensure proper coverage, rather than to structure the interviews in any constraining way. This proved an appropriate approach, because the interviewees had so much more to express than was envisaged at the outset. The schedule of questions is included as Appendix 1. Interviews each took between 2 and 3 hours. Despite different contexts and personnel policies, there emerged a substantial degree of consensus in the manner in which selection was practised by these companies.
This Section concentrates on three representative companies, to illustrate the type of variation encountered and to demonstrate the consensus. Other case histories are included in Appendix 3. All case histories are presented so that the companies may remain anonymous. The section will be summarised by drawing out common steps that will form the basis of suggestions for Section 11 concerning a general approach to selection practices.

Each case history will be structured as follows:

- Background to recruitment;
- Product range;
- Type of processes;
- Training/accreditation philosophies;
- The attitude to selection;
- Commitment to long term employment of staff;
- Range of selection criteria;
- Other functions of the selection process;
- Stages in the selection process;
- Concluding remarks;

7.2 **Case Histories**

7.2.1 **Case History 1**

*Background to recruitment:* The company had no specific recruitment needs, but undertook an annual recruitment exercise as a matter of routine.

*Product range:* The company is a large chemical company manufacturing heavy chemicals.

*Type of work:* Work entails operation of large continuous process plants.
Training/accreditation philosophies: Operators are recruited at the same time as maintenance technicians. They are trained together over an 18 week course in order that a broader perspective is gained by both parties regarding the process/maintenance relationship. However, people are designated process or maintenance at the time of recruitment. Process control trainees are trained to meet the company’s accreditation standards, which the company maintains are higher standard than the Chemical Industry Association’s standards.

The Attitude to Selection: There is a very positive attitude to operator selection. The personnel managers concerned were clearly committed to the process and had made great effort to sort out a systematic approach; the preparation and administration of the whole recruitment cycle extended over some 8 months. Invoking this selection cycle was an annual event.

Commitment to long term employment: The company were committed to employing operators over the long term and this influenced the care with which they approached the selection procedure.

Range of selection criteria: The company were clearly alert to both the social and cognitive dimensions of selection.

Other functions of the selection process: The company saw the selection process as an opportunity for applicants to view the company so that they could withdraw their application if they were unhappy. It was also clear that the personnel managers concerned saw selection as a means of getting line management committed to the people who were to be recruited and so involved them directly in the interviewing process. That is, they were not excessively concerned with the validity of the interviewing process if it served the purpose of establishing managerial commitment.

Stages in the Selection Process:

- **Assessment of Staffing Needs**: The selection cycle started with a review of recruitment needs about the site. This entailed a systematic approach to all line managers for their labour projections.

- **Advertising**: Adverts were placed in local papers for process control jobs inviting people to obtain application forms. About 2000 completed application forms were typically received.

- **Screening of Application Forms**: Application forms were screened. Age profiles were considered important for process operators. They looked for people between 23 and 32, mature enough to understand the commitment to shift work and dirty work. Merchant seamen were regarded as good bets because they had experienced a similar life-style. Screening brought numbers down to around 200 people.
• **Selection Testing**: Approximately 200 people would be invited to attend a 1 day selection process. A battery of 4 tests were administered by consultant occupational psychologists. The company used the following tests:

  - a spatial test;
  - a verbal test;
  - a perceptual test;
  - an arithmetical test;
  - a mechanical test.

The tests were broken up by a video about the company and process control work to enable applicants to gain a clearer picture of what they were applying for. The tests were scored by the psychologists and those people meeting the predetermined criteria were taken forward. Approximately 40/50 people would pass forward at this stage.

• **Selection Panel**: The 40/50 applicants who were selected from the test session were brought before a selection board. The board comprised an interview, followed by a plant tour with a supervisor, followed by a further interview. During the plant tour, the supervisor was able to form an impression of the candidates’ interest in the job. The second interview was able to draw on the impression that the tour had made on the applicant. The interview panel consisted of line managers, trainers and personnel management. All interviewers had undergone interviewer training.

• **Final selection**: The final selection was made by all parties in committee using the range of available information.

• **References/Vetting**: Job offers were made subject to successful references and medicals.

• **Validation**: The success of the interviewing process was appraised by routine meetings with plant personnel.

**Use of outside advice**: The company had taken advice from a firm of consultant occupational psychologists, who had advised on the use of tests to be adopted and also carried out testing and scoring of tests.

**Concluding remarks**: The company were clearly systematic and were probably doing all they could practically do to optimise their selection processes. They appear to have used their consultants effectively, firstly to advise them on an appropriate test battery, then to carry out the routines of test administration. It was also clear that the personnel managers involved were well informed about selection issues and appreciated the problems involved.
7.2.2 Case History 2

Background to recruitment: The company is a large chemical company manufacturing heavy chemicals in a number of continuous processes. There is currently little external recruitment, although in 1985 there was a need for a large recruitment exercise. The company was located in an area where there was a high level of employment in the process industries.

Type of work: Work is conventional continuous process operation.

Training/accreditation philosophies: Operators are recruited at the same time as maintenance technicians. Process control trainees are trained to meet the Chemical Industry Association’s accreditation standards.

The Attitude to Selection: There is a very positive attitude to operator selection. The manager interviewed was responsible for supporting line management in their selection activities concerned. The company had developed a well thought out selection procedure which was described in the “Guide to Good Practice” which was available to help line managers develop their own selection methods. The company were considering moving towards collaboration with other local leading companies in their selection and training activities.

Commitment to long term employment: The company were committed to employing and developing staff over the long term.

Range of selection criteria: The company employed both the social and cognitive dimensions in selection.

Other functions of the selection process: The company saw close links between selection and training.

Stages in the Selection Process:
The following are stages that were used in the major exercise in 1985.

- **Assessment of Staffing Needs:** There was a need to recruit 30 process operators for a new plant.

- **Advertising:** Adverts were placed in the local press. People with process control experience were sought. Applicants were sent an application form and information about the company. About 2000 completed application forms were returned.

- **Screening of Application Forms:** Application forms were screened. They were scored on a scale of 1-3 on academic qualifications, 1-3 on relevant experience and 1-3 for the overall presentation of the application. The composite score was used to select the short-list.
• **Selection Testing:** Approximately 150 applicants were invited to attend a selection testing session. The company used the following tests:

  - a test of general intelligence;
  - a maths test;
  - personality test;
  - a mechanical test.

80/90 people were brought forward for interview from this stage.

• **Selection Panel:** The 80/90 applicants who were selected from the test session were invited to attend an interview. The interview panel consisted of one member of the personnel department and two members of the production department (a supervisor and a manager). Prior to the interview, the team debated the types of questions to be asked.

• **Final selection:** The final selection was made by interview panel ranking applicants and then making offers.

• **References/Vetting:** Job offers were made subject to successful references and medicals.

• **Validation:** There was no systematic validation procedure. There was crude evidence that the selected people had progressed well. It was felt that this was no major problem, although the company were seeming to make efforts to introduce the CIA's techniques for accreditation, which could lead them to a more systematic validation method. They were generally satisfied with their method. In any case, they could not see how this could be done more effectively as there was no review process with their weekly paid staff. Even where staff concerned were party to an appraisal system, the personnel manager interviewed was not confident that it was done very effectively as it was felt that negative feedback conflicted with gaining the full co-operation of staff. They had tried to mount a systematic validation exercise by enlisting the help of a team from a local university. Unfortunately, this study had not achieved a successful outcome.

*Use of outside advice:* The company had received advice from specialists outside the company and from their headquarters' personnel function.

*Concluding remarks:* The company attempted to be as systematic as they could, although the processes advocated by personnel, seemed to be compromised by line personnel.
7.2.3 **Case History 3**

**Background to recruitment:** The company is a large chemical company manufacturing heavy chemicals in a number of continuous processes. The company was located in an area where there was a high level of employment in the process industries.

**Type of work:** Work is mainly continuous process operation.

**Training/accreditation philosophies:** The company had developed a new approach to employing process operators, combining operations with maintenance, where operators carried out 80% of the maintenance in their areas. Following recruitment, new operators followed an extensive training course.

**The Attitude to Selection:** There is a long standing commitment to selection and the personnel responsible were very experienced in this area. The manager interviewed was involved both in selection and training. This meant that there was an informal opportunity to follow recruits through the training process to gain some impression of how they developed.

**Commitment to long term employment:** The company were committed to employing and developing staff over the long term.

**Range of selection criteria:** The company were alert to both the social and cognitive dimensions of selection. They were committed to a profiling approach where they sought patterns of social, cognitive and personality variables.

**Stages in the Selection Process:**

- **Assessment of Staffing Needs:** Recruitment needs were ascertained through discussion with line management. There was usually a requirement to recruit 10 - 14 new operators a year.

- **Advertising:** The jobs were advertised widely. People with process control experience were sought.

- **Screening of Application Forms:** Application forms were screened. An interest in science was sought - a top CSE grade or bottom GCE pass was sought in at least one science subject. All people meeting this criterion were invited for selection testing.

- **Selection Testing:** The test mainly used was a well established aptitude inventory which had been used extensively by the company worldwide, over several years. The inventory produced a profile of scores, including:
- verbal reasoning tests;
- arithmetic tests;
- perceptual tests;
- a shapes test;
- a mechanical aptitude test.

The test producers published profiles of different occupational groups as a guide to people making selection decisions. The testers in the company concerned have developed the interpretation of the test somewhat further, according to their extensive use of it. They claim to be able to recognise more subtle patterns in the profiles, which they have informally validated as they have followed people through training. For example, recognising the relative strengths of some of the attributes appears to indicate different ways in which people are able to set about learning process control skills. It was stressed that the selection test was to eliminate people from interviews and was not used in the final selection.

- **Selection Panel:** About half of the people tested were brought forward for interview. The interview panel typically consisted of one member of the training department, one member of personnel and a line manager. The personnel manager was present for all interviews; the other members of the panel varied. A major argument for interviews was that they commit the interviewers to the personnel selected. The interviewers were all trained. The interviews examined the extent of technical knowledge and personal attributes. Personal attributes were examined by considering how applicants approached these interests.

- **Final selection:** The final selection was made by the interview panel discussing the results of the interviews. Test results were not considered at this stage, although they were sometimes considered when people were being placed in jobs.

- **References/Vetting:** Job offers were made subject to successful references and medicals.

- **Validation:** There was no systematic validation procedure, although the people concerned with selection were actively involved in the subsequent training processes and were able to gauge, intuitively, how effective the training process was.

**Use of outside advice:** The managers responsible for selection had undergone extensive training in the use of the test instruments they employed. They were clearly receptive to good advice and were supported by selection specialists at headquarters.

**Concluding remarks:** The company attempted to be as systematic as they could, although the processes advocated by personnel seemed to be compromised by line personnel.
7.3 Observations

While there were variations between companies, several common observations can be made.

7.3.1 Systematic Approach

It was clear from discussions that selection was taken seriously and was treated as a proper task to be managed properly. This commitment clearly extended beyond the people we interviewed, since management clearly supported the activity generously. The commitment was demonstrated in terms of the systematic way in which each selection campaign was initiated, that each stage was planned and the resources made available.

7.3.2 Interest, Expertise and Receptiveness

The people interviewed exhibited genuine interest in the selection process, accompanied by pride in what they had achieved. People interviewed also exhibited considerable expertise and were alert to the limitations of the methods adopted. They were generally well informed about the technical nature of psychological testing and understood issues of reliability and validity. They sought advice where and when needed.

7.3.3 Interest and Cooperation

There appeared to be fair support from other line managers for the efforts made in personnel selection.

7.3.4 Common stages in Selection

From a comparison of all cases considered a common set of stages emerges across each case. These are as follows:

- Assess requirements (numbers/attributes);
- Design selection process (select test methods etc);
- Advertise for applicants;
- Screen application forms;
- Carry out selection testing;
- Enable self-selection;
- Carry out interviews;
- Make decisions;
- Vet applicants (references and health checks);
- Follow up selection process to validate.

7.3.5 Care in the Promotion of Reliability and Validity

A final significant point is that each stage in 7.3.4 was carried out carefully as far as the managers concerned were able. So, for example, interviews were planned, selection tests were administered strictly in accordance with the test instructions that accompanied them.

The point was made in section 4 that one source of low validity of selection methods is inconsistency in their administration. Following controlled and consistent procedures at each stage is likely to improve reliability of the selection method or stage in the selection process. Improving reliability will contribute to validity. Thus, it is suggested, careful conduct of each stage of the selection process will enhance the validity of selection, even though it may not be possible to measure this validity. This issue is developed in Section 11 where methods to enhance a principled approach to selection is discussed.
SECTION 8: APPROACHES ADOPTED BY CONSULTANTS

8.1 Introduction

Just as it was seen to be appropriate to examine practices adopted by companies in dealing with selection, it also seemed worthwhile to consider the role that consultants in selection methods could play. Consultants are supposed to be experts. Consultants in this field are usually formally trained in occupational psychology methods. They have also often been engaged, at some stage of their careers, in formal development and validation of selection tests and so understand the ramifications of test construction and the issues entailed in measuring reliability and validity. One would, therefore, expect such people to be in closest touch with appropriate selection methods. If there are ideal solutions to the problems of process operator selection, then these are the people who should know.

8.2 The Telephone Survey

At the start of the project, it was intended to carry out a small survey of consultants by telephone to ascertain the extent of their involvement in selection issues for process control tasks. In the same way that the companies surveyed in Section 7 focused, not on a representative sample, but on a group of promising companies, the consultants survey aimed to locate people likely to be in a position to offer good advice.

To identify a sample of consultants reference was made to the register of the Division of Occupational Psychology of the British Psychological Society. This was seen as an appropriate strategy for good reasons. The Division of Occupational Psychology is the professional body which represents practising occupational psychologists. Selection testing is the province of occupational psychologists; qualification to administer many occupational selection tests often rests with formal qualification in psychology and often with membership of the professional body. The Division of Occupational Psychology Register, therefore, was seen as a likely place to locate such expertise. The Register categorises members with respect to their professional expertise. As a criterion for selecting likely candidates for the study, members of the Division of Occupational Psychology were selected who professed a consultancy expertise in personnel selection. There were about 50 such people, more than could be accommodated in the proposed study. To reduce the pool, it was further decided to consider only those people who were members of larger consultancy organisations. The reason for focusing on members of a larger consultancies was so that, should the person contacted have nothing to offer, they would be in a better position to suggest a more qualified colleague. About 12 people were thus listed.

The survey was then carried out, but proved to be of little overall value as virtually none of the consultants claimed any experience of the process control field. Only one company claimed such expertise, though not the person contacted.
Reference was made to a colleague who was contacted later for discussion. While the survey was a failure in terms of the purpose for which it was set up, it indicated two important things. First, it was reassuring that consultants did not claim expertise they did not have. The second point is that there is clearly a dearth of expertise in selection for process operators.

8.3 Contact with Consultants

While the telephone survey revealed this apparent dearth of consultants able to discuss the issue of process operator selection, contacts with companies, described in Section 7 of the report made it clear that there were some people who were in business to provide such consultancy.

Discussion was held with two consultants. The first contact with a consultant arose from a personal recommendation made from a senior member of a training agency. The person suggested was said to be experienced in this field. The second set of observations came from discussions with the consultant who had been referred to the researchers by a colleague during the telephone survey. These discussions proved extremely valuable, as they generally confirmed the conclusions of the other sections of the report, in particular, the value of the principled approach introduced in section 7 and developed in section 11.

There was consensus for the need for careful task analysis in the construction of selection methods. There was also consensus in the view that selection methods had to be administered with care, that interviews had to be carefully structured, and that test procedures had to be adhered to strictly. The consultants did not have an entirely satisfactory solution to the problem of validating selection methods. The problem of idiosyncratic job demands, biased samples, and lack of valid job measures were all acknowledged.

While it was recognised that validity could not be measured in any satisfactory way, the concept of validity remained central to these consultants' considerations. Validity was estimated subjectively. No simple or systematic procedure was offered, but considerable effort was devoted to applying professional judgement in sifting through all available information pertinent to the adequacy of selection decisions. Such information is used to tighten up selection procedures rather than attach a value to a validity coefficient. In this respect the need for expert judgement was justified. This view deserves support. The efforts to examine information critically, to determine its effectiveness as evidence for validity and justify modification to selection methods, entails research skill such as that which would result from professional training in psychology or ergonomics and experience in dealing with selection issues. It is an entirely valid view that professional expertise has an important role to play here.
8.4 **Concluding Remarks**

While accepting that the number of people contacted was very small, it seems fair to conclude the following:

- There are few consultants in the process control selection field;
- Consultants appear to follow the same general processes as the people operating within companies - namely they try to be systematic and careful. They have no special approaches to offer;
- They more fully understand the issues associated with selection processes;
- They are more aware of the potential of different methods that can be adopted;
- They belong to a network in which better selection methods are more likely to become known;
- They may have accrued wider experience than might be possible by a person employed within one company.
SECTION 9: APPROACHES ADOPTED IN OTHER CONTEXTS

9.1 Introduction

As part of the effort to identify good practice, consideration of some other contexts was made. Two major sources were considered. First, we considered foreign process industry utilities to identify their practices and assess their relevance to the UK. Second, we considered contexts in the United Kingdom which exhibited similar problems to the process industries. In particular, there was interest in the general methods by which recruitment was undertaken and in whether any defensible validation measures had been obtained which were of relevance to the UK context. Such studies could only be of relevance if the contexts in which selection took place had sufficient similarities to the context found in the UK.

9.2 Foreign Nuclear Utilities

Two sources of information were located concerning recruitment in foreign utilities. First, a small postal survey was undertaken to establish similar information from foreign nuclear utilities as had been sought from UK companies. Second, a survey contrasting international recruitment practices was located in IAEA (International Atomic Energy Agency 1984), which discussed examples of practices in training and qualifications of nuclear power plant personnel in various countries.

9.2.1 The Survey of Foreign Nuclear Utilities

A number of utilities were approached in Europe, the U.S.A. and Africa. The different educational profiles of different countries, coupled with different employment cultures means that it cannot sensibly be assumed that validity coefficients could be related to the UK. However, note has been taken of any general methodology followed for selection.

A number of foreign nuclear utilities were approached via a postal survey. The questions posed were the same as those used for UK companies. As with the British survey, the aim was to establish instances of good practice, not to assess the state of the art.

The general conclusions from this survey match the pattern established from the UK survey. Key points are summarised in Table 9.1. The selection methods that are instigated within foreign nuclear plants are always formal processes. Operator candidates are recruited from various sources i.e. applications, community colleges and the Nuclear Navy. Company policy influences recruitment in 3 main ways:
1. Desirable to have Nuclear Navy experience;
2. Individuals to live in close proximity to the plant;
3. Consider internal applications and then external.

Pre-employment testing is then conducted and particular plant personnel are widely used. Recruitment specialists identify and administer pre-employment tests. Doctors and psychologists check for physical and mental stability. Interviewees can be rejected at any point during selection because of insufficient qualifications/experience, or failure to fulfil medical and security clearance. Candidates who satisfy these criteria are finally interviewed by senior plant personnel (Operations Manager) who then make the final employee recommendation. Traits such as aptitude, experience, ambition, qualifications and personality are all considered during the selection process, as they offer the basis of the training program's requirements.

The methods and techniques used in the selection process range include seeking individuals with relevant experience (i.e. Nuclear Navy) or education (i.e. technical training from a community college). Examinations (technical, physical and mental) and fulfilment of operator profile specifications are also necessary. Interviews with potential employees are usually the final selection technique that is used.

Selection procedures tend to be validated by operational experience and licensing as these are considered appropriate and precise methods for employing the right calibre person. The major problem identified with current operator selection methods is identifying candidates who will pass the pre-employment testing, screening and interviews. Also many potential candidates are lost due to the time consuming nature of the selection process. Improvements to the current selection procedures could be:

1. Performance under emergency conditions;
2. Job offers to go out quicker;
3. Better marketing of careers in operating.

Foreign utilities tended to follow the same general approach to selection as UK companies. The response from Commonwealth Edison included a flow-chart of the selection process. This is included as Figure 9.1. It is clear that the same principled approach is followed as with the UK companies considered. Detailed responses from these utilities can be found in Appendix V.

In the US utilities, there seemed to be a general preference for ex-military personnel, specifically naval nuclear operators. This probably reflects the greater number of people available in this category in the US than in the UK.
<table>
<thead>
<tr>
<th>Utility</th>
<th>Country</th>
<th>Experience sought</th>
<th>Criteria</th>
<th>Selection methodology</th>
<th>Responsibility for selection</th>
<th>Method of validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commonwealth Edison</td>
<td>USA</td>
<td>none special</td>
<td>• aptitude</td>
<td>Typical</td>
<td>operating dept industrial relations medical</td>
<td>None formal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• ambition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• qualifications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Carolina Electric &amp; Gas</td>
<td>USA</td>
<td>ex-military</td>
<td>basic psychological test</td>
<td>Typical</td>
<td>Final authority is plant managers, with advice from other specialists</td>
<td>Subjective judgement over time</td>
</tr>
<tr>
<td>Ginna Operations Training</td>
<td>USA</td>
<td>nuclear navy</td>
<td>Written exam on knowledge</td>
<td>Typical</td>
<td>• operations manager</td>
<td>• experience</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• employee relations manager</td>
<td>• observation on simulator</td>
</tr>
<tr>
<td>Eskom Koebreg</td>
<td>South Africa</td>
<td>general</td>
<td>• personality tests</td>
<td>Typical</td>
<td>operations manager makes final choice, supported by other specialists</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• cognitive tests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duke Power Corporation</td>
<td>USA</td>
<td>naval</td>
<td>• aptitude</td>
<td>Typical</td>
<td>• recruitment specialists advise operations management make selection</td>
<td>• validated by Company human resources dept (no method given)</td>
</tr>
</tbody>
</table>
Figure 9.1: Recruitment Process as used by Commonwealth Edison

1. RECRUITMENT EFFORTS
   - Everyone reads the BROCHURE

2. COMPLETE APPLICATION
   - Only 1 application per 12-month period

3. INDUSTRIAL RELATIONS
   - APPLICATION REVIEW

4. TESTING

5. INDUSTRIAL RELATIONS
   - INTERVIEW

6. APPLICATION AND
   - BACKGROUND CHECK

7. CANDIDATE POOL
   - Qualified

8. DEPARTMENT INTERVIEW

9. JOB OFFER

10. MEDICAL EXAMINATION
    - PSYCHOLOGICAL EXAMINATION

11. ADD TO PAYROLL

12. NEW EMPLOYEE ORIENTATION

13. PERFORMANCE REVIEWS
    - DURING PROBATION PERIOD

REPLACEMENT NEEDS
9.2.2 **International Comparisons of Recruitment Practices**

The following information described in Sections 9.2.2.1 to 9.2.2.4 has been used to illustrate various national patterns. The information is somewhat general and their value is questionable, bearing in mind the more specific details obtained through the postal survey, described in Section 9.2.1. This information does not invalidate the general conclusions reached in this report by other methods. They do serve, however, to reinforce the view that selection is conducted pragmatically and not in accordance with any highly sophisticated psychometrics.

9.2.2.1 **France (EdF)**

During personnel recruitment for a new nuclear power plant, EdF has to deal with two types of candidates:

- those who already have operating experience, acquired in an EdF power station, whether conventional or nuclear.
- those who do not have this experience and who in general are just out of school.

The candidates of the first category are personally known to the management of the power station where they work. Those who are already working in a nuclear power station also have an individual training book in which the training received is summarised. The profile of each candidate is then clearly defined and graded according to the following criteria:

- level of school education;
- training received in EdF;
- experience acquired and length of service;
- assessment of the candidate by his superiors;

For candidates in the second category, the only criterion that may be taken into account is the level of school education, which constitutes the basis for pre-selection. This pre-selection is easy because technical training is well defined, e.g. engineer in electricity, welder etc. Depending on the origin of the candidates, selection is then based up on the criteria of school education and experience.

If candidates satisfy the training and experience criteria, they are then subjected to an additional written and oral examination. Technical and psychological tests are also used. After this two-stage selection, only 5 to 15% of the candidates are accepted. The percentage of failure after training is therefore very low.
9.2.2.2 Germany

Nine years of elementary school and three years of trade school are needed for employment as a professional in nuclear power plants.

For control-room operators, the initial training programme covers a period of 28 months and consists of 65 weeks of theoretical training (classroom, power plant school etc), 47 weeks of practical training on shift duty and 8 weeks of simulator training.

The final examination, which covers the entire content of the initial training, comprises a written part and an oral part. The oral examination is performed by a reviewer of the licensing authority and their technical adviser.

The primary responsibility of the decision as to which candidates are competent to operate the nuclear power plant lies with the utility. This decision has to be endorsed by the representatives of the authority to be valid.

9.2.2.3 United Kingdom

Nuclear power station engineers are currently recruited almost entirely from within the United Kingdom’s electricity supply industry. During the nuclear expansion in the 1960's some engineering staff were recruited from the United Kingdom Atomic Energy Authority (UKAEA) or the Royal Navy’s Nuclear Submarine Service. This was not the case during the 1980s. With some 20 years of nuclear experience behind the Board’s engineers, this group of mobile engineers and physicists move from nuclear station to nuclear station, developing their careers. Therefore, one would expect to staff a proposed nuclear power station with engineers possessing considerable nuclear and/or conventional power station experience. In junior grades, there are sufficient candidates from within the industry’s training programme. This provides at least two year’s post-graduate training in general power station engineering before initial appointment.

Health and reactor physics graduates may be recruited directly from universities, although the current position for engineers (in surplus, due to conventional station closure) within the United Kingdom’s electricity supply industry is such that retraining or conversion to physicists’ positions is being undertaken.

Until recently job opportunities were freely advertised throughout the Generating Board’s (now privatised) internal system; rarely these days are they advertised outside the industry because of stagnation within the industry, conventional power station closure and the need to retrain and redeploy staff. Since privatisation, however, notification of job opportunities between separate generators has now ceased. From applications received, the station manager draws up a short list and convenes an interview panel - a formal process involving himself, senior members of his staff and a personnel officer. The station manager will make his choice on the basis of the
interview, coupled with his knowledge of the candidate's experience, qualifications and general background. No formal aptitude or psychological selection techniques are employed. In summary, all industrial and non-industrial staff are selected by the power station manager and his senior staff. With some twenty years of nuclear experience, it is now expected that non-industrial, professional-grade staff above, say, shift charge engineer or shift manager would have considerable nuclear experience.

9.2.2.4 USA

Licensed operators are persons responsible for the manipulation of plant controls, monitoring plant parameters, directing hands-on operations of equipment and performing licensed activities. Licensed operators principally manipulate plant controls from the control room.

The minimum education and experience requirements for nuclear plant personnel are described in the American National Standard ANSI/ANSI 3.1, Selection, Qualification and Training of Personnel for Nuclear Power Plants (1987). This generally reflects current practices for minimum education and experience. The following is specified for licensed operators:

(a) Education: High School Diploma;

(b) Experience: At the time of core loading or appointment to the position, whichever is later, a licensed operator shall have 3 years of power plant experience, which shall include 2 years of Nuclear Power Plant experience, 6 months of which should have been onsite. Also the applicant must hold an NRC Operator's Licence for the unit(s) assigned.

The selection process should consider such selection factors as problem solving ability, emotional stability, motivation, initiative, background, experience, educational level and mechanical aptitude and may involve a selection test. Selection should be based on the ability to meet position qualification criteria with reasonable amounts of training.

Initial and continuing training programs are to be implemented to ensure that personnel are qualified to the performance requirements of the job. The basic elements for establishing a systematic training program include:

1. Systematic analysis of the job to be performed, using for example job or task analysis or both.

2. Establishment of prerequisite education, skills and knowledge required for entry into the training programs.

3. Design and development of training programs based on job performance requirements.
4. Implementation of trained ability to meet job performance requirements.

5. Evaluation of trained ability to meet job performance requirements.

6. Evaluation and revision of training programs.

9.3 Examination of Recruitment in Other Contexts

It was initially felt that a further source of information would be similar contexts in the UK. However, to justify this, it is necessary to consider how such contexts may be similar or dissimilar. Referring to Section 3, it is apparent that the context of process control tasks embodies a number of specific features. It is very difficult to match these features in other employment contexts in the UK. Critical features from Section 3 include:

- the high applicant/recruit ratio;
- the validity problems;
- the cognitive/technical nature of the work;
- the potential hazards of the environment.

A further consideration was that larger recruiting organisations are likely to have in-house psychologists, able to demonstrate appropriate selection methods.

Despite the general principle that other contexts should be considered, there is an irony in the fact that where operational characteristics of a different situation match those of process control, so too would one expect conditions to prevail where any validation measures reported would be unsatisfactory, in view of the arguments in Section 3. Should conditions prevail in a different context where satisfactory validities were reported, one would immediately suspect that the contexts are not comparable.

One source that was felt likely to be of considerable information value was the British armed services, who recruit substantial numbers of people for technical positions. The services may be less constrained than people in the process industries regarding proper validation of selection methods. Furthermore, the concern with placing personnel in technical positions may also be able to suggest selection methods that might readily be adapted to process control contexts.

In the event, such organisations proved to be of little relevance to the problem in hand. The basic recruitment pattern tends not to be comparable. People are first recruited into the services, and then are selected for placement in a technical position. This means that there are ample opportunities to appraise people in similar contexts and the opportunities to assign them to other duties should they prove unsatisfactory.
In the process industries, by way of contrast, people are selected directly for the operational position in which they are to be employed.

In the process industries opportunities for redeploying people who prove unsatisfactory do not exist to any appreciable extent. Apart from this, it is questionable whether there is anything particular concerning the jobs for which service personnel are to be recruited which justifies giving them special attention over other occupations.

One context which seems operationally relevant is the Navy, because of the need to recruit people to operate power plants in nuclear submarines. Following discussion with a representative of Naval recruiting, it was apparent that the recruitment pattern for nuclear operators on submarines was quite different to that of process operators. Selection for trades within the Navy is done by the specialist trades themselves who can base selection on the complete service record. Such scrutiny is of substantial benefit to a recruiting organisation and is not available to most process industries. Selection to the Navy from outside of the service is different to process control in that selection is made for a range of trades, many of them not intellectually demanding.

In the event, it transpired that, even though recruitment numbers to the Navy were large in comparison to process control companies, no formal validation of selection methods was undertaken. This may reflect a need to encourage people to join, rather than to select from a wide range of applicants.

9.4 Conclusions

While a close examination of recruitment in other contexts may reveal some individual practices of relevance to process control in the UK we have no reason to believe that there are any substantial messages to be drawn from these sources that have not already been gleaned from examination of the UK context and the general literature.
SECTION 10: EXISTING PRACTICES IN SELECTION - CONCLUSIONS

The main conclusions that can be drawn from Sections 6 to 9 are as follows.

1. No entirely satisfactory published studies concerned with validation of selection methods for process control jobs could be found. Even where extensive effort is made in studies, wholly acceptable validity coefficients are not forthcoming. Thus, no evidence has been identified from these studies to challenge the conclusions from Part II, outlining the methodology problems inherent in process control selection. It remains questionable whether a process operator selection methodology, based on the conventional wisdom of personnel selection techniques will ever be established.

2. Some general conclusions from published validation studies are worth noting. The use of spatial, numeric, verbal and reasoning tests should be considered. It was interesting to see that tests of this type generally featured in the test batteries adopted by the companies studied.

3. In view of problems of formally measuring validity coefficients, the major emphasis in promoting the validity of selection methods rests with care in developing and managing the selection process. This conclusion emerges from appraisal of UK companies, consultants, published accounts of selection exercises and the information collected from foreign utilities.

4. In practical contexts, selection is seen, in the main, as a process of filtering down a pool of applicants rather than confidently selecting people who seem to have the right personal attributes for the job in question. Selection testing is used in companies as a means of reducing a recruitment pool to a manageable size to enable more detailed examination of applicants. The importance of training and work design is emphasised as being important, often more important, than selection.

5. Formally measuring validity is seldom undertaken. Where it is performed, its limitations are recognised.
PART IV: AREAS FOR IMPROVED PRACTICE

Outline

In Part IV some issues that could lead to improved practice of selection in the process industries are discussed.

First, Section 11 suggests that the near consensus approach for selection in the good companies visited and endorsed by the consultants who are interviewed may be used as a framework both to prescribe methods for companies and to review the effort made by companies.

Sections 12, 13, 14 and 15 then consider improvements that can be made to key steps within the approach discussed in Section 11. Section 12 discusses developing a practical approach to identifying suitable predictors, using a functional model for use by people concerned with selection to diagnose the selection requirements of particular process plant jobs.

Section 13 then considers the largely neglected area of criterion measurement. We could find no evidence within industry of valid and systematic measures of job performance in a form suited to making judgments about the adequacy of selection methods. Without these measures a rigorous approach to selection cannot be pursued.

Section 14 discusses the issue of demonstrating validity. To make progress here requires, at the least, progress to be made concerning the criterion measurement problem discussed in Section 13, and, ideally, progress to be made concerning the predictor problem discussed in Section 12. With effective predictor and criterion measures, we may then address the issue of validating the predictor measures against the criterion. Section 14 then considers the research that would need to be done to examine whether techniques in validity measurement can be improved to deal with the characteristics of the process industries.

The recommendations in Section 14 are not made with much confidence that the problems of validity measurement can be solved. The cognitive approach to selection testing as an alternative to the traditional psychometric approach is considered in Section 15.
SECTION 11 : SUPPORTING A PRINCIPLED APPROACH TO SELECTION

11.1 Discussion

Discussion in Part III indicated that there were no fundamental approaches to process operator selection that would be entirely satisfactory according to the ideals set out in Section 2. This was shown by interviews with experts in companies and consultants, and reinforced by a review of practices discerned from the published literature.

11.2 A principled Approach to Selection

It was evident that much thought has gone into developing practicable approaches to selection. The most prominent feature is the adoption of a systematic methodology for selection for which there seemed to be a broad consensus. This framework was used in Section 7 to organise the reports from companies. The framework is as follows:-

1. Assess requirements (numbers/attributes)
2. Design selection process (select test methods etc)
3. Advertise for applicants
4. Screen application forms
5. Carry out selection testing
6. Enable self-selection
7. Carry out interviews
8. Make decisions
9. Vet applicants (references and health checks)
10. Follow up selection process to validate

All improvements to practise at process operator selection that we might envisage may be addressed to one of these stages. We may consider each of these in turn:-
11.2.1. **Assess requirements (numbers/attributes)**

The practices of experienced companies may be collated and communicated to less experienced companies. For example, the manner in which they may conduct an annual audit of personnel needs. Another feature relates to the employment philosophies of companies; some companies recruit to specific jobs as they arise, while others carry out an annual recruitment. Different companies design their jobs in different ways, with a greater or lesser maintenance component, for example. Each of these affects recruitment needs and could be aired to help less experienced companies evolve effective processes which suit their needs. In addition to calculating numbers of operators to recruit, effort must be made to set out the person specification required. This entails some form of job analysis leading to statements of personal characteristics sought. In the absence of their own direct experience, or more practical tools for analysis, companies could seek the advice of a selection consultant at this stage. The functional model outlined in Section 12 could be developed for such a purpose and added to the advice that might be offered here.

11.2.2. **Design selection process (selection test methods etc)**

Help may be given to companies in efficient methods for identifying and designing the selection methods that might be adopted. Recommended techniques should be well thought out, rational and with a realistic cost of application. Help may be offered in the form of a matrix relating selection methods to identified characteristics. It should be noted that all steps from advertisement onwards need to be considered in establishing the appropriate filtering process.

A further aspect here is the use that can be made of outside consultants in helping with this process.

11.2.3. **Advertise for applicants**

Again, practices of experienced companies may be offered. It is clear that there are regional variations in the best ways to recruit a satisfactory pool of applicants. These features could be collated and publicised. Advertising methods need to attract as wide a range of potential applicants as possible but also deter unsuitable candidates.

11.2.4. **Screen application forms**

Companies may need help both in the design of forms to ensure that adequate information is accrued and in the examination of those forms to filter the pool of applicants in the most efficient manner.
11.2.5. **Carry out selection testing**

Given that appropriate selection methods have been devised, they must be executed carefully. This is understood by the experienced companies and needs to be conveyed to less experienced companies. Careful and consistent execution of selection methods is a major contributor to reliability. This, allied to choosing appropriate methods in the first place, is also a major contributor to validity. A selection test battery should include tests for spatial, verbal, numeric and reasoning abilities, and be used to select the best people available who also match personal characteristics. If six operators are required, for example, choosing 3 or 4 times this number, provided they are all at a similar level, would provide an adequate group of candidates to take forward to later stages in the selection process. With regard to the selection of standardised selection tests, Anastasi's (1982) guidelines should be circulated.

It was generally felt that selection testing was not an ultimate selection method, which would arrive at the final group of people to be offered a job, but rather, it was seen as an effective stage in the filtering process. This point may need explanation to companies wishing to improve their selection processes.

11.2.6. **Enable self-selection**

There seems to be a consensus that providing means by which applicants are helped to recognise their own suitability is worthwhile. It may not add to the validity of selection, but it certainly adds to the productivity of selection since it reduces subsequent wastage. There will be techniques that are found to be effective in helping applicants better understand the real nature of the work involved, so that they can make an informed judgement about whether they would wish to pursue the application. Techniques will include appropriate job adverts, appropriate company brochures, well-made videos describing the job, and plant tours.

11.2.7. **Carry out interviews**

Interviews remain a central method of finalising the selection, despite their questionable validity. They should aim to obtain relevant information about aspects of the candidate that cannot be obtained by other methods. The better companies clearly recognise the importance of planning and exercising care in the execution of interviews; the literature supports these steps as a means of improving validity of selection. Schmitt's (1976) suggestions concerning the preparation for interviews are worth circulating to support this stage.

The involvement of line personnel in the interviewing process also featured strongly, to commit them to the personnel selected as well as using their operational expertise. Interviewer training, therefore, should be given.
11.2.8. **Make decisions**

Companies interviewed varied in the extent to which decisions were made using just the interview and selection test results, for example. In some cases both sources of information were included, while in others only interviews were considered, selection testing having served to reduce the recruitment pool. There may be good and bad practice here that can be conveyed to companies. Provided that an adequate pool of recruits is established and a sufficient pool can be selected all of whom show reasonably high scores on the test measures (though useful norms for British process operators are sparse) the company can then go forward and select on other criteria from within this pool of satisfactory applicants.

11.2.9. **Vet applicants (references and health checks)**

It was generally accepted that this is an independent step following the main selection process. That is, offers are made at stage 8, subject to satisfactory health checks and vettig.

11.2.10. **Follow up selection process to validate**

This is the crucial stage which determines whether the selection processes adopted are satisfactory and whether the cost and effort was well directed. It is also the stage which begs the most serious questions, namely, the question of criterion measurement and validity measurement.

On the question of criterion measurement, current practice seems to be limited to asking whether new operators respond well to training and whether line managers are satisfied with the choices made. Both of these are by subjective assessments. There may be advice concerning how these subjective assessments could be made most effectively. There is certainly scope for investigating more objective methods, as discussed in Section 13.

On the question of judging validity, again this seems to be done subjectively, in the context of discussion with line managers. Indeed, the question of validity is not really distinguished from the question of criterion measurement; the opinions of line managers are simply used to tune or not to tune the selection methods used.

Of considerable practical benefit at this stage is any effort that can be made to check whether there are any scores or test profiles which seem to be unacceptable in view of the applicant's subsequent development.
11.3 **Recommendations**

Recognising this methodology has two potential benefits:

- That the framework can be used to communicate good practice and offer innovations;
- That the framework can be used as a yardstick for judging areas of weakness in selection procedures adopted.

The following recommendations are made:

1. That a framework of this kind is developed and used to collate best practice at the various stages and focus on areas for development.

2. The framework should be published according to the current state of the art and updated regularly as progress is made in the development of better practices. Appendix 4 gives an illustration of what could be communicated to practitioners.
SECTION 12: IDENTIFICATION OF SELECTION CRITERIA—OUTLINE OF A FUNCTIONAL MODEL

12.1 Discussion

A critical stage in developing selection is identifying the personal attributes that an applicant should possess and hence, the methods for measuring these attributes. If this can be done effectively then it will substantially increase the validity of the selection process, even if the validity is not formally measured. Currently, this is not done very well in industry. The methods that are discussed in the literature are often technical, using complex approaches to task analysis, such as the Position Analysis Questionnaire (McCormick et al, 1969; Sparrow et al, 1982) which may not be practicable in the context of a company, since the time or expertise may not be readily available. Furthermore, they assume that a comprehensive validation process will be undertaken. Thus the selection methods may have to be fine-tuned should the validity not prove acceptable. Weaknesses associated with methods of validation have been emphasised in this report and so such fine-tuning cannot be relied upon. It follows that great care should be exercised in establishing appropriate predictors for a selection method. It would, therefore, be beneficial to develop systematic techniques for examining selection criteria within the company context.

A major source of difficulty in dealing with selection issues for process control tasks is that there is such a wide range of possible tasks to be considered. This was made clear in Section 3. This makes it impossible to prescribe a simple list of personal attributes of process controllers for specific plants. It is also difficult to make straightforward suggestions in this report; for the same reason it is equally difficult for people within companies to identify their real needs.

12.2 A Possible Approach to Identifying Selection Requirements

To provide a framework for examining the personal attributes of process operators more systematically, we propose a functional model of process control tasks. If properly developed, such a model ought to be a template against which managers in process control companies can match their operational needs to identify selection criteria.

The model is hierarchical and adaptive, allowing, in principle, the establishment of any pattern of functional requirements peculiar to specific plants. In this way we are better able to collate the range of personal attributes that might be desired in a process operator for a specific plant. This enables the attributes identified to be examined to establish whether they constitute useful selection criteria and the manner in which such selection decisions might be made, for example, by testing or interviewing. This approach to identifying selection requirements is far more rational than those currently adopted by many process control companies.
It must be emphasised, however, that this is not an objective method, either in its construction or use, but has been proposed on the basis of expert judgement. For it to be used effectively would require careful development, phrasing and exemplification.

The functional model suggested here is not complete, but merely illustrates the approach. Further work to produce a more comprehensive model would be required as well as work to refine the selection options offered. However, the model can be used, as it stands, to provide evidence for the range of potential selection criteria that might be considered. It is believed this set of criteria is more exhaustive than those used in the companies that have been visited.

12.3 Outline of the Functional Model

The functional model states the broad objectives of the set of tasks we are interested in - in this case we are considering the general function of 'operate continuous process plant safely and effectively'. It then breaks this overall function into a range of sub-functions that might be entailed in achieving the overall function. These in turn are further broken down into sub-functions. The model could be made to be general, in the sense that the sub-functions could exhaust the range of activities that might be encountered in any continuous process plant. It also purports to be adaptable to model any specific plant by selecting those sub-functions appropriate to the plant. If further developed, the model would provide the basis for a tool to aid the design of selection methods for companies.

The model shares features with hierarchical task analysis (HTA) (Duncan, 1974). It has links to HTA but it is different in important respects. An HTA describes the components of an actual task including specifying the planning elements of a task. Moreover, the HTA contains only the components relevant to the task in question. The functional model is more general, but lacks the specific task detail that is possible with a proper HTA. The functional model was developed from a range of HTAs of different processes. The functional model exploits the fact that different continuous process control tasks have a number of similarities and a number of differences. The same approach could be developed with both batch processing and maintenance.

12.4 Components of the Model

The model is shown in detail in Table 12.1 and is diagrammatically represented in Figure 12.1. The table permits easier development of comments appropriate to the model. The diagram shows how the overall function is successively broken down into sub-functions. The table contains the same basic structure set out with the components of the model, namely the 'hypothetical task elements', in the left-hand column and 'comments on selection criteria' appropriate to the sub-functions in the right-hand column.
In the left-hand column, there are notes (following a hyphen underneath some of the identified functions) which indicate how the sub-functions which follow may be included in a specific task. For example, following the first operation, it is suggested that local decisions will determine the extent to which the various sub-functions would be utilised. This would continue throughout, thereby including some functions for consideration and dropping others. Eventually, these statements could be refined to provide a decision tool for people concerned with selection in companies, to help them decide which functions they should be concerned with, and the functional model would serve as a framework for a selection methodology.
Figure 12.1

1. Start-up plant
   - Operate continuous process plant safely and efficiently
   - 1.1 Prepare/plant equipment/materials
   - 1.2 Carry out prescribed actions to start up plant
   - 1.3 Adapt actions to attain target states/uniting
   - 1.4 Adapt actions to maintain target states

2. Run plant
   - 2.1 Monitor plant
   - 2.2 Deal with off-spec conditions
   - 2.3 Deal with samples
   - 2.4 Adjust plant throughput

3. Carry out shutdown

4. Carry out emergency shutdown

5. Communicate/collaborate with colleagues
   - 5.1 Receive information
   - 5.2 Supply information
   - 5.3 Write reports, logs, tables etc
   - 5.4 Collaborate with colleagues

6. Coordinate maintenance
   - 6.1 Coordinate scheduled maintenance
   - 6.2 Collaborate with maintenance dealing with unscheduled circumstances

7. Commission/decommission

8. Coordinate maintenance

1.3 Recognize system status
   - 1.3.1 Recognize system status
   - 1.3.2 Select action to achieve target
   - 1.3.3 Carry out actions
   - 1.3.4 Monitor and interpret feedback from plant

2.1 Monitor equipment
   - 2.1.1 Monitor equipment
   - 2.1.2 Monitor external plant
   - 2.1.3 Monitor process via instrumentation

2.2 Diagnose problems
   - 2.2.1 Diagnose problems
   - 2.2.2 Move plant to safe condition
   - 2.2.3 Rectify problem
   - 2.2.4 Recover target conditions

2.2.1.1 Diagnose faults from a limited set
   - 2.2.1.2 Diagnose problems following a set procedure
   - 2.2.1.3 Diagnose unforeseen problems

2.2.2.1 Identify safe condition
   - 2.2.2.2 Move to safe condition
### TABLE 12.1

**HYPOTHETICAL TASK ELEMENTS**

**OPERATE CONTINUOUS PROCESS PLANT SAFELY AND EFFICIENTLY**

-Typically a process control task will entail the operator carrying out several of these, especially 1, 2, 3, 5 to 7 will depend upon local decisions, and the autonomy afforded the operator for knowing when to carry the options will vary between plants.

1. Start-up plant
2. Run Plant
3. Carry out Shutdown
4. Carry out Emergency Shutdown
5. Communicate / Collaborate with colleagues
6. Coordinate Maintenance
7. Commission/ Decommission

**1. START-UP PLANT**

-Most of the following will be involved in any process control plant, however, the extent to which operators are required to do 1.3 and 1.4 will vary between plants and management philosophies.

1.1 Prepare Plant / Equipment /Materials.

Involves carrying out prescribed routines, Procedures should be documented and trained. The importance of these routines should be trained to ensure compliance. Supervision should ensure compliance, but problems may arise if unsupervised. There is a need to observe safety procedures.

**COMMENT ON SELECTION CRITERIA**

There may be selection issues concerned with choosing people to accept responsibility and show confidence for large decisions such as these.

**Selection Criteria to be Considered:** (a) Evidence of responsibility; (b) appropriate safety attitude.
1.2 Carry out Prescribed Actions to Start-Up Plant.

See comments on 1.1. Also involved are (a) perceptual skills to discriminate various plant configurations / system states, (b) communication skills to coordinate action with colleagues and (c) monitoring skills. There is a training element in each of these. If there is a component of dealing with equipment on plant, then safety procedures must be followed.

**Selection Criteria to be Considered (as necessary):**
(a) perceptual fitness, eyesight, colour vision; (b) communication skills; (c) responsibility; (d) concentration; (e) aptitude for handling multiple informational sources / information management; (d) appropriate safety attitude.

1.3 Adapt Actions to Attain Target States / Tuning

- There may be a need for operators to exercise flexibility in attaining system states, especially in circumstances where there has been unforeseen circumstances in the start-up. This entails decision making and confidence in judgement. These facets will be improved by good training but there may also be scope for selection.

1.3.1 Recognise System Status

Enabling reliably collecting information about the system, distinguishes legitimate variations from the unacceptable ones.

**Selection Criteria to be Considered:**
(a) reasoning skill for decision making; (b) skills at thinking through the action and anticipating consequences; (c) confidence in and defence of decisions.

1.3.2 Select Action to Achieve Target (including desired rate of change towards the target).

Essentially decision making to select an appropriate action to deal with a problem and a capability to rehearse mentally the likelihood of consequences of the chosen action before carrying it through.

**Selection Criteria to be Considered:**
(a) reasoning skill for decision making; (b) skills at thinking through the action and anticipating consequences; (c) confidence in and defence of decisions.
1.3.3 Carry out Actions.

This is unlike 1.2 (carry out prescribed actions) since it is concerned with activities that have not been prior-planned and scrutinised by plant management. Clearly there must be constraints and controls laid down by management regarding what freedom for action is permissible. Even so, the operator must be an effective planner, implicitly working out the stages entailed in a proposed action, the parameters that must be monitored to ensure a safe transition and contingencies that should be followed if anything does not go according to plan. There is probably considerable scope for training here. There may also be individual dispositions to planning.

**Selection Criteria to be Considered:** (a) planning capability; (b) confidence in and defence of decisions.

1.3.4 Monitor and Interpret Feedback From Plant.

This is a recursion of 1.3 and would, in principle, entail the same qualities. However, should the operator be faced with a problem at this stage, then it may be dangerous to compound the problem further and the operator should opt for some safe action. This will almost certainly be suboptimal in terms of productivity and there is a danger of such action being frowned upon by management and team members, especially if the conservative action proves subsequently to have been unnecessary. Such actions should not be discouraged by management as they are inherently safe. Operators must be confident of the reception they will receive.

**Selection Criteria to be Considered:** (a) for monitoring, see 1.3.1; (b) confidence in and defence of decisions.
1.4 Adapt actions to maintain target states.

2. RUN PLANT

- Continuous process plants will vary in the extent to which they entail 2.1 to 2.4

2.1 Monitor Plant
- Some plant monitoring activities are essential components of the operators task.

2.2.1 Monitor Equipment.

2.2.2 Monitor External Plant.

2.2.3 Monitor Process Via Instrumentation.

2.2 Deal with off-spec conditions

2.2.1 Diagnose Problems

2.2.1.1 Diagnose faults from a limited set

2.2.1.2 Diagnose problems following a set procedure e.g. using a decision tree

2.2.1.3 Diagnose unforeseen problems

2.2.2 Move Plant to Safe Condition

2.2.2.1 Identify Safe Conditions

2.2.2.2 Move to Safe Conditions

2.2.3 Rectify Problem.

2.2.4 Recover Target Conditions.

2.3 Deal with Samples

**Selection Criteria to be Considered:** see 1.3

**Selection Criteria to be Considered:** (a) disposition to minimise risk re safety procedures; (b) perceptual fitness.

Where this is required it may entail collecting samples from sampling points, hence, safety must be observed. Dealing with samples may also entail some rudimentary analysis involving various perceptual judgements for which the operator must be fit.
2.4 Adjust Plant Throughput

There may be requirements from time to time to adjust throughput rate. These may be predetermined by management (e.g. working on a 50% throughput rate, making product to a different specification, or returning to full operations from an intermediate 'safe' state). In which case, actions should be prescribed (as in 1.2). Or the adjustments must be made according to the conditions as judged by the operator (e.g. to compensate for a problem or recover from an unforeseen state), in which case actions are adapted as in 1.3.

3. CARRY OUT SHUTDOWN

- Shutdown is largely procedural although there may be elements of disruption. Task elements will be covered in 1.2 (start-up plant)

4. CARRY OUT EMERGENCY SHUTDOWN

- Emergency shutdown is usually tightly prescribed. See 1.2 below.

Operators must adhere to any emergency procedures set down.

**Selection Criteria to be Considered: see 1.2 or 1.3 as appropriate.**
5. COMMUNICATE / COLLABORATE WITH COLLEAGUES

Most plants require operators to work in teams collaborating with one another and collaborating with colleagues on other plants. This collaboration may entail supplying information to colleagues pertinent to their colleagues planning, receiving information from colleagues regarding the operators own plans, providing reports, filling in logs etc. Collaboration also entails an operator carrying out activities for the convenience of colleagues and not simply for his/her own convenience. One of the main problems with communication collaboration is that the operator is required to carry out activities which provide no direct benefit for the operator in question, but which are for the benefit of colleagues.

5.1 Receive Information

This entails listening/reading explicit instructions and conscientiously reading appropriate circulars. It may also entail interpreting data presented in a mathematical form, e.g. a graph or a table. The ease with which information is understood by operators is clearly related to how clearly it is conveyed, so attention must be paid to communication skills of all team members and the adequacy of communication channels.

**Selection Criteria to be Considered:** (a) listening skills; (b) verbal comprehension; (c) reading skills.

5.2 Supply Information

This is the other side of the coin of 5.1. Operators should be able to express themselves verbally and in writing, clearly and concisely. These skills can be learned to some extent, but they are extremely difficult for some people to acquire and so selection may be important here.

**Selection Criteria to be Considered:** (a) verbal expression; (b) writing skills.
5.3 Write Reports, Logs, Tables

Operators may be required to write simple reports and make intelligible log entries. They may also be required to prepare clear tables. Methods of presenting data can probably be trained, but it may be more satisfactory to select people who already possess these abilities.

5.4 Collaborate with Colleagues

Much of this collaboration will emerge from adopting effective team organisation and building team skills. Operators should appreciate the extent to which they are contributing to a larger system. There may be some appropriate selection criteria.

6. COLLABORATE WITH MAINTENANCE

Maintenance may be scheduled or to deal with specific problems. Good relations with maintenance is essential for efficient operation.

6.1 Coordinate Scheduled Maintenance

6.2 Collaborate with Maintenance Dealing with Unscheduled circumstances

See Below

7. COMMISSION/ DECOMMISSION

Commissioning and decommissioning is usually carried out by more qualified personnel that operations 1 to 6. In addition there is a greater emphasis on planning actions and dealing with unforeseen circumstances.

**Selection Criteria to be Considered:**
(a) writing skills.

**Selection Criteria to be Considered:**
(a) team collaboration.

**Selection Criteria to be Considered:**
These will be those aspects more concerned with up-planned activities.
12.5 **Attributes Elicited from the model**

While the model needs further development to ensure its completeness and enable its use as part of a selection methodology, it is already useful in helping focus on some of the characteristics of behaviour required of process operators. By considering the lists of selection criteria suggested in the right hand column of table 12.1, we are able to collate the different selection criteria that seemed appropriate for a full range of process control tasks. These are now considered. For each of these it is necessary to expand on what is meant by the aptitude involved and discuss what sort of selection method would be appropriate.

It would also be important to establish whether these are indeed attributes which should be selected for or whether they can be trained. This would have to be the subject for further research. It is also possible that with further investigation these observations could be related to well established traits for selection. Until then they can only be discussed speculatively.

- **Evidence of responsibility**
  Selectors need to be confident that people recruited are able to take responsibility for their work, that they appreciate the nature of the work they are embarking on (e.g. shift-work, dirty work, system supervision) and that they will turn up for work and work conscientiously.

  Such evidence could be sought at interview and in examination of previous work records and references. Have people worked in such a capacity in the past? It is not obvious whether psychological tests would serve in this respect.

- **Appropriate safety attitude**
  Will people adopt a safe approach to work? Will they adopt a responsible attitude towards balancing safety with productivity?

  There are probably personality traits that would indicate a disposition towards safety, for which there exist satisfactory reliable tests. It is also possible that there is an intellectual component concerned with the extent to which the operator is able to reason about events and judge their consequences. This seems similar to the skills entailed in reasoning through actions, that are required when the operator is working out courses of action in changing the status of plant.

- **Fitness, eyesight, colour vision**
  The operator must be fit to undertake the work entailed. This includes eyesight and hearing adequate for the job - if there are any extreme conditions then these must be screened for. There should be well established medical tests for any aspect required, for example, tests for colour blindness.
- **Communication skills**
  In all process plant situations there is a need for communication between personnel. The relevance of these skills depends upon the particular plant context and managerial preferences. It is also likely that much can be done to minimise relying on the individual operator possessing a high degree of skill in these areas, for example by stereotyping information presented and the responses required. For example, consistent use of technical terms might be stressed; training might be given in encouraging concise verbal communication; forms might be designed to standardise responses. In addition, these skills are typically covered by psychological tests if steps cannot be taken to minimise problems for operatives. The aspects of communication include:

  - **Listening skills**
    Can the operator listen carefully to a request or instruction? Can the operator reliably translate this verbal communication into an appropriate action?

  - **Reading skills**
    the same issues apply to written information as verbally presented information.

  - **Verbal expression**
    Often, operators are required to communicate crucial information to colleagues, managers or maintenance staff. There is often benefit in formalising such communication to reduce reliance upon a person’s ability to articulate detailed information in a form appropriate to the person receiving information.

  - **Writing skills**
    Written communication embodies the same issues as verbal expression.

- **Concentration**
  There are frequent operations where operators must attend carefully without succumbing to distraction. Appropriate tests for this sort of attribute should be sought.

- **Handling multiple informational sources/information management**
  There are occasions when the operator is required to attend to several goals at once, switching attention between them in an appropriate fashion as situations and priorities change. This entails aspects of attention span and working memory. There are psychological tests which may apply to aspects of this, but whether they cover the whole picture is a question for further research.
• **Reasoning skills**
  There are several aspects where the operator is required to exhibit reasoning skills. It is likely that each of these can be predicted by a general reasoning test. However, each of them entails slightly different features, so further investigation would appear worthwhile. It must also be remembered that various approaches to training may help in providing operators with appropriate reasoning strategies. It would appear that general reasoning tests are generally the best predictors that can be adopted in process control situations.

• **For resolving apparent inconsistencies in available information**
  Operators must often confirm the adequacy of information presented on displays and resolve inconsistencies. This may entail reasoning about the implications of various aspects of a system’s state to identify other parameters that can be reliably confirmed. This would appear to be deductive reasoning for which there are available psychological tests.

• **For decision making**
  Operators must examine symptoms to determine causes, e.g. in fault diagnosis. This sort of inferential reasoning is not obviously the same as the deductive reasoning described above, and it should be noted that diagnostic skill can be improved by training. It can be argued that people are more able to formulate effective diagnostic strategies if they are able to dissociate features presented to them from the specific context in which a problem is presented and generalise to other situations. If this is the case, these people may be predicted from a measure of their field independence, possibly measured by an embedded figures test.

• **For thinking through a proposed action and anticipating consequences i.e planning capability**
  Thinking through problems in process plant entails a capability to mentally model plant and anticipate the complexities that might be encountered by features such as heat exchange systems and control systems that conspire to confound simple predictions of events. The operator would appear to benefit from appropriate working memory capacity, to remember intermediate states, while hypotheses are tested, and, probably, a spatial memory ability enabling the model to be held in the imagination and manipulated. The importance of spatial ability as a selection criterion for process control is stressed by a number of the people visited on plant.

• **Confidence in and defence of decisions**
  Operators need to act on their decisions with confidence and conviction. They should be conscientious in confirming that their decision is correct, then they should hold that view and not be easily swayed by colleagues who have not undertaken such a rigorous appraisal.
There is a danger in confusing this with stubbornness, where the operator is never prepared to shift ground. This feature may have some personality component which can be selected for. It also has a skills aspect, where the operator is practised and confident in decisions made.

- **Team collaboration**
  Operators must work in teams. In addition to the communications skills above, this implies a willingness to collaborate with and support colleagues. There are likely to be attributes which some people may claim will measure the operator's disposition for team work. Evidence should also be sought from interviews and previous employers.

12.6 **Further development of the model**

The model in its present state appears to offer some potential as a device for identifying common attributes for selection, which should be investigated further. It also would appear to be a rational structure which could be exploited in a methodology for devising selection methods, since users could compile their selection methods according to the parts of the model which reflected their particular circumstances. If these two benefits appear worth exploiting, then further work on the model needs to be carried out.

12.7 **Recommendations**

We would recommend the further development of a model with the characteristics and potential of the functional model described here, developing it into a form which could be used within companies and into which future developments can be added.

The further work would include:

1. Developing the content of the model by further refinement and checking its content against analyses of other process control tasks.

2. Clarifying further the constituent attributes which are seen as useful selection criteria.

3. Investigating the selection suggestions made, to identify available selection methods and establish how they map onto the attributes identified in the model.

4. Developing the structure of the model and its representation to enable its use within a practicable selection methodology.
SECTION 13 : MEASUREMENT OF JOB PERFORMANCE

13.1 Discussion

A crucial problem that has emerged from the study is that there are no effective methods for objective evaluation of job performance. This has been confirmed both in the review of company practices and the review of the published literature on process control selection. In the absence of such measures, there is no basis for objectively measuring validity of selection methods, and so no formal judgement of the value of selection methods can be made. There is, then, a need to improve the means by which job performance can be measured.

There are steps that can be taken to improve such measurements. These will be outlined only briefly.

First, the practice of task analysis needs to be encouraged in companies. Apart from the benefits that this will bring to improving other aspects of human factors, this will specify what operators are required to do.

Secondly, an appropriate task taxonomy needs to be devised to indicate different aspects of the task which need to be measured differently. For example, it is relatively easy to judge whether a person is competent to carry out fixed procedures, by using a ‘walk-through’ test on plant. Decision making tasks are less easy, however, and may require some form of simulation in which the operator can demonstrate skill - in much the same way that an airline pilot may be appraised in a simulator.

Thirdly, simulation should be addressed to satisfy the needs of the task types identified. Simulation which will fairly test a person who has gained experience in an operational situation will be very expensive and difficult to produce, since it needs to replicate the operational situation very accurately. The cost and the technical constraints may prove prohibitive for practical purposes. In this case, reduced fidelity simulations will need to be used. This may entail investigating the skill required of expert judges who are able to take evidence gained from simulation performance and combine it to arrive at a valid job criterion score. For example it may be necessary to devise a low fidelity simulator which would make it possible to judge whether a person can handle information appropriately, then revise one’s opinion of this performance in the light of the operator’s resistance to stress. This combination of evidence may be made, in principle, by a human judge or an expert system.
13.2 Recommendations

Developing effective job criterion scores is crucial if progress is to be made to validate selection methods even using informal approaches.

Three recommendations are made.

1. Methods for analysis of tasks and categorisation of task elements should be reviewed to identify the different sorts of task element for which measurement needs to be made.

2. There are a number of techniques, including simulation, concerned with performance measurement available in the literature. These should be reviewed along with the issue of simulation to ensure that methods can be prescribed for the task elements identified in recommendation 1.

3. Accepting that entirely accurate simulations are technically extremely difficult to produce, and that they may be prohibitively expensive, effort needs to be directed towards developing techniques for combining evidence from tractable measurement methods to achieve valid job criterion scores. These techniques may combine expert judgement with expert systems technology.
SECTION 14: MEASURING VALIDITY

14.1 Discussion

Throughout this review, the question of the validity of selection methods has been at the forefront of discussion. Unless a selection method can be shown to be a valid predictor of job performance, its use cannot logically be justified. A great deal of the psychometric literature discussed in Section 2 and Section 4 is concerned with formal measurement of selection method validity. The most powerful method of demonstrating validity is by applying statistical methods to show that predictors correlate highly with performance criterion measures. However, Section 3, concerned with the characteristics of the process industries, described the methodological difficulties in achieving this. Section 4 on methodological developments in selection offered some potential techniques for overcoming some of these problems, but failed to produce wholly convincing evidence that this could be done. Section 6, reviewing published accounts of process operator selection also gave no cause for optimism.

An important point that must be emphasised is that validity and validity measurement are not the same thing. That is, a selection method can be valid, even if it cannot be shown to be so by application of a statistical technique. Even if we are unable to solve the problems associated with measurement of validity, steps can still be taken to make selection methods as valid as possible. This has been the argument behind the recommendations made in Sections 11, 12 and 13.

The formal measurement of validity fails due to its inability to obtain satisfactory validity coefficients, with regard to the dependency of scores on selection methods to criterion measures. Validity scores pertaining to particular jobs are low as a consequence of the introduction of error via statistical features. Controlling these features would precipitate a greater precision factor. Validity generalisation (as described in Section 4.5 and defined in the Glossary) should therefore be based on similar selection methods that incorporate evidence gained from parallel studies. Should no further statistical understanding be yielded from validity generalisation, the use of cognitive ability tests as a means of job prediction will remain as a powerful concept.

14.2 Recommendations

There is still hope that satisfactory methods for validating selection methods will be developed. However, this would appear to be a long shot and so no recommendation that concerted effort should be made to develop such methods has been made. It is recommended, however, that developments in this field be continually monitored.
SECTION 15: COGNITIVE APPROACHES TO SELECTION

15.1 Discussion

Section 4.7 discussed the issue of 'tests of cognitive ability'. A basic idea of this approach was described by Hunt (1983).

"Mental behaviour should be explained by identifying the processes involved in problem solving, rather than by producing abstract descriptions of the outcomes of thinking. In other words, intelligence should be defined in terms of individual differences in cognitive acts, rather than in terms of a person's position determined by an abstract set of factors".

The relevance of tests of cognitive ability has been emphasised throughout the report, but the traditional 'psychometric' approach to identifying such tests is insensitive to the requirements of specific process control tasks. In the traditional approach to psychometric test development, outlined in Section 3, the psychologist will label a test as a 'test of cognitive ability' by virtue of the kinds of criterion behaviour it predicts. For example, if a test correlates highly with deductive reasoning, then it could be classified as a test of deductive reasoning. If an occupational psychologist were to look for a test to predict, say, fault finding capability, then such a test may well be adopted. Such a test could, in principle, be shown to be a valid predictor if it were possible to correlate the scores on the test of sufficient numbers of people with their scores on a criterion test. However, as has been emphasised throughout the report, the conditions for collecting such data do not exist, due to the small numbers of people typically employed in these industries. Apart from this problem, it would be surprising if we did obtain a particularly high correlation. Fault diagnosis tasks are rarely purely deductive reasoning. People carry out real tasks by integrating a number of skills. Some of these variations are due to individual differences regarding the manner in which the problems are tackled. Moreover, a test designated 'deductive reasoning' is likely to encompass additional elements, for example memory and 'reading ability', rather than pure deductive reasoning. All tests derived from conventional psychometric methods should be qualified in this manner. Their link to the psychological factors they are claimed to represent is empirically determined and it is often unwise to assume they map closely to the behaviours for which selection is undertaken. At best psychometric cognitive tests serve as a gross predictor, enabling general personnel decisions to be taken. That is, by adopting a psychometric test we can argue that the selection made is better than if a psychometric test had not been used, because the method of selection is shown to correlate highly with the predictor. However, when the conditions for reliably measuring predictor and criterion in sufficient numbers cannot be made, one cannot resort to this sort of statistical reasoning to justify choice of a test.
In addition to the basic weaknesses of psychometric tests within the process control context, a further complication is the diverse pattern of actual skills required to carry out what, in reality, may be regarded as similar tasks. For example, operators who are required to examine plant problems and work out a course of action to overcome a plant disturbance may, superficially, be regarded as carrying out an activity demanding similar cognition. It is a fundamental tenet of human factors research, however, that human performance is an interaction of a number of factors. Thus, the extent to which a person is capable of dealing with a particular problem is influenced by:

(i) the manner in which the task and resources are represented to the operator - this is influenced by the display philosophy;

(ii) the frequency and range of problems and disturbances confronting the operator over the course of the working day - this is influenced by the technology, the product and managerial influences concerned with market requirements, and human resource management;

(iii) the nature of the training and support provided for operators - these factors are also consequences of management philosophy;

(iv) the manner in which different tasks are allocated between members of a shift team.

The list could be extended. This complexity means that a specific individual, in a specific context cannot automatically be assumed to be utilising the same skills as an operator undertaking a formally similar task in a different context. A major challenge to selection of process operators is to find ways of predicting the cognitive skills that are required in the given context by the operator. As the list above suggests, the operator's interaction with the plant needs to be modelled to identify the problems of interaction. This would entail establishing a method to describe how the plant presents information to the operator through displays and the manner in which this information should be handled. Thus, we would seek to identify, for example, the need for an operator to switch attention from small details to a broader picture, the extent to which the operator needs to handle information in a rapidly changing situation, and the extent to which the individual needs to cope with context specific cues versus more context free cues. Such a list would extend to a range of factors that might feature in a cognitive model of decision and action.

This sort of approach, based on cognitive psychology, would identify the cognitive demands to be placed on operators in accordance with operational demands. Thus, it would consider how an operator responds to the environment in which he or she is placed, assuming the training and aiding provided. It would seek to establish the strategies and knowledge to be brought to bear upon the task and the task environment in order to establish satisfactory performance.
This approach to selection would integrate other aspects of human factors which would seem, in principle, to be a sensible approach. It would include establishing the pros and cons of different cognitive styles.

To exploit this general approach, we would then need tests of the constituent abilities. Many tests that would be appropriate already exist, for example, tests of cognitive style. Other tests would need to be sifted from experimental literature and developed into a suitable form for personnel selection. The method for developing such tests would involve the established approaches of test development. But such tests would be created in accordance with an appropriate methodology of applying them in the process control context.

A practical cognitive approach would entail a number of research steps:

1. Establishing methods of representing the operator’s task in a useful fashion, taking account of the manner in which information is represented and the temporal pattern of task demands.

2. Establishing methods of modelling the mental operations of the type used in process control, in terms of a set of reliable descriptors. This would entail modelling information processing behaviour and appropriate knowledge.

3. Establishing reliable methods of describing the target process control task in terms of these descriptors, i.e. the information processing behaviour and the knowledge required.

4. Developing and appraising tests which reliably indicate the extent to which an applicant possesses or will acquire the appropriate information processing behaviour and knowledge.

15.2 Recommendations

The cognitive approach to selection shows promise in establishing an effective method for selection for process control jobs. However, the costs entailed in reaching a practical outcome cannot be underestimated. In view of this, it would not be practical to recommend a major research effort, but it is worthwhile trying to stimulate interest in this approach and maintain a watching brief on developments in the area. Section 4.7 discussed the issue of ‘tests of cognitive ability’. A basic idea of this approach was described by Hunt (1983).
PART V : SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Whilst based on a limited study, the following conclusions can be drawn with some confidence.

1. The context of process control places major constraints on designing and validating selection methods.

2. There is no evidence from the literature or from examining practices that fool-proof selection methods or the means to formally validate based on established psychometric approaches exist.

3. There is no really sound way of identifying selection criteria. A functional model is suggested as a method for doing this.

4. There is no evidence of systematic performance measurement being adopted in companies in the process industries. In the absence of such measures no attempt can be made to develop systematic validity measures.

5. While the research must be accepted with caution, there is a consensus that selection of process operators should take account of spatial, verbal, numeric and reasoning abilities, as well as screening for appropriate aspects of personality.

6. Even if adequate measures of operator performance were to be devised and adopted, the small samples, sample biases and the factors that can influence the relationship between criterion and predictor scores over time mean that computed validity coefficients in studies in the process industries are of dubious value. Several techniques are available to overcome this sort of problem. The extent to which these may be useful in the process industries may benefit from closer examination.

7. There appears to be a consensus of good practice within the process industries. This can form the basis of a principled approach to selection that can be recommended to other companies.
Recommendations

Several recommendations have been made in the report, and discussed mainly in Sections 11 to 15. These are as follows.

1. Concerning development of a principled approach to a selection methodology

1.1. That the framework setting out the principled approach to selection discussed in Section 11 be developed and used to collate best practice at the various stages and focus on areas for development.

1.2. That the framework should be published according to the current state of the art and updated regularly as progress is made in the development of better practices.

2. Concerning the Functional Model of Process Operation

It is recommended that attention be given to developing a functional model of process control tasks (Section 12) to enable company management more easily to identify suitable performance predictors when designing a selection method. Further development would include:

2.1. Developing the content of the model by further refinement and checking its content against analyses of other process control tasks.

2.2. Clarifying further the constituent personal attributes which are seen as useful selection criteria.

2.3. Investigating the selection suggestions made, to identify available selection methods and establish how they map onto the attributes identified in the model.

2.4. Developing the structure of the model and how it should be represented, and exemplified, to enable its use within a practicable selection methodology.

3. Development of Methods for Measuring Job Performance

Developing effective job criterion scores is crucial if progress is to be made to validate selection methods. Three recommendations are made.

3.1. Methods for analysis of tasks and categorisation of task elements should be reviewed to identify the different sorts of task element for which measurement needs to be made.
3.2. There are a number of techniques, including simulation, concerned with performance measurement available in the literature. These should be reviewed along with the issue of simulation to ensure that methods can be prescribed for the task elements identified in recommendation 3.1.

3.3. Accepting that entirely accurate simulations are technically extremely difficult to produce, and that they may be prohibitively expensive, effort needs to be directed towards developing techniques for combining evidence from tractable measurement methods to achieve valid job criterion scores.

4. Concerning Development of Effective Validation Methods

Clearly any methods to overcome the problems of calculating validity coefficients should be noted and developed. However, there are severe problems associated with such methods stemming from the nature of the process industries. We are not confident that a concerted attack on these issues would yield much benefit. So, we recommend that a watching brief be maintained on developments, rather than initiating any concerted research programme.

5. Development of Cognitive Approaches to Selection

The cognitive approach to selection would appear promising in dealing with several of the problems encountered by conventional psychometric methods. However, since this is a field fraught with its own methodological problems, it would not be practical to recommend a major research effort, but it is worthwhile trying to stimulate interest in this approach and maintain a watching brief on developments in the area.
REFERENCES


Hanson T J, and Balesteri-Spero, J C (1985): An alternative to interviews. Personnel Journal, 64, 14, 123.


APPENDIX I

Questionnaires Used in the Project
I. QUESTIONS FOR PERSONNEL (AND TRAINING) DEPARTMENTS

This section should be answered only by personnel and training staff

Line managements and operators should answer Part II, Section E only.

A. APPROACH TO SELECTION

A1 What approach do you take to recruit and select people, who will operate your company's process plants (both on plant and in the control room)? Please describe each step briefly.

A2 At what points in the selection process are decisions made in which some applicants are rejected and others selected?

On what basis are these decisions made?

A3 Is the selection process formal or informal? (For example a formal and rigidly defined procedure as opposed to informal recruitment from within the organisation).

A4 Which of the following do you consider to be important in selecting process operators for your plant?

- Aptitude
- Experience
- Ambition
- Qualifications
- "Personality" or "personal disposition"
- Other (please specify)

A5 Are process operators usually selected from a well defined target population? (For example, are control room operators usually drawn from a pool of plant operators, are they usually technically qualified at graduate level, or are they usually drawn from ex-military personnel?)

A6 Does company policy influence or limit the approach taken to selection?

B. CHOICE OF METHODS & TECHNIQUES

B1 What methods and techniques do you use in the selection process? (For example selection tests, recommendations by line management, interviews, specific requirements for qualifications or experience, etc.).

B2 Why was this approach, and these particular methods and techniques adopted?
B3  Do you use, or have you considered using, more formal methods in the selection process. 
    Why? or why not?

B4  Have any methods or techniques been discontinued? 
    Why?

C.  ISSUES IN THE APPLICATION OF METHODS

C1  Has the approach used for selection been validated either within or outside the company? 
    If so what methods of validation were used (if known).

C2  Have you encountered any particular problems with your approach to process operator selection?

C3  Are there any improvements you feel could enhance your current approach to selection?

Please add any further comments you would like to make, or note issues you wish to raise.

D.  PERSONNEL INVOLVED IN THE SELECTION PROCESS

D1  Which personnel from within the company are involved in the selection process with respect to process operator selection?

D2  Which stages of the selection process do they contribute to? 
    What is their role at each stage?

D3  Do you use or have you used, external consultants in setting up and/or carrying out the selection process?

D4  If so, what is their involvement in the process and what in particular do they contribute?

Please add any further comments you would like to make, or note issues you wish to raise.
II. QUESTIONS FOR LINE MANAGEMENT AND PROCESS OPERATORS

Personnel and training staff should not complete the following Section E.

E1 How important do you think the selection process is in providing operators for your company's process plants.

E2 Are you involved in the selection and recruitment of personnel who will work for you, with you or elsewhere in the company?

E3 If so what is your role and which decisions are you involved in?

E4 Do you have a role in deciding what approach is taken to the selection/recruitment of operators and which selection methods are used?

E5 Have you had any involvement in validating the selection methods used by your company?

Please add any further comments you would like to make, or note issues you wish to raise.
APPENDIX II

Sources of Literature Reviewed
Literature Sources

The following journals were referred to, from 1970 to the present, to identify papers relevant to selection in process control.

* Annual Review of Psychology
* Cognition
* Ergonomics
* Human Factors
* International Journal of Man Machine Studies
* Journal of Applied Psychology
* Journal of Occupational Psychology
* Perceptual and Motor Skills
* Personnel Psychology
* Psychological Bulletin
APPENDIX III

Reports of Companies Visited

This appendix provides visit reports of a further 7 company contexts to supplement the cases discussed in Section 7. The reports are an interpretation of interviews with often more than one person in each company and so, some reconciliation of opinions offered has had to be made. This has not prevented any novel contributions to be included from any company. The cases are described under a set of standard headings. These are described overleaf.

The additional evidence from these cases is consistent with the conclusions drawn from the 3 cases discussed more fully in Section 7.
<table>
<thead>
<tr>
<th>COMPANY:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Background to recruitment</td>
<td>This discusses any special features which characterise the</td>
</tr>
<tr>
<td></td>
<td>company, relevance to the selection process. For example,</td>
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<td></td>
<td>it may discuss local difficulties or the hazardous nature of</td>
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<td></td>
<td>processes.</td>
</tr>
<tr>
<td>Product Range</td>
<td>This describes the types of products made.</td>
</tr>
<tr>
<td>Type of work</td>
<td>This states the type of processing, batch and/or continuous</td>
</tr>
<tr>
<td></td>
<td>process control.</td>
</tr>
<tr>
<td>Training/accreditation philosophies</td>
<td>This states whether the company subscribes to any general</td>
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<tr>
<td></td>
<td>training schemes, which might have wider implications</td>
</tr>
<tr>
<td></td>
<td>regarding qualification and, hence, attractiveness of the</td>
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<td></td>
<td>post, e.g. City and Guilds. Such schemes are quite common but</td>
</tr>
<tr>
<td></td>
<td>not as common as might be expected.</td>
</tr>
<tr>
<td>Commitment to long term employment</td>
<td>This describes whether the company anticipates long term</td>
</tr>
<tr>
<td></td>
<td>employment for applicants, or whether no such commitment can</td>
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<td></td>
<td>be undertaken. Company's vary considerably here. This is</td>
</tr>
<tr>
<td></td>
<td>generally a market issue.</td>
</tr>
<tr>
<td>Range of selection criteria</td>
<td>This describes the factors the company sees as particularly</td>
</tr>
<tr>
<td></td>
<td>relevant to the selection process.</td>
</tr>
<tr>
<td>Other functions of selection process</td>
<td>This is filled in where the company has declared some</td>
</tr>
<tr>
<td></td>
<td>general purpose of selection, e.g. providing the</td>
</tr>
<tr>
<td></td>
<td>opportunity for applicants to see the nature of work for</td>
</tr>
<tr>
<td></td>
<td>themselves. This opportunity for self-rejection is typical,</td>
</tr>
<tr>
<td></td>
<td>of some companies</td>
</tr>
<tr>
<td>Assessment of staffing needs</td>
<td>This describes what steps the company takes to decide how</td>
</tr>
<tr>
<td></td>
<td>many staff and against what criteria to select. Sometimes</td>
</tr>
<tr>
<td></td>
<td>this is done systematically, but often there are no obvious</td>
</tr>
<tr>
<td></td>
<td>steps taken.</td>
</tr>
<tr>
<td>Advertising</td>
<td>This describes the general approach adopted in advertising</td>
</tr>
<tr>
<td></td>
<td>for applicants.</td>
</tr>
<tr>
<td>Screening of application forms</td>
<td>Application forms are used throughout. Specific comments</td>
</tr>
<tr>
<td></td>
<td>may not be made here.</td>
</tr>
<tr>
<td>Selection testing</td>
<td>This describes whether or not psychometric tests are</td>
</tr>
<tr>
<td></td>
<td>adopted and the types of tests used. Use of tests is quite</td>
</tr>
<tr>
<td></td>
<td>common.</td>
</tr>
<tr>
<td>Selection panel</td>
<td>This describes the make-up of the selection panel, whether</td>
</tr>
<tr>
<td></td>
<td>these people are trained in interviewing, generally how</td>
</tr>
<tr>
<td></td>
<td>long interviews take and what evidence is sought.</td>
</tr>
<tr>
<td>References/vetting</td>
<td>References are common, as are medical reports. Usually these</td>
</tr>
<tr>
<td></td>
<td>take place after short-listing.</td>
</tr>
<tr>
<td>Validation</td>
<td>This describes what steps are taken, if any, to validate</td>
</tr>
<tr>
<td></td>
<td>selection methods. As expected, this is done, generally</td>
</tr>
<tr>
<td></td>
<td>poorly in contrast to the prescriptions of psychometric tests.</td>
</tr>
<tr>
<td></td>
<td>There is also no evidence of really effective criterion</td>
</tr>
<tr>
<td></td>
<td>measurement and little attempt at criterion</td>
</tr>
<tr>
<td>COMPANY:</td>
<td>4</td>
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<tr>
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</tr>
<tr>
<td>Background to recruitment</td>
<td>- Local external recruitment, of 16-17.5 year olds</td>
</tr>
<tr>
<td></td>
<td>- Two intakes per year</td>
</tr>
<tr>
<td></td>
<td>- Internal recruitment</td>
</tr>
<tr>
<td>Product Range</td>
<td>Reprocessing</td>
</tr>
<tr>
<td>Type of work</td>
<td>Batch/continuous process control in safety critical context</td>
</tr>
<tr>
<td>Training/accreditation philosophies</td>
<td>- Junior process worker training scheme</td>
</tr>
<tr>
<td></td>
<td>- training over 2 years</td>
</tr>
<tr>
<td>Attitude to selection</td>
<td>Positive</td>
</tr>
<tr>
<td>Commitment to long term employment</td>
<td>- Intention for long term employment</td>
</tr>
<tr>
<td></td>
<td>- Initially offer 2-year fixed term contract training</td>
</tr>
<tr>
<td></td>
<td>- Probationary period</td>
</tr>
<tr>
<td></td>
<td>- New contract offered</td>
</tr>
<tr>
<td>Range of selection criteria</td>
<td>- Application forms</td>
</tr>
<tr>
<td></td>
<td>- Interviews</td>
</tr>
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<td></td>
<td>- Psychometric tests</td>
</tr>
<tr>
<td></td>
<td>- Qualifications (GCSE)</td>
</tr>
<tr>
<td></td>
<td>- School reports</td>
</tr>
<tr>
<td></td>
<td>- References</td>
</tr>
<tr>
<td>Other functions of selection process</td>
<td>None special</td>
</tr>
<tr>
<td>Stages in selection process</td>
<td>Typical for this type of company</td>
</tr>
<tr>
<td>Assessment of staffing needs</td>
<td>- Plant requirements</td>
</tr>
<tr>
<td>Advertising</td>
<td>- Local press</td>
</tr>
<tr>
<td></td>
<td>- Schools career service</td>
</tr>
<tr>
<td></td>
<td>- Careers fairs</td>
</tr>
<tr>
<td>Screening of application forms</td>
<td>- Numerical reasoning test</td>
</tr>
<tr>
<td>Selection testing</td>
<td>- Verbal reasoning test</td>
</tr>
<tr>
<td>Selection panel</td>
<td>- 30 minute interview</td>
</tr>
<tr>
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<td>- 2 interviewers training dept rep and technical rep</td>
</tr>
<tr>
<td></td>
<td>- Interviewers are trained</td>
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<td></td>
<td>- Explores chemistry, physics/engineering concepts, technical reasoning</td>
</tr>
<tr>
<td>Final selection</td>
<td>- Short list of about 70 after testing</td>
</tr>
<tr>
<td></td>
<td>- 36 plus reserves eventually selected each year</td>
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<tr>
<td>References/vetting</td>
<td>- Medical vetting after shortlisting by site doctor</td>
</tr>
<tr>
<td></td>
<td>- Personal references essential</td>
</tr>
<tr>
<td>Validation</td>
<td>- No specific method</td>
</tr>
<tr>
<td></td>
<td>- Interviews by plant management after training</td>
</tr>
<tr>
<td>Use of outside advice</td>
<td>Use consultants for selection and training advice</td>
</tr>
<tr>
<td>Use of outside advice</td>
<td>Validation</td>
</tr>
<tr>
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</tr>
<tr>
<td>Medical testing after sterilizing by the doctor</td>
<td>Personal refs essential</td>
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<tr>
<td>Personal skills essential</td>
<td>Personal refs essential</td>
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<td>Personal refs essential</td>
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<td>COMPANY:</td>
<td>6</td>
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<td>-------------------------------------------------------------------</td>
</tr>
<tr>
<td>Background to recruitment</td>
<td>- Water-based, non-toxic processes</td>
</tr>
<tr>
<td></td>
<td>- Multiple sites</td>
</tr>
<tr>
<td></td>
<td>- Different levels of automation on different sites</td>
</tr>
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<td></td>
<td>- Difficulty in obtaining adequate responses to adverts</td>
</tr>
<tr>
<td></td>
<td>- Lack of development/promotion opportunity</td>
</tr>
<tr>
<td>Product Range</td>
<td>- Foodstuffs</td>
</tr>
<tr>
<td>Type of work</td>
<td>Batch process control</td>
</tr>
<tr>
<td>Training/accreditation</td>
<td>- Positive</td>
</tr>
<tr>
<td>philosophies</td>
<td></td>
</tr>
<tr>
<td>Attitude to selection</td>
<td>- Large component of casual, seasonal labour</td>
</tr>
<tr>
<td>Commitment to long term</td>
<td>- Age range sought can reflect need to maintain</td>
</tr>
<tr>
<td>employment</td>
<td>- manpower age distributions</td>
</tr>
<tr>
<td>Range of selection criteria</td>
<td>- Application forms</td>
</tr>
<tr>
<td></td>
<td>- Interviews</td>
</tr>
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<td></td>
<td>- Psychometric tests</td>
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<td>- Qualifications (GCSE)</td>
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<td></td>
<td>- School reports</td>
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<td></td>
<td>- References</td>
</tr>
<tr>
<td>Other functions of selection</td>
<td>- Management perception of requirements</td>
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<tr>
<td>process</td>
<td>- Local advertisements</td>
</tr>
<tr>
<td>Stages in selection process</td>
<td>Standard form</td>
</tr>
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<td>Assessment of staffing needs</td>
<td>- Manual Dexterity</td>
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<tr>
<td>Advertising</td>
<td>- Personality profile (specifically seeking high values)</td>
</tr>
<tr>
<td>Screening of application</td>
<td>- Local management</td>
</tr>
<tr>
<td>forms</td>
<td>- Personnel manager</td>
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<td>Selection testing</td>
<td></td>
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<tr>
<td>Selection panel</td>
<td></td>
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<td>Final selection</td>
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</tr>
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<td>References/vetting</td>
<td></td>
</tr>
<tr>
<td>Validation</td>
<td>- No formal method</td>
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<tr>
<td>Use of outside advice</td>
<td></td>
</tr>
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<td>COMPANY:</td>
<td>7</td>
</tr>
<tr>
<td>--------------------------------------</td>
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</tr>
<tr>
<td>Background to recruitment</td>
<td>- To serve needs of oil industry</td>
</tr>
<tr>
<td></td>
<td>- Recruitment of some 16 - 17.5 year olds</td>
</tr>
<tr>
<td>Product Range</td>
<td>Oil-drilling</td>
</tr>
<tr>
<td>Type of work</td>
<td>Continuous process control</td>
</tr>
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<td>Training/accreditation philosophies</td>
<td>Positive</td>
</tr>
<tr>
<td>Attitude to selection</td>
<td>- Not really, aimed at meeting current needs</td>
</tr>
<tr>
<td>Commitment to long term employment</td>
<td>- Application forms</td>
</tr>
<tr>
<td></td>
<td>- Age profiles</td>
</tr>
<tr>
<td>Range of selection criteria</td>
<td>- Qualifications</td>
</tr>
<tr>
<td></td>
<td>- Motivation and good attitude</td>
</tr>
<tr>
<td></td>
<td>- Interviews</td>
</tr>
<tr>
<td></td>
<td>- References</td>
</tr>
<tr>
<td></td>
<td>- Past experience (e.g. experience of way of life)</td>
</tr>
<tr>
<td></td>
<td>- Impressions regarding fitting in</td>
</tr>
<tr>
<td></td>
<td>- Resistance to stress (as judged in interview situation)</td>
</tr>
<tr>
<td>Stages in selection process</td>
<td>- To emphasise nature of work, working shifts off-shore</td>
</tr>
<tr>
<td>Assessment of staffing needs</td>
<td>Typical</td>
</tr>
<tr>
<td>Advertising</td>
<td>- Basic technical audit</td>
</tr>
<tr>
<td>Screening of application forms</td>
<td>- Local advertisements</td>
</tr>
<tr>
<td></td>
<td>- Roadshow</td>
</tr>
<tr>
<td></td>
<td>- Careers talks</td>
</tr>
<tr>
<td>Selection testing</td>
<td>Yes</td>
</tr>
<tr>
<td>Selection panel</td>
<td>- basic maths (without calculators)</td>
</tr>
<tr>
<td></td>
<td>- basic english</td>
</tr>
<tr>
<td></td>
<td>- mechanical reasoning test</td>
</tr>
<tr>
<td>Final selection</td>
<td>- At least one interview at different stages of the selection process</td>
</tr>
<tr>
<td></td>
<td>- Looks for motivation, observations around plant</td>
</tr>
<tr>
<td></td>
<td>- Off-shore personnel used</td>
</tr>
<tr>
<td></td>
<td>- Personnel (trained in interviewing)</td>
</tr>
<tr>
<td>References/vetting</td>
<td>Security vetting required</td>
</tr>
<tr>
<td>Validation</td>
<td>- Skills assessed and compared with group norms</td>
</tr>
<tr>
<td>Use of outside advice</td>
<td></td>
</tr>
<tr>
<td>COMPANY:</td>
<td>8</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Background to recruitment</td>
<td>- To serve needs of oil industry</td>
</tr>
<tr>
<td></td>
<td>- No strong career opportunities</td>
</tr>
<tr>
<td></td>
<td>- Often agency staff recruited</td>
</tr>
<tr>
<td></td>
<td>- Intensive training given to obviate too much reliance on selection</td>
</tr>
<tr>
<td>Product Range</td>
<td>Oil-exploration</td>
</tr>
<tr>
<td>Type of work</td>
<td>Continuous process control</td>
</tr>
<tr>
<td>Training/accreditation philosophies</td>
<td>Positive</td>
</tr>
<tr>
<td>Attitude to selection</td>
<td>- Not really, aimed at meeting current needs</td>
</tr>
<tr>
<td>Commitment to long term employment</td>
<td>- Application forms</td>
</tr>
<tr>
<td></td>
<td>- Interviews</td>
</tr>
<tr>
<td></td>
<td>- References</td>
</tr>
<tr>
<td></td>
<td>- Past experience (e.g. experience of way of life)</td>
</tr>
<tr>
<td></td>
<td>- Impressions regarding fitting in</td>
</tr>
<tr>
<td></td>
<td>- Resistance to stress (as judged in interview situation)</td>
</tr>
<tr>
<td>Range of selection criteria</td>
<td>Other functions of selection process</td>
</tr>
<tr>
<td>Stages in selection process</td>
<td>Stages in selection process</td>
</tr>
<tr>
<td>Assessment of staffing needs</td>
<td>Assessment of staffing needs</td>
</tr>
<tr>
<td>Advertising</td>
<td>Advertising</td>
</tr>
<tr>
<td>Screening of application forms</td>
<td>Screening of application forms</td>
</tr>
<tr>
<td>Selection testing</td>
<td>Selection testing</td>
</tr>
<tr>
<td>Selection panel</td>
<td>Selection panel</td>
</tr>
<tr>
<td>Final selection</td>
<td>Final selection</td>
</tr>
<tr>
<td>References/vetting</td>
<td>References/vetting</td>
</tr>
<tr>
<td>Validation</td>
<td>Validation</td>
</tr>
<tr>
<td>Use of outside advice</td>
<td>Use of outside advice</td>
</tr>
<tr>
<td>Concluding remarks</td>
<td>Concluding remarks</td>
</tr>
</tbody>
</table>

- Basic technical audit
- Local advertisements
- Engineers from platform (probably untrained in interviewing)
- Personnel (trained in interviewing)
Security vetting required
- No formal method
### COMPANY:

**Background to recruitment**

- To serve needs of oil industry
- Process apprenticeships available, developed through local training schemes
- Extensive recruitment from within company or, at least, from within process industries
- In-company recruitment means that detail personnel knowledge is known
- Little opportunity for change other than supervisory jobs

**Product Range**

**Type of work**

**Training/accreditation philosophies**

**Attitude to selection**

**Commitment to long term employment**

**Range of selection criteria**

#### Other functions of selection process

- Basic technical audit
- Advertisements run for 5 - 6 weeks to obtain good pool of applicants

#### Stages in selection process

- Selection panel includes personnel officer and production engineer who jointly decide selection criteria
- Application forms
- Interviews
- References
- Past experience (up to 5 years in process industries)
- Evidence of safe operations
- Resistance to stress (as judged in interview situation)

### Attitude to selection

**Positive**

- Not really, aimed at meeting current needs

### Commitment to long term employment

**Attitude to selection**

**Commitment to long term employment**

**Range of selection criteria**

#### Other functions of selection process

- Basic technical audit
- Advertisements run for 5 - 6 weeks to obtain good pool of applicants

#### Stages in selection process

- Selection panel includes personnel officer and production engineer who jointly decide selection criteria
- Application forms
- Interviews
- References
- Past experience (up to 5 years in process industries)
- Evidence of safe operations
- Resistance to stress (as judged in interview situation)

### Use of outside advice

- UK nationals security vetting
- Generally no systematic validation, but there is a staff development process
- In-company specialists
<table>
<thead>
<tr>
<th>COMPANY:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background to recruitment</td>
</tr>
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<td>Product Range</td>
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<tr>
<td>Type of work</td>
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<td>Range of selection criteria</td>
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<tr>
<td>Other functions of selection process</td>
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<tr>
<td>Stages in selection process</td>
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<tr>
<td>Assessment of staffing needs</td>
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<tr>
<td>Advertising</td>
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<tr>
<td>Screening of application forms</td>
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<td>Selection testing</td>
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<tr>
<td>Selection panel</td>
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<tr>
<td>References/vetting</td>
</tr>
<tr>
<td>Validation</td>
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<td>Use of outside advice</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Ageing work population</td>
</tr>
<tr>
<td>- Currently recruiting temporary operators</td>
</tr>
<tr>
<td>- Good training provision</td>
</tr>
<tr>
<td>- Multiple sites, recruit locally</td>
</tr>
<tr>
<td>- Initial recruitment to company into manual work, then recruitment to process work</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
</tr>
<tr>
<td>Batch and continuous process control</td>
</tr>
<tr>
<td>Positive</td>
</tr>
<tr>
<td>- Little currently, mainly aimed at meeting current needs</td>
</tr>
<tr>
<td>- Performance in previous employment</td>
</tr>
<tr>
<td>- Maturity</td>
</tr>
<tr>
<td>- Technical/academic ability, intellectual capability, logical thinking</td>
</tr>
<tr>
<td>- Dependability</td>
</tr>
<tr>
<td>- Health</td>
</tr>
<tr>
<td>- Attendance record</td>
</tr>
<tr>
<td>- Familiarity with shiftwork</td>
</tr>
<tr>
<td>- Will fit in socially with shift</td>
</tr>
<tr>
<td>- Interviews</td>
</tr>
<tr>
<td>- References</td>
</tr>
<tr>
<td>- According to plant requirements</td>
</tr>
<tr>
<td>- Local advertisements</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>- Personnel officer and Line manager Final selection</td>
</tr>
<tr>
<td>- Subjective</td>
</tr>
<tr>
<td>- Record of mistakes</td>
</tr>
</tbody>
</table>
APPENDIX IV

Suggested Guide to Process Operator Selection
SELECTING PROCESS OPERATORS

Proper selection of process operators is important to ensure that people are recruited who will respond well to training and become conscientious and effective process operators. It is impossible to offer a simple prescription for operator selection as the needs of different companies vary so much. The following guidelines are designed to help companies develop effective selection procedures.

Some basic ideas about selection.

- Selection is the process of choosing people for jobs to ensure that they will respond well to training and then perform well at the tasks for which they are recruited.

- Selection is carried out by considering the information available about the applicant, then using this information to predict how the applicant would fare if recruited into the company.

- Selection will not overcome poor training, poor design or poor supervision and management.

- While we obviously try to recruit the best people available in any set of circumstances, we can never guarantee that this has been achieved.

- Selection is a decision process. By using a range of different sorts of information, gathered carefully, we try to make the best match we can. We try to avoid selecting people who will be unable to fulfil expectations and try to avoid rejecting people who would do well.

- The ideal method of showing that a selection method really works is to show that the selection decision predicts the subsequent performance of the people selected. In process control contexts, it is rarely, if ever, possible to demonstrate this wholly convincingly. This is due to a number of factors, including, the small numbers of people selected in relation to the numbers of people rejected for any job. Another major problem is that it is difficult to judge accurately how good a person is at all aspects of the job, especially since some critical process control tasks occur infrequently.

- These steps in designing selection procedures for process control, outlined in the following guide, are based on the practices of a number of companies experienced in selection.
Stages in the Selection of process operators

1. Determine WHEN to commence a recruitment programme

2. Assess requirements: number of people to be recruited; attributes to be sought

3. Design the selection process (select methods etc)

4. Advertise for applicants

5. Screen applicants' forms

6. Help applicants decide whether they really want the job you're offering

7. Carry out selection testing

8. Carry out interviews

9. Make decisions

10. Vet applicants (reference and health checks)

11. Follow up selection process to validate
1. Determine WHEN to commence a recruitment programme

- When to undertake recruitment rests with individual companies and depends on the need to ensure that all plants will be satisfactorily manned and operated to a high standard of productivity and safety.

- An annual or more frequent recruitment programme may be advisable. This may be due to staff turnover or promotion. If staff turnover is a problem, selection may not be the only thing that should be looked at.

- Some companies may prefer to recruit as and when they need new staff. However, new staff need training and it may be uneconomical to mount a training programme for individual operators.

- Some companies operate flexibly and efficiently by carrying out a regular audit of recruitment needs.

- Whatever pattern of recruitment is followed, setting up the various stages of the recruitment process takes time. It is impossible to respond instantaneously to a recruitment need in the process control context and also maintain selection standards. Each step in the selection and recruitment process and the means by which each step will be tackled should be set out. This will enable effective selection to be mounted in the shortest period possible and so, enable selection to be most responsive to the company's needs.

A recruitment procedure for the company should be worked out to ensure that the lead time of the recruitment process and the resources required can be accurately judged - see stage 3.
2. Assess requirements: number of people to be recruited, attributes to be sought

- Different companies design their jobs in different ways.
- Some incorporate maintenance duties, for example. This affects the qualifications sought.
- Some companies expect process operators to deal with most problems that arise, while others expect operators to refer problems to other, more experienced or qualified members of an operating team. This can affect the need to recruit people who are effective at problem solving.
- In some processes, there is a high physical component, so that appropriate physical fitness needs to be sought.
- A job or task analysis should be undertaken to establish the skills, knowledge and other attributes to be sought in a particular recruitment programme.
- While effort is made to examine recruitment criteria through the adoption of job analysis, attention should be paid to training needs and the design of operating instructions and other aspects of the workplace. It may be possible to simplify selection requirements, and generally improve plant performance, by attending to these other factors.

Careful appraisal of job requirements should be made by systematic application of job or task analysis. In addition to focusing carefully on the skills and attributes that each job requires, it will help identify problems which cannot be solved by selection.
3. Design the selection process (select test methods etc)

- Each part of the job must be examined to identify the best method of assessment. Some parts may not benefit from selection but must rely on training.

- Aspects such as willingness to accept responsibility, coping with shiftwork, or working in dirty environments, may be assessed by considering employment history.

- Ability to cope with complex problems or with stress may be assessed through a psychological test.

- Information on which to base selection decisions may be gleaned from a number of sources:
  - application forms
  - aptitude tests
  - interviews
  - references.

- It becomes increasingly costly to process each applicant. Therefore, an aim of any stage is to reduce the applicant numbers for consideration at later stages.

- However, reducing numbers too drastically at any stage, reduces the pool of potentially suitable applicants, e.g. rejecting too many people by application form and test results could result in insufficient numbers of suitable people at the interview stage, so that the recruitment exercise has to be repeated.

- Selection processes must not discriminate unfairly on grounds of sex or race.

- Outside consultants can be helpful in developing a fair selection process suited to the needs of a particular company.

A selection process must be designed which collects information about each applicants by a variety of methods most suited to making sound and fair decisions.
4. Advertise for applicants

- Advertising for applicants should be based on general personnel practices.

- There are important local and regional variations concerning the best ways to recruit a satisfactory pool of applicants.

- A key feature is whether there are other industries locally where relevant experience may be sought. This experience may be technical, e.g. familiarity with process operations, or it may be a familiarity with certain sorts of work organisation, e.g. shiftwork. This will affect the extent to which it is possible to recruit locally or whether a wide net needs to be cast.

- Advertising for applicants can be through local or national press, recruitment agencies, colleges, employment-fairs, etc.

- It is important to recognise that the advertisement (through whatever medium) is the first step in the selection process. It is clearly better to attract an excessive number of people through the advertisement, rather than risk attracting too few applicants.

The aim of the advertisement is to attract sufficient numbers of people who are likely to be worth considering, whilst deterring people who would be unsatisfactory.
5. Screen application forms

- Application forms should be designed carefully, to anticipate what information can be sensibly collected concerning subsequent employment for process control.

- As well as the typical biographical information, effort should be made to establish the type of work experience the applicant has had, rather than simply where they have been employed.

- If the application form has been well designed and establishes pertinent information as identified in the job analysis, the process of screening the forms, to determine who should be brought forward for more detailed consideration, should be straightforward.

- The purpose of screening application forms is to reject obviously unsuitable candidates and then to select, from the remainder, a group of people who will be subjected to greater scrutiny at later stages of the recruitment process. However, there is danger in rejecting too many people too early as there is a risk of being left with insufficient people for later examination.

Application forms should be designed carefully to facilitate the selection of a group of people who will subsequently be subjected to greater scrutiny.
6. Help applicants decide whether they really want the job you are offering

- Applicants may withdraw on their own volition at any stage. This may be as they come to recognise the true nature of the job and the impact it will have on their lives e.g. shiftwork. It is worth making an effort to show applicants what the job consists of, so they can make these personal decisions before spending, unnecessarily on interviews and training.

- Helping people make up their own minds may be carried out throughout the recruitment process, from the job advertisement onwards.

- When applicants are brought forward for attitude testing, there is an opportunity to provide a clearer picture of the nature of the work, for example by giving a talk to a group of applicants or by showing them a video of the plant and the work carried out.

- When applicants are brought forward for interview, there is an opportunity to provide a tour of the plant. This can also provide an opportunity for questioning applicants about what they have seen, to establish how observant or motivated they are.

These exposures to the plant and the job should be realistic. Deterring suitable applicants would be a mistake, but if someone should judge that they do not wish to undertake this sort of work, the costs of subsequent selection stages and of training will have been saved.
7. Carry out selection testing

- Selection tests are tests which have been designed with some rigour to provide fair and objective assessments of applicants.

- Appropriate tests will have been chosen in Stage 3. In principle, the tests chosen will depend on the specific nature of the job in question. In practice, most selection processes for process control rely on assessing:
  - numerical ability
  - spatial ability
  - verbal reasoning
  - problem solving.

- A number of different psychological tests may be used to assess these attributes.

- Given that appropriate selection methods have been chosen, they must be carried out carefully. This means that they should be conducted in accordance with the test instructions issued with the test. These instructions include test timings, the instructions that should be read to the people being tested, whether the test is given in groups or individually and marking criteria.

- Following these instructions carefully is essential to ensure that the measures made are as reliable as possible.

- Selection testing tends to be used by companies as a stage in the filtering process to focus on likely candidates and tends not to be used as the ultimate selection method, to arrive at the final group of people to be offered jobs.

- Some tests must be administered by qualified people, possibly people holding a qualification in psychology of personnel management or people who have attended a course with a test distribution agency.

- Recruitment consultants may be used to recommend, administer, score and interpret psychological tests.
8. Carry out interviews

- Companies rely on interviews. This is often for the purpose of involving line management in selection decisions. In this respect the interviews serve not just to select people, but to make line management committed to the people selected. This is a good personnel practice.

- Although interviews remain the central method of finalising personnel selection in most companies, it should be recognised that it is very difficult to make sound judgements on the basis of an interview.

- To overcome these problems, every effort should be made to ensure that interview decisions are as valid as possible.

- To make interviews as effective as possible, they should be carefully planned to establish what information should be sought and what questions should be asked to collect it.

- Interviewers should be trained in interviewing.

- Both personnel and operating staff should be involved in interviews.

**Interviewers should:**

- decide what the purpose of the interview is to be
- know the job requirements of the job to be filled
- recognise the public relations implications of the interview
- allow the applicant time to talk
- be aware of the need to avoid bias in interviewing persons of race, sex, beliefs.
9. Make decisions

- It is difficult to generalise about the best way to use available information to reach a decision. This can vary from company to company.

- Some companies rely solely on interview information to make a final decision, using the testing simply as a device for filtering out unsuitable applicants.

- It may be best for a panel of operating and personnel staff, who have been involved in the selection process to weigh all available evidence.

- The important thing is that every effort has been made to be as objective and consistent as possible and to be able to justify each decision against the needs of the company as established in Stage 2.

10. Vet applicants (references and health checks)

- When decisions have been made, job offers are typically made subject to satisfactory references, medical examination and, possibly, security vetting.
11. Follow up selection process to validate

- Once recruitment has been completed, there remains the question of whether the decisions made were the right ones. If the people recruited were unsatisfactory in some respect, steps should be taken to improve future recruitment exercises.

- Establishing whether a recruitment process is satisfactory is known as validation.

- Validation should be undertaken formally by establishing how well people carry out the job, then linking this to their scores on the various selection components.

- In some industries measuring work performance and relating it to selection scores is straightforward. This is rarely straightforward in process control. It is still essential, though, to make every realistic effort to establish whether the selection method adopted has served the company most effectively.

- A number of practical steps can be taken:

  - A performance appraisal should establish the operator's strengths and weaknesses. This may point to areas for improving selection, as well as pointing to individual or general training needs.

  Where formal measures of performance can be made, in terms of productivity or accident records, these should supplement staff appraisal data.

  - There are no wholly proven methods for measuring performance of process operators that are practical and effective. Such developments may be forthcoming in the future.

\[\text{The validation of selection tests is crucial. While no comprehensive proven method can be offered at the present time, companies should nevertheless estimate whether or not their selection methods are as effective as they could be, and should take steps to rectify deficiencies.}\]
Numbers to Consider at each stage

- The filtering process implied by Stage 3 to 8 are designed to reduce the numbers of applicants to be considered at each stage. However, it is not obvious what numbers should be considered. There can be no hard and fast rules.

- If too many people are removed at each stage, there is a danger that insufficient people will remain to meet the required criteria at the later stages, or even want to take up the job. If this mistake is made, there will be considerable costs incurred in readvertising the job and repeating the process, as well as the costs entailed in not having adequate staffing.

- Keeping too many people in at each stage will make subsequent discrimination that much more difficult. It will also increase the costs of later stages, since more people will need to be interviewed.

- As a simple guide, for each job on offer, 20 to 25 people should be tested to produce 4 to 5 people to be considered at interview. It is to be hoped that all of the candidates brought forward for interview would be capable of doing the job.

There are often good local reasons for tailoring the selection process to the company's specific needs. The above guidelines generally conform to good practice in the process industries. Variations may be entirely justified in line with good personnel and management practices.
APPENDIX V

Selection Practices in Foreign Nuclear Utilities

This appendix provides further insight into the selection criteria and practices in Foreign Nuclear Utilities to supplement Section 9. The reports are in response to those questions stated in Appendix 1 and are therefore described under a set of standard headings.
Utility No 1

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities' Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A formalised and intensive selection process exists in order to ensure the right calibre person is employed for Operating. Applicants are measured against a profile (man specification), which is considered to be the ideal operator.</td>
</tr>
<tr>
<td></td>
<td><strong>Stages:</strong></td>
</tr>
<tr>
<td></td>
<td>1. Pre screening/shortlisting</td>
</tr>
<tr>
<td></td>
<td>2. Technical Questionnaire</td>
</tr>
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<td></td>
<td>3. Interview by line and personnel representatives</td>
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<td></td>
<td>4. Psychometric testing</td>
</tr>
<tr>
<td></td>
<td>5. Pre-employment radiological medical examination and security clearance</td>
</tr>
<tr>
<td></td>
<td>7. Final Recommendation</td>
</tr>
<tr>
<td>A2</td>
<td>Applicants can be rejected at any of the above-mentioned specified stages 1-7</td>
</tr>
</tbody>
</table>

Decisions are based on the following for the different stages:

1. Can be numerous reasons such as qualification, experience, pay package too high, criminal record.

2. Level of basic knowledge on maths, science and power plant to elementary.

3. Compliance to the job and man specifications for the specific position in operating.

4. Specialist recommendation by Station Psychologist on personality and cognitive abilities.

5. Specialist recommendation by medical doctor and security department.

6. Recommendation by NIPR.
Utility No 1 Cont’d

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities’ Answer to Each Question</th>
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<tbody>
<tr>
<td>A3</td>
<td>Formal</td>
</tr>
<tr>
<td>A4</td>
<td>- Aptitude</td>
</tr>
<tr>
<td></td>
<td>- Experience</td>
</tr>
<tr>
<td></td>
<td>- Personality</td>
</tr>
<tr>
<td></td>
<td>- Trainability</td>
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<td></td>
<td>- Enquiring Mind</td>
</tr>
<tr>
<td></td>
<td>- Adaptability to shift work</td>
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<tr>
<td></td>
<td>- Keenness to learn</td>
</tr>
<tr>
<td></td>
<td>- Team Worker</td>
</tr>
<tr>
<td></td>
<td>- Commitment</td>
</tr>
<tr>
<td>A5</td>
<td>School-leavers and in general from other heavy industries and overseas. Selection does not take place from a defined type of population.</td>
</tr>
<tr>
<td>A6</td>
<td>Company policy regarding recruitment is to first consider internal applications and then external. Company policy does not limit intakes.</td>
</tr>
<tr>
<td>B1</td>
<td>As mentioned in A1</td>
</tr>
<tr>
<td>B2</td>
<td>To ensure employment of the right calibre person, for security reasons and as part of the licensing requirements.</td>
</tr>
<tr>
<td>B3</td>
<td>Already formal. This method was adopted to ensure a certain standard.</td>
</tr>
<tr>
<td>B4</td>
<td>No</td>
</tr>
<tr>
<td>C1</td>
<td>Post-employment interviews 3 to 6 months after employment with the new employee and supervisor. Performance Appraisals.</td>
</tr>
<tr>
<td>C2</td>
<td>This is a long process (+ or - 2 months until offer is made) has led to loss of candidates. Ratio of applicants considered vs appointment is high due to the strict selection process, which makes it costly.</td>
</tr>
<tr>
<td>C3</td>
<td>- Job offers to go out quicker</td>
</tr>
<tr>
<td></td>
<td>- Marketing of a career in operating</td>
</tr>
<tr>
<td></td>
<td>- In depth study of the job market to establish possible other sources of supply</td>
</tr>
<tr>
<td>D1</td>
<td>1. Recruitment officer</td>
</tr>
<tr>
<td></td>
<td>2. Shift Manager - Operations, Shift and Training</td>
</tr>
<tr>
<td></td>
<td>3. Station Psychologist</td>
</tr>
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<td></td>
<td>4. Operations Manager</td>
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Utility No 1 Cont'd

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<th>Utilities' Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2</td>
<td>Recruitment officer: Stage 1,3,4,7 - Evaluates personality, would person fit into culture of organisation and sees that interviews are conducted correctly. Operating Line Representative: Stage 2,3,7 - Technical suitability, level of appointment, would person fit into the culture and Operations Medical Doctor: Stage 5 - Medically fit. Station Psychologist: Stage 4 - Abilities and personality sufficient. Operating Manager: Stage 7 - Final Recommendation.</td>
</tr>
<tr>
<td>D3</td>
<td>No</td>
</tr>
<tr>
<td>D4</td>
<td>-</td>
</tr>
<tr>
<td>E1</td>
<td>Very important. Wrong or poor selection can lead to reduced Unit availability and reliability.</td>
</tr>
<tr>
<td>E2</td>
<td>Yes</td>
</tr>
<tr>
<td>E3</td>
<td>Assists with the selection process and makes final recommendations.</td>
</tr>
<tr>
<td>E4</td>
<td>Yes</td>
</tr>
<tr>
<td>E5</td>
<td>No</td>
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# Utility No 2

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<tr>
<th>Ques Nos</th>
<th>Utilities' Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>The corporate recruiter, identifies qualified candidates for plant operator learner positions by accepting applications, resumes, and visiting local community colleges. After identifying candidates, pre-employment testing is conducted, after which successful candidates are considered for interviewing at a plant location. After interviewing, Operational Management selects the best candidates based on the results of the interview. The operators start out as learners and progress upwards through the ranks.</td>
</tr>
<tr>
<td>A2</td>
<td>Applicants are rejected at the testing level or after an interview at the plant (if they pass the pre-employment tests, but do not fit the job requirements after interviewing with Operations management).</td>
</tr>
<tr>
<td>A3</td>
<td>The selection process is formal in that an applicant must follow the hiring procedures in order to be selected. Effort is made to consider minorities and females. The recruiting specialists interview and test as many qualified minority and female persons as possible in order to attempt to have fair representation from among these two groups.</td>
</tr>
</tbody>
</table>
| A4       | Aptitude - Very Important  
Experience - Important  
Ambition - Important  
Qualifications - Very Important, especially maths and mechanical ability  
Personality - Important, needs to get along with others  
Other - Location, attempts are made to hire candidates who live in close proximity to the plant in the hopes of avoiding a high staff turnover rate |
| A5       | Company policy has an influence on the recruitment approach to operator learners in that it is desired that these individuals live in close proximity to the plant. Due to the demanding screening process, it is sometimes difficult to recruit the calibre of person required for operations work from such a restricted geographical area. |
### Utility No 2 Cont’d

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities’ Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>The recruitment of operation learners begins with seeking candidates with experience or education that will provide the background to be successful. The most desirable background is Nuclear Navy experience. This type of experience lends itself nicely to the civilian plant environment. Technical training from a community college in a technical curriculum is also desirable. After candidates have been selected, pre-employment testing in the areas of maths, basic mechanical comprehension, reading comprehension and divided attention are administered. Those candidates who successfully complete the validated test battery, then an interview takes place with operations management. Operations management evaluates the candidates’ skills, experience, appearance, interests, education and decides which candidate to offer employment.</td>
</tr>
<tr>
<td>B2</td>
<td>This approach to recruiting candidates, testing and interviewing was chosen in order to select the best possible candidates.</td>
</tr>
<tr>
<td>B3</td>
<td>N/A</td>
</tr>
<tr>
<td>B4</td>
<td>The methods for recruiting operation learners for our nuclear stations has not been changed significantly over the years. The pre-employment testing has improved to include tests which relate better to the work.</td>
</tr>
<tr>
<td>C1</td>
<td>The pre-employment tests used to predict success on the job are validated on a regular basis.</td>
</tr>
<tr>
<td>C2</td>
<td>We have not encountered major problems with our approach to operator learner selection than the occasional difficulty identifying candidates who can successfully pass the pre-employment testing and screening interviews.</td>
</tr>
<tr>
<td>C3</td>
<td>None</td>
</tr>
<tr>
<td>D1</td>
<td>The personnel involved in the selection process of operator learner includes recruitment specialists and nuclear station operations management.</td>
</tr>
<tr>
<td>D2</td>
<td>The Recruitment Specialists identify and administer pre-employment tests to potential candidates. Operations management interviews qualified candidates and selects those who best match the requirements of an operator learner.</td>
</tr>
</tbody>
</table>
Utility No 2 Cont'd

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities' Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>D3</td>
<td>N/A</td>
</tr>
<tr>
<td>D4</td>
<td>N/A</td>
</tr>
<tr>
<td>E1</td>
<td>Very important. The selection process is primarily important from the standpoint of allowing the power station more than one opportunity to see the candidate face to face. Testing, campus interviewing and the plant interview allows the prospect to be seen three or four times by various power plant employees.</td>
</tr>
<tr>
<td>E2</td>
<td>Involved primarily with the operational learners, but does have input into the decision making associated with hiring those engineers who work with him.</td>
</tr>
<tr>
<td>E3</td>
<td>The recruitment of operation learners involves going on recruitment trips to community colleges and interviewing qualified candidates at the nuclear station. The respondent is involved in the selection decisions for those candidates that is offered employment.</td>
</tr>
<tr>
<td>E4</td>
<td>The respondent has a role in deciding what selection methods are to be used, but this has not made significant change to the utility’s formal selection process.</td>
</tr>
<tr>
<td>E5</td>
<td>The tests used to predict success in the job are validated by the company's Human Resources Department. Other aspects of the recruitment and selection processes are based on experience with backgrounds and training which have proven through the year to be successful.</td>
</tr>
</tbody>
</table>
Utility No 3

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities' Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Operator candidates are recruited from the Nuclear Navy, referrals from existing operators, and via trade publications. The actual selection and hiring of a candidate is the joint effort of Employee Relations and the Operations Department. The training program has very specific entry level requirements which are used as the first screening for potential operators. The Employee Relations department will not consider an individual for employment unless these criteria are met, once satisfying these requirements then an interview is arranged. The initial interview consists of a personal interview and administration of a standard employment test for psychological profile. The candidate is then sent out to the plant where the operations manager conducts an interview. The decision to hire is made based on a combination of the results of these interviews. They do not hire anybody directly into the control room.</td>
</tr>
<tr>
<td>A2</td>
<td>As stated previously, the initial cut would be based on a review of the applicant’s resume and whether or not they meet the training program entry requirements. The next cut would be if the applicant failed the psychological profile and finally if they were to interview badly.</td>
</tr>
<tr>
<td>A3</td>
<td>This process is formal to ensure all applicants are handled fairly. There is some subjectivity inherent to the personal interview, but there is guidance for what to look for during the process.</td>
</tr>
<tr>
<td>A4</td>
<td>All of these items are considered important during the process, experience and qualification have to be very important due to the fact they are the basis of the training program requirements.</td>
</tr>
<tr>
<td>A5</td>
<td>Those personnel who will operate the plant are hired in from the nuclear navy. After working as Equipment Operators for 4 years before they are allowed to try for License class at the SRO level. Engineering personnel who have a degree are allowed to try for License Class at the SRO level but will not be allowed to operate the plant. If they complete the NRC exams then they are placed on the Inactive License list which prevents them supervising the manipulation or the manipulation of controls of the plant. This is to ensure License expertise on staff. Candidates are preferred to live near the plant to keep turnover to a minimum, however this is only a preference.</td>
</tr>
</tbody>
</table>
Utility No 3 Cont’d

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities’ Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Selection of Licensed Operators occurs at two levels, i.e. RO and SRO. RO candidates come from the equipment operator group and each candidate must pass a comprehensive written exam based on the knowledge requirements for that job. In addition, operations management must state that the individual is ready to participate in the License Program based on performance. SRO candidates who are currently RO’s and are being upgraded must have demonstrated satisfactory performance and proficiency through participation in the operator requalification program. Operations management must always submit a letter stating that the candidate has demonstrated satisfactory performance and supervisory skills to be considered for entry. SRO candidates who are from the engineering group must also complete portions of the equipment operator program and take a similar exam. They also have to have a letter from their manager stating the same things as operations.</td>
</tr>
<tr>
<td>B2</td>
<td>The training programs are all based on the tasks which the operators are required to perform. The entry requirements for our program assumes that the candidate has successfully completed the equipment operator program. They have found that, after 20 years of operational experience that this process assures the best results.</td>
</tr>
<tr>
<td>B3</td>
<td>Due to the wide variety of reactor types there has never been a test instrument developed that we are confident in. Until one is, they plan to continue to use their own process.</td>
</tr>
<tr>
<td>B4</td>
<td>N/A</td>
</tr>
<tr>
<td>C1</td>
<td>The process has not been validated in a statistical sense. Experience has, shown however, that they have obtained an operations crew that is very stable, professional and knowledgeable.</td>
</tr>
<tr>
<td>C2</td>
<td>No</td>
</tr>
<tr>
<td>C3</td>
<td>The addition of a plant specific simulator has allowed management an opportunity to evaluate the operators who will be going for SRO upgrade in a new way. Performance under casualty conditions was never really observed before, now it can be used to determine if an RO is really ready to go up to SRO.</td>
</tr>
<tr>
<td>D1</td>
<td>As stated before, initial selection for hire is done by the operations manager and employee relations. When an individual is eligible for license class then the responsible manager and training supervisor is responsible for monitoring the performance of the student. Poor performance as identified by procedure, warrants a License Review Board which could result in removal from the program.</td>
</tr>
</tbody>
</table>
Utility No 3 Cont'd

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities' Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2</td>
<td>As above</td>
</tr>
<tr>
<td>D3</td>
<td>Yes. At the completion of their training program they hire an outside consultant to conduct an examination of our license candidates. Results of this process can determine who will actually sit for license.</td>
</tr>
<tr>
<td>D4</td>
<td>As above</td>
</tr>
<tr>
<td>Comment</td>
<td>Their license selection process and training program is as performance based as possible. There is some subjectivity in the program due to the individual biases of the evaluators. -If it appears that an individual is not ready or capable of handling a control room position then he will not sit for the final license. In some cases extra training may solve the problem, sometimes this isn’t enough and the individual doesn’t go up. Instead they are transferred out of operations and trained for a new job if possible.</td>
</tr>
</tbody>
</table>
Utility No 4

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities’ Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>The selection of personnel starts with recruitment, by means of advertising in the press and by other recruiting actions from the plant recruitment office. Other operators to be, are also recruited by personal contact through relevant staff, and students from universities. On the basis of the interest shown a questionnaire is filled out by applicants and a curriculum vitae provided. The individual questionnaire results are analysed by the recruitment office and the operations management on the applicants acceptability. This is usually based on university results, recommendation from the university and any previous experience. Applicants that are shortlisted for the position of control room operator have to pass medical, sociological/psychological examinations. On the basis of the results from these examinations and of the results from informal talks with the relevant head in the plant, complex assessment is conducted, and a decision is made as to his future position. When selecting plant personnel, the following main criteria are assessed: 1. Professional qualification and previous employment; 2. Health conditions for control room operators and for operators of refuelling machine, additional psychological abilities are required; 3. Age below 45 years 4. No criminal record 5. Males are preferred to females when employing.</td>
</tr>
<tr>
<td>A2</td>
<td>If the applicant fails any part of the selection criteria (see A1) then he is either rejected or advised to apply for another more suitable position</td>
</tr>
<tr>
<td>A3</td>
<td>The process of selection is formalised on the basis of the organisational management.</td>
</tr>
<tr>
<td>A4</td>
<td>The main criteria in selection are:- Qualifications, aptitude, personal disposition, and ambitions. For operators, successful psychological examination is also important.</td>
</tr>
</tbody>
</table>
## Utility No 4 Cont’d

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities’ Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5</td>
<td>The selection of control room operators is aimed at university graduates, predominantly with a nuclear specialisation, but also from power and electrotechnical specialisation.</td>
</tr>
<tr>
<td>A6</td>
<td>No, it does not</td>
</tr>
</tbody>
</table>
| B1       | For the selection of operators the following techniques and methods are used:  
- Recommendation from university, university study results, and the recommendation from plant entrance commission.  
- Prefer university graduates from nuclear specialisation or a related subject.  
- The assessment of health and psychological abilities on the basis of the medical examination and the results of the psychological tests and of psychological instrumental techniques carried out in a specialised psychological/sociological laboratory, this is also repeated once every two years.  
- Successful graduation and study results from the Training Centre for the preparation of NPP personnel.  
- Informal talks with leading persons prior to placing the applicant in the plant and to assess his experience and results.  
- Successful passing of a test before the State Examination Commission in accordance with an act. In the course of this test, complex professional ability for performing the functions of operators is evaluated and is repeated every two or three years. |
| B2       | The fundamental approach is set obligatory by a decree of the ministry of power and fuel and by a decree by the Atomic Energy Commission from the act on the regulatory authority in nuclear safety, qualify the efficiency of recruiting and high level selection for assuring plant reliability from the view of nuclear safety. |
Utility No 4 Cont’d

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>B3</td>
<td>Methods used are basically formalised and standardised in the area of psychological examination. We believe that further formalised techniques would not contribute to more objective assessments of applicants.</td>
</tr>
<tr>
<td>B4</td>
<td>None</td>
</tr>
<tr>
<td>C1</td>
<td>The approach used for selection is applied basically equally in all the plants. The licensees consider the application of the ultimate method of informal talk with leading managers on the basis of the data from the interview paper and from other data obtained from the selection procedure as significant for the selection. The data that is required for the selection procedure is as follows:-&lt;br&gt;- relation to team work;&lt;br&gt;- moral qualities;&lt;br&gt;- social and wage requirements.</td>
</tr>
<tr>
<td>C2</td>
<td>The cases of unsuccessful results from psychological tests remain questionable. Such operators that fail this test have to be found a less challenging position in the plant.</td>
</tr>
<tr>
<td>C3</td>
<td>Because psychological examinations are provided by an external organisation, it is considered useful to establish a sociological-psychological laboratory in every plant. For Chief Shift Supervisors it is considered useful to acquire personal experience together with their staff during training in accident management on simulators from the point of view of their psychological-social behaviour and cooperation.</td>
</tr>
<tr>
<td>D1</td>
<td>Reactor operator, secondary operator, chief unit supervisor, chief plant shift supervisor, inspection physicist, and operator of refuelling machine are included in process operations. The process of selection is successfully assured by:&lt;br&gt;- recruitment centres;&lt;br&gt;- training sections;&lt;br&gt;- plant medical centres;&lt;br&gt;- psychological-sociological centres, or plant psychologist;&lt;br&gt;- operations division. &lt;br&gt;In the plants that are operating, the recruitment centre is omitted from the process, its functions are taken over by the training section.</td>
</tr>
</tbody>
</table>
Utility No 4 Cont’d

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>D2</td>
<td>The recruitment personnel acquire pertinent applicants, evaluate the qualification requirements, and the adequacy. The training section plans and inspects the training examinations, and the verification of the level of medical and psychological abilities in the relevant centres. The head of the operations division agrees the placing of the applicant into the expected position. In this decision-making process of selection, the results from both psychological and medical examinations are considered significant.</td>
</tr>
<tr>
<td>D3</td>
<td>No</td>
</tr>
<tr>
<td>D4</td>
<td></td>
</tr>
<tr>
<td>E1</td>
<td>The selection process is considered important by all respondents. 40% of the respondents/operators consider professional, health, psychological and moral qualities as important.</td>
</tr>
<tr>
<td>E2</td>
<td>Operators do not participate directly in the recruitment or selection. The more experienced operators are charged with leading the on-the-job training of the operator to be, and in this case they express their opinion on the prerequisites to perform the functions of the operator. They also express their opinion in the position of commissioners in the course of final examinations, and in the course of the examinations before the State Examination Commission. Chief Shift Supervisors make the final decision of acceptance or rejection for operator positions.</td>
</tr>
<tr>
<td>E3</td>
<td>Chief Unit Supervisors evaluate the ability of personnel to manage unit operation modes independently, and they either recommend that they are able to perform these functions or are not.</td>
</tr>
<tr>
<td>E4</td>
<td>They use their own methods and abide by the obligatory rules. They prefer the holders of scholarship, then the graduates for the positions of the operators-to-be. Psychological prerequisites on the basis of psychological tests are considered as the most significant, subject specialisation is also taken into account.</td>
</tr>
</tbody>
</table>
Utility No 4 Cont’d

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities’ Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>E5</td>
<td>The Training Section evaluates the efficiency of methods in accordance with the level of efficiency of recruitment and of performing the functions. Some information is obtained from the talk with the person when he requires to cancel his service contract. The methods of psychological selection were developed and verified in a research and development project that was terminated in 1980. Two psychological laboratories for operator selection deal with this issue professionally. These laboratories have their own test batteries for selection, and they thus verify their criteria.</td>
</tr>
</tbody>
</table>
Utility No 5

<table>
<thead>
<tr>
<th>Ques Nos</th>
<th>Utilities' Answer to Each Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Recruitment, Selection and Orientation Process:-</td>
</tr>
<tr>
<td></td>
<td>1. Recruitment Effort (read the brochure)</td>
</tr>
<tr>
<td></td>
<td>2. Complete Application:- 1 job only, 1 application per 12 month</td>
</tr>
<tr>
<td></td>
<td>3. Industrial Relations Application Review</td>
</tr>
<tr>
<td></td>
<td>4. Testing (possibly)</td>
</tr>
<tr>
<td></td>
<td>5. Industrial Relations Interview</td>
</tr>
<tr>
<td></td>
<td>6. Application and Background Checking</td>
</tr>
<tr>
<td></td>
<td>7. Candidate Pool</td>
</tr>
<tr>
<td></td>
<td>8. Department Interview</td>
</tr>
<tr>
<td></td>
<td>9. Job Offer</td>
</tr>
<tr>
<td></td>
<td>10. Medical Examination, Psychological Examination</td>
</tr>
<tr>
<td></td>
<td>11. Add to Payroll</td>
</tr>
<tr>
<td></td>
<td>12. New Employee Orientation</td>
</tr>
<tr>
<td></td>
<td>13. Performance Reviews During Probation Period.</td>
</tr>
</tbody>
</table>

Recruitment efforts usually consist of resume/application evaluation to determine applicants for testing. All other steps are self explanatory.

<table>
<thead>
<tr>
<th>A2a</th>
<th>Steps: 1,2,3,4,5,6,8,10</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2b</td>
<td>For the most part established criteria</td>
</tr>
<tr>
<td>A3</td>
<td>Formal</td>
</tr>
<tr>
<td>A4</td>
<td>Aptitude, experience, ambition and qualification.</td>
</tr>
</tbody>
</table>
Utility No 5 Cont'd

<table>
<thead>
<tr>
<th>Ques No</th>
<th>Utilities' Answer to Each Question</th>
</tr>
</thead>
</table>
| A5       | No. However, typical backgrounds for possible candidates for operator testing include but are not limiting:  
  1. Ex-military personnel:  
  2. Technically qualified Jr College Graduates:  
  3. Existing plant personnel:  
  4. Others with Maths, Physics and/or Chemistry backgrounds: |
| A6       | Candidates who fail the pre-employment physical and/or test will not be hired. |
| B1       | Step 1 through to 10. |
| B2       | Consistency throughout the company and past experience with operators who have successfully completed operator training. |
| B3       | The method presently used is more formal than previously used methods. |
| B4       | No. The methods have been more formalised to assure consistency. |
| C1       | The testing part of the selection process has been validated by the Edison Electric Institute. |
| C2       | No. |
| C3       | No. Seems to be working well. |
| D1 & D2  | 1. Operating Department - Step 8  
  2. Industrial Relations - Steps 1,3,4,5,6,and 9  
  3. Medical Department - Step 10 |
| D3       | No. |
| D4       | No. |
| E1       | Very Important. |
| E2       | Yes |
| E3       | Evaluate background and interview candidates to assure compatibility with Nuclear Operations. |
| E4       | No, except for E3 |
| E5       | Validating - No. However, due to operational input, the testing process was implemented to aid in operator selection. |
Utility No 6

The response from this questionnaire does not follow the same format as the other questionnaires. The results have been recorded in a table, the questions are not numbered.

<table>
<thead>
<tr>
<th>Utilities’ Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection of plant operators is based on the needs of the Operations department, i.e. a vacancy exists. Even though the vacancy may be an advanced operator level all new hires are brought in at the entry level position, Auxiliary Equipment Operator. At that time the personnel office is notified of the need. They have on file the basic education and experience requirements for each plant position.</td>
</tr>
<tr>
<td>Company policy requires job openings be posted within the Company. Any permanent employee may apply. Applications are forwarded to the Operations Manager for his review and consideration. He has approval authority to accept or reject the applicant.</td>
</tr>
<tr>
<td>If a permanent employee is not selected for the operator position, usually the case, the personnel office attempts to locate qualified people outside the company. There are several sources.</td>
</tr>
<tr>
<td>- Employment applications on file with the company from persons not hired due to lack of job openings.</td>
</tr>
<tr>
<td>- Contacting employment agencies.</td>
</tr>
<tr>
<td>- Advertising in local newspapers in areas where there are known populations of nuclear power plant trained people.</td>
</tr>
<tr>
<td>- Advertising in trade magazines.</td>
</tr>
<tr>
<td>Resumes of applicants obtained from these sources are forwarded to the Operations Manager. He makes the first selection based on the content of the resumes, and notifies the personnel office if a follow up interview is desired.</td>
</tr>
<tr>
<td>Interviews are scheduled by Personnel and conducted by the Operations Manager and his assistant. The main decision to hire or not to hire, is based on these interviews. Since this is a subjective assessment all the factors of questionnaire item number A4 are considered.</td>
</tr>
<tr>
<td>At the time of the interview the applicant is also given a physical examination, a psychological test and a background investigation is initiated. If all the tests and investigations are satisfactory the applicant recommended by the Operations Manager is offered the job.</td>
</tr>
<tr>
<td>The majority of operators employed in this company (90%) are ex-military personnel from the navy, a few are technical school graduates.</td>
</tr>
</tbody>
</table>
Utility No 6 Cont'd

Utilities' Statement

The sole criterion for selection of operators is the recommendation of Operators Management; given the applicant passes the physical, background and psychological requirements.

The plant does not use selection or screening tests. They are not used because of possible legal challenges concerning bias or discrimination against minority groups. Selection of primarily ex-navy personnel offers some assurance that the person is qualified to do the job. The only validation of this approach has been the quality of the operators as proven over time. Generally the results have been good.

The major problem with this approach is that the Operations Manager has to make a critical decision based on sketchy information, the resume, and a subjective interview that seldom exceeds 30 minutes to an hour. Within the company it is easier to hire than to fire and the wrong decision is hard to correct. Employee problems are usually in areas of attitude and work habits that the screening tests would not detect.

The following personnel within the organisation are involved in the selection process:

- Operations Manager - Has the main responsibility for deciding if the applicant is qualified for the job and recommending employment.
- Personnel Manager - Has the responsibility for locating potential employees and scheduling interviews.
- Security Manager - Has the responsibility for conducting background investigations. He can only "disqualify" an applicant based on the background investigation.
- Company Physician - Has responsibility for conducting physical examinations. He can only "disqualify" based on specific physical problems.
- Company Psychologist - Has the responsibility for determining the emotional stability of the applicant. He can only "disqualify" based on the detection of emotional problems.
- Plant Manager - Has the final approval authority for job offers. This is based on the recommendations of the Operations Manager and the lack of a "disqualifier" from the other personnel.

The plant does not use external consultants in the selection process.