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NUREG/CR-3414
ORNL/TM-8848

Evaluation of Training Programs and Entry Level Qualifications for Nuclear Power Plant Control Room Personnel Based on the Systems Approach to Training

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National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161

Available from

GPO Sales Program
Division of Technical Information and Document Control
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

NUREG/CR--3414

DE84 000442

NUREG/CR-3414
ORNL/TM-8848
Distribution Category RX

Contract No. W-7405-eng-26

Engineering Physics Division

EVALUATION OF TRAINING PROGRAMS AND ENTRY-LEVEL QUALIFICATIONS FOR NUCLEAR-POWER-PLANT CONTROL-ROOM PERSONNEL BASED ON THE SYSTEMS APPROACH TO TRAINING

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Manuscript Completed: August 1983
Date Published: September 1983

This Work Performed For
Nuclear Regulatory Commission
Under
DOE Interagency Agreement 40-550-75
NRC FIN No. B0461

Work Performed Under
ORNL Subcontract No. 40X-70527

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ABSTRACT

This report summarizes results of research sponsored by the U.S. Nuclear Regulatory Commission (NRC) Office of Nuclear Regulatory Research to initiate the use of the Systems Approach to Training in the evaluation of training programs and entry level qualifications for nuclear power plant (NPP) personnel. Variables (performance shaping factors) of potential importance to personnel selection and training are identified, and research to more rigorously define an operationally useful taxonomy of those variables is recommended. A high-level "model" of the Systems Approach to Training for use in the nuclear industry, which could serve as a model for NRC evaluation of industry programs, is presented. The model is consistent with current publically stated NRC policy, with the approach being followed by the Institute for Nuclear Power Operations, and with current training technology. Checklists to be used by NRC evaluators to assess training programs for NPP control-room personnel are proposed which are based on this model. In an appendix, a "typical" media selection model is illustrated which might be used in the design of training systems for NPP control-room personnel. Further assessment of the proposed checklists to assure practicality, utility and acceptability is recommended. In addition, other issues related to training-effectiveness evaluation are identified, and a comprehensive research approach to address them is outlined.

1. INTRODUCTION

1.1. Background

Along with other areas related to human factors in nuclear power plant design and operation, the area of personnel qualification, education and training has been undergoing intensive study and rather dramatic change in the "post-TMI" era. Both the U.S. Nuclear Regulatory Commission (NRC), the Office of Nuclear Regulatory Research (RES) and the Office of Nuclear Reactor Regulation (NRR), and the nuclear power industry — especially the Institute of Nuclear Power Operations (INPO), but individual utilities and other organizations as well — have developed programs to assess and improve methods and practice for nuclear power plant (NPP) operator training. Although there are many different activities and diverse opinions on specific needs and approaches, there is now virtually unanimous agreement that one of the basic efforts to improve personnel performance has to be examination and improvement of the training process. There now also appears to be agreement that nuclear industry training would benefit from adaptation of a "systematic approach" to the design, implementation and evaluation of training programs or "training systems."

Oak Ridge National Laboratory (ORNL) has conducted several studies for NRC/RES related to operator training and operator performance in general. One of the few active NRC programs in human factors prior to the TMI-2 incident was the Safety-Related Operator Actions Program at ORNL,[1] which involved collection and assessment of data (from plant records and from simulators) on NPP operator performance during abnormal/emergency events. In 1979, shortly after the TMI-2 incident, a project was initiated under that program to summarize and assess the current state-of-the-art of NPP simulators and the use of simulators in NPP operator training. One of the primary recommendations of that study[2] was that the "systems approach to training" used by the U.S. military and some other high-technology industries (most notably the aerospace industry) should be examined and adapted for the nuclear industry.

Later, in 1980 and 1981, a two-part study was conducted[3,4] which initially focused more specifically on simulator characteristics but led to a further investigation of the systems approach to training and a stronger recommendation that

> *"the nuclear industry should adopt, and NRC regulatory and research actions should support the systems approach to training as a structured framework for development and validation of personnel training systems."*[5]

A "participative" or cooperative role was suggested for NRC, and a number of specific actions were recommended for NRC to initiate and support implementation of the methodology including: (1) formulation of an NRC/industry planning group, (2) development of program plans for NRC research, and (3) assessments to support the systems approach to training and the development of a "users guide" for application of the methodology. The work described in this report was initiated, in part, in response to those recommendations.

1.2. Study Objectives and Approach

The research summarized in this report was conducted as part of a program entitled "Nuclear Power Plant Personnel Selection and Training," which was initiated by NRC/RES at ORNL in March 1982. The initially defined objectives of the program focused on further assessment and demonstration of the feasibility of adapting the systems approach to training to NPP operator training and on development of a program plan for its implementation by NRC to establish operator selection, qualification and training requirements. There were five tasks specified: (1) define the elements and performance shaping factors related to selection and training on NPP control room personnel; (2) assess the applicability of existing methods such as Systems Approach to Training and Instructional Systems Development (SAT/ISD); (3) using INPO job/task analytic data, demonstrate the use of applicable methods used to determine selection, qualification and training program requirements; (4) provide a comprehensive program plan for development, validation and application of a process such as SAT/ISD for establishing operator selection, qualification, and training requirements; and (5) develop and demonstrate a technique for selecting malfunctions which should be required for NPP training simulators.

The fifth task, which was completed by ORNL staff, is the subject of another NUREG/CR report which is being written at this time and will be published shortly after this document. The other four tasks were addressed primarily by Eclectech Associates, Inc. with project management and technical support by ORNL.

The general approach planned to accomplish these tasks was to (a) assemble information from three primary sources — literature, site visits and interviews with subject-matter experts, and a government-industry review group which was formed specifically for this project; (b) assess the information from all of these sources to determine (and if possible, demonstrate) the feasibility of adapting existing methodology; and (c) based on assessment of the needs and the (likely) role of NRC, develop the desired program plan.

As the work progressed, the emphasis of the program was somewhat redirected in recognition of relatively rapid changes in both industry practice and NRC needs that were (and are) occurring. Some of the findings from the early site visits and interviews with nuclear industry training technologists that confirmed the occurrence of this transition in industry philosophy and practice are discussed in Chapter 3. The INPO efforts in adapting the ISD process to the nuclear industry and in their plant evaluation program clearly are the dominant force in moving the industry to greater acceptance of these approaches. The parallel move at NRC has been influenced greatly by INPO's results as well as the addition to both NRR and RES staff of individuals with formal education and previous experience in training technology. Certainly the recommendations of the Human Factors Society[6] and of previous NRC studies such as Refs. 2—4 have also influenced NRC's actions. At any rate, NRC during the course of this project work (early 1982 to April 1983) has moved from (in our perception) initial recognition of the potential of the systems approach to training to public statement of plans to issue a rule that "specifies the use of a systematic approach to training"* and a "Regulatory Guide to indicate methods of compliance that NRC views as acceptable."[7]

*It is important to note the distinction between specifying a "systematic approach" to training and the "Systems Approach to Training." The former suggests considerably more flexibility on the part of the NRC. However, the essential elements described in Ref. 7 are consistent with those identified in Ref. 4 as those of the Systems Approach to Training.

These changes diminished the need to demonstrate the feasibility of adapting SAT methods to the nuclear industry and increased (or rather, accelerated) the need for development of useful tools for NRC to evaluate training system design. A specific impact on the project is that a good portion of the work focused on development of checklists for use by NRC staff to evaluate utility-developed training systems. These checklists assume a systems approach is in use. The emphasis on the "demonstration" (Task 3, above) shifted from "walking through" the SAT process with realistic data to illustrating (by way of developing the checklists) the feasibility of an evaluative process and "generic" guides for NRC evaluators to follow the systems approach. In order to accomplish this, it was necessary to specify, or make explicit, what we feel is an appropriately general "model" of the SAT for the nuclear industry. In addition, an illustrative media-selection model, one critical element of the process, was created. Finally, internal actions on the part of NRC/RES to (1) identify the major issues in operator education, training and licensing, (2) relate them to the fundamental issue of operator performance measurement, and (3) develop a comprehensive research program to address these interrelated issues, reduced the emphasis on the program planning effort for this project.

1.3. Summary of Report Content

Despite these changing emphases in response to a changing environment, the basic approach to collection and assessment of information originally outlined was followed, and the project results reported here are aligned with the original four tasks. Chapter 2 presents an initial listing of performance shaping factors to be considered in selection and training of NPP control room personnel. (The emphasis in personnel selection is on identification of entry level qualifications, job-related abilities, not on psychological screening tests for emotional stability, etc.) This listing is based on a compilation of existing taxonomies of human performance variables, plus input from interviews with NPP training personnel, and from the project review group. An attempt is made to suggest those variables that are probably best treated in the selection process versus those that are more relevant to training. As noted in Chapter 2, the listing is intended only as a point of departure for further study. A critical element of future research should be to develop a validated taxonomy of human performance variables and performance measures related to NPP job performance.

Chapter 3 describes the systems approach to training "model" that has been assumed to develop the evaluative process for NRC. A summary of the essential elements of the SAT process and the history of its use are included. Since much of this material was discussed in Ref. 4, these sections are quite abbreviated. Chapter 3 also describes the results of the selected visits to nuclear training sites and interviews with trainers to update the project staff on the current trends in training practice (essentially, the level of acceptance of and movement toward use of SAT methods). On the basis of this information, a description of a SAT model appropriate for NRC to use to evaluate the nuclear industry is presented. Included is the illustrative media-selection model, which is outlined in more detail in Appendix B.

Chapter 4 presents checklists designed to aid NRC in evaluating each element of the suggested SAT model, with a discussion of each question to explain its content and the rationale for its existence. The checklists certainly require "validation" to demonstrate their utility and practicality. Additional work will be necessary to define criteria for acceptance, and some sort of guidelines and aids to users will likely be required. However, the checklists in their current form provide a solid basis for further work and, probably, a useful tool for interim use.

Chapter 5 identifies further research issues related to the adaptation of the systems approach to training by NRC with particular emphasis on the area of training effectiveness evaluation, which is considered to be one of the primary concerns of NRC in the area of personnel training.

In addition to the five chapters this report also contains four appendices. Appendix A is a glossary of terms used in this reort. In order to obtain a better understanding of terminology used in Chapters 2-5 it may be helpful to review this appendix prior to reading those chapters. Appendix B is a discussion of a Media Selection Model. In this appendix the development of a media selection model is discussed and an illustrative media selection model developed as a part of this program is presented. Appendix C is the interview guide used to obtain information discussed in Chapters 2 and 3. And finally, Appendix D is a sample of evaluation forms which could be used by trainees to evaluate courses and instructors.

2. PERFORMANCE SHAPING FACTORS

Since the essence of the systems approach to training is its relating of training requirements to specific performance requirements, a fundamental need, if not *the* fundamental need, is to be able to define and measure performance. To the extent possible, it is desired to quantify the relationship between training requirements and on-the-job performance. In fact, by establishing "validity" of training requirements we mean precisely that — demonstrating that there is a (or an acceptable degree of) relationship between the training requirements and the job performance requirements.

To do this, it is necessary to identify the important variables, both dependent and independent, relevant to job performance. There appears to be a number of terms used by various disciplines and subdisciplines to denote these variables. We have chosen to refer to the independent variables as "performance shaping factors" (PSFs) following Swain and Guttmann,[8] who have to some extent popularized that term in the nuclear industry. (The dependent variables are referred to as "performance measures.")

2.1. Swain and Guttmann Taxonomy

In the nuclear industry much of the earlier work in human factors, particularly at NRC, focused on human reliability analysis as part of probabilistic risk assessment (PRA), and much of it was either performed by Swain or based on his work. Our examination of this area initially concentrated on his taxonomy of PSFs, though we also reviewed those of Meister[9] and Embrey,[10] which are relevant to human reliability analysis.

In reference 9 Meister listed "elements and subelements" that influence "system efficiency." He categorized them according to the major elements he views as comprising the "man-machine system" — equipment, environment, tasks, and personnel. This listing, reproduced in Table 2.1, is relatively broad, but at a macro level.

Table 2.1. Elements and Subelements Influencing Efficiency of Man-Machine System (MMS) (Reproduced from Reference 9)

Equipment	Environment	Tasks	Personnel
Controls	Temperature	Content (procedures)	Intelligence
Displays	Illumination	Duration	Sensory capability
Equipment dimensions	Vibration	Feedback	Motor capability
• Type and arrangement of internal components	Noise	Response frequency requirements	Training
• Test points	Ventilation	Accuracy requirements	Experience
• Primarily for maintenance men		Speed requirements	Motivation

Embrey in reference 10 defines PSFs as "the set of factors which, when acting alone or in combination, determine the probability success of human action in a particular situation." He lists approximately fifty factors classified into four major types: individual factors, task factors, environmental factors, and stress factors. Since Embrey's work has for the most part focused on human reliability analysis, it is not surprising that there is a good deal of similarity between his and Swain's taxonomy, though Embrey does propose a somewhat broader application of the concept of PSFs.

The listing of PSFs published by Swain and Guttmann in reference 8 is reproduced in Table 2.2. The factors are categorized as "External," "Internal," or "Stressors." External PSFs, those outside of the individual, are those that define the work situation. They are further categorized as "situational characteristics," "task and equipment characteristics," and "job and task instructions." Internal PSFs are those variables having to do with skills, abilities, attitudes, and many other human attributes the individual brings to the job.

Swain and Guttmann note that stress is more logically categorized as an internal PSF, but because of their importance they have chosen to list "stressors" as a separate categorization. In their view, stress, psychological or physiological, arises when there is a mismatch between external and internal PSFs, i.e., between task demands and individual capability.

This listing, of course, was not developed specifically for NPP operators from studies of operator performance. It has been used in essentially the same form for many years by Swain and co-workers in a variety of contexts. Though it certainly has benefited from the experience of Swain's pioneering efforts in human reliability analysis in NPPs, and it is very useful as a basis for further study, it needs further refinement and validation by continued observation and measurement of NPP operator performance. While some variables may be shown to be less significant for NPP control room tasks, others may demand more explicit attention. For example early in the study it was recognized that to develop and evaluate requirements for entry level qualifications and training, it may be necessary to examine internal PSFs in greater detail. The current listing is at a relatively gross level; e.g., personality and intelligence, which include many human variables are listed as a single PSF.

2.2. Modified Berliner Taxonomy

A performance taxonomy that has been adopted by the NRC for use in its NPP control room crew task analysis effort[11] is a modified version of the Berliner taxonomy,[12,13] which was developed as part of a pilot study[14] under the ORNL SROA program. The Berliner listing is a descriptive taxonomy with task actions categorized hierarchically according to general task activities under four basic types of human "processes" — perceptual, mediational (or cognitive), communication, and motor. It is suggestive of human abilities and variables affecting performance, but does not readily lend itself to specifying human variables of concern for selection and training. The modified version for NPP control room tasks presented in reference 14 (which was influenced by previous work by Davis, Mozour, et al.,[15]) is presented in Table 2.3.

Table 2.2. Performance Shaping Factors Listed by Swain and Guttman (Reproduced from Reference 8)

External		Stressors	Internal
Situational Characteristics	Task and Equipment Characteristics	Psychological Stressors	Organismic Factors
Architectural features	Perceptual requirements	Suddenness of onset	Previous training/experience
Quality of environment:	Motor requirements (speed,	Duration of stress	State of current practice or
temperature, humidity, and	strength, precision)	Task speed	or skill
air quality	Control-display	High jeopardy risk	Personality and intelligence
Lighting	relationships	Threats (of failure,	variables
Noise and vibration	Anticipatory requirements	loss of job)	Motivation and attitudes
Degree of general	Interpretation	Monotonous, degrading, or	Knowledge of required
cleanliness	Decision-making	meaningless work	performance standards
Work hours/work breaks	Complexity (information	Long, uneventful	Physical condition
Availability/adequacy of	load)	vigilance periods	Attitudes based on influence
special equipment, tools,	Narrowness of task	Conflicts of motives about	of family and other outside
and supplies	Frequency and repetitiveness	job performance	persons and agencies
Manning parameters	Task criticality	Reinforcement absent or	Group identifications
Organizational structure (e.g.,	Long- and short-term	negative	
authority, responsibility,	memory	Sensory deprivation	
communication channels)	Calculational requirements	Distractions (noise,	
Actions by supervisors,	Feedback (knowledge	glare, movement, flicker,	
co-workers, union	of results	color)	
representatives, and	Continuity (discrete)	Inconsistent cueing	
regulatory personnel	vs continuous)		
Rewards, recognition,	Team structure	**Physiological Stressors**	
benefits	Man-machine interface		
	factors:	Duration of stress	
Job and Task Instructions	Design of prime	Fatigue	
	equipment, test	Pain or discomfort	
Procedure required (written	equipment, manufacturing	Hunger or thirst	
or not written)	equipment, job aids, tools,	Temperature extremes	
Written or oral	fixtures	Radiation	
communications		Oxygen insufficiency	
Cautions and warnings		Vibration	
Work methods		Movement constriction	
Plant policies (shop		Lack of physical exercise	
practices)			

Table 2.3. Modified Delivery Taxonomy Suggested for NPP Control Room Codes (Reproduced from Reference 14)

Processes	Activities	Specific Behaviors
1. Perceptual	1.1 Searching for and receiving information	1.1.1 Inspects
		1.1.1 Observes
		1.1.3 Read
		1.1.4 Receives
	1.2 Identifying objects, actions, events	1.2.1 Identifies
		1.2.2 Locates
2. Cognitive	2.1 Information processing	2.1.1 Calculates
		2.1.2 Interpolates
		2.1.3 Tabulates
	2.2 Problem solving and decision making	2.2.1 Analyzes
		2.2.2 Calculates
		2.2.3 Chooses
		2.2.4 Compares
		2.2.5 Plans
		2.2.6 Verifies
3. Communication	3.1 Within view	3.-.1 Answers
	3.2 Not within view	3.-.2 Communicates
	3.3 Outside control room	3.-.3 Directs
		3.-.4 Informs
		3.-.5 Instructs
		3.-.6 Requests
		3.-.7 Records
4. Motor	4.1 Simple/discrete	4.1.1 Activates
		4.1.2 Moves
		4.1.3 Positions
		4.1.4 Removes
	4.2 Complex/continuous	4.2.1 Adjusts
		4.2.2 Balances
		4.2.3 Touches

2.3. General Types of Taxonomies

Fleishman,[16] one of the foremost proponents of development and use of taxonomic structures to improve generalizations and predictions of human performance research, identifed four major conceptual bases underlying (then) current task description and classification. The descriptions of these below are excerpted from reference 16:

1. *Behavior description approach.* In this conceptual approach to task classification, categories of tasks are formulated based on observations and descriptions of what operators actually do while performing a task. Most often, overt behaviors such as dial setting, meter reading, and soldering are employed. In spite of the large number of terms available for this approach to task description, relatively few descriptive systems have been developed that are based exclusively on operator behaviors or activities.

2. *Behavior requirements approach.* A second approach to "task" description emphasizes the cataloging of behaviors that are assumed to be *required* in order to achieve criterion levels of performance. The human operator is assumed to possess a large repertoire of behaviors that will serve to *intervene* between stimulus events and responses. There has been a great deal of interest in codifying the required intervening processes (functions, behaviors, etc.), cataloging tasks in terms of the types of processes required for successful performance, and then relating to particular training methodologies the types of tasks that emerge. Typical of the functions used to differentiate among tasks are scanning function, short-term memory, long-term memory, decision making, and problem solving.

3. *Ability requirements approach.* The third conceptual basis for the description and classification of tasks, which we call the ability requirements approach is in many respects similar to the behavioral requirements concept. Tasks are to be described, contrasted, and compared in terms of the abilities that a given task requires of the operator. These abilities are relatively enduring attributes of the individual performing the task. The assumption is made that specific tasks will require certain abilities if performance is to be maximized. Tasks requiring similar abilities would be placed within the same category or would be said to be similar.

   The abilities approach differs from the behavior requirements approach primarily in terms of concept derivation and level of description. The ability concepts are empirically derived through factor-analytic studies and are treated as more basic units than the behavior functions.

4. *Task characteristics approach.* A fourth approach differs from the preceding approaches in terms of the type of task description that is attempted. This approach is predicated on a definition that treats the task as a set of conditions that elicit performance. These conditions are imposed on the individual and have an objective existence quite apart from the activities they may trigger, the processes they may call into play, or the abilities they may require. Having adopted this point of view, appropriate descriptive terms are those that focus on the task per se. The assumption is made that tasks can be described and differentiated in terms of intrinsic, objective properties they may possess. These properties or characteristics may pertain to the goal toward which the operator works, relevant task stimuli, instructions, procedures, or even to characteristics of the response(s) or the task content. The obvious problem is the selection of those task components that are to be described, as well as the particular terms or parameters by means of which description is to be accomplished.

Fleishman concludes by noting that it may not be possible to develop a single, generalized taxonomy suitable for all purposes, that it may be necessary to have several task classifications schemes for several different purposes but, ". . . with the linkage between them understood and specified." He suggests that a system which links ability requirements and task characteristics could provide such an organizing framework, and he presents a research paradigm for developing such a system.

2.4. Criteria for Evaluating Taxonomy

In a 1982 paper, Companion and Corso[17] identified four types of taxonomy which somewhat parallel Fleishman's — (1) task qua task, (2) task as behavior requirement, (3) task as behavior description, and (4) task as ability requirement. They then evaluate these general types and five specific taxonomies. The evaluations of these five specific taxonomies, which are summarized in Table 2.4, are of interest for further study, but of more immediate concern are the criteria used for evaluation:

1. The taxonomy must simplify the description of tasks in the system. The goal of any taxonomic scheme is to make the subject matter of the taxonomy more manageable.
2. The taxonomy should be generalizable. If it is not generalizable, the taxonomy is essentially a system specific task analysis.
3. The taxonomy must employ terms that are compatible with the terms of the users. Unless the taxonomy is in a form that is meaningful to those who use it, its application will be inappropriate and often ignored.
4. The taxonomy must be complete and internally consistent. It must deal with all relevant aspects of human performance in the system without logical error.
5. The taxonomy must be compatible with the theory or system to which it will be applied.
6. The taxonomy must provide some basis on which performance can be established or predicted. This criterion is necessary in order to evaluate and compare performance between operators on different as well as identical tasks.
7. The taxonomy must have some practical utility. The practical utility may be either applied or theoretical.
8. The taxonomy must be cost-effective.
9. The taxonomy must provide a framework around which all relevant empirical data can be integrated. A taxonomy which fails to meet this criterion is merely a verbal device with no ties to reality and, therefore, has no applicability or validity.
10. The taxonomy should account for the interaction of task properties and operator performance.
11. The taxonomy should be applicable to all system levels.

Table 2.4. Critical Review of Five Taxonomies by Companion and Corso (Reproduced from Reference 17)

Criteria	Abilities (Fleishman)[a]	Task Characteristics (Farina & Wheaton)[b]	Criterion Measure (Teichner & Olson)[c]	Information Theoretic (Levine & Teichner)[d]	Information Translation (Teichner)[e]
	Taxonomic Approach				
Simplify task description	Yes	Yes	Yes	Yes	Yes
Generalizability	Yes	Yes	Yes	Yes	Yes
Compatibility of terms	No	No	Yes	Yes	Yes
Completeness	No	No	No	No	Yes
Compatible with system or theory	No	Yes	No	Yes	Yes
Performance evaluation	No	No	No	No	No
Utility	Yes	Yes	Yes	Yes	Yes
Integrates empirical relations	No	No	No	No	No
Accounts for task property by operation interaction	No	Yes	Yes	Yes	Yes
Applicable to all system levels	Yes	Yes	Yes	Yes	Yes

[a]E. A. Fleishman, "Performance Assessment Based on An Empirically Derived Task Taxonomy," *Human Factors* **9**, 349-366 (1967).

[b]A. J. Farina and G. R. Wheaton, "Development of a Taxonomy of Human Performance: The Task Characteristic Approach to Performance Prediction," Technical Report, AIR-726-2/71-TR-7, Washington, D.C.: American Institutes for Research (1971).

[c]W. H. Teichner and D. E. Olson, "Predicting Performance in Space Environments," NASA Report No. CR-1370, Washington, D.C.: National Aeronautics and Space Administration (1969).

[d]J. M. Levine and W. H. Teichner, "Development of a Taxonomy of Human Performance: An Information Theoretic Approach," Technical Report AIR-726-2/71-TR-9, Washington, D.C.: American Institutes for Research (1971).

[e]W. H. Teichner, "Quantitative Models for Predicting Human Motor Visual/Perceptual Motor Performance," Technical Report NMSU-ONR-TR-74-3, Las Cruces: New Mexico State University, Department of Psychology (1974).

These criteria overlap to some extent those presented by Siegel.[18] The latter were used to evaluate existing taxonomics as part of an effort to develop a taxonomy of perceptual/psychomotor abilities for the U.S. Air Force. The criteria in reference 18 which were extrapolated from Miller[19] and Fleishman[16] are:

1. Compatibility — the scheme should be fully compatible with the Air Force task structure.
2. Understandability — the scheme must be readily apparent and comprehensible to Air Force users.
3. Objectivity — the standards for evaluation must be free from bias.
4. Scalability — the technique should allow for the assignment of a magnitude value (a number) to the tasks of a job relative to each class in the scheme.

5. Practicality — the scheme should be relatively simple to apply and interpret and should not place undue time requirements on operational personnel.
6. Validity — the scheme should be based on acceptable constructs relevant to Air Force job consent, and seem reasonable to the Air Force users.
7. Reliability — the scheme should be amenable to psychometrically reliable data acquisition methods.
8. Comprehensive, generality, and flexibility — the scheme should be applicable to the full range of tasks involved in Air Force career fields.
9. Cost effective — the taxonomy should have characteristics that permit it to be embedded within a scheme that is relatively inexpensive to employ and the taxonomy should be purposeful in establishing an approximate job-personnel interface.
10. Unidimensionality — each skill within the scheme should be unique.

Reference 18, examines in considerable depth six published taxonomies and other implied taxonomies from five published general test batteries. The taxonomics and the test batteries of this literature search identified a total of 89 non-unique perceptual/psychomotor abilities that appeared to be applicable to these Air Force specialities. This was combined with a list of 17 abilities previously identified as applicable by the U.S. Air Force. From the total of 106 a taxonomy was developed through a seven-step process as follows:

1. Identical and apparently redundant abilities were considered.
2. Vaguely defined and grossly categorized abilities were eliminated.
3. Abilities unrelated to the perceptual/psychomotor domain and non-representative of the ability represented in Air Force career fields were eliminated.
4. The remaining abilities (61) were totaled using basically the criteria cited above. Ratings were made on a five point scale by two psychologically trained and experienced raters who possessed knowledge of different types of Air Force career fields and tasks performed in them.
5. Inter-rater reliability was determined by comparison of the ratings in compatibility and comprehensiveness.
6. The ratings for compatibility and comprehensiveness were summed to determine cut-off points for elementary "less important" variables.
7. The final set of proposed abilities was selected by further evaluation of the remaining (33) abilities. The final list consisted of 13 abilities.

The thirteen abilities and their definitions are reproduced from reference 18 in Table 2.5.

Table 2.5. Taxonomy Developed by Siegel et al. for U.S. Air Force (Reference 18)

1. **Control Precision** — the ability to perform rapid, precise, fine controlled adjustments by either arm and hand movements or leg movements.
2. **Manual Dexterity** — the ability to perform skillful, well-directed arm and hand movements to manipulate either fairly large or fairly small objects under speeded conditions.
3. **Finger Dexterity** — the ability to perform skillful manipulations of small objects with the fingers.
4. **Multilimb Coordination** — the ability to coordinate the movements of a number of limbs simultaneously, e.g., two hands, two feet, and hands and feet together.
5. **Rate Control (Tracking)** — the ability to perform continuous anticipatory motor adjustments relative to changes in speed and direction of a continuously moving object.
6. **Visual Speed and Accuracy** — the ability to perceive small details quickly and accurately.
7. **Visual Memory** — the ability to recall and state verbally or recall and reproduce through writing and drawings based on past visual experiences.
8. **Position Memory** — the ability to recall rapidly and accurately the position of objects from past experience.
9. **Auditory Discrimination** — the ability to discriminate and interpret sounds.
10. **Auditory Memory** — the ability to recognize and reproduce either verbally or in writing prior auditory experiences.
11. **Clerical Perception** — the ability to read or copy rapidly and accurately pertinent details in scales, graphs, or charts.
12. **Perception of Size and Form** — the ability to see slight differences in the size and shape of objects.
13. **Depth Perception** — the ability to determine the position of objects in space and to perceive in three dimensions.

2.5. Tentative List of Performance Shaping Factors Relevant to Selection and Training of NPP Control Room Personnel

Within the scope of the project and the resources available for this task, it has been possible to conduct a limited evaluation of the many existing taxonomies including an assessment of importance by subject matter experts (SMEs) (NPP training personnel with plant operational experience). It is important to emphasize, however, that the evaluation was *not* conducted in a rigorous manner following a systematic process and explicit criteria such as those outlined above. A rating was made by SMEs of more important PSFs by way of a survey form. The list provided to the SMEs, however, was not derived from a thorough review and compilation of existing taxonomies. The survey was conducted early in the program during site visits conducted for project team familiarization with NPP practice. It was based primarily on Swain's taxonomy plus judgement of the project team as to areas within that listing that needed further elaboration. However, we do feel that even the limited evaluation was helpful to suggest the more important PSFs, and the results were used, along with a review of the other taxonomies noted in Section 2.1 through 2.4 to arrive at a tentative list of PSFs. These were further categorized, strictly on the basis of judgement of the project team, as to their relevance to training, personnel selection, or both.

Two lists of PSFs were prepared, one referred to as "operator characteristics," the other, as "environmental characteristics." During semi-structured interviews, training supervisors and staff members at six utilities and three training "vendors" (a total of fourteen individuals) were asked to review the lists and rank the items on a five-point scale as to its importance to control room operator performance (1 = least important, 3 = average, 5 = greatest importance).

Results of the ranking are shown in Table 2.6. Because of the small sample size, the lack of rigor in identifying and explicitly defining each variable, the lack of uniqueness of variables, and the limited scope of participants (i.e., training staff only, no operators, management, etc.), we view these results only as suggestive of areas to emphasize.

Table 2.7 is the tentative listing of PSFs suggested as potentially significant to NPP control room operators. As noted above, it is based on a review of all of the literature noted in the previous sections, the limited survey of ranking by SMEs, and the judgement of the project team. It is essentially Swain's taxonomy with an expanded list of ten internal PSFs and related subelements.

From the expanded list of internal PSFs we find that some of the factors are considered what might be called selection PSFs, that is, no amount of training will affect the degree to which the student demonstrates the PSF. Minimum performance levels for these factors can only be achieved through the selection process. Other factors can be affected by the training process, but are still basically achieved through a selection screening process. Factors which fall into either of these two categories will be referred to as a selection factor. Similarly there are PSFs which will be referred to as training factors. In addition there are those factors where the training and selection processes are complementary to each other and a deficiency in either one can be accommodated by the other. In Table 2.4 the internal PSFs from Table 2.3 are designated as being primarily selection, primarily training, or a complementary combination of both.

2.6. Summary

The quantification of the relationship between training requirements (including entry-level or selection requirements) and job performance is a fundamental goal and requirement for development and assessment of "criterion referenced training." One step toward the goal is

Table 2.6. Results of Ranking of Performance Shaping Factors by Subject Matter Experts

Rank Order	Operator Characteristics
1	Motivation
2	Training and experience
3	Intelligence level
4	Reaction time
5	Coordination
6	Overall personality
7	Dexterity
8	Fatigue limits
9	Motor response
10	Sensory responses (touch, smell, etc.)
11	Mobility
12	Health and handicaps
13	Equilibrium
14	Size
15	Sex
16	Strength
17	Age
18	Cultural background
19	Family background
	Environmental Characteristics
1	Control panel design
2	Job training
3	Information inputs (displays)
4	Supervision
5	Procedures
6	Task complexities
7	Stresses (temperature, noise, radiation)
8	Operational stresses (emergencies, accidents)
9	Other shift personnel
10	Career opportunities
11	Pay and benefits
12	Manning levels
13	Technical documentation
14	Shift work

to develop a taxonomy which can serve as a structure to make explicit those variables that affect job performance and to generalize results of human performance research. Development, and especially, validation of a comprehensive taxonomy will require a rather extensive research effort far beyond the limited resources available in this project. In Fleishman's words,[16] "Taxonomies are not out there to be discovered, some invention is required. However, this invention must be grounded in empirical data, research and evaluation." The limited efforts conducted in this project provide a reasonable point of departure, but it is extremely important that a more comprehensive program be initiated to provide the necessary research, empirical data, and evaluation.

Table 2.7. Listings of Performance Shaping Factors

Internal	Stressors
PERCEPTUAL CAPABILITIES Visual Auditor Kinesthetic MOTOR CAPACITIES Speed Strength Coordination PERCEPTUAL MOTOR Communication Reaction time Perceptual load Aging Drugs and alcohol	ORGANISMIC FACTORS Attitudes Physical condition Group identification Physical attributes KNOWLEDGE IN REQUIRED AREAS Fundamentals Plant systems Operating practices EXPERIENCE Military nuclear propulsion plant Reactor simulator On the job nuclear power plant Other power plant experience PERSONALITY Reaction to stress (anxiety) Contact with reality Introversion Trustfulness Stability (depression/mania) Paranoia Psychopathic tendencies Leadership INTELLIGENCE Memory Verbal comprehension Perceptual organization MOTIVATION Job satisfaction Incentive Interests CENTRAL PROCESSES Decisionmaking Problem solving Attention Time perception Search and scanning
External	**Stressors**
SITUATIONAL CHARACTERISTICS Architectual features Quality of environment: temperature, humidity, and air quality Lighting Noise and vibration Degree of general cleanliness	PSYCHOLOGICAL STRESSORS Suddenness of onset Duration of stress Task speed Task load High jeopardy risk threats (of failure, loss of job)

Table 2.7. Continued

Internal	Stressors
Work hours/work break	Monotonous, degrading, or meaningless work
Availability/adequacy of special equipment, tools, and supplies	Long, uneventful vigilance periods
Manning parameters	Conflicts of motives about job performance
Organizational structure (e.g., authority, responsibility, communication channels)	Reinforcement absent or negative
Actions by supervisors, coworkers, union representatives, and regulatory personnel	Sensory deprivation
Rewards, recognition, benefits	Distractions (noise, glare, movement, flicker, color)
	Inconsistent cueing
JOB AND TASK INSTRUCTIONS	
Procedures required (written or not written)	PHYSIOLOGICAL STRESSORS
Written or oral communications	Duration of stress
Cautions and warnings	Fatigue
Work methods	Pain or discomfort
Plant policies (shop practices)	Hunger or thrist
	Temperature extremes
TASK AND EQUIPMENT CHARACTERISTICS	Radiation
Perceptual requirements	Atmospheric pressure extremes
Motor requirements (speed, strength, precision)	Oxygen insufficiency
Control-display relationships	Vibration
Anticipatory requirements	Movement constriction
Interpretation	Lack of physical exercise
Decisionmaking	
Complexity (information load)	
Narrowness of task	
Frequency of repetitiveness	
Task criticality	
Long- and short-term memory	
Calculational requirements	
Feedback (knowledge of results)	
Continuity (discrete versus continuous)	
Team structure	
Man-machine interface factors: design of prime equipment, test equipment, manufacturing equipment, job aids, tools, fixtures	

Table 2.8. Designation of Primary Means for Achieving Internal PSFs

Internal PSF	Primarily Selection	Primarily Training	Either Selection or Training
Perceptual Capacities			
Visual	X		
Auditory	X		
Kinesthetic	X		
Motor Capacities			
Speed	X		
Strength	X		
Coordination	X		
Perceptual-Motor			
Communication	X		
Reaction Time	X		
Perceptual Load Limit	X		
Drugs and Alcohol	X		
Organismic Factors			
Physical Condition	X		
Physical Attributes	X		
Attitudes			X
Group Identification			X
Experience			
Reactor Simulator		X	
On-the-Job Nuclear Power Plant		X	
Military Nuclear Power Propulsion	X		
Other Power Plant	X		
Knowledge of Required Performance Standards			
Fundamentals		X	
Plant Systems		X	
Operating Practices		X	

Internal PSF	Primarily Selection	Primarily Training	Either Selection or Training
Personality			
Reaction to Stress	X		
Contact with Reality	X		
Trustfulness	X		
Stability	X		
Paranoia	X		
Psychopathic Tendencies	X		
Leadership Abilities	X		
Intelligence			
Memory	X		
Verbal Comprehension	X		
Perceptual Organization	X		
Motivation			
Job Satisfaction			X[a]
Incentive			X[a]
Interests			X[a]
Central Processes			
Decision Making			X
Problem Solving			X
Time Perception			X
Search and Scanning		X	

[a]These factors may be heavily influenced by factors external to the selection and training process.

3. A STRUCTURE FOR TRAINING SYSTEM EVALUATION BASED ON THE SYSTEMS APPROACH TO TRAINING

In this chapter we will identify a SAT framework for use in designing or evaluating training systems in the NPP industry. In Section 3.1, findings from previous ORNL studies on the history of SAT methodologies in other industries and the use of a SAT in the nuclear industry will be discussed along with more recent insights on the conclusions of those studies. This will be followed in Section 3.2 by a discussion of trends in nuclear power plant training as pictured from a limited number of plant site visits. The information discussed in Sections 3.1 and 3.2 will then be used in Section 3.3 to identify the key elements of a SAT process at the level deemed appropriate for evaluation purposes.

3.1. The Systems Approach to Training

In this section of the report the systems approach to training (SAT), will be discussed historically and in relation to personnel selection and training. The systems approach to the development of instructional programs emphasizes the important components of a training system, its development, and their interactions. The purpose is to provide a clear direction in the development process.

The systems approach has taken many forms and has been called by many names over the last 30 years since its initial appearance. General agreement exists as to the acceptance of the term SAT, but its meaning has generated wide disagreement. Montemerlo and Tennyson[20] suggest three reasons for disagreement and confusion concerning the meaning and implications: (1) lack of terminological standardization, (2) problems associated with educational innovations, and (3) the evolutionary nature of the SAT concept.

Over 100 SAT manuals have been published since 1960 that have used common terminology in an idiosyncratic manner, e.g., the term systems approach to training has been referred to by the names Systems Engineering Training (SET), Training Situation Analysis (TSA), the Developmental Approach to Training (DAT), the Design of Instructional Systems (DIS), and most recently, Instructional System Development (ISD). Each of these terms denotes an instructional systems technology method that includes most of the typical stages in the process (i.e., task analysis, behavioral objectives, media selection, objective performance measures, criterion testing, and some form of internal or external evaluation used as a quality assurance check). Each stage represents different processes, depending on the manual consulted or the instructional model used. Andrews and Goodson[21] present a comprehensive comparative analysis of over 40 different models for instructional design. Each of the models contains most of the processes mentioned above out of a possible 14 different instructional design stages (Table 3.1).

In Refs. 2, 3, and 4, the concept of a systems approach to training in the NPP industry was examined. This included a review of the use of a SAT and the results of its usage in other industries. One of the most influential SAT processes was identified in Ref. 4 as the Instructional Systems Development methodology (described in AFM 50-2[22] published by the Air Force Air Training Command). The ISD approach was recognized as a useful methodology for systematically approaching complex training in different environments and has been used in all branches of the military.

Table 3.1. Fourteen Common Stages in SAT Model Development

Task	Definition
1	Formulation of broad goals and detailed subgoals stated in observable terms.
2	Development of pretest and posttest matching goals and subgoals.
3	Analysis of goals and subgoals for types of skills/learning required.
4	Sequencing of goals and subgoals to facilitate learning.
5	Characterization of learner population "as to age, grade level, past learning history, special aptitudes or disabilities, and, not least, estimated attainment of current and prerequisite goals" (Gropper, 1977, p. 8).
6	Formulation of instructional strategy to match subject matter and learning requirements.
7	Selection of media to implement strategies.
8	Development of courseware based on strategies.
9	Empirical tryout of courseware with learner population, diagnosis of learning and courseware failures, and revision of courseware based on diagnosis.
10	Development of materials and procedures for installing, maintaining, and periodically repairing the instructional program.
11	Assessment of need, problem identification, occupational analysis, competence, or training requirements.
12	Consideration of alternative solutions to instruction.
13	Formulation of system and environmental descriptions and identification of constraints.
14	Costing instructional programs.

From Reference 21.

With respect to its use in the nuclear industry, the ISD process appears to have three major deficiencies.

1. **The lack of a front-end analysis to identify the role of the operator in the man-machine system.** The ISD process assumes that a front-end analysis has previously been performed to allocate system functions and subfunctions to appropriate system components, e.g., hardware, computer, personnel, etc. This process typically includes time-line analyses, synthesis of system design, a trade-off study, and a cost effectiveness analysis; results should be considered an integral part of a systems approach to training. In the NPP industry it is important that personnel performance requirements be based on this type of an analysis, i.e., that *personnel* performance requirements be based on *system* performance requirements.

2. **The lack of a fully developed entry level screening process.** In the military where the ISD process was developed, training programs deal with large numbers of trainees with a wide range of knowledge and skill levels. The ISD model assumes that trainees are assigned to a training program as a result of previous demonstrations of aptitudes or interests. The training program per se is normally based on a standard level of trainee and in most instances is not affected by the trainee entry level. With a reduced number of trainees as found in the NPP industry there should be a greater emphasis toward gearing training to individual requirements. This implies that a SAT process for use in the NPP industry should be directly affected by variations in trainee entry level.

3. **The process is very proceduralized in a linear stepwise manner.** The ISD process as originally perceived resulted in the production of proceduralized manuals which, at a very microscopic level, provided a linear process for developing a training program. The level of detail of many of these procedures can be illustrated by the use of steps such as "alphabetize your list of training objectives" and "grade test." Even in the military this level of detail has been found to stifle the creativity of the training staff. At times training development teams have been more concerned with possible punishment from not following the rules than with solving training problems.[23] The Air Force handbook for ISD users recognizes this problem and advises its users that:

   "Many constraints may bear on your specific situation. Based on your knowledge of the ISD process and a consideration of these constraints, you should selectively apply those procedures and techniques . . . that meet your needs."

   In the NPP industry some procedures or standardization is necessary. However, it should only be to a level necessary to maintain an audit trail. This suggests considerably less detailed proceduralization than that implied by many ISD manuals.

Because of these deficiencies and other potential implementation problems; it has not been recommended that the ISD process be indiscrimanately adopted for the development of training programs in the NPP industry. Nevertheless the framework of the ISD process does represent a base for the development of a complete SAT structure for use in the NPP industry.

3.2. Current Nuclear Industry Practices

It is clear that over the last couple of years training in the nuclear industry has been undergoing dramatic changes. This makes it extremely difficult to maintain an accurate and up-to-date picture of training practices. Thus early in this program, visits were made to a variety of relevant sites (6 utilities, an NRC regional office, 3 training vendors, and INPO) to update our understanding of industry practices. It was felt that any SAT structure developed as part of this program should not only meet regulatory needs, but from a practical viewpoint should also encompass structured approaches to training planned or already being used in the industry.

A semi-structured interview* was carried out with training supervisory personnel at each site. Questions were asked concerning structured processes for training program development, selection processes for screening trainee candidates, media selection methodologies, task analysis, and training effectiveness validation techniques. A diversity of responses were obtained for almost every question asked at each site.

With regard to SAT procedures for the development and implementation of training materials, most of the utilities visited were just beginning to understand the advantages of such an approach. Two of the utilities visited had backfitted an ISD-type approach into their existing training program. The use of ISD over other structured approaches appeared to be due to the military background of the training staff. About half of the industry training organizations visited were familiar with a structured systems approach but were depending on INPO to develop a process which they could use.

All of the training organizations visited used task analysis** to define training requirements. However, differences existed in the level of detail to which the task analysis was performed. The task analysis described by a few organizations would probably be more appropriately called job analysis.

As stated earlier, INPO is having a major impact on the structure of training programs. Thus, it is important to understand the INPO's "Comprehensive Training and Qualification System."[25] This process, illustrated in Fig. 3.1 is based on the Instructional Systems Development methodology developed and used by the military. Other than wording changes, there are two major differences between the INPO process and the ISD model as originally conceived in the military organizations: (1) the importance of the personnel selection process and its impact on the training system is clearly emphasized; (2) the INPO process has deemphasized the proceduralized nature of the ISD process. INPO plans to provide guidelines as to how the process may be performed, but there is substantial flexibility to allow for innovation by the training staff. These two changes address two of the deficiencies identified in Section 3.1 as being inherent to the ISD process.

The third deficiency in the ISD process as identified in Section 3.1 is not specifically addressed by INPO and thus requires some further explanation. From a pure systems approach to training, operator performance standards should be systems based, i.e., they

*The semi-structured guide used in this interview process is shown in Appendix C.

**Reasons for using task analysis ranged from "it is the only way to really identify the operators job" to "ANS-3.1 says training should be based on task analysis."

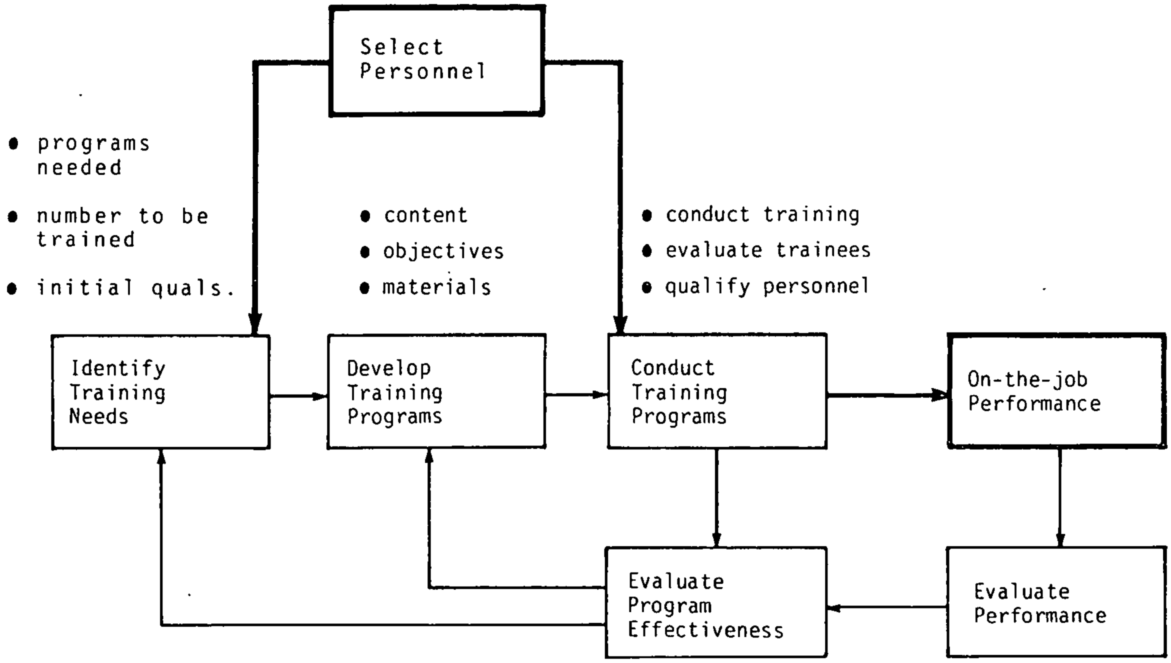

Fig. 3.1. INPOs Comprehensive Training and Qualification System (From Reference 23).

should be established with reference to system requirements. The INPO process uses norm-based performance for establishing performance standards, i.e., they are established almost exclusively on the basis of a group history analysis. Thus, the performance requirements and standards are based on practiced procedures and do not address the validity of those procedures from the basis of a systems design requirement. Clearly in most instances, some form of a front-end analysis has been performed to define procedures, but the documentation of this process is not normally available. Unfortunately, redoing this front-end analysis for documentation purposes could be very expensive and the value in terms of increases in training effectiveness due to performing this analysis is difficult to determine. Thus in the diagram presented in Section 3.3, the front-end analysis section is presented using dashed lines. The dashed lines are used to show that this step should be a part of the process; but it may not be a practical point for evaluation of existing training programs because existing NPPs do not have the rigorous documentation of a formal front-end analysis. It is extremely important that as new procedures and training programs are developed, the front-end analysis which defines the system requirement for the procedure should be documented in a manner amenable for use in a SAT-structured system.

3.3. An SAT Model for the Nuclear Industry and NRC

The structure recommended to NRC as part of this program, shown in Fig. 3.2, also has its roots with the ISD process. The blocks shown in Fig. 3.2 are in principle very similar

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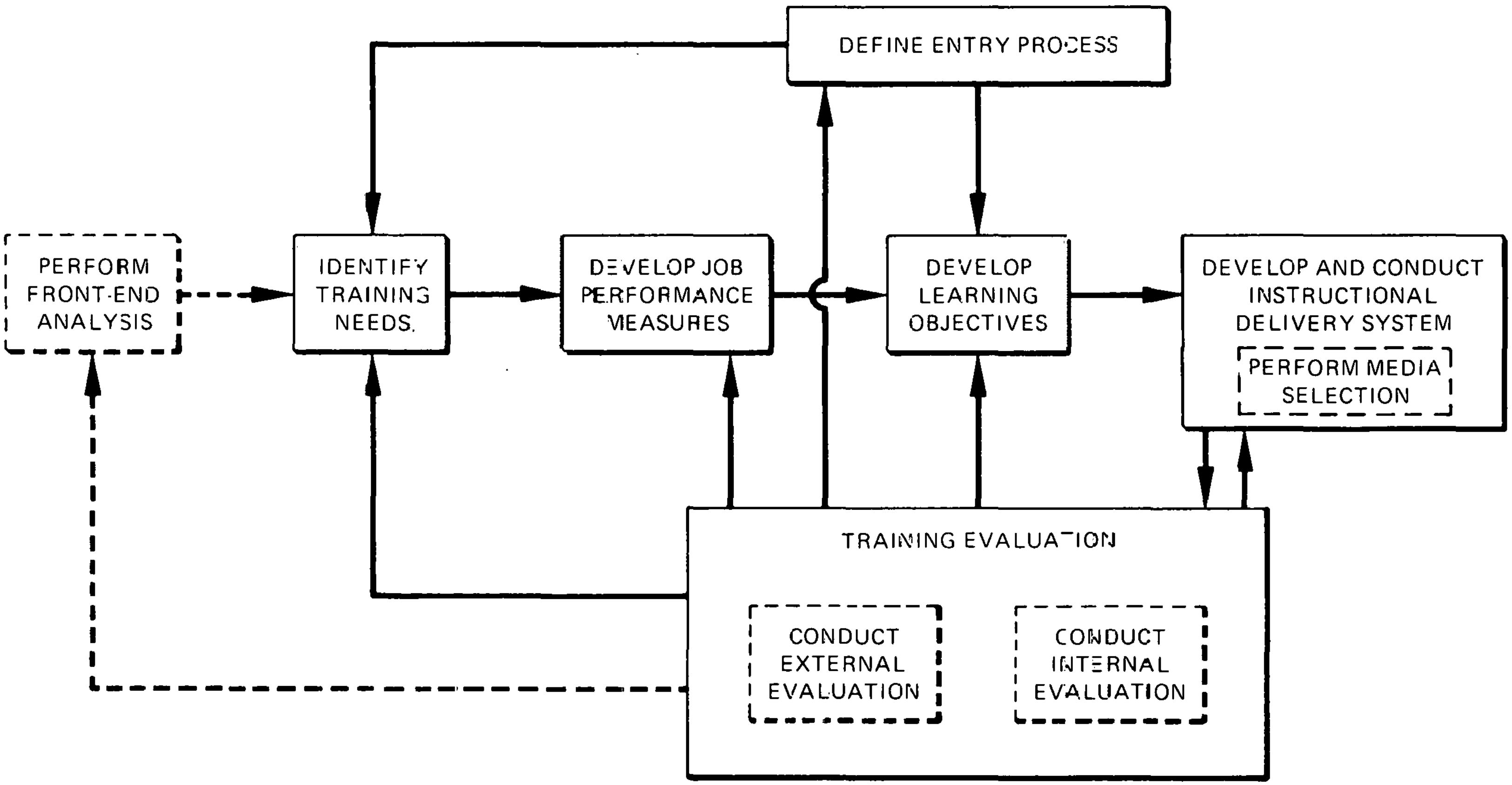


Fig. 3.2. A SAT Structure for Use in Evaluating NPP Training Systems.

to the INPO model, but are structured to represent independent segments of an evaluation process. Thus each block represents a point in the training process at which an evaluation could be made. Each step of this process is defined below:

1. *Identify Training Needs.* Identical to the first step of the INPO process, this goal is accomplished through three operations:

   a. *Use of a job and task analysis to define trainee performance requirements* — One of the first considerations in performing a training system evaluation is to determine where the raw data were obtained for constructing operator performance requirements. This data is normally collected as part of a job and task analysis. Job analysis is the means by which the duties and tasks necessary to perform a specific job are determined. The purpose and product of a job analysis is to establish an inventory of tasks which the individual is expected to be able to perform as part of his job. This is most appropriately accomplished through a systems requirements analysis. In this analysis the functional role and duties of the job are established with reference to system requirements. Other processes which have been used to form task inventories are job interviews, questionnaires, and reviews of similar job/task analyses.

      The task analysis is the means by which the actions necessary to perform each task are defined. This process should include explicit descriptions of: (1) when is the task performed, (2) how is the task performed, and (3) to what extent is the task performed.

   b. *Use of a selection process to identify the initial minimum performance level for trainees* — Minimum entry-level requirements should be established based on performance requirements, manning requirements, available entry-level population, and the cost of training. For an emerging system an analysis of anticipated entry-level behavior would be required, but for an existing system the analysis of entry-level behavior and its impact on performance both in training and on the job should be an integral part of the training system.

   c. *Identification of tasks which require training* — It is necessary to compare specific job performance requirements to the entry-level behavior of trainees in order to determine the changes necessary in skills, knowledge, and attitudes to meet those requirements. These changes in skills, knowledges, and attitudes are designated as training requirements.

2. *Develop Job Performance Measures.* It is not specifically stated but this appears to fall under both "identify training needs" and "develop training programs" in the INPO system. This is the point in the process where (measurable) behaviors necessary to achieve performance standards are defined. These job performance measures should include the performance standards to which on-the-job proficiency would be judged. Trainee testing performed as part of the training program or the licensing process should be based on these job performance measures.

3. *Develop Learning Objectives.* This falls under the "develop training programs" step in the INPO system. Two types of learning objectives (terminal and enabling) are developed in this step. A Terminal Learning Objective (TLO) can be defined as a precise description of what the trainee is expected to learn in order to perform a specified segment of a job.[26] A TLO describes the behavior embodied in a task, the conditions for performance, and the standard of achievement expected for completion of the task. Terminal objectives usually describe a complete task from the job/task listings. An Enabling Learning Objective (ELO) is defined as those component behaviors, conditions, and standards required to best attain the TLO.[26] Several ELOs may be written to support a single TLO. These ELOs should be based on knowledge of the actual entry-level capability of the trainees and could be considered the day-by-day lesson plan objectives which will facilitate the trainees acquisition of the terminal learning objectives.

4. *Develop and Conduct the Instructional Delivery System.* Again there is a corresponding step, "conduct training programs" in the INPO system. It is this portion of the process where the actual instruction is designed, developed, and implemented. This would include development of a media selection process,* instructional materials, tests, instructor qualification requirements, and instructor guides. Also important in this step is the development of a management and administrative plan for implementation and continued support of the training program, as well as development and validation of the instructional materials.

5. *Perform Media Selection.* The importance of media selection is illustrated in Fig. 3.2 by making it a separate step even though it is still part of the Instructional Delivery System. The evaluation of a training system must include the selection and implementation procedures for media that support learning objectives. To properly address all of the stimulus requirements for each learning event, the media selection process has to anticipate and support the internal process of learning. In the training of nuclear power plant personnel, thousands of instructional events must occur to carry out the total program within several instructional contexts. Depending on the administrative constraints of time, cost, and location, a sizable pool of media alternatives may exist from which each utility may select for instructional purposes.

6. *Training Evaluation.* Both internal and external evaluations will be discussed in this report as one part of the training effectiveness evaluation. The primary purpose of an internal evaluation is to determine whether the instructional effort has accomplished what was originally intended. The primary purpose of an external evaluation is to find out whether students who successfully complete training can perform, to established standards, the job which they were trained for. External evaluation is different from internal evaluation in two major ways:

   a. While internal evaluation is conducted both before and during instruction, external evaluation is conducted after the students have completed the instruction and have been assigned to a job.

*Media selection although part of the Instructional Delivery System is presented as a separate topic in this report, step number 5.

b. An internal evaluation reviews the instructional process to determine its effectiveness in accomplishing what was originally intended, while an external evaluation reviews on-the-job behaviors to determine the effectiveness of the training process.

The system described in this section is clearly a dynamic one. The results of a training effectiveness evaluation should be used to assess or redefine each of the steps of the process. As stated in Ref. 25,

The process must be designed based on expected input and evaluated by the quality of the output. The training system should be adjusted to meet the needs of the personnel who are selected; it should also be changed as necessary to achieve safe, reliable plant operation.

3.4. Summary

The potential of the systems approach to training process discussed in this chapter is that it provides a structured framework for compiling and assessing information, evaluating the information objectively, and providing objective criteria for making decisions and tradeoffs. The process clearly requires a large commitment on the part of the utility, but as stated in Ref. 25, "efforts can be cost-effective in the long run, especially if consistent approaches are accepted and coordinated industry-wide projects are undertaken."

4. A TRAINING PROGRAM EVALUATION METHODOLOGY BASED ON THE SYSTEMS APPROACH TO TRAINING

4.1. Introduction

In the previous chapter a general SAT methodology for use in the nuclear power industry was introduced. In this chapter, checklists are introduced and discussed whereby the steps of the SAT model could be evaluated.* The checklists identify the key features of each step in the SAT process presented in Chapter 3. However we have not provided in great detail, at this time, guidelines as to how each point on the checklists can be evaluated; nor have we provided standards or criteria by which a passing or failing evaluation occurs. These items should be based on extensive demonstrations of the evaluation materials and a rigorous study of training effectiveness evaluations. The checklists do, however, present a menu of details which in some form or fashion should exist in a training program based on a systems approach to training.

4.2. Job and Task Analysis Checklist

The job and task analysis checklist is shown in Fig. 4.1. A five-point Likert scale is provided along with three generalized anchors which define the extremes and midpoint of the scale. Most responses should be easily identified with one or the other end of the scale, i.e., consistently positive or consistently negative within a category. Some exceptions may be found to this rule. For these circumstances, a three-point intermediate scale exists within which the evaluator may assign a value based on his judgment. Since each question is based on a subject matter expert judgment or opinion, a five-point scale works well since it is accepted as having "psychological reality" especially when used with scale anchor points. A rater is most apt to find responses falling at either end of the scale since a procedure is expected to be carried out throughout the job analysis once conducted for a single task. The questions on the checklists have been divided into two major categories: (1) those dealing with the validity of the job and task analysis (questions 1-8), and (2) those dealing with the structure of the job and task analysis (questions 9-15). The purpose of each question is described below:

1. **Were available job analysis data used, e.g., functions analysis data, human reliability analysis, human factors task analyses, subject matter expert listings of job functions, design engineering data, similar existing task listings, and previous task listings for the existing system?** The first step to take in a job analysis is to collect as much data concerning the functions and tasks of a job. Data comes from either similar or same system data if it exists. A variety of data may be obtained for the analysis including human factors data, design engineering requirements, and other similar system training tasks analyses. The SME judges whether the existing data base was adequate for developing task listings.

*Although these checklists were prepared primarily for NRC, they do provide substantial information that may be useful to utility management and training staff as they develop and evaluate their own training programs.

JOB AND TASK ANALYSIS CHECKLIST

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

	Question	COMPLETELY		GENERALLY		NOT AT ALL
1.	Were available job analysis data used, e.g., functions analysis data, human reliability analysis, human factors task analyses, subject matter expert listings of job functions, design engineering data, similar existing task listings, and previous task listings for the existing system?	5	4	3	2	1
2.	Was the task analysis information gathered in a reasonable manner?	5	4	3	2	1
3.	Do task and task element descriptions give a complete picture of the job?	5	4	3	2	1
4.	Were verification documents generated?	5	4	3	2	1
5.	Have all equipment related tasks been identified?	5	4	3	2	1
6.	Are all tasks on the job task inventory list actually performed?	5	4	3	2	1
7.	Is documentation of the data resource available for each task statement?	5	4	3	2	1
8.	Was the job inventory validated by sending questionnaires to a sample of the target population?	5	4	3	2	1
9.	Does each task statement include specific cues, standards, and elements?	5	4	3	2	1
10.	Was there a systematic method used for selecting tasks for training?	5	4	3	2	1
11.	Is there a ranking of tasks by estimated frequency each task will be performed?	5	4	3	2	1
12.	Is there a ranking of tasks based on the difficulty of training each task?	5	4	3	2	1
13.	Is there a ranking of tasks based on the consequences of not performing the task or performing it incorrectly?	5	4	3	2	1
14	Is there a composite ranking of each task based on the frequency of performance criticality of each task and the consequences of not performing correctly?	5	4	3	2	1
15.	Is there a listing of only those tasks that have been selected for training?	5	4	3	2	1
16.	Are tasks which have similar performance requirements clearly identified?	5	4	3	2	1

Fig. 4.1. Job and Task Analysis Checklist.

2. **Was the task analysis information gathered in a reasonable manner?** There are several methods by which information for a task analysis may be obtained. The evaluator should examine the method or methods chosen for obtaining task performance information including when and how the method was used. This information should then be compared with standard practices as illustrated in Table 4.1 to evaluate the appropriateness of the information gathering process.

3. **Do task and task element descriptions give a complete picture of the job?** Based on an evaluation of the tasks and task elements, a judgment is made whether these listings give a total description and complete picture of the job. The evaluator may make judgments based on personal experience in performing the job or based on data mentioned in item 1 of this checklist.

4. **Were verification documents generated?** Verification of task listings is an important step before attempting to utilize the listings. A number of approaches may be used to verify that the listings that exist are accurate. A documented procedure for carrying out a review by a jury of experts, questionnaires, or other approach should be available for examination.

5. **Have all equipment related tasks been identified?** Equipment related tasks are important to identify since they identify computing, testing, detecting, or other mechanical devices necessary to carry out the job. These identifications are important for the design of training in simulation or actual equipment related tasks.

6. **Are all tasks on the job task inventory list actually performed?** Tasks may be included on the job task inventory because job incumbents believe these tasks should be part of their job. Only those tasks that are observable and measurable should be included on a job task inventory.

7. **Is documentation of the data resource available for each task statement?** When carrying out job tasks, operators may require a number of reference documents; i.e., operational procedures, technical references, and other administration references. These should be listed for each task since the training and performance of some tasks are contingent upon the proper interpretation of these reference data.

8. **Was the job inventory validated by sending questionnaires to a sample of the target population?** Once the job task inventory has been verified, the next step is to send the inventory to job incumbents to determine their validity. This is usually an expensive and time consuming process but is necessary to assure that the inventory is complete and that no extraneous tasks have been included. Such a validation is usually part of a scheme for setting priorities in choosing tasks for training relative to the frequency a task is performed, the difficulty of the task, and criticality of the task.

9. **Does each task statement include specific cues, standards, and elements?** In carrying out this evaluation the evaluator should remember that:

   a. task statements should be simple sentences which start with an action word,

Table 4.1. Standard Practice for Performing Task Analysis (Reproduced from Reference 25)

Method	When It Is Used	How It Is Used
(1) **Review of Task** Information	*When starting your analysis.* This is a good starting point for analysis of any task, especially if you are not an expert in performance yourself. It should never be used as the only method of analysis *When preparing a rough draft.* You may wish to use this information to fill out a rough draft of the Task Analysis Worksheet; then you can verify and refine the information when you conduct another method of task analysis.	*Review.* Locate and read as many sources of task information as possible, i.e., field and technical manual, training films, course outlines from both institutional and extension training document of equipment manufacturer, etc. *Evaluate.* From all the sources, decide which is the preferred method of task performance. *Describe.* Record task conditions, cues, standards, elements, tips and references on Task Analysis Worksheet.
(2) Consensus Group (SME's)	*When analyzing soft-skills tasks.* This method is particularly useful for analyzing supervisory and managerial tasks (soft-skills) in which many of the critical elements are not directly observable, or for which there are optional methods of performance and alternative paths. *When analyzing new tasks.* When you are analyzing a new task, that is, one which has not yet been introduced to the field, this is the only method available. The "experts" in this case are personnel who have expertise in similar tasks, or who have been contractor trained on the new equipment.	*Selecting a group.* Assemble a group of personnel (three or more) who have knowledge and experience in the task. *Pool information.* SME's share information. *Evaluate.* SME's evaluate all information in order to make decisions as to the most acceptable method of task performance. In order to do this for alternate path tasks, key elements must be identified. *Describe.* Same as method 1.
(3) On-Site Observation Interview	*When analyzing hard-skills.* This is the best method for analyzing operator/performer tasks (hard-skills) which generally have a fixed sequences of performance. *When analyzing all tasks.* Whenever budgetary and time constraints allow, this method should be used, either alone or in combination with another method.	*Observe performance.* Watch a soldier who is proficient perform the task. Observe the cues which initiate performance of each step and the steps (elements) which follow each cue. *Interview soldier.* Tactfully question the soldier about various aspects of his performance. For example you may say, "Is that step always done that way?" or "Can you do anything else at this point?" *Describe.* Same as Method 1. Note: More than one soldier should be observed/interviewed ideally in more than one location.
(4) Self-Performance	*When on-site interview/observation is not possible.* This method is not recommended because it is very difficult to be objective and to method can be used as final check on another method.	*Reconstruct task performance.* Here you mentally rehearse or actually perform the task yourself. *Describe.* Same as Method 1.

b. statements should present definite beginning and ending points,

c. each task statement should describe a specific part of the job which is independent from other tasks

d. task elements should give a step-by-step physical description of exactly what is required to successfully perform the task

10. **Was there a systematic method used for selecting tasks for training?** Documentation should exist that demonstrates a systematic method by which the performing agency has selected tasks for training. This method should be based in part on minimum entry level trainee characteristics.

11, 12, 13, 14. **Is there a ranking of tasks by estimated frequency each task will be performed? Is there a ranking of tasks based on the difficulty of training each task? Is there a ranking of tasks based on the consequences of not performing the task or performing it incorrectly? Is there a composite ranking of each task based on the frequency of performance, criticality of each task, and the consequences of not performing it correctly?** A ranking of tasks should be performed based on the frequency that a task is performed, the difficulty of training the task, and the criticality of the task when not performed correctly. A combination of these ranking schemes should be used to determine which task out of the total job task inventory will be included for training and the proportionate amount of time that will be allotted for the adequate training of each.

15. **Is there a listing of only those tasks that have been selected for training?** After stipulating the rationale for choosing tasks for training and ranking these tasks, the result should be a task listing that includes all of the tasks which have been chosen to be trained and should thus be included for detailed analysis in a subsequent task analysis.

16. **Are tasks which have similar performance requirements clearly identified?** If the performance requirements are highly similar for two or more tasks which require training, it should not be necessary to specifically train each task, but only the most representative task of that group. The evaluator should examine whether or not a grouping of similar tasks has been performed.

4.3. Job Performance Measures (JPMs) Checklist

The checklist shown in Fig. 4.2 includes the necessary assessments for JPMs. Since JPMs are directly related to task listings, it is likely that a positive assessment of the JTI will lead to a positive assessment of JPMs. The most important aspects of JPMs are that they be written at an adequate level of detail and that they be observable behaviors that can be directly measured. Questions 1-3 deal with the first issue while questions 4-7 deal with the second issue.

1. **Is each JPM written at the task level?** Because job performance measures are a measure of how well an individual can perform his job, they are written at

JOB PERFORMANCE MEASURE CHECKLIST

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

		COMPLETELY		GENERALLY		NOT AT ALL
1.	Is each JPM written at the task level?	5	4	3	2	1
2.	Are JPM standards adequate for the measure of performance without being too stringent for the level of training?	5	4	3	2	1
3.	Were JPMs validated based on a representative sample of the target population?	5	4	3	2	1
4.	Is each JPM the best approximation to a measure of actual required performance as can be made considering costs, time, and the ability to measure?	5	4	3	2	1
5.	Is each JPM capable of discriminating satisfactory performance from unsatisfactory performance?	5	4	3	2	1
6.	Is the scoring of each JPM as quantitative as possible with a minimum of subjective interpretation?	5	4	3	2	1
7.	Are JPMs observable elements that do not require inferences from those judging performance and are they observable within the training environment?	5	4	3	2	1

Fig. 4.2. Job Performance Measure Checklist.

the task level. This means that actual job performance is taken into consideration as much as possible along with the cues, standards, and conditions under which measurement should be taken.

2. **Are JPM standards adequate for the measure of performance without being too stringent for the level of training?** The evaluator should examine JPM statements to determine if they clearly reflect the performance requirements as specified by the task analysis. In addition the evaluator should determine whether or not the performance measurement requirements are too stringent for the level of training to which they are being applied (e.g., novice vs. requalification).

3. **Were JPMs validated based on a representative sample of the target population?** As in task validation, job performance measure validation should be carried out using a sample of job incumbents from the target population. These procedures assure that the job performance measure is accurate and that the total set of job performance measures are complete for describing those tasks that are selected for training. The behaviors, cues, and standards for each of the JPMs is examined as part of the validation process.

4. **Is each JPM the best approximation to a measure of actual required performance as can be made considering costs, time, and the ability to measure?** A documented analysis should exist for how job performance measures were derived. This analysis should reflect engineering system requirements.

5. **Is each JPM capable of discriminating satisfactory performance from unsatisfactory performance?** Exceptable bands of performance should clearly be defined. The evaluator should examine the criteria for standards in job performance measures as illustrated in Table 4.2.

Table 4.2. Standards in Job Performance Measures (Reproduced from Reference 25)

Criteria for Good Standards	What is Specified
Completeness	The precise nature of the output.
	Number of features that output must contain.
	Number of steps, points, pieces, etc., that must be covered or produced.
	Any quantitative statement that indicates acceptable portion of total.
Accuracy	How close to correct the performance must be.
	Exact numbers reflecting tolerances.
	Values or dimensions that acceptable answers/performance can assume. (These may be qualitative.)
Time	How many days, hours, minutes, or seconds can be used.

6. Is the scoring of each JPM as quantitative as possible with a minimum of subjective interpretation? As much as possible scoring schemes for JPMs should be based on quantitative measures rather than subjective interpretations by judges. Subject matter experts will be used in almost all job performance measures, but to the greatest extent the scoring procedures should be structured leaving as little latitude for interpretation as possible.

7. **Are JPMs observable elements that do not require inferences from those judging performance and are they observable within the training environment?** Breaking down the job performance measures into observable elements assures that the judgment of performance will be as objective as possible. In addition, in order to be measured within the training process, it must be measurable within thc training environment.

4.4. Training Objectives Checklist

Training objectives may exist for many courses of training within the total training program. Evaluators should not assume that because one course uses adequate objectives for training that other courses are as adequate. Instructors may use their own lessons and topic guides in conducting training but should draw upon format and content requirements that are found in training program planning documents. The following are guidelines for use in conducting a training objectives assessment. The checklist (Fig. 4.3) can be used for academic or hands-on settings, self-instruction, or instructor-based learning.

1. **Is there a terminal learning objective (TLO) for every task that is selected for training?** TLOs embody task listings. They are easy to identify since they are similar to tasks in statements of the behaviors, conditions, and standards. Terminal objectives should exist for those tasks selected for training out of the total JTI.
2. **Has each TLO been broken down into enabling learning objectives (ELO)?** For every TLO there should be a set of supporting ELOs. The evaluator will find ELOs listed in instructor guides or lesson and topic guides. Lessons should include clear and well coordinated statements of TLOs and ELOs as part of instruction.
3. **Does each TLO and ELO state a behavior that the student is to exhibit upon completion of the task?** Each objective should consist of a behavior statement, conditions under which performance of the behavior will be expected, and a standard of performance that is acceptable based on some criterion. Requiring objectives to exist in this form assures a development process that is performance based. The behavior portion of an objective should have a clearly stated beginning and end. The behavior should be directly observable through actions of the student.
4. **Does each TLO and ELO state conditions related to behaviors that specify successful task completion?** Each objective should be written clearly enough so the student and the instructor will understand when it is successfully completed. There should be a statement concerning the conditions or cues that will signal completion.
5. **Does each TLO and ELO state a specific criteria and standard for successful performance of the training objective?** When the objective behavior has been attempted by a student and the behavior is complete, it will be compared in some objective manner to a standard of acceptable performance. The standard should be based on job performance requirements.

TRAINING OBJECTIVES CHECKLIST

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

		COMPLETELY		GENERALLY		NOT AT ALL
1.	Is there a terminal learning objective (TLO) for every task that is selected for training?	5	4	3	2	1
2.	Has each TLO been broken down into enabling learning objectives (ELO)?	5	4	3	2	1
3.	Does each TLO and ELO state a behavior that the student is to exhibit upon completion of the task?	5	4	3	2	1
4.	Does each TLO and ELO state conditions related to behaviors that specify successful task completion?	5	4	3	2	1
5.	Does each TLO and ELO state a specific criteria and standard for successful performance of the training objective?	5	4	3	2	1
6.	Can each behavior that is specified by ELO and TLO be measured directly in the training environment?	5	4	3	2	1
7.	Can each TLO and ELO be classified into a type of learning?	5	4	3	2	1
8.	Does each ELO convey the level of detail necessary for instructional design?	5	4	3	2	1
9.	Does each TLO reflect the adjustment and competency required of a student and is it appropriate to the instructional setting?	5	4	3	2	1
10.	Are all training objectives separate from one another (i.e., can be taught at one time)?	5	4	3	2	1
11.	Is the sequence of both TLO and ELO properly identified?	5	4	3	2	1
12.	Do the ELOs support the TLOs?	5	4	3	2	1
13.	Do the combined ELOs fulfill the TLOs?	5	4	3	2	1
14.	Can the TLOs be taught in a reasonable period of time?	5	4	3	2	1

Fig. 4.3. Training Objectives Checklist.

6. **Can each behavior that is specified by ELOs and TLOs be measured directly in the training environment?** There should not be any objectives for training that are not measurable in the training environment. This is usually controlled by task selection. If a task performance cannot be measured in training, then it should not become a terminal objective.

7. **Can each TLO and ELO be classified into a type of learning?** Instruction varies based on the learning nature of the objective. Media selection, instructional techniques, curriculum materials, and instructor qualifications are a function of the training demands of an objective. Proper instructional design cannot occur when the type of learning required by an objective is not considered. One example of learning categories and subcategories is illustrated in Table 4.3.

8. **Does each ELO convey the level of detail necessary for instructional design?** Enabling objectives determine the instruction that will be related to TLOs. Each ELO should be specific in its statement of behavior conditions and standards so that an instructor or other curriculum designer will know exactly what the course must provide. This item is related to items 3, 4, and 5 above since they all address specificity in objective statements.

9. **Does each TLO reflect the adjustment and competency required of a student and is it appropriate to the instructional setting?** Each objective should be complete enough so that the student understands what is required of him. The student and the instructors should understand the entry skills of the student in comparison to what an objective requires. Part of the purpose of instruction guides and planning is to assure that student entry level skills are matched at the beginning of instruction and that the instruction is planned in understandable increments of student learning.

10. **Are all training objectives separate from one another (i.e., can be taught at one time)?** Training objectives should represent only a single action. The evaluator should examine objectives to make certain that it is indeed a unitary action rather than consisting of compound elements.

11. **Is the sequence of both TLO and ELO properly identified?** The evaluator should remember that there are no hard and fast rules for sequencing objectives. However, there are many possible relationships between tasks and there are basic rules of thumb for sequencing in each case. Three relationships and associated sequencing are described in Table 4.4.

12. **Do the ELOs support the TLOs?** Each enabling objective should be directly related to a TLO. In their entirety enabling objectives should describe what a student must come to know and do to reach the behavioral standard of the terminal objective. Enabling objectives are based also on the entry skills and knowledge of the student population of the lesson in question.

13. **Do the combined ELOs fulfill the TLOs?** These questions analyze the enabling objectives as the subset of the terminal objective. All of the enabling objectives should be clearly stated and all of them together should describe the one terminal objective intended for instruction. The combined properties of enabling objectives (i.e., behaviors, standards, and conditions) should be descriptive of the terminal objective.

Table 4.3. Example of Learning Categorics and Subcategories (Reproduced from Reference 25)

Learning Category	Learning Subcategory	Definition of Subcategory	Sample Action Verbs
MENTAL	Identifying objects and symbols	Giving one unvarying response whenever a particular object/ symbol is presented	Identify Interpret Read
	Recalling information	Repeating memorized information orally or in writing	List State Recite Define
	Discriminating	When presented with items that appear to be similar, identifying the differences between them	Monitor Distinguish Detect Discriminate
	Classifying	When presented with items that appear to be different, identifying the features which they have in common	Identify Recognize Classify
	Rule-learning and and using	Stating when and how a principle applies to a given situation	Select Predict Determine Specify Apply
	Decision-making	Specifying a course of action for use in a problem situation	Choose Decide Formulate Select Evaluate
	Gross motor skill	Moving all or part of the body in order to perform a set action	Cut Weld Saw Drill Splice Draw
PHYSICAL	Responsive motor skill	Moving all or parts of the body in response to continually changing cues to action	Track Control Steer Guide Regulate
ATTITUDINAL	Attitude-learning	Exhibiting a pattern of behavior or of response towards something	Accept Choose Comply with

Table 4.4. Three Types of Relationships Between Objectives and Their Recommended Sequencing (Reproduced from Reference 25)

Dependent	Independent	Supportive
Skills and knowledges in one learning objective are closely related to those in the other learning objective.	Skills and knowledges in one learning objective are unrelated to those in the other learning objective.	Skills and knowledges in one learning objective have some relationship to those in the other learning objective.
To master one of the learning objectives, it is first necessary to master the other.	Mastering one of the learning objectives does not simplify mastering the other.	The learning involved in mastery of one learning objective transfers to the other, making learning involved in the mastery of the other easier.
EXAMPLES: In math, in order to learn multiplication one must first learn addition One cannot send messages in Morse Code without first having mastered the codes for each of the letters and numbers. The "sending" skills are totally dependent on the prior learning.	EXAMPLES: For a clerk typist, "type letters from drafts" is independent of "maintain files." For a wheeled vehicle mechanic, "adjust carburetor" is independent of "torque engine head studies." In both examples, knowing how to do one would not help much with the other.	EXAMPLES: "Assemble weapon" has a supportive relationship to "disassemble weapon." "Drive a 1/4 ton truck" has a supportive relationship to "drive a 2-1/2 ton vehicle." In both examples, learning to do one would help considerably in learning to do the other.
The learning objectives must be arranged in the sequence indicated by the above hierarchy.	In general, the learning objectives can be arranged in any sequence without loss of learning.	The learning objectives should be placed close together in the sequence to permit optimum transfer of learning from one learning objective to the other.

14. **Can the TLOs be taught in a reasonable period of time?** For more than one reason a lesson should be contained in a managable time frame. If too much information is attempted to be taught too quickly, the learning process breaks down. The trainees will lose perspective of where lessons begin and end and how they relate to the job.

4.5. Instructional Delivery System

Evaluation of the instructional delivery system can be accomplished by several methods, e.g., course audits, student evaluations of course and instructor, and evaluation of materials. The last approach is most useful because instructional materials reflect all SAT processes and the skill of instructors in using available data and materials. An evaluation of instructional materials can best be accomplished with an evaluation of the Instruction Guide (sometimes called lesson guides or lesson plans). Generally, instruction guides are the blueprint of instruction and stipulate a series of lesson topic guides. Instruction guide assessment will cross all parts of the training program.

The critical elements which an evaluator should look for are included in the Instruction Guide Evaluation checklist shown in Fig. 4.4 and are explained in the following item descriptions:

INSTRUCTION GUIDE CHECKLIST

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

	COMPLETELY		GENERALLY		NOT AT ALL
1. Is there a documented procedure for instruction guide development and modification?	5	4	3	2	1
2. Is the Sequencing of objectives performed in a logical manner?	5	4	3	2	1
3. Does the instruction guide adequately state the terminal objectives?	5	4	3	2	1
4. Does the instruction guide adequately support the terminal objectives?	5	4	3	2	1
5. Does the instruction guide state the desired behavior, condition, and standards of the terminal objectives?	5	4	3	2	1
6. Does the instruction guide state a criterion objective?	5	4	3	2	1
7. Does the instruction guide adequately state the enabling objectives?	5	4	3	2	1
8. Does the instructor guide have a detailed outline to cover the following nine events of instruction:					
a. Gaining attention	5	4	3	2	1
b. Informing the learning of the objective	5	4	3	2	1
c. Stimulating recall of prerequisite learner	5	4	3	2	1
d. Presenting the stimulus material	5	4	3	2	1
e. Providing learning guidance	5	4	3	2	1
f. Eliciting the performance	5	4	3	2	1
g. Providing feedback about performance correctness	5	4	3	2	1
h. Assessing the performance	5	4	3	2	1
i. Enhancing retention and transfer	5	4	3	2	1
9. Is the use of various media devices/aids addressed for each instructional event?	5	4	3	2	1
10. Is there a procedure for validation of instruction guide content?	5	4	3	2	1

Fig. 4.4. Instruction Guide Checklist.

1. **Is there a documented procedure for instruction guide development and modification?** A standardized process should exist within the training department of each utility for developing instructor/lesson guides. This process assures a minimum acceptable approach to development and affords latitude for updating and changing materials as the plant and the entry level characteristics of individuals change. An important aspect of a Systems Approach to Training is the requirement to provide for feedback and procedures for documenting changes to upgrade deficient items in the training materials. It is important that these documentation procedures be tied into the development of instruction guides as a means for identifying changes.

2. **Is the sequencing of objectives performed in a logical manner?** The cohesiveness of the materials presented in the course and the courses combined to make up the curriculum, depends on the order in which the information is presented. When training objectives are first developed, a consensus of SMEs also determine whether TLOs are dependent, independent, or complementary to one another. That information should be used when organizing the sequence of instruction. If the TLOs are independent, then other logic should dictate the order of instruction. The order may be by degree of complexity, difficulty in understanding or criticality. The important point is that there should exist a rationale for the sequencing of instruction.

3. **Does the instruction guide adequately state the terminal objectives?** This question should clearly tell the trainees what it is that the instructor intends to teach in the time frame allotted. It should be simply a rewording of all or part of a task from the task analysis.

4. **Does the instruction guide adequately support the terminal objectives?** After the statement of the terminal objective the rest of the instructor guide content must support that original statement. This is accomplished by first stating enabling objectives. These enabling objectives can be considered subtasks or sublessons which need to be understood to entirely understand the terminal obective. The rest of the instruction guide should be a logical outline of the instructor's plans for employing various techniques to accomplish learning objectives. Four events should take place for each objective; present the objective, allow for practice, give guidance, and provide feedback information.

5. **Does the instruction guide state the desired behavior, condition, and standards of the terminal objectives?** It is important that the instructor convey to the trainees just how well and under what conditions they should be able to perform the stated action or behavior. Performance goals and the range of acceptable performance will have been determined for all of the training objectives by previous performance evaluation of actual system responses. In the case of basic knowledge, this is done by previous test scores as stated in job performance measures.

6. **Does the instruction guide state a criterion objective?** The criterion objective should be a summation of what the trainees should be able to do to demonstrate they have mastered the instructional material related to the terminal objective.

7. **Does the instruction guide adequately state the enabling objectives?** Subject matter experts determine the adequacy of enabling objectives. Enabling objectives should be a complete and logical sequence of the necessary skills and knowledge to be acquired by the student to accomplish the terminal objective.

8. **Does the instruction guide have a detailed outline to cover the following nine events of instruction: gaining attention, informing the learner of the objective, stimulating recall of prerequisite learnings, presenting the stimulus material, providing learning guidance, eliciting the performance, providing feedback about performance correctness, assessing the performance, and enhancing retention and transfer?** An instructor should always give an introduction to the class at which time: contact is established. He then states TLOs, motivates trainees, gives lesson overview, presents and summarizes the lesson, describes applications, performs some form of student or class evaluation, and assigns reference materials so the student may continue mastering the subject.

9. **Is the use of various media devices/aids addressed for each instructional event?** One of the tools of the instructional delivery system is the media selection process. Each training objective should be put through the selection process to determine the most appropriate instructional device or aid to train the given objective. The instruction guide should have a means for specifying the type of media and its use.

10. **Is there is a procedure for validation of instruction guide content?** The process of validation should be done for all materials presented for the first time. It involves giving a pretest to a sample group from the target population using the newly designed materials. A posttest is given immediately following instruction. The test scores are evaluated, the areas of least comprehension are reviewed for more appropriate methods of instruction and the instruction guide is revised.

4.6. Media Selection Checklist

Media selection is the process of selecting the most effective medium for the presentation of instruction to trainees. In a systems approach to training this process should also be carried out in a structured manner. This structure should be based on:

- practical constraints
- instructional nature of the objectives (certain behaviors may be important in training, but not on the job)
- presentation mode implied by the objectives (visual, auditory, etc.)
- type of learning involved (e.g., simple visual discrimination; chain of skilled performance).

Appendix B is a sample media selection model that has been created as part of this project for the selection of media to support licensed operator training programs. As shown, it is a trade off between a model that can be generally applied across most NPP positions and one that is specifically designed for licensed operators. Any media selection model draws on the same set of candidate media categories but each model varies in the logic of application.

Figure 4.5 presents a checklist prepared for an evaluation of media selection methods. An evaluator uses this checklist only after familiarizing himself with the training system being evaluated and the particular training requirements of a utility. The results of this evaluation will aid in an understanding of how the instructional delivery system uses available media and whether it is used effectively. The utility itself should carry out a similar evaluation to validate the use of media.

The following are item descriptions for the media selection checklist:

1. **Have similar objectives for training been grouped together for the purpose of media selection?** A grouping of objectives should be conducted previous to the initiation of media selection. This can be done in a number of ways but is usually based on the type of learning that each objective represents.
2. **Have instructional settings been specified?** Before any media selection process can be performed the training staff must be aware of the media available. Therefore a list of available media including constraints on its use, e.g., time constraints, availability constraints, etc., must be generated.
3. **Has the scope of instruction been determined?** This refers to the type of training that will be carried out using any of the media devices within the total available pool. Examples of types of training are full scale training, deferred training, refresher training, and new training for those tasks that overlap with entry level characteristics.
4. **Has the plan of instruction and instructional events been determined (Instruction Guide)?** Determining the plan of instruction and instructional events is necessary for the proper integration and identification of various media devices. The plans show the instructional need for various media. This allows a training management decision concerning the resources that will be expended to obtain various devices and the numbers of devices that must be devised to support the total curriculum.
5. **Have objectives been classified into types of learning?** Classifying objectives into types of learning provides a method by which objectives can be grouped. Additionally, it can be found that the higher forms of learning, e.g., decision making and problem solving, usually require higher fidelity training media with a wider range of stimulus characteristics that mimic the real environment.
6. **Has an objective worksheet been prepared as part of the media selection?** An objective worksheet is illustrated in Table 4.5. This is an analysis tool that aids the instructional designer in selecting the proper media (by objective).

MEDIA SELECTION CHECKLIST

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

		COMPLETELY		GENERALLY		NOT AT ALL
1.	Have similar objectives for training been grouped together for the purpose of media selection?	5	4	3	2	1
2.	Have instructional settings been specified?	5	4	3	2	1
3.	Has the scope of instruction been determined?	5	4	3	2	1
4.	Has the plan of instruction and instructional events been determined (Instruction Guide)?	5	4	3	2	1
5.	Have objectives been classified into types of learning?	5	4	3	2	1
6.	Has an objective worksheet been prepared as part of the media selection?	5	4	3	2	1
7.	Does the model, or process, of selection consider memory demands?	5	4	3	2	1
8.	Does the model; or process, consider self instruction and use of an instructor based on the demands of the training objectives?	5	4	3	2	1
9.	Does each set of decisions branch to a final media pool?	5	4	3	2	1
10.	Is the logic for media selection explained in written form for use with the model?	5	4	3	2	1
11.	Is the final selection of media based on a set of predetermined administrative requirements (e.g., time, cost, location, size, etc.)?	5	4	3	2	1
12.	Has media selection been carried out for each objective or set of similar objectives?	5	4	3	2	1
13.	Is the use of media periodically evaluated to determine effectiveness of use?	5	4	3	2	1
14.	Is the media pool periodically updated to include advances in instructional technology?	5	4	3	2	1
15.	Is media selection also carried out whenever new instructional courses or materials are prepared or old material is modified?	5	4	3	2	1

Fig. 4.5. Media Selection Checklist.

Table 4.5. Media Selection Worksheet

1. LIST TLO AND ELO
2. CHECK APPROPRIATE MEDIA
3. MAKE FINAL SELECTION BASED ON MEDIA MODEL AND ANALYSIS OF CHART

	OBJECTIVES															
ACTUAL EQUIPMENT																
SIMULATOR																
TRAINING DEVICE																
COMPUTER																
TRAINING AID																
PORTABLE EQUIPMENT																
MOCK-UP																
TV																
PROGRAMMED TEXT																
INTERACTIVE VIDEO DISC																
CHART																
MOVIE																
FILMSTRIP																
PRINTED TEXT																
OVERHEAD PROJECTION																
SLIDES																
INSTRUCTOR																

7. **Does the model, or process, of selection consider memory demands?** Memory demands vary across objectives. They significantly affect the design and selection of media since higher memory demand objectives would require more redundent positive stimuli. A memory demand may also require a mix of media especially when rote memorization of procedural tasks is required. Some media are better suited for rote memorization and proceduralization than others.

8. **Does the model, or process, consider self instruction and use of an instructor based on the demands of the training objectives?** A selection criteria within the media selection process will be the necessity for an instructor. When no instructor is required, self-instruction is usually indicated. These decisions can be made only by considering the conceptual demand or skill requirements of an objective.

9. **Does each set of decisions branch to a final media pool?** Each leg of the media selection media model should branch to a media pool that has similar media characteristics that meet the training requirements of an objective based on the conditions and standards of the behavior identified in the objective.

10. **Is the logic for media selection explained in written form for use with the model?** Media selection logic should be clearly explained in a written form so that all of the rationale behind the various decisions in selecting media are clear. This includes definitions of the available media pool and the process by which various media are pooled together.

11. **Is the initial screening and final selection of media based on a set of predetermined administrative requirements (e.g., time, cost, location, size, etc.)?** After

each objective is processed using the media selection model criteria, a final selection of one medium for each objective should be made based on a predetermined administrative requirements analysis. This includes considering the time available to training, the cost of training devices compared to the financial resources available, the possible locations available where media may be placed, the size of media especially in the acquisition and use of simulators, the number of trainees to be trained, etc.

12. **Has media selection been carried out for each objective or set of similar objectives?** Each objective or set of objectives should be processed through the media selection procedure. It is only after all objectives have been processed that a set of media can be identified that will fulfill the major portion of training objective requirements.

13. **Is the use of media periodically evaluated to determine effectiveness of use?** The use of media for any one medium should be periodically evaluated to determine how effective that media has been in meeting the determined instructional support requirements. Media may have to be replaced or upgraded depending upon how effective that media has been in supporting the objectives for which it was selected.

14. **Is the media pool periodically updated to include advances in instructional technology?** Advances in instructional technology are rapid especially with the innovation of computer-based instruction and display capabilities. It will pay to have the training manager stay abreast of the latest advances in instructional technology so that he may upgrade use of media in the training program. This can be true not only for the implementation of more advanced technology but for the removal of older media that may require an inordinate amount of maintenance in view of newer more advanced devices.

15. **Is media selection also carried out when new instructional courses or materials are prepared or old material is modified?** Because the SAT process is a closed loop where internal and external evaluations constantly feed back into job analysis task listings, training objectives, etc., medium selection must be carried out when instructional course materials or objectives are modified or new objectives are added to the curriculum.

4.7. Training Evaluation Checklists

In this section a series of checklists are presented which could be used by an evaluator to determine the extent to which a utility follows training quality assurance procedures. These checklists are divided into internal and external evaluations as described in Section 3.3.

4.7.1. Internal Evaluations

The internal evaluation consists of three types of evaluation:

1. *Criterion Tests* — This is the process by which the students' performance level is measured within the training system.
2. *Student and Instructor Evaluations* — This is a feedback mechanism whereby the student and the instructor can judge the relative effectiveness of the training program.
3. *Internal Training Process Review* — A plan should exist to allow the training staff to periodically review each step of the training process.

Checklists have been developed for each of the three evaluation types. These checklists are shown in Figs. 4.6a, 4.6b, and 4.6c, respectively and are described below.

Criterion Tests

1, 2, 3. **Are posttests routinely administered at the completion of lessons, modules or complete courses? Are actual scores (as opposed to pass/fail results) on these tests recorded and retained? Besides written tests, are practical works and exercises evaluated and the results recorded?** These questions are concerned with the periodic administration of student performance tests. These tests must be routinely administered in order to assist in the assessment of student progress. Proper assessment requires that the administration of these tests follow a logical sequence throughout the course of instruction. Although pass/fail determinations are generally sufficient for both student and instructor, other personnel in the instructional chain can make good use of the actual scores. These tests usually take the form of written examinations following a series of lectures but should also be administered following practical exercises and labs in order to better evaluate the skills required in these areas.

4. **Are tests based on job performace measures?** Tests should be based on job perforance measures as defined prior to the training process. This assures that tests are related to job performance requirements.

5. Are performance measurement requirements used to identify the most appropriate method of testing? There are several types of tests which can be used in any training program: written multiple choice, written true/false, written essay, oral, simulator, etc. The instructor should use performance measurement requirements to evaluate the most appropriate testing method.

6, 7. **Are several series of tests covering the same material used to avoid skewed test results? Are the frequency of use of these tests (or questions from an exam bank) recorded.** These questions address the issue of repetitive use of the same test material over time. There is a need to have available several different test series covering the same material in order to allow the administration of different tests to sequential groups of students. Such a procedure avoids contamination of tests results due to student foreknowledge. Besides different test series, this objective can be met by use of examination question banks. These banks allow for a different test to be constructed every time an exam is administered.

CRITERION TESTS

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

	COMPLETELY		GENERALLY		NOT AT ALL
1. Are posttests routinely administered at the completion of lessons, modules or complete courses?	5	4	3	2	1
2. Are actual scores (as opposed to pass/fail results) on these tests recorded and retained?	5	4	3	2	1
3. Besides written tests, are practical works and exercises evaluated and the results recorded?	5	4	3	2	1
4. Are tests based on job performace measures?	5	4	3	2	1
5. Are performance measurement requirements used to identify the most appropriate method of testing?	5	4	3	2	1
6. Are several series of tests covering the same material used to avoid skewed test results?	5	4	3	2	1
7. Are the frequency of use of these tests (or questions from an exam bank) recorded?	5	4	3	2	1
8. Does the training staff use criterion test results for analysis in the following:					
a. Areas of consistent student weakness	5	4	3	2	1
b. Areas of consistent lesson/course weakness	5	4	3	2	1
c. Adequacy of examinations	5	4	3	2	1
d. Adequacy of test bank questions	5	4	3	2	1
9. Is there evidence that the results of such analysis are used to modify the course where appropriate?	5	4	3	2	1

Fig. 4.6a. Internal Evaluation Checklist — Criterion Test.

STUDENT AND INSTRUCTOR EVALUATIONS

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

	COMPLETELY		GENERALLY		NOT AT ALL
1. Are student questionnaires routinely administered at specific points during the course of instruction?	5	4	3	2	1
2. Does the student questionnaire cover the following areas:					
a. The instructor(s)	5	4	3	2	1
b. The method of instruction	5	4	3	2	1
c. Learning objectives	5	4	3	2	1
d. Course content	5	4	3	2	1
e. Examinations	5	4	3	2	1
3. Are the responses to questionnaires systematically summarized?	5	4	3	2	1
4. Are instructor questionnaires routinely administered?	5	4	3	2	1
5. Does the instructor questionnaire cover the following:					
a. Instructional methods	5	4	3	2	1
b. Course content	5	4	3	2	1
c. Student performance	5	4	3	2	1
d. Student motivation, effort, and ability	5	4	3	2	1
6. Is there evidence that the responses to questionnaires are used to modify the course where appropriate?	5	4	3	2	1

Fig. 4.6b. Internal Evaluation Checklist — Student and Instructor Evaluations.

INTERNAL TRAINING PROCESS REVIEW

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

	COMPLETELY		GENERALLY		NOT AT ALL
1. Does a training process procedural plan exist?	5	4	3	2	1
2. Is there evidence that the plan is routinely reviewed during internal evaluations?	5	4	3	2	1
3. Does the training process plan include the following major activity procedures:					
a. Task analysis	5	4	3	2	1
b. Job performance measures (JPMs) development	5	4	3	2	1
c. Training objectives development	5	4	3	2	1
d. Test development	5	4	3	2	1
e. Training sequence development	5	4	3	2	1
f. Media selection	5	4	3	2	1
g. Instruction validation	5	4	3	2	1
h. Internal and external evaluations	5	4	3	2	1
i. Course feedback or revision system	5	4	3	2	1
4. Are the following student selection procedures periodically reviewed by the utility:					
a. Selection prerequisites	5	4	3	2	1
b. Tests of entry level skills	5	4	3	2	1
c. Unit or course pretests	5	4	3	2	1
5. Is a course review conducted periodically? (It can coincide with an internal evaluation.)	5	4	3	2	1
6. Does the training process review contain the following major review elements:					
a. Training plan	5	4	3	2	1
b. Curriculum outline	5	4	3	2	1
c. Job task inventory	5	4	3	2	1
d. Testing procedures	5	4	3	2	1
e. Instructional methods and techniques	5	4	3	2	1
f. Instructors	5	4	3	2	1
g. Supervisory personnel	5	4	3	2	1
h. Instructional materials	5	4	3	2	1
7. Does the internal evaluation result in a report that is a summary statement of the procedures used, findings, interpretations, pretations, and course revision recommendations?	5	4	3	2	1

Fig. 4.6c. Internal Evaluation Checklist — Internal Training Process Review.

8. **Does the training staff use criterion test results for analysis in the following: areas of consistent student weakness, areas of consistent lesson/course weakness, adequacy of examinations, and adequacy of test bank questions?** This question is concerned with the training staffs use of student performance test information. An evaluation should focus on areas of the course that present particular problems for the students as evidenced by poor examination results. These areas of distress may in fact be due to improper lesson preparation or delivery. Consistent poor test performance that does not appear to be related to lesson or topic deficiencies may be caused by inadequate examination questions. Analysis of the adequacy of the individual test questions as well as the examination's applicability to the lesson material should be conducted by the training staff.

9. **Is there evidence that the results of such analysis are used to modify the course where appropriate?** Question 9 addresses the previously discussed necessity for the completion of the evaluation loop. Proof of performance test evaluation is required as well as indications that the results of this evaluation are fed back into the instructional system. This feedback process should be formalized and consist of review and implementation procedures.

Student and Instructor Evaluations

1 and 4. **Are student questionnaires routinely administered at specific points during the course of instruction? Are instructor questionnaires routinely administered?** These questions concern the desirability of routine administration of feedback questionnaires to both students and instructors. These questionnaires should be administered several times during the course of instruction at logical points. A system of several intermittent questionnaires instead of one end-of-course questionnaire is superior in its ability to elicit pertinent and precise responses from the students.

2 and 5. **Does the student questionnaire cover the following areas: the instructor(s), the method of instruction, learning objectives, course content, and examinations? Does the instructor questionnaire cover the following: Instructional methods, course content, student performance, and student motivation, effort, and ability?** These questions address the content of both types of questionnaires. Student impressions regarding instructional techniques and course content often prove invaluable to the analysis of course problem areas. As subject matter experts, the instructors can often provide positive feedback regarding the technical correctness of the course as well as the manner in which the information is presented to the students. Instructor's subjective observations on student progress and performance provides a valuable adjunct to performance test results. Examples of typical student evaluation forms are shown in Appendix D.

3 and 6. **Are the responses to questionnaires systematically summarized? Is there evidence that the responses to questionnaires are used to modify the course where appropriate?** These questions are concerned with the analysis of

the data provided by both types of questionnaires. Some form of questionnaire summarization is required in order to correlate subjective comments. These summaries are then used by the evaluator to detect areas in the instructional system that appear to be deficient in some manner. Formal feedback of this information is required to keep the system responsive to both the student and the instructor.

Internal Training Process Review

1, 2. **Does a training process procedural plan exist? Is there evidence that the plan is routinely reviewed during internal evaluations?** These questions address the importance of having some form of training system procedural plan. Such a plan provides the keystone of the instructional process and is necessary to the formalized and orderly conduct of the course of instruction. Such a plan cannot remain perpetually shelved. It must periodically be reviewed in order to ensure its continued applicability to the training system.

3. **Does the training process plan include the following major activity procedures: task analysis, job performance measures (JPMs) development, training objectives development, test development, training sequence development, media selection, instruction validation, internal and external evaluations, and course feedback or revision system?** This question delineates the basic ingredients required of an adequate training plan. The major activities listed form an orderly chronological sequence in the development and maintenance of training materials. The listed procedures provide a minimum menu of selections to ensure a controlled and responsive training system.

4. **Are the following student selection procedures periodically reviewed by the utility: selection prerequisites, tests of entry level skills, and unit or course pretests?** This question concerns the review of fundamental student selection procedures. Formalized student criterion and selection procedures must exist in order to ensure a standardized and consistent level of input. These procedures must be responsive to changes in the course of instruction, job requirements, and the prospective student population.

5, 6. **Is a training process review conducted periodically? (It can coincide with an internal evaluation.) Does the course review contain the following major review elements: training plan, curriculum outline, job task inventory, testing procedures, instructional methods and techniques, instructors, supervisory personnel, and instructional materials?** These questions address the requirement for a periodic course review. Such a comprehensive review must be periodically conducted to ensure that the training process procedures previously discussed are fully and correctly implemented. The major review elements cover the entire spectrum of instructional activities.

7. **Does the internal evaluation result in a report that is a summary statement of the procedures used, findings, interpretations, and course revision recommendations?** This question specifies the requirement for a formal report summarizing the results of the internal evaluation. Such a report is a distillation of all the pertinent information derived from the previous checklists along with written course revision recommendations.

4.7.2. External Evaluations

In addition to internal evaluations the utility should perform external evaluations of the training program. This is the process whereby performance on the job is evaluated and used to examine the effectiveness of the training program. This type of evaluation can be conducted in several manners. Four types of external evaluations were identified as part of this study:

1. *Supervisor Evaluations* — This is a subjective assessment of on-the-job performance by the supervisor who is a subject matter expert.
2. *Review of Operational Data* — In this evaluation, data dealing with plant reliability, operator errors, etc., is reviewed to judge training effectiveness. This process is considered somewhat more objective than supervisory evaluations but may not be a direct measure of training effectiveness because of the numerous factors other than operator training that can also affect plant and operator performance.
3. *Reviews with Personnel and Supervisors* — Interviews with personnel and supervisors should be conducted at some period of time after personnel have completed training and have had time to settle into a job position. These interviews provide opinions from personnel and supervisors as to how well new personnel are prepared to perform their job. If interviews cannot be conducted, personnel entering new positions and their supervisors should be given an opportunity to respond in writing to discuss the level to which training prepared them to enter their job position. This written evaluation should be in the form of a structured questionnaire.
4. *Review of Licensing Exam Results* — The licensing exam represents a testing process which is external to the training. The utility should use the results of the licensing exam to evaluate the effectiveness of the training program. Ultimately, of course, it is desired to have the licensing exam validated to be predictive of on-the-job performance just as training requirements are validated to be relevant to job performance. Other NRC programs are addressing these validation issues.

Checklists have been developed to determine the level to which each of these forms of external evaluation may exist and to what extent they are used. These checklists are shown in Figs. 4.7a, 4.7b, 4.7c, and 4.7d, respectively, and are described below:

Supervisor Evaluations

1, 2, 3. **Are supervisor evaluations of operator job performance conducted routinely? Does the evaluation require information that directly assesses the operator's present job performance? Is some form of a job performance measure (JPM) used as an assessment tool for evaluation in those areas where actual performance of tasks is impractical?** These questions address the area of operator job performance. Supervisor evaluations of operator job performance

SUPERVISOR EVALUATION CHECKLIST

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

		COMPLETELY		GENERALLY		NOT AT ALL
1.	Are supervisor evaluations of operator job performance conducted routinely?	5	4	3	2	1
2.	Does the evaluation require information that directly assesses the operator's present job performance?	5	4	3	2	1
3.	Is some form of a job performance measure (JPM) used as an assessment tool for evaluation in those areas where actual performance of tasks is impractical?	5	4	3	2	1
4.	Are these evaluations made available to the utility's external evaluation team for analysis?	5	4	3	2	1
5.	Does the utility's external evaluation team directly observe operator performance on a simulator?	5	4	3	2	1
6.	Does the utility's external evaluation team use validated JPMs during observation of the operator on the simulator?	5	4	3	2	1
7.	Is the above performance data compiled, analyzed, and then used to modify the course of instruction where appropriate?	5	4	3	2	1

Fig. 4.7a. External Evaluation Checklist — Supervisor Evaluations.

REVIEW OF OPERATIONAL DATA CHECKLIST

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

	COMPLETELY		GENERALLY		NOT AT ALL
1. Does a formalized procedure for annotating plant availability (operating history) exist?	5	4	3	2	1
2. Is availability of the plant compared to operator actions or performance?	5	4	3	2	1
3. Is analysis of operating history compared to the training program to identify areas requiring extra emphasis?	5	4	3	2	1
4. Is there a procedure for reviewing licensee event reports (LERs) and other operational data sources generated both at the specific plant and at similar plants?	5	4	3	2	1
5. Are training program managers and supervisors included in this review process?	5	4	3	2	1
6. Is there evidence that the training program is modified where appropriate based on both specific plant and similar plant data sources?	5	4	3	2	1

Fig. 4.7b. External Evaluation Checklist — Review of Operational Data.

should be conducted routinely. These evaluations are often already a part of a normal in-place system for operator job performance assessment and need not pose an added burden to supervisors. These evaluations should require that information be provided by the supervisor that directly assesses the operator's present job performance. Evaluations of the future potential of the operator are neither required nor desired since the evaluation is primarily designed to measure the operator's job performance relative to his performance in the course of instruction that he just graduated from. In those areas where the nature of the task makes its actual performance impractical, some form of job

STRUCTURED QUESTIONNAIRES FOR EVALUATING TRAINING

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

	COMPLETELY		GENERALLY		NOT AT ALL
1. Are post-course completion questionnaires routinely administered to new operators?	5	4	3	2	1
2. Is a time interval after course completion specified for administering the questionnaire?	5	4	3	2	1
3. Is this time interval sufficient to ensure the graduate has had adequate time on the job, but not so long that he has acquired more skills through additional training?	5	4	3	2	1
4. Does the questionnaire contain questions that cover the followingareas:					
a. Present job performance	5	4	3	2	1
b. Differences between course training and actual job requirements	5	4	3	2	1
c. Feedback for possible course modification	5	4	3	2	1
d. Additional training received since arriving on the job	5	4	3	2	1
5. Are completed questionnaires compared to present supervisor evaluations?	5	4	3	2	1
6. Are similar questionnaires routinely administered to the supervisors of new operators?	5	4	3	2	1
7. Does the questionnaire direct the supervisor's responses only toward new operators?	5	4	3	2	1
8. Does the questionnaire contain questions that cover the following areas:					
a. New operator present job performance	5	4	3	2	1
b. Feedback for possible course modification	5	4	3	2	1
c. Amount and type of additional job training required by the new operator	5	4	3	2	1
d. Comparisons between the new operator and operators who were a product of a different training method	5	4	3	2	1
9. Are the supervisor and operator questionnaires compared to discover inconsistencies or biases?	5	4	3	2	1
10. Are completed questionnaires compared to the individual's course performance?	5	4	3	2	1
11. Are the responses to the questionnaires used in course modification where appropriate?	5	4	3	2	1

Fig. 4.7c. External Evaluation Checklist — Structured Questionnaires for Evaluating Training.

REVIEW OF LICENSING EXAM RESULTS CHECKLIST

Answers to the following questions are to be rated on a scale of 1 to 5. A rating of 5 indicates either complete agreement with the question or the fact that the item always occurs. A rating of 1 indicates that the item does not exist or that it never occurs. Yes or no answers correspond to 5 or 1 respectively.

	COMPLETELY		GENERALLY		NOT AT ALL
1. Are pass/fail results of operators' licensing exams recorded, correlated, and analyzed?	5	4	3	2	1
2. Are records kept on the percentage of course graduates that are not allowed to take the licensing exam?	5	4	3	2	1
3. Are reasons for barring a graduate from taking the exam indicated?	5	4	3	2	1
4. Are records kept on the amount and type of any post-course instruction required of graduates prior to their being certified to take the exam?	5	4	3	2	1
5. Is there evidence that the above data is analyzed and used to modify the course where appropriate?	5	4	3	2	1

Fig. 4.7d. External Evaluation Checklist — Review of Licensing Exam Results.

performance measure (JPM) needs to be used as an assessment tool for evaluation. Examples of such tasks include abnormal or emergency control room operations that could not be conducted routinely thus preventing the supervisor's use of them for evaluation purposes.

4. **Are these evaluations made available to the utility's external evaluation team for analysis?** This question addresses the need for these evaluations to be made available to the external evaluation team for further analysis. These evaluations need to be reviewed by the external evaluation team on both an individual and group basis. Such analysis allows for comparisons of job performance to student performance during the course of instruction.

5, 6. **Does the utility's external evaluation team directly observe operator performance on a simulator? Does the utility's external evaluation team use validated JPMs during observation of the operator on the simulator?** These questions address the role of the external evaluation team in the observation of operator job performance in simulators. Such observations should routinely be conducted on a simulator vs. in the actual control room so that abnormal or emergency tasks, or other tasks that are impractical for normal operations, can be viewed by the external evaluation team. During the course of these evaluations the team should use validated JPMs in order to assess the operator's performance on the simulator. This process could be part of the requalification training program.

7. **Is the above performance data compiled, analyzed, and then used to modify the course of instruction where appropriate?** This question once again addresses the requirement that performance data be compiled and analyzed and then fed back into the course of instruction where appropriate. This formalized feedback feature is necessary to ensure the continued responsiveness of the course of instruction to the changing demands of the job.

Review of Operational Data

1, 2, 3. **Does a formalized procedure for annotating plant availability (operating history) exist? Is availability of the plant compared to operator actions or performance? Is analysis of operating history compared to the training program to identify areas requiring extra emphasis?** These questions address the requirement for investigation of the relationship between plant operating history and operator performance. An annotated plant availability record should exist as well as some type of formalized procedure for periodic review. Availability of the plant can be compared to specific operator actions or performance in order to assess the possible effects of the training program on plant availability. Such investigations into plant operating history can often identify areas in the training program that need to be upgraded in order to improve operator performance.

4, 5. **Is there is a procedure for reviewing licensee event reports (LERs) and other operational data sources generated both at the specific plant and at similar plants? Are training program managers and supervisors included in this review process?** These questions address the potential uses for LERs. Internally generated LERs and LERs generated at other similar plants should have a specific review procedure that includes the training program managers and supervisors in order to facilitate the correlation of plant problems to the training program. Training program managers and supervisors can then feed back this operational information input into the training program in order to assure that emphasis is placed on these areas in the training program.

6. **Is there evidence that the training program is modified where appropriate based on both specific plant and similar plant data sources?** This statement address the feedback mechanism whereby data gathered from the process described in items 4 and 5 is incorporated into the training program. A procedure for this process should exist and should be documented.

1 — 4. **Are post-course completion questionnaires routinely administered to new operators? Is a time interval after course completion specified for administering the questionnaire? Is this time interval sufficient to ensure the graduate has had adequate time on the job, but not so long that he has acquired more skills through additional training? Does the questionnaire contain questions that cover the following areas: present job performance, differences between course training and actual job requirements, feedback for possible course modification, and additional training received since arriving on the job?** These questions address the requirement for the administration of post-course completion interviews or questionnaires to all new operators. The time interval after course completion for the administration of these interviews or questionnaires should be specified. The time interval should be sufficient so that a new operator has had time to become familiar with his job but not so long as to allow him excessive amounts of on-the-job training. The operator's personal assessment of his own present job performance is necessary for comparison with his supervisor's assessment. The questions that elicit responses pertaining to differences between course training material and the actual job requirements are necessary for the eventual feedback and possible course modification based on these results.

5 — 8. **Are completed questionnaires compared to present supervisor evaluations? Are similar questionnaires routinely administered to the supervisors of new operators? Does the questionnaire direct the supervisor's responses only toward new operators? Does the questionnaire contain questions that cover the following areas: new operator present job performance, feedback for possible course modification, amount and type of additional job training required by the new operator, and comparisons between the new operator and operators who were a product of a different training method?** These questions concern the requirement for administering similar interviews or questionnaires to the new graduate's supervisor. The format used should be similar to that determined in item 1 — 4. This simplifies the comparison of supervisor and operator responses. These questionnaires should follow a format similar to that used in the new operator's questionnaire. Responses to questions that address the need for additional job training by new operators prior to their qualification are necessary for possible course modification feedback.

9. **Are the supervisor and operator questionnaires compared to discover inconsistencies or biases?** This question requires a comparison of supervisor and operator responses in order to discover any possible inconsistencies or biases present. If any such inconsistencies are found, they can then be further evaluated or investigated by the utilities external evaluation team.

10. **Are completed questionnaires compared to the individual's course performance?** This question concerns the comparison of completed interviews and questionnaires to an individual's course performance. Such comparisons will allow to some degree the correlation of course performance to future job performance.

11. **Are the responses to the questionnaires used in course modification where appropriate?** This question addresses the need for a feedback procedure in order to allow responses to these questionnaires to be used in possible course modification. Such a step is necessary in order to keep the course responsive to the job requirements and also to close the evaluation loop.

Review of Licensing Exam Results

1. **Are Pass/fail results of operators' licensing exams recorded, correlated, and analyzed?** This question requires that the pass/fail results of operator's licensing exams be correlated, recorded, and analyzed. Such results provide valuable feedback to the training program for use in assessment of the instructional material. Permanent records of these results should be retained in order to allow for future trend analysis.
2. **Are records kept on the percentage of course graduates that are not allowed to take the licensing exam?** This question addresses the need for records to be kept on the percentage of course graduates that are not allowed to take the licensing exam. Such records can be used in conjunction with student selection criteria in order to assess the overall rate of attrition.
3. **Are reasons for barring a graduate from taking the exam indicated?** This question requires that for those students not allowed to take the licensing exam the reason for barring the graduate be indicated. These reasons are of particular importance to the assessment of the training program's materials. If, over a period of time, consistent graduate deficiencies are noted that prevent them from taking the exam, course modifications or changes in entry level screening process may be indicated.
4. **Are records kept on the amount and type of any post-course instruction required of graduates prior to their being certified to take the exam?** This question requires records to be kept on the amount and type of any post-course instruction that may be required of graduates prior to their being certified to take the licensing exam. These records pertain to that group of graduates that are judged not quite ready to take the exam but not sufficiently deficient to require being permanently barred from taking the exam. The listing of specific post-course instruction areas over a period of time may indicate the need for possible course modification in those areas.
5. **Is there evidence that the above data is analyzed and used to modify the course where appropriate?** This question requires there to be evidence that all of the above information and data analyzed and used to modify the course of instruction where appropriate. This analysis could take the form of periodic reviews by the utility external evaluation team or by various individuals designated by the training program manager.

4.8. Summary of Checklist

In order to use these checklists an evaluator would not necessarily have to be an expert in training technology, but would have to be trained in training techniques. A one-week course in instructional systems assessment is envisioned. This would give examiners a basis for decision making in the field without having to rely heavily on procedural steps. This training of raters is important because there can be wide variations in the criteria which an individual may apply to a checklist depending on the level of familiarity with training development procedures. The ability of the rater to determine the criticality and relevance of a checklist item is linked to the understanding of the underlying performance shaping factors which may be involved. Thus, rater training should not only concentrate on a theory of instruction, but should also emphasize the practical use of the particular checklist information and structure. That is, the relative importance of any item on the checklist may vary depending on specific plant procedures, existing training levels, and available training equipment. For example, in a mythical plant "A," it is company policy to only use supervisor evaluations to examine on-the-job performance. In this example the questions on the checklist associated with supervisor evaluations become critical. In other words, assessment procedures should be formal but flexible enough to allow the evaluator to judge the consistency of program elements with overall program goals. Closely associated with checklist usage is the issue of inter-rater reliability. Topics covered in the training of raters should also include familiarization with the sources of rater differences as well as an assessment of the checklist vulnerability to such differences.

It is clear that scoring on the checklist should be based on valid assessment standards and criteria. At present these standards and criteria have not been developed. For most purposes, the issues of standards and criteria are answered empirically through research. In Chapter 5 of this report these issues are discussed in terms of research requirements.

5. TRAINING RESEARCH

5.1. Training Research Issues

The development of a preliminary set of training evaluation checklists does not by any means answer all questions associated with training of NPP personnel. Additional training research issues which were identified during the course of this study as being important to NRC are:

- Validated and complete list of performance shaping factors
- Entry level personnel evaluation processes
- Simulator fidelity requirements
  - — Site specific vs. similar simulator
  - — Level of simulator sophistication required
- Influence of various training inputs on learning
- Influence of learning techniques on retention
- Influence of team training on learning
- A validated set of criteria for use with the checklists developed in this report
- Criteria for subtasks which should be included as part of simulator training
- Methods for evaluating training effectiveness.

To some extent all of these issues are related to the last issue of evaluating training effectiveness. Questions dealing with each issue are concerned with how each issue impacts the end product of training effectiveness. Thus a research program to address these issues must concentrate on the subject of training effectiveness.

5.2. Training Effectiveness

Development and use of training programs in the nuclear utility industry requires significant amounts of time and financial resources. Until recently, little data have been derived to substantiate the dividends of such investments in terms of increased training effectiveness. Within the nuclear industry, standard methods do not exist that can be employed to describe the effects of training, either within courses of instruction or for improved on-the-job performance as a result of training. Existing programs meet regulatory requirements, but few programs go further to identify the training gains due to any part of the overall training program.

The following subsections describe major components of a total programmatic approach to training effectiveness experimentation in the nuclear industry. Methods for conducting effectiveness studies are provided with discussions of the value of each approach and its particular problems/advantages for implementation. Section 5.2.1 classifies training effectiveness issues for the three primary instructional settings used in the nuclear industry. Section 5.2.2 describes a general approach suggested for research in training effectiveness, and Section 5.2.3 illustrates the execution of the approach for the specific issue — "retention." Section 5.2.4 then outlines a multi-year programmatic framework for conducting the training effectiveness research on all of the issues of concern to NRC.

5.2.1. Training Effectiveness Issues

Training effectiveness issues exist for all parts of training systems; however, it is convenient to examine issues according to the three primary instructional settings in the nuclear industry:

Classroom	Fundamentals Systems Integrated systems
Simulator	Generic (similar) Plant specific
On-the-job	Plant observation Control room

Training within these contexts exist for all licensed operators in either initial or refresher training. For each of these instructional settings training effectiveness is determined by:

- Lesson content as represented by training objectives,
- The structure of training as represented by the sequence of lessons,
- The quality of instruction as determined by instructor capabilities,
- The instructional aids, devices, and simulators applied.

Thus any training effectiveness evaluation methodology must address the above four issues within the three primary instructional settings. These are the essentials of any program of instruction. What, when, where, and how to instruct are the variables of combined importance in planning any training effectiveness evaluation (TEE). The specifics of these essentials must be broken down into independent analyzable factors that have observable indices of performance. These indices of performance can then be measured in four possible ways.

- *Qualitative Evaluation.* This method is based on documentation review, interviews with operators, and direct observation of training; and usually based on a procedural evaluation of training as it is conducted in the existing training system.
- *Noncomparative Evaluation.* This is carried out to accomplish a low level of quantitative assessment of training effectiveness. Such a method relies on "within program" measures of gains in skills or knowledge at the end of training compared to that measured at the beginning.

- *Comparative Evaluation.* This method deals with manipulating the training environment to examine various alternatives to the existing program of instruction. Compared to the two preceding methods, comparative evaluations seek to more closely constrain training variables to provide a more controlled analysis of various instructional factors. This evaluation is usually broken down into fixed cost/variable effectiveness, variable cost/variable effectiveness, fixed cost/fixed effectiveness, variable cost/fixed effectiveness paradigms.
- *Transfer of Training Evaluation.* The evaluation of a training program's ability to enhance on-the-job performance is the truest test of effectiveness. This last method of evaluation seeks to directly compare training performance to the "real world." Straightforward experimental comparisons of a trainee's performance in the instructional scenario (e.g., simulator) is compared to that same scenario in actual plant operation.

The method employed will depend on the feasibility of quantitative measurement based on the degree of interference a training program will tolerate for the sake of experimentation.

5.2.2. Training Effectiveness Evaluation Approach

Based on discussions in previous sections, an approach consisting of seven tasks has been identified to develop and demonstrate a training effectiveness evaluation methodology. These seven tasks are described below.

Task 1: Obtain "evaluation-relevant" materials. Prior to entering an effectiveness evaluation, one or several sites must be chosen that will cooperate with the intent of the effectiveness evaluation program. Visits to a candidate plant will allow detailed discussion and familiarization with:

- Existing training objectives,
- Use of training materials,
- Types of tests given to each trainee,
- Use of training devices within the program along with tests associated with their use,
- Use of test results to describe a trainee's overall performance.

Task 2: Determine the possibility for quantitative measurement. Designing a training effectiveness evaluation must assess the possibilities and alternatives for carrying out either qualitative or quantitative measurements. During the visits to a utility, an estimate of the feasibility for carrying out quantitative measurement will be made. The type of evaluation that can be made will be determined based on the existing training system.

Task 3: Construct a comprehensive set of measurement tests and evaluations to cover the examined areas. Once a determination has been made as to the level of measurement possible in the areas of training to be examined, an appropriate collection of existing and new tests will be designed. The level of testing to be instituted will depend on a number of practical considerations. Of these, the most important will be the amount of involvement the training program will allow for carrying out an effectiveness evaluation.

Task 4: Develop a preliminary training effectiveness evaluation plan. After discussing training programs with those who implement them and examining existing materials and testing techniques, an evaluation plan can be developed. The primary purpose of the preliminary plan is to determine that the appropriate level of evaluation will be carried out and that the results will be valid.

Task 5: Train subject matter experts in the use of testing and evaluation forms for use in a effectiveness evaluation. During the effectiveness evaluation, several subject matter experts (SMEs) will be employed to collect the data at the level of description determined in Task 3. According to the qualitative/quantitative nature of evaluation tests, the subject matter expert will require training in their implementation. Instruction will be given to the SMEs on the purpose, use, scoring, and interpretation of the evaluation forms. This will allow a more integrated use of subject matter experts who are not necessarily training systems experts.

Task 6: Carry out the training effectiveness evaluation. Subsequent to the review of the preliminary effectiveness evaluation plan and its finalization, the trained subject matter experts will carry out the effectiveness evaluation under the direction of instructional systems experts. Training programs chosen for participation in evaluation experiments will provide the necessary opportunities for measurement throughout the requalification and certification cycle.

Task 7: Summarize the training effectiveness evaluation results and prepare a training effectiveness evaluation report. An evaluation report would then be prepared that will describe the detailed procedures for carrying out the evaluation, descriptions of the actual data collected, the procedures used to analyze the data, and a discussion of its relevance for training.

These seven tasks represent a general approach for addressing each of the issues identified in Section 5.1. The topic of "retention" will be used as an example to illustrate how each of these tasks could be performed for each issue.

5.2.3. An Illustrative Example of a Training Effectiveness Evaluation

"Retention" simply means the amount of knowledge or skill that remains after a specified amount of time has passed. This is of great importance to the training program designer since more or less of certain types of training may be supported by such research. Skills and knowledge that are more susceptible to loss over time demand a greater portion of training time. The purpose of retention research is to plot falloff for skills and knowledge as a function of time and translate that falloff into expected performance effects.

Regardless of the specificity of existing standards, a requirements analysis should be conducted concerning requalification. An analysis of retention and its relation to training requirements must begin with an understanding of what the trainee is capable of (skills and knowledge) regarding the intended area(s) of training (i.e., entry level characteristics). The pattern of requalification training is not presently based on an analysis of information that the operator has forgotten since initial qualification or the last requalification. Additionally, since pretesting is not widely used throughout the industry, little can be said presently about the rate of skill and knowledge loss over time.

Many theories exist to account for the loss of knowledge over time. Simply put, they can be grouped according to the two processes that are believed to reduce skill and knowledge over time. The first of these is called "decay." Decay is a process that is strictly time dependent. Decay will have varying effects depending on the type of knowledge or skill involved. A good example of decay is the difficulty people have in remembering a string of numbers or strings of sequences that have no inherent meaning. These memories fade quickly depending on the amount of time spent rehearsing the material.

Interference is the other process contributing to skill and knowledge decrements. Although interference may increase over time, it is more a function of the amount of related materials that an individual is exposed to over a given time. An instance of interference occurs when trying to remember one set of numbers (e.g., a new phone number, while trying to dial another). The amount of interference also depends on the similarity of the interferring material and how well the original material was first learned.

It is clear that some operator skills diminish over time; otherwise, refresher training and requalification would be unnecessary. What remains to be determined are answers to the following questions concerning the patterns of retention.

- Which operator skills and knowledge elements diminish to a point so low that they require periodic retraining after initial licensing?
- How often do these various skill and knowledge items require refresher training?
- What measures can be devised for determining operator performance in relation to the operator's job tasks?
- What instructional methods can be devised to accomplish retraining requalification in the identified periods of time?
- Which training settings and devices are best for accomplishing retraining/refresher given instructional methods and measures?

These five questions are not independent nor are they easily answered. A research program which parallels the seven general tasks summarized above and addresses these issues could be organized in the following manner:

Task 1: Establish liaison with the training management and staff. Retention research is necessarily a long-term commitment for both the research agency and the utility training staff and trainees. It is important that a rapport be developed with these people to gain their cooperation.

An issue to be resolved for all utility management concerned with training is the amount of involvement and the possibilities for disruptions to the ongoing training program. The training analysts involved will gain cooperation by assuring the utility that their involvement will be beneficial and disruptions will be held to a minimum. The project team must:

- Explain the purpose of the project.
- Outline the duration and depth of utility involvement.
- Give specific numbers of trainees required for research purposes.
- Describe the benefits to the utility in terms of enhanced training effectiveness.

Task 2: Evaluate the utility training program for sufficient training objectives and performance measures to carry out an evaluation. The evaluation of retention is based on training objectives and associated quantifiable performance measures. Before examining the need to develop additional training objectives with supporting performance measures, a detailed examination of several existing training programs will have to be made. Initial training and requalification programs will be studied for:

- Overall structure (as stated in FSAR),
- Use of task analytic data (i.e., plant specific or INPO),
- Consistency between tasks and training objectives within those training areas mentioned in Section 1.1,
- Amount of useable existing historical training data,
- Variability in qualifications within and between instructors,
- Reliability in use of instructional techniques within each area studied,
- Training management documentation of the existing program training procedures.

A study of training programs at this level of detail will require the use of: classroom observations, training material audits, and interviews with students and instructors.

Task 3: Construct a set of retention measurement and evaluations to cover the fundamental areas related to selected tasks. Based on the level of measurement possible, as determined in Task 2, comprehensive tests and evaluations will be constructed to measure the training system support of training objectives within selected areas. Tests will evaluate the knowledge and skill that an operator retains over the retention interval. Such tests will be coordinated with the instruction of associated fundamental areas normally taught by the utility. The instructional settings for these types of tests will be the classroom and simulator as specified by the ongoing program.

Existing simulator examinations will be used if the level of measurement manifest is consistent with the research requirements. There must be at least a moderate amount of quantitative material available within simulator examinations so that training effectiveness and retention can be related over time. Automatically recorded data, supervisor checklists/ratings, or associated written exams are all possible components of the simulator examination.

Direct observation in an actual control room is possible as an example of on-the-job performance. Measurement within this context is quite possible when periodic maintenance routines must be carried out in conjunction with normal plant operation. Scheduled shutdowns, start-ups, and other component maintenance procedures can be incorporated into the on-the-job performance context. This is, however, much less likely and reliable a context to carry out retention and training effectiveness experiments since there is much less control over the environment that can be obtained in either the classroom or the simulator.

The methods employed for constructing tests and evaluation instruments will be directly related to the methods for evaluation developed in the earlier phases of the selection and training program. This means that, as much as possible, existing instruments and those required to be developed will be based on the systems approach to training. Testing will be based totally on training objectives that exist for each training area and their associated job performance measures. A good deal of transfer is anticipated between the initial selection and training project and the retention training effectiveness experiments. Many of the approaches to evaluation can be used to determine the level of operator performance throughout the requalification cycle.

Task 4: Develop a preliminary retention evaluation plan. Specific techniques and methods used for carrying out the training evaluation for the retention area will be compiled for inclusion in the training effectiveness evaluation plan (TEEP). This plan will include specifications of the following:

- The facilities and personnel who will take part in the retention experiment,
- The specific methods to be employed based on the level of measurement possible,
- The tests and measurements that exist within the utility's training program that can be used for retention purposes,
- A list of those measurements and evaluations that are necessary to be developed as part of the retention evaluation,
- The statistical and other analytical methods to be employed in analyzing the results,
- A description of the possible alternative outcomes and some indication of what the meaning of those outcomes will have for training programs as they exist today,
- Logical extensions of the research into other areas of licensed operator training.

Task 5: Carry out training of subject matter experts to support the retention evaluation. As part of the measurement of various operator skills and knowledge in the classroom and simulator contexts, experts in the training of operator skills and knowledge must be employed. These experts will have demonstrated operational expertise along with some familiarization with the instructional systems methodology being used. Most of these individuals will have served in an instructor capacity for various utilities or vendor organizations. The primary usage of these individuals will be in the support of construction of new tests and the evaluation of existing tests within each utility training program.

The performance of an individual, at several points along the retention interval, will have to be done by subject matter "content" experts along with education experts. Content experts are expected to have at least an SRO license and a substantial familiarization with the plant under consideration. These individuals can be plant personnel who have been designated by management for participation in the retention evaluation or other experts from similar plants in other utilities. Additionally, examiners who have worked for the NRC either in the past or currently may be used depending upon their availability.

It is expected that subject matter experts (SMEs) will require a significant amount of training on the systems approach to training and related retention testing procedures. The content of those areas is expected to have already been mastered by each of the SMEs. What remains to be trained are the SMEs understanding of the purpose of these evaluations, the types of evaluations and the form of results necessary as part of the data collection, and the format of the scoring of these retention tests. It is anticipated that at least several weeks of SME training will be required as part of the effectiveness evaluation for retention.

Task 6: Carry out retention experiments. After planning and designing retention experiments, utility training programs will be monitored and at the appropriate intervals (e.g., 3-month or 6-month) tests will be administered. A sequence of tests will proceed as follows:

1. Baseline tests will be administered to reactor operators. Both initial and requalification trainees will be tested for the RO subject pool.
2. After several prespecified intervals, retesting will be administered. Tests will be carried out in the classroom for fundamentals, systems, and procedural areas. Additional systems tests will be carried out on the simulator used by the utility.
3. Experiments will be collated and analyzed using appropriate statistical techniques.

Experiments will examine the kinds of skill and knowledge deficits experienced by operators for each of the training contexts mentioned.

Task 7: Prepare a report on retention experiments. Results of retention experiments will be presented in terms of training effectiveness. Normal cycles of training will be described in comparison to rates of dropoff of skills and knowledge. An attempt will be made to graphically profile the rising and falling of operator behaviors directly related to job performance.

An evaluation report will be prepared describing: the procedures used to obtain data, the actual data collected, a discussion of the practical significance of findings for NRC's regulation of the training process, and the generality of findings to all types of related training (e.g., nonlicensed NPP positions).

Implementation. It is suggested that the first five tasks described for retention research be carried out in a 7-month period. Utility liaison, experimental planning, and training of SMEs can all be carried out within this period of time.

The balance of retention tasks should be carried out over a two-year period. The length of the project can be adjusted to the time intervals of most interest (i.e., 1-year requalification and 2-year certification cycles). A minimum commitment of 18 months is considered necessary for a reasonably productive retention analysis.

5.2.4. Training Effectiveness Program Plan

The Training Effectiveness Program Plan presented in this section (summarized in Fig. 5.1) uses the process illustrated in Section 5.2.3 to address the major training effectiveness issues. As is evident from its longitudinal scope; the procedure implies a multi-year data collection and evaluation effort to identify the many variables which affect the operational task and to determine their effects on performance. Each of the tasks presented in Fig. 5.1 can be described as follows:

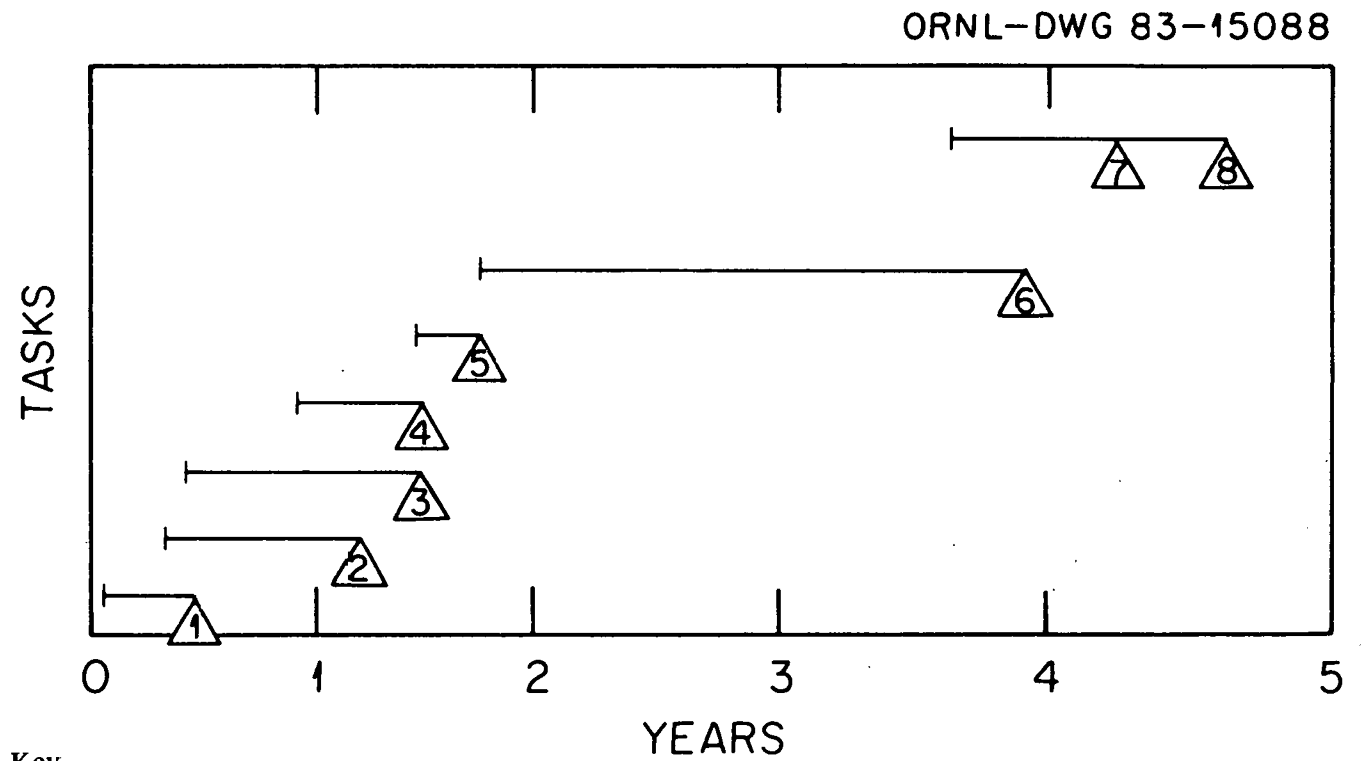
1. *Obtain baseline data* — During a 6-month initial phase the major training effectiveness issues would be defined and existing data would be collected and examined for its usefulness. In Section 5.1 we gave examples of nine training issues which we felt should be addressed in this training effectiveness research. Given a comprehensive list of the research issues of concern, existing data should be examined for applicability and utility in NPP training effectiveness evaluation.

2. *Perform feasibility analysis for data collection and metric development* — Our experience has shown that the data review in Part 1 will reveal a significant lack of data. Thus a one year task should be undertaken to identify data needs and data collection plans including the sources of data and the feasibility of data acquisition.

3. *Generate measurement tests/evaluations and JPM methodology* — Training effectiveness should be based on job performance. Unfortunately the actual measurement of job performance is very difficult. A one-year effort is allocated to develop job performance measurement tests and tools. This effort should include the validation of the tools as well as their initial development.

4. *Develop training effectiveness evaluation plan* — Before the actual data collection takes place, a well laid out plan should be written to define how, when, and where the data will be used. This plan should then be used by data collectors as a guide to make the most efficient use of resources and available time. The effort should take approximately 6 months and should not be started until Task 2 is nearly complete.

5. *Train evaluation personnel for field data collection* — To collect data as specified in Task 2 using the tools developed in Task 3, the data collector must be familiar with the tools he is to use including the purpose behind their use. It should take about a month to develop a training session and a couple of days to carry out the training. This task cannot start until all evaluation tools are completed, but must be performed before data collection begins.



Key

1. Obtain baseline data
2. Perform feasibility analysis for data collection and metric development
3. Generate measurement tests/evaluations and JPM methodology
4. Develop training effectiveness evaluation plan
5. Train evaluation personnel for field collection
6. Execute training effectiveness evaluation plan
7. Review results
8. Prepare final report

Fig. 5.1. Research Program Plan.

6. *Execute training effectiveness evaluation plan* — When the training of the data collector is completed, the plan developed in Task 4 can be initiated. By necessity this task must cover at last a two year period of time to allow for repeated examinations to determine skill decay overtime.
7. *Review results* — Prior to publishing the results of the data collection and evaluation the material should undergo a thorough peer review by qualified persons in NRC and industry. This review effort should take approximately 6 months.
8. *Publication of final report* — Even though several reports should be published covering different segments of the evaluation process, for reference purposes one final report should be published which summarizes the complete programmatic effort.

Table 5.1 is a sample list of some of the products which should be produced from this program — along with the projected time frame. More significant than any of these products, of course, is the potential for producing better performance through training that is inherent with a more adequate understanding of transfer of training for nuclear power plant operations.

5.3. Training Evaluation Checklists

The development of a validated set of criteria and guidelines for using the checklists described in Chapter 4 is directly related to tasks which are part of the training effectiveness evaluation research described in Section 5.2.4. Therefore a complete data validated set of checklists would not be available for ≈ 4 years. In the interim, however, several activities can take place to develop criteria and guidelines with a high degree of confidence. The most critical of these activities would be a full scale demonstration of a training program evaluation using the checklists. As part of this demonstration each question on the checklists would be examined with respect to questions such as:

1. What is the most feasible means of obtaining the answer to the question?
2. What are anchor points associated with the scales given for responses to each question?
3. Are the scale structures adequate for identifying the appropriate response?
4. What is the anticipated inter-rater reliability?

In addition a demonstration will address general questions such as:

1. How long should an evaluation take?
2. What knowledge and skill levels are required of the evaluator to adequately perform an evaluation?
3. How much cooperation is required of the organization being evaluated?

A demonstration of this type should take about one year and would result in a user's manual for performing training program evaluations with the checklists.

Table 5.1. Effectiveness Program Products

Completed Program Period	Products
6 months	• Aggregate set of baseline analysis data
8 months	• Completed usability analysis and screened data set
1 year	• Job performance measures (JPM) • Completed set of test instruments • JPM generation methodology for training effectiveness
18 months	• Preliminary training effectiveness implementation plan
19 months	• Final implementation plan following sponsor review
23 months	• Trained subject matter expert data collection team
2 years	• Completed demonstration of data collection instruments
3 years 9 mo.	• Completion of training effectiveness field collection, aggregate performance data • Validated set of performance shaping factors • List of entry level effects on training effectiveness • Team training recommendation • Validate set of training evaluation checklist criteria
4 years 2 mo.	• List of training media recommendations • Set of simulation fidelity requirements based on field performance data
5 years	• Final report

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APPENDIX A

GLOSSARY OF TERMS USED IN THIS REPORT

ABILITY GROUPING

Arrangement whereby students are assigned to groups on the basis of aptitude testing.

ABSOLUTE STANDARDS

A statement defining the exact level of performance required of a student as a demonstration that he has mastered the course objectives. Criterion-referenced tests are usually based on an absolute standard for each item.

ABSENTEEISM

Protracted absence of an individual from his work or other duties.

ACCELERATED TRAINING

A program which permits especially well-qualified personnel to complete the training prescribed in a course of instruction in less than the normal length of time or prior to the normal stage of the career.

ACHIEVEMENT GROUPING

Arrangement whereby students are assigned to groups according to their performance on pretests.

ACTUAL EQUIPMENT

The tools, materials, or devices that are used in the normal performance of a job task. For licensed NPP operators, this mean the actual control panels that are used for operating the plant and related devices that are used to aid the operator in carrying out various tasks.

AFFECTIVE LEARNING

A domain of learning that is concerned with the acquisition of desired perceptions by the earner. That part of student learning objectives which require the acquisition of perceptions in the students, promoting, for example, self-confidence, responsibility, respect, dependability and personal relations.

AGING

The continuous process wherein the structures and functions of an immature organism first become mature and then deterioriate. Some functions age more rapidly than others as do some individuals.

ANALOG DISPLAY

A system in which points in nature are represented by certain physical quantities. These might be the intensity of an electric current, the amount of voltage, or the angular rotation of a pointer.

ANALYSIS

Separation of a whole into its component parts for detailed study or examination (e.g., a job is broken down into all its observable components: duties, tasks, task elements, and skills).

ANNUNCIATOR WARNING SYSTEMS

Method of displaying visual and auditory signals of cautions and warnings to alert the operator of a potential error or failure. This is concerned with the use of coding, readability requirements, prioritization of signals, and the location of alarms and response control.

ANTICIPATORY REQUIREMENTS

Requires the person to have the ability to perceive one or more signals while already performing a task. With practice, a person can rapidly switch his attention among several stimuli but at any given moment, a person can only attend to one stimulus.

ANXIETY

An unpleasant emotional state in which a present and continuous fear of low intensity exists. Anxiety has a stable (trait) and variable (state) components that are characteristic of the individual.

APPLICATION SHEET

An instruction sheet designed to cause students to apply their knowledge of concepts in the classroom, under the guidance of an instructor, after presentation of the subject matter.

ARCHITECTURAL FEATURES

The general work area or area in terms of size, shape, and use.

ARITHMETIC

An individual's basic understanding of number concepts in logical and daily problems. For intelligence test, an additional understanding of verbal problem solving, memory, and concentration are required.

AROUSAL AND VIGILANCE

The consequences of a sensor event that determines how ready a person is to respond at a certain time to a certain kind of situation or simulation.

ATTENTION AND SET

The active selection of and emphasis on one dimension or cue in the range of those to which the organism is responding; the maintenance of a stable orientation response towards certain environmental stimuli or events rather than towards others; a predisposition for apprehension that facilitates responding to certain activities rather than theres.

ATTITUDE MEASURE

An instrument designed to gather information about how people feel toward a particular object or activity. This could include liking or disliking subject matter, usefulness of a medium, or opinions about the medium.

AUDIOVISUAL AID

Any static or dynamic demonstrative audiovisual product utilized to facilitate and reinforce learning through one or both of the physical senses of sight and hearing.

AUDIOVISUAL PRODUCTS

Materials containing sound or imagery for conveying a message. Refer to still photography, graphic arts, still projectuals (overhead transparencies, slides, filmstrips, etc.), motion pictures (film, video tape, and disc), audio recording (tape and disc), and combinations such as multi-media.

AUDITORY PERCEPTION

Perceiving by the act of hearing. (See PERCEPTION)

AUTOMATIC CONTROL

An arrangement for the response of components or systems to signal from sensors or computer without human interaction.

BASELINE DATA

Valid and reliable information about the current level of performance of the intended student population. This data can be used to confirm the need to develop new instructions, or can be used as a comparison in ascertaining differences between "students" performance before and after instruction.

BEHAVIOR

In the instructional setting, any measurable action(s) performed by trainee (student).

BEHAVIOR STATEMENT

That portion of a learning objective which identifies what the trainee will do to demonstrate what he has learned.

BLOCK DESIGN

The pure measure of spatial non-verbal intelligence and general spatial skills necessary for such tasks as engineering. (A scale on the Wais Intelligence Test)

CHAINING

The linking together of a series of discriminable responses in a particular order. The completion of each response provides the stimulus for the next response. May involve chains of verbal responses (reciting a list of numbers) or chains of motor responses (following a procedure).

CLOSED LOOP SYSTEM

A system in which information about its outputs are fed back to become part of the system's inputs so that the system's errors can be responded to. Human error is part of the system error. This type of system can be contrasted with an "open loop" system in which this feedback is absent.

CLUSTERING

A process of organizing many tasks into groups for the purpose of deciding upon the optimal instructional setting mix for that group of tasks.

COGNITIVE LEARNING

A domain of learning that is concerned with knowledge and the various mental activities and processes by which the learner acquires knowledge and mental skills.

COMMON-FACTOR LEARNING OBJECTIVES

Refers to learning objectives that are identical, or that have identical action word and similar objects of the action in the learning objective statement.

COMMUNICATION

Transmitting and/or receiving information, signals, or messages by means of gestures, words, or other symbols, from one point to another. In terms of the man-machine interface, communication refers to the process whereby physical energy acts upon a sensory receptor. This includes oral and written methods of passing information to conduct operations in normal and off-normal conditions.

COMPLEXITY

Pertains to tasks that have components that are either interdependent or in a relationship of subordination to other tasks. When used in human reliability research, complexity refers to the number of actions stated in steps or paragraphs of written instructions.

COMPLEXITY (INFORMATION LOAD)

The amount of information, rate of information, and the level of interpretation required to process the information to perform a task or series of tasks.

COMPREHENSION

Knowledge or understanding of an object, situation, event, or verbal statement.

COMPUTER ASSISTED INSTRUCTION (CAI)

The application of computers to the delivery of instruction wherein there is an ongoing interchange of stimulus and reaction between computer and student.

CONDITION (AIDING, LIMITING)

Situations, physical or mental, which either aid or limit the performance called for in a learning objective.

CONTIGUITY

Refer, in learning, to the principle that events which occur closely together become associated by the learner.

CONTROL-DISPLAY RELATIONSHIPS

The relationship between a control and a corresponding display or group of controls and displays in a compatible and expected manner. NUREG 0700 Section 6.9 covers guidelines.

CONTROL-DISPLAY INTEGRATION

The interrelationship of the correct controls with appropriate and corresponding displays.

CONTROL ROOM WORKSPACE

The control room workspace involves the general overall design, layout, and ambiance of the operator's work area. It takes into consideration anthropometric parameters for reach distances, eye heights, etc.; levels of comfort for climate, visibility and the auditory environment; and good practices for the use of procedures.

COURSE DOCUMENTATION

Information described in the current content of a course (instructional materials, tests, instructor's guide, evaluation plan, trainee guide) and its developmental history (job analysis, criteria for selecting tasks for training, previous revisions).

COURSE REVIEW

A review of a course conducted to ensure that learning objectives are based on task analysis; that accurate and appropriate criterion measures are provided; that effective use is made of student test data; and that efficient and effective supervisory support is provided.

CRITERION OBJECTIVE

See LEARNING OBJECTIVE.

CRITERION-REFERENCE TEST

A measure of what a trainee must know or do to successfully perform a task based on performance standards from an analysis of job requirements.

CUE-PROMPT/SIGNAL

Initiate and guide behavior.

CURRICULUM

The planned interaction of students with instructional resources and instructional processes attainment of learning objectives.

CURRICULUM OUTLINE

The control document for a course expressed in outline from listing lesson topics in their sequential order with the learning objectives which they support.

DECAY RATE

The amount of time it takes a trainee to forget what he has been learning in school. If the decay rate is high, then a trainee should not receive instruction in a specific task until shortly before he will actually perform it.

DECISIONMAKING

The formulation of a course of action with intent to execute it.

DEPENDENT RELATIONSHIP

Occurs when skills and knowledge in one learning objective are closely related to those in the other learning objective. In order to master one of the learning objectives, it is first necessary to learn the other.

DIGIT SPAN

A measure of immediate auditory memory.

DIGIT SYMBOL

A measure of basic learning skills especially the ability to associate a symbol with a number. Digit symbol is the most sensitive subtest for motor problems in the dominant hand.

DIGIT DISPLAY

A digital display is a quantitative readout. A digital readout generally provides the most rapid and accurate method for presenting purely quantitative information.

DISPLAY

Any instrument or device that presents information to any sense organ (visual, auditory, or other).

EFFECTOR PROCESSES

Processes related to muscles or glands considered the executive organs or organ of a response.

ENABLING LEARNING OBJECTIVE

A three-part objective that helps the student achieve a terminal learning objective. It describes the behavioral actions, the performance conditions, and the attainment standard expected of the student when he completes the task.

ENTRY BEHAVIOR

The skill, knowledge, and/or attitude required before beginning a new segment of instruction; also may refer to the capability a person has prior to new learning.

ENTRY SKILLS

Specific, measurable behaviors that have been determined through the process of analysis of learning requirements to be basic to subsequent knowledge or skill in the course.

ENTRY LEVEL TEST

See TESTS.

EVALUATION

The process of interpreting the results of measurement data (e.g., tests, JPMs).

EXTERNAL EVALUATION

The process of determining training effectiveness based on transfer of training from performance in the instructional context to job-related behaviors.

EXTERNAL PERFORMANCE SHAPING FACTOR (PSF)

A performance shaping factor which is outside the individual and defines the work situation for him.

FATIGUE

Diminished ability to do work, either physical or mental, as a consequence of previous and recent work.

FEEDBACK

Information about the output of a system which is fed back to the control function of the system for analysis and subsequent use in maintaining the desired quantity and/or quality of its output.

FIDELITY

Refer to how well the actions, conditions, cues, and standards of the JPM approximate those of the task.

FRONT END ANALYSIS

The system design effort which structures the logistic support system and describes the human/hardware interface.

FUNCTION

An activity (or a static role) performed by one or more system constituents (people, mechanisms, structures) to contribute to a larger activity or goal state.

GO NO-GO

Pass-fail; criterion of evaluation whereby student cannot be "partially correct." He is either 100 percent correct (go) or incorrect (no-go).

GROUP IDENTIFICATIONS

Attitudes of an individual that are determined by those accepted by the group whole.

HANDS-ON TRAINING

Training employing the use of the particular equipment or system for which students are being trained to operate or maintain.

HUMAN CAUSED ERROR (HCE)

An error whose primary causal factors are related to some human characteristic of the work situation.

INCENTIVE

A condition perceived by an individual to be one capable of satisfying an aroused need (motivation).

INDEPENDENT RELATIONSHIP

Occurs when skills and knowledge in one objective are unrelated to those in the other objective. Mastering one of the objectives does not simplify the other.

INDIVIDUAL FACTORS

The abilities that the operator brings to the task.

INDIVIDUAL PERFORMANCE SHAPING FACTORS (PSFs)

The characteristics of a human which affect his performance in a job, including personality characteristics, body structure, level of skill, attitudes, etc.

INFORMATION

Knowledge or facts gained through investigation, observation, study or instruction.

INSTRUCTIONAL DELIVERY SYSTEM

Any method containing plans and procedures for the presentation of instruction. Platform instruction, television, formal, and OJT are all delivery systems.

INSTRUCTIONAL MANAGEMENT (IM)

The process of planning, organizing, controlling, and evaluating the delivery of instruction to students.

INSTRUCTIONAL MATERIAL

All items of material prepared, procured, and made use of in a course or program as part of the teaching or planning process. This includes the general categories of training aids (instructional aids), training devices, training equipment (instructional equipment), training aid equipment (instructional aid equipment), and instructional literature. Also known as "Training Material."

INSTRUCTIONAL MODULES

A self-contained instructional unit which includes one or more learning objectives, the appropriate learning materials and methods, and associated criterion-referenced measures.

INSTRUCTIONAL PROGRAM

A course of study designed to meet a training requirement.

INSTRUCTIONAL PROGRAM DEVELOPMENT (IPD)

The process of analyzing job and training task data; designing and developing a program of instruction; and validating the program.

INSTRUCTIONAL SETTING

The circumstances under which a study is provided with the means and opportunity for achieving learning objectives (e.g., classroom, simulator, formal OJT, correspondence courses, etc.).

INSTRUCTIONAL SYSTEMS DEVELOPMENT (ISD)

An orderly process for planing, developing, implementing and evaluating instructional programs which ensures that personnel are taught the knowledge, skills, and attitudes essential for successful job performance.

INSTRUCTION GUIDE

A series of lesson topic guides grouped in units or by phases which collectively outline the teaching/learning activities to be accomplished.

INTELLIGENCE

An individual's total repertory of those problem-solving and cognitive-discrimination responses that are usual and expected at a given age and in a large population unit to which that person belongs. (Intelligence tests were first created to offer an appropriate educational or work placement, or a type of therapeutic approach.)

INTERACTIVE VIDEO DISK

This medium combines a microcomputer with a video disk. Within the program the video and sound can be combined as a teaching device that has branching capabilities and can provide feedback tailored to the individual student.

INTERNAL EVALUATION

The process by which the instructional delivery system is evaluated to determine whether the instructional effort has accomplished what was originally intended. The instructional delivery system includes the instructor, instructional materials, and the instructional techniques applied.

INTERNAL PERFORMANCE SHAPING FACTORS (PSFs)

The characteristics of a human which affect his performance in a job, including personality characteristics, bodily structure, level of skill, attitudes, etc.

INTERPRETATION REQUIREMENTS

The amount of mental processing required by a person once presented with information. The longer it takes to interpret the data, the greater the probability of error.

JOB

The duties and tasks performed by a single worker constitute his job. If identical duties and tasks are performed by several individuals, they all hold the same job. The job is the basic unit used in carrying out the personnel actions of election, training, classification, and assignment.

JOB ANALYSIS

The basic method used to obtain a detailed listing of duties, tasks, and elements necessary to perform a clearly defined, specific job, involving any or all of the techniques of systems analysis, job interviews, questionnaire surveys, jury-of-experts, and group interviews.

JOB FIDELITY

The degree to which a testing situation truthfully and accurately reflects the job situation. This should not be confused with simulator fidelity.

JOB PERFORMANCE AID (JPA)

A document, device, guide, tool which supplies information to the operator/technician in performing his job.

JOB PERFORMANCE MEASURES (JPM)

These are the measurable dimensions of the behaviors necessary to achieve performance requirements including the standards defined in terms of those dimensions.

JOB PERFORMANCE REQUIREMENTS (JPR)

The tasks required of the human component of a system, including the associated job performance measures. JPRs describe what people must do to perform their jobs.

JOB PERFORMANCE STANDARDS (PPS)

A scaler value along the dimension of a JPM.

JOB TASK INVENTORY (JTI)

Lists of duties and tasks varying in refinement from basic input data to duties and tasks which constitutes the job performed by incumbents. The Job Task Inventory is normally the result of a Job Analysis.

KINESTHETIC PERCEPTION

Perception through the senses that gives knowledge of the movements of the body or of its several members (i.e., muscle sense, tendon sense, joint sense, and static sense). (See PERCETION).

KNOWLEDGE

Specific information, or facts that are required to develop the required skills and desired attitudes to accomplish effectively the jobs, duties, and tasks of a prescribed task.

LEARNING

Acquisition of knowledge or skills.

LEARNING HIERARCHY

Graphically portrays the relationships among learning tasks in which some tasks must be mastered before others can be learned.

LEARNING OBJECTIVE

A statement of the behavior or performance expected of a student as the result of a learning experience, expressed in terms of the behavior, the conditions under which it is to be exhibited, and the standards to which it will be performed or demonstrated. Both terminal and enabling objectives are learning objectives.

LEARNING OBJECTIVES HIERARCHY

A graphic representation of the relationship between learning objectives. The sequence of objectives and the dependency of objectives are illustrated in a learning Objectives Hierarchy.

LESSON

The period of time during which a skill or knowledge is taught and learned. Lessons vary in length depending upon the skill or knowledge to be acquired. During this period, the instructor uses the basic steps of instruction and the learner acquires the intended skill or knowledge. The basic components of instructional units (or topics).

LESSON GUIDE

An organization outline of a single lesson topic taken from the course of study and serving as a blueprint of what is to be accomplished in class. It is complete in detail and states all objectives, topics, subtopics, references, training aids, methods, procedures, and other supplemental information as needed. In general, the lesson guide is the formal lesson plan.

LOCATION AIDS

Enhancements such as the use of color, mimics, and demarcation lines to aid in the act of identifying controls, displays, or other equipment.

LONG-TERM MEMORY (LTM)

The repository of one's permanent knowledge and skills containing everything one knows that is not currently an act of memory. Information in LTM is of three kinds: sensory-perceptual knowledge, procedural-motoric knowledge, and propositional knowledge or beliefs.

MANNING PARAMETERS

How many and what kinds of people are used to perform which types of jobs.

MANUAL DEXTERITY

Skillful use of the limbs of the body, especially the hands.

MEASUREMENT, CRITERION-REFERENCED

The process of determining, as objectively as possible, a student's achievement in relation to a fixed standard which is based on learning objectives.

MEASUREMENT, NORM-REFERENCED

The process of determining a student's achievement in relation to other students. Grading "on the curve" involves norm-referenced measurement since an individual's position on the curve (grade) depends on the performance of other students.

MEDIA

Means for presenting instructional material to learners; for example, books, audiotapes, filmstrips, and simulators.

MEDIA MIX

Combination of different media used to present a unit of instruction.

MEDIA SELECTION

The act of selecting the most effective medium for the presentation of instruction to learners.

MOCKUP

A three-dimensional training aid designed to represent operational equipment. It may be a scaled or a cutaway model.

MODEL

1. As a training aid, a static or dynamic device which is a presentative of an actuality or one or more of its parts, assemblies, or systems in which all spatial and sequential relationships are preserved.
2. A graphic or verbal description of a system in terms of its functional subsystems and their interrelationships.

MODE OF INSTRUCTION

Method of scheduling materials presentation, e.g., individualized (self-paced), group (block scheduling), etc.

MORALE

The prevailing temper or spirit in individuals forming a group which is shown by confidence in the group; self-confidence with respect to one's role in the group, group loyalty, and readiness to strive for group goals.

MOTIVATION AND ATTITUDES

The interests, drives, needs, and preferences of an individual that give rise to differential responding. Motivation causes some behaviors to be more dominant over other possible responses in the same situation.

MOTOR REQUIREMENTS

Control, adjustment, connecting, or other actions performed normally by hands or feet. Speed, strength, and coordination are beneficial, however, seldom required to perform operator tasks.

NARROWNESS OF TASK

Complexity and number of discrete steps involved in a task.

OBJECT ASSEMBLY

A measure of an individual's ability to visually analyze and to use visual motor skills.

OBJECTIVE

A definite learning specification in behavioral terms, it states exactly what the student should be able to do after having received the instruction. See LEARNING OBJECTIVE.

ON-THE-JOB TRAINING

Training in a task or duty while engaged in its performance during daily operation and maintenance situations. The training can be part of a formal program or simply, and more commonly, knowledge and skills acquired primarily on the initiative of the individual learner.

ORGANIZATIONAL ENVIRONMENTAL FACTORS

Includes factors such as the presence of effective supervision, managerial practices and attitudes, and the existence of structures within the organization which allow the free flow of information which may have significance to the operator from a safety standpoint.

ORGANIZATIONAL STRUCTURE AND ACTIONS BY OTHERS

The effectiveness of administrative and regulatory controls with regard to work habits and policies. Of the individual personalities of the authorities play an important role.

PART-TASK TRAINER

A device which permits selected aspects of a task to be practiced independently of other elements of the task. Its purpose is to provide economical training on certain elements requiring special practice which are not dependent upon the total equipment.

PERCEPTION

An event in the person or organism, primarily controlled by the excitation of sensory receptors, yet also influenced by other factors of a kind that can be shown to have originated in light of the history of the organism.

PERCEPTUAL (MENTAL) LOAD

Sensory perceptual system capacity compared to the number and magnitude of sensory stimuli impinging on the system at any point in time.

PERCEPTUAL REQUIREMENTS

Those requirements of a task that are determined by the task and equipment features that convey information to the personnel (i.e., visual and auditory requirements).

PERFORMANCE SHAPING FACTORS (PSFs)

Internal or external factors that affect performance in a job context.

PERSONALITY

An individual's emotional states, interpersonal relations, motivations, interests, and attitudes.

PERSONALITY AND INTELLIGENCE VARIABLES

Dispositional and structural features that make up an individual's adaptive social skills and define the ability to learn.

PHYSICAL ENVIRONMENTAL FACTORS

Aspects of a situation such as extreme temperature, noise or vibration which can either directly cause errors by affecting the operator's physical or mental ability to perform the task or which can interfere with the operator's actions because of cumbersome or uncomfortable protective clothing (e.g., radiation suits).

PHYSIOLOGICAL STRESSORS

Stressors, arising from physiological conditions such as fatigue, discomfort, high temperature, etc.

PICTURE ARRANGEMENT

An evaluation of several major skills including: visual perception of individual pictures, organization of a series of pictures, awareness of social sequences, planning skills, ability to form and test hypotheses, flexibility, and general ability to sequence material in a logical order.

PICTURE COMPETITION

A measure of an individual's ability to perceive and visually organize a situation and then recognize that an essential element of some kind is missing.

POSITIONING MOVEMENT

A change in position of an organism or of one or more of its parts.

PREDICTIVE VALIDITY

The ability of a test score to accurately forecast future performance.

PREFERRED LIMBS

Preferred actual use of the limbs on the left or right side of the body. Similar to right or left handedness.

PREREQUISITE TRAINING

That training which personnel must have previously completed successfully in order to be qualified for entry into training for which they are now being considered.

PRETEST

See TEST.

PROBLEM SOLVING

A process by which the learner discovers a combination of previously learned rules which can be applied to achieve a solution for a novel situation.

PROCEDURAL-MOTORIC KNOWLEDGE

Knowledge of how to do something from motor skills to intellectual skills to speech production.

PROCESS COMPUTERS

The computer system available to the control room operator to aid him in gathering necessary information. The information concerns plant and equipment parameters to facilitate the operators job. An analysis of the computer system should include: access, data entry, location, content, and speed.

PROCESSING AND TRANSMISSION OF INFORMATION

The psychological process of perceiving, thinking, feeling, or acting in relation to the directing of factual or quantitative information from one source or point to another (COMMUNICATION).

PROFICIENCY TESTS

See TESTS.

PROPOSITIONAL BELIEFS

Beliefs about oneself and one's world; one's knowledge of concepts and word meanings; one's knowledge of general facts, and of specific objects, events, and episodes.

PSYCHOLOGICAL STRESSOR

Stressor arising from external or internal factors, that cause mental tension (e.g., test load, threats, sensor deprivation, etc.). Psychological stressors can result in disruptive stress or facilitative stress.

PSYCHOMOTOR

The coordination of sensor cognitive processes and motor activity (i.e., throttling a valve).

QUALITY OF WORKING ENVIRONMENT

The quality of the temperature, humidity and air quality, noise and vibration, illumination, and degree of general cleanliness surrounding the worker.

REACTION TIME

The interim between application of a stimulus and the beginning of a subject's response.

REFRESHER TRAINING

Training of personnel in areas that have been previously mastered but, because of the passage of time or interference, require re-instruction.

SEARCH AND SCANNING

To scrutinize closely for certain particulars give a summary of the facts to be searched for which will enable confirmation or rejection of an hypothesis.

SELF-INSTRUCTIONAL TRAINER

A trainer which can be used without immediate or continuous supervision by an instructor. It contains programmed instructions to guide the trainees and provides means for correcting and directing the student when errors are made. It may also include provisions for automatically scoring and recording the trainee's performance.

SENSORY

The activity of a sense organ, usually referring to directly observed objective data (i.e., sense data).

SENSORY-PERCEPTUAL KNOWLEDGE

Knowledge represented in analog form in our sensory information store. It is used in classifying sensory patterns and storing memories of sensation of things.

SERIAL MOVEMENT

Movement in which the temporal order of several responses is the important feature and for which movements are a function of the whole series.

SHORT-TERM MEMORY

The process of retaining sensory, perceptual, or cognitive events over a short period of time, usually seconds.

SIMILARITIES

An individual's ability to form verbal concepts, specifically generalizations, when give two members of a given verbal class.

SIMULATION

Any change from reality or any imitation of reality. Three types are common: simulating part of the system, simulating the operation of the system, and simulating the environment in which the system will operate.

SIMULATOR (TRAINING)

A training device which substitutes for but emulates the functions and environment of actual equipment or systems.

SITUATION CAUSED ERROR (SCE)

An error whose primary causal factors are related to design of the work situation.

SKILL

A person-referenced attribute involved in carrying out tasks and jobs.

SKILL OF THE CRAFT

Those tasks in which it is assumed that the workers know certain aspects of the job and need no written instructions (e.g., a plumber replacing a washer in a faucet).

SLEEP DEPRIVATION

The lack of necessary rest periods characterized by relative inactivity, reduced consciousness and reduced responsiveness to external stimuli.

STANDARD

The criterion indicating the level of proficiency required by the behavior element in a learning objective.

STATE OF CURRENT PRACTICE OR SKILL

The retention of knowledge and skill level that define an operator's job-related capabilities.

STRESS

Sometimes regarded as being due to a mismatch between capabilities of the operator and the demands of the situation in which he is placed. The interpretation of stress involves an interaction between operator characteristics and task factors.

STRESSOR

Any external or internal forces that cause bodily or mental tension (i.e., stress).

SUBJECT MATTER EXPERT (SME)

A person who has high level knowledge and skill in the performance of a job.

SYSTEM

A whole which functions as a whole by virture of the interdependence of its parts. An organization of interdependent constituents that work together in a patterned manner to accomplish some purpose.

SYSTEM (INSTRUCTIONAL)

The composite of equipment, skills, techniques (including all related facilities, equipment, materials, services, and personnel) that is capable of performing and/or supporting an operational role.

SYSTEMS APPROACH

A generic term referring to the orderly process of analysis, design, development, evaluation, revision, and operation of a collection of interrelated elements.

TACTILE PERCEPTION

Perception through the sense of touch. (See PERCEPTION)

TARGET POPULATION

The pool of potential entrants to training for which instructional materials are designed and tried out.

TASK

A specific action performed by a single system constituent — person or equipment — that contributes to the accomplishment of a function. Defined by a particular system-type objective.

TASK ANALYSIS

An analytical process for determining the specific behaviors required of the human components in man-machine systems. It involves the determining of the detailed performance required of people and equipment, and the effects of: environmental conditions, malfunctions, and other unexpected events on both. Within each task to be performed by people, behavioral steps are analyzed in terms of (1) the sensory signals and related perceptions, (2) the decisions, memory storage, and other mental processes, and (3) the required responses. See JOB ANALYSIS.

TASK ANALYSIS TEAM (or JOB ANALYSIS TEAM)

A team composed of subject-matter specialists in the rating to be analyzed, who have demonstrated their competencies in actual job performance, possess the ability to communicate clearly with others at various levels in their field, and have demonstrated the ability to analyze, design, and develop training materials.

TASK ELEMENT

A tasks element is a subdivision of a task. It is the smallest unit of work contained in the job that is considered by the Task Analysis Team (Job Analysis Team) in carrying out the Job Task Analysis process.

TASK INVENTORY

List that itemizes all of the tasks that make up a selected job/duty.

TASK STATEMENT

A statement of action which has a verb and object; for example, sort mail.

TEAM STRUCTURE

The work load responsibilities of individuals working within a team not the sociological aspects of the team make-up.

TERMINAL LEARNING OBJECTIVE

A three-part objective expressed in terms of and keyed to tasks as listed in the Training Analysis Summary that helps the student achieve the course objective. It describes the behavioral actions, the performance conditions, and the attainment standard expected of the student when he completes the task.

TESTS

Any device or techniques used to measure the performance of a student on a specific task or subject matter.

1. *Achievement Test.* A general term for tests designed to measure relative accomplishment in a specific area.

2. *Criterion-Referenced Test.* Measures what an individual can do or knows, compared to what he must be able to do or must know in order to successfully perform a task. Here in individual's performance is compared to external criteria or performance standards which are derived from an analysis of what is required to do a particular task.

3. *Diagnostic Test.* A test designed to diagnose learner deficiencies.

4. *Entry Level Test.* A test administered to determine the appropriate point in an instructional program at which a student should enter on the basis of his current knowledge and skills.

5. *Performance Test.* A sample work situation in wich personnel being tested perform a practical task which requires them to demonstrate how well they have mastered the skills required for the performance of their job. For some circumstances this could be a written test if designed as a job sample for personnel whose responsibilities involve only paper procedures.

6. *Posttest.* A test administered after the completion of instruction to assess whether a student has mastered the objectives of the course.

7. *Pretest.* Administered prior to instruction to determine how much the student already knows.

8. *Progress Test.* A test administered at some point in a course to determine the degree to which trainees are accomplishing the desired learning.

9. *Quiz (Blitz).* A short test administered by the intructor to measure achievement on material recently taught or on any small, newly completed work.

TRACKING MOVEMENT

Intermittent or continuous adjustment of an instrument or machine to maintain a normal or designed value (compensatory tracking), or to follow a moving reference marker (pursuit tracking).

TRAINEE GUIDE

A generic term for the various printed materials developed by instructors for trainee use.

TRAINING AID

A surface layout, model, or mockup providing a display of parts and processes of the system on which an instruction is being given.

TRAINING MATERIALS

A broad term covering instructional materials and management training materials such as curriculum development and acquisition specifications.

TRAINING OBJECTIVE

A statement of the ultimate purpose to which the trainee expects to put the skils acquired through his training program.

TRAINING SETTING

The environment within which training occurs (e.g., classroom, OJT, or simulator).

TRAINING TASK ANALYSIS

A system for proceeding from an inventory of tasks, such as that provided by a job task analysis (job analysis) to an organized set of terminal, and enabling learning objectives.

VISUAL DISPLAYS

Any symbol or group of symbols representing information which aid in the process of performing a function. The form could be alphanometries, pictorials, lights, colors, forms, or combinations which facilitate the interpretation of information. NUREG 0700 discusses the standards for using different kinds of displays.

VISUAL PERCEPTION

Characterizes an experience as belonging to the sense of vision. (See PERCEPTION).

WAIS

The Weschler Adult Intelligence Scale.

WORK METHODS

Structure patterns and practices for conducting one's job. The orderly and effective use of procedures and checklists.

WORK SITUATION APPROACH

An approach to identifying and analyzing error-likely situations in which it is assumed that the primary causal factors behind most human errors in a well-structured work situation are more closely related to such system elements as operating procedures, equipment design, and management practices than to the individual characteristics of trained personnel.

WORKING MEMORY

An internal memory of the environment providing the framework within which changes in the perceptual world take place following update of our current model of the environment.

APPENDIX B

MEDIA SELECTION MODEL

An evaluation of a training system must include the selection and implementation procedures for media that support learning objectives. Gagne[B-1] stipulates a set of nine events that must occur during instruction of objectives. To properly address all of the stimulus requirements for each learning event, the media selection process has to anticipate and support the internal processes of learning. Depending on the type of media that is used and the stimulus capabilities of that media, many or all of these instructional events may be accomplished. In the training of nuclear power plant licensed operator's thousands of instructional events must occur to carry out the total program within several instructional contexts. Depending on the administrative constraints of time, cost, and location, a sizable pool of media alternatives may exist from which each utility may select for instructional purposes.

The media selection process has been created to provide the instructional system designer with a structured procedure for identifying the most cost effective media within each application. Because of the potentially high cost of any given media and the substantial influence a medium may have on training effectiveness, it is essential that the media necessary for each objective be identified in a reliable and effective manner.

Various forms of media selection have been designed in the past to meet varying needs of the military, commercial industries, and education institutions. Most of these procedures for media selection have been part of instructional systems development (ISD). An extensive set of development procedures, and examples of how to implement those procedures was presented in the interservice procedures for instructional systems development published in 1975. This document has served to guide training materials development for much of the military and has had influence in the development of guidelines in commercial industry. In 1981, a research project concerning media selection was completed at the Army Research Institute for the Behavioral and Social Sciences. This document is entitled "A Learning-Based Model for Media Selection," a three-volume set that describes the development and use of a more simplified media selection method. It is perhaps the most comprehensive military effort to date concerning the real world implementation of a media selection process. Most significant about the Army Research Institute media selection model is simplification of selection procedures so that they may be used by individuals who are not instructional systems development experts.

The model described in this appendix is based on several instructional systems developments including a report developed by Hanley, Bertsche, and Hammell.[B-2] That report was an application of the systems approach tailored to a program for the training of navy personnel. Most notable about the Hanley et al. report is the use of instructional systems development technology in a flexible manner to accomplish media selection in varying contexts. A similar development process was used to arrive at the model that is included in this report. The model is not considered to be a product that can be used in its current form by all instructional evaluators and designers in the nuclear industry. It serves as a representative example of what may be accomplished by employing a systems approach to licensed operator training media selection. The function of this model is to demonstrate a process of media selection.

The Model. Media selection is a structured process that ensures consideration of many media selection issues during the choice of media for the many instructional events that exist. The structure becomes most obvious when viewing a graphic representation of the selection process. Figure B-1 is a media selection model that has been created for the selection of media to support licensed operator training programs. As shown, it is a trade off between a model that can be generally applied across most NPP positions and one that is specifically designed for licensed operators. Any media selection model draws on the same set of candidate media categories but each model varies in the logic of application. Portions of the logic can be quite specific depending on the number of varied positions for which the instructional designer intends to apply the model. At present and specifically in this report, we have been most concerned with licensed operator positions. Because of this, a good deal of specificity has been built into the model. This leads to a better choice of media for sets of operator objectives.

The model shares a number of common attributes with other media selection models. For the purposes of training systems evaluation, these attributes are the critical features to be examined for adequacy of design and application.

Model Utility. User acceptance of a media selection model and the evaluation method for assessing the media selection process, depend on a practical, usable procedure for implementation. Some models (e.g., Braby et al.[B-3] have attempted to define the selection process in scientific terms. The precision of a selection process is enhanced as it becomes more quantifiable. Precision, however, should be balanced with the co-occurring increase in user constraints for the sake of scientific rigor. In the nuclear industry, training supervisors/managers will have to understand the media selection process so that it can be used effectively. Scientific terms and equations that depend on a sophisticated grasp of instructional system design and use of a complicated process are not likely to aid the training evaluator or implementer.

The model shown in Figure B-1 has been constructed for the user who has a moderate understanding of the media selection processes. The user must be capable of applying a knowledge of:

- Identifying objectives to be trained,
- The difference between a need for self-paced versus instructor-based objectives,
- Objectives requiring "hands-on" application in a laboratory or on a simulator,
- Objectives that require individual versus integrated systems training,
- Definitions of candidate media.

Assumptions of the Model. Certain assumptions are made about exiting conditions for the selection of media. Gagne, Reiser, and Larsen[B-4] suggest that the following conditions should exist before media are selected:

1. Instructional settings have been specified.
2. Instructional scope has been determined.
3. Instruction has been planned in terms of objectives.

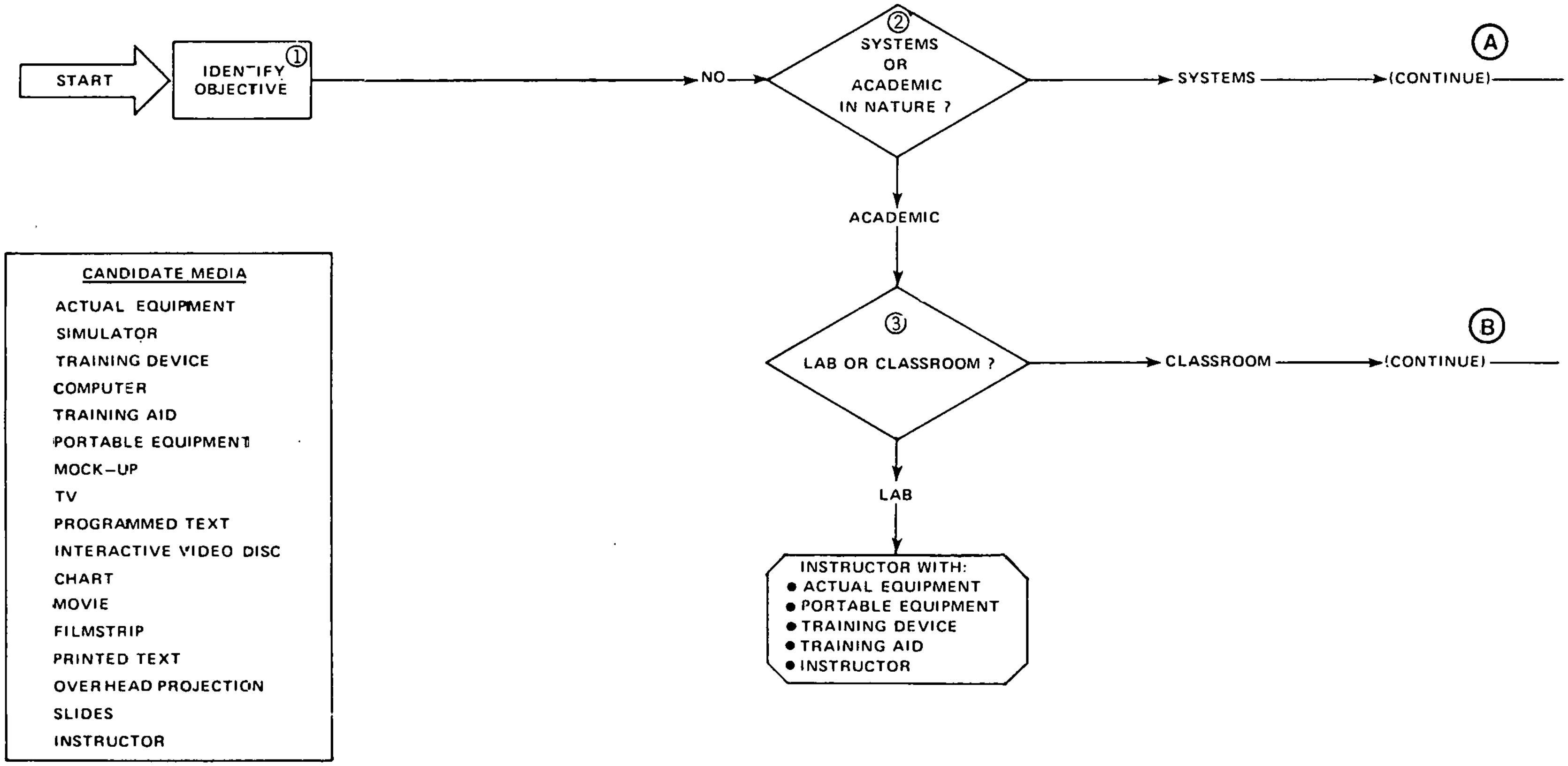

Fig. B-1. Media Selection Model.

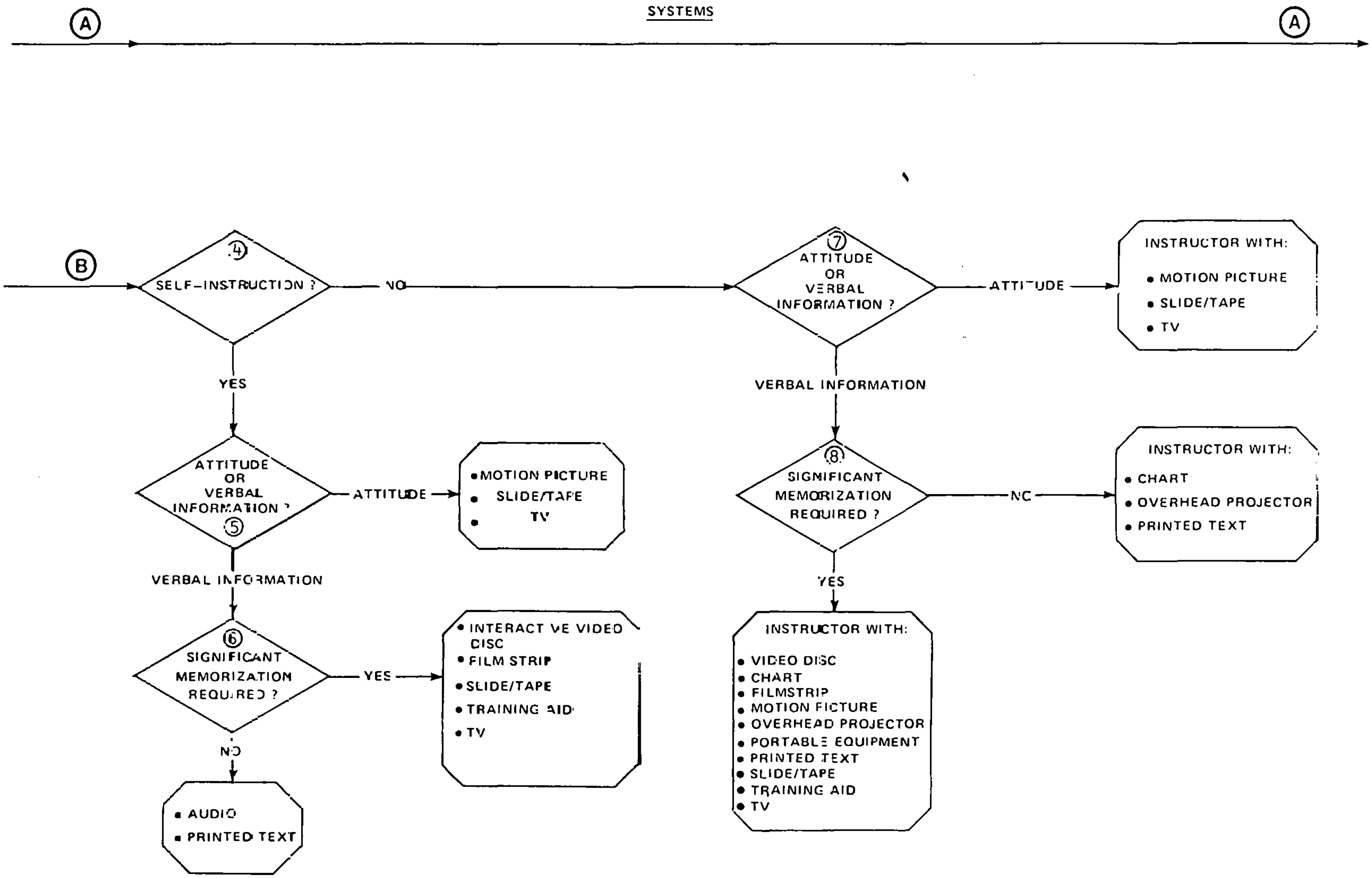

Fig. B-1. Continued.

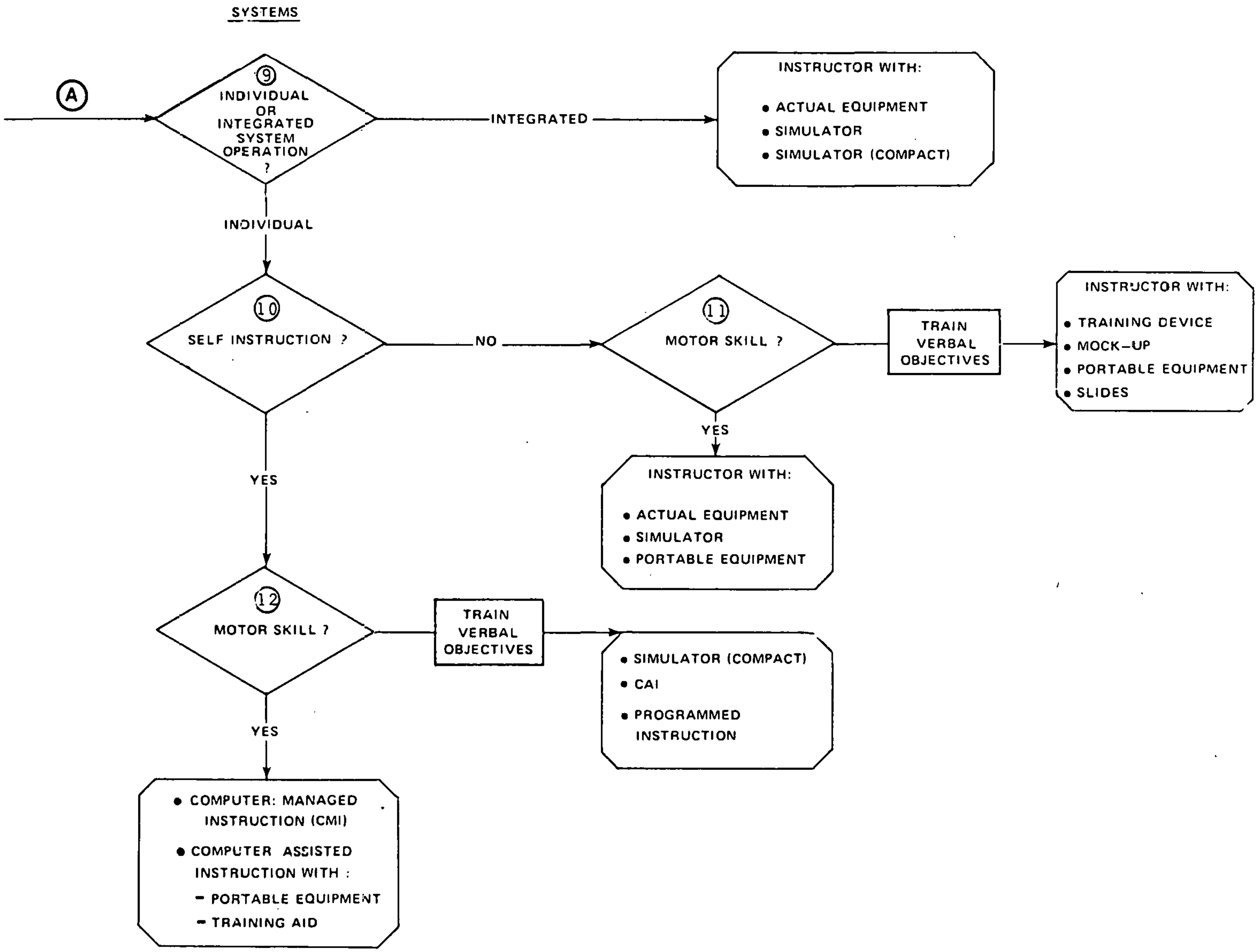

Fig. B-1. Continued.

4. Objectives of instruction have been classified into types of learning outcomes.
5. Events of instruction are planned so that selected media will be capable of activating and supporting internal processes of learning.

Given these user capabilities and the existence of the information contained in the assumptions of the model, media selection can proceed.

Selection Process

1. **Identify Objective.** As with any SAT process, training objectives serve as the basis for all decisions. The first step in Fig. B-1 is to identify the objective for instruction. Objectives are derived from task listings. Those chosen for training are further analyzed into an objectives hierarchy. Similar objectives are usually grouped together for media selection purposes. Groupings into similar objectives can be done at the training objectives level or previously in a grouping of similar tasks. It is important to understand that SME groupings of similar objectives reduces the total media selection process when performed properly.
2. **Is the nature of the objective primarily one of systems or academic learning?** A decision concerning the nature of the objective must now be made. The nature of each training objective has been divided into two alternatives: systems or academic. The reasons for such a division are several:
   a. Most training described in ANS 3.1 is either academic in nature (i.e., fundamentals and theory) or deals with systems operation. For media selection purposes, the theoretical aspects of systems training are more simply classified as academic alone. Operations, however, is almost always concerned with the operation of one or more systems. Systems, therefore, is a term that describes higher level plant operating; concepts, principles, rules, decision making, and problem solving objectives.
   b. Such a classification task is usually well within the capabilities of the training evaluator or implementer.
   c. A task analysis for licensed operators was published by the Institute of Nuclear Power Operations (INPO) in 1982. Each task element (of which there may be thousands) to that analysis has been classified as a "systems" or "academic" skill or knowledge by job incumbents. To be consistent with that analysis and to keep the demands on expert knowledge reasonable, it is sensible to divide all training objectives into these two groupings for media selection purposes.
3. **Does the academic objective require laboratory or classroom instruction?** Laboratory settings are a means for integrating academic knowledge with real world, hands-on instruction. In many instances, the laboratory setting will teach a task using actual equipment. Labs may also be used to teach an individual a concept or principle by demonstration using a scaled-down version of actual materials. Additionally, an instructor can be used to demonstrate or model the desired operator job behaviors using a training aid or other hands-on medium.

4. **Is self-instruction indicated or is an instructor required?** Depending on the complexity and difficulty of a training objective as judged by a SME, self-instruction may be a cost-effective method of dealing with instructional demands, especially those of high throughput. Many devices exist to guide the individual student through various phases of training depending on the answer to the next decision point.

5. **Is the objective one of instructing attitudes or verbal information?** An attitude is a part of an individual's personality and is difficult to modify and measure. Since modeling is one of the most successful methods for attitude change, a medium capable of successfully portraying an easily identifiable model is necessary. Motion pictures, slides, and television are quite useful and cost-effective media for accomplishing attitude change. Attitude training may or may not be a substantial area of NPP licensed operator instruction. This will depend on the comprehensiveness of selection methods and the accompanying job task analysis.

6. **Is significant memorization required?** For many NPP positions, procedural memorization, technical specification, spatial locations, color codings, etc., put substantial memory demands on the individual. To address this demand, instructional media requirements will specify mediums capable of redundant sensory inputs that are sensitive to the characteristics of the subject matter. In most instances, a visual input supplemented with audio will suffice. It is possible that tactual and kinesthetic stimuli can aid in memorization (e.g., writing notes during a lecture reinforces what has been heard by the act of writing (kinesthetic) and the sight of the words just spoken). When memory demands are not a problem, verbal information may be readily communicated by audio, printed text alone, or both.

7. **Is the objective one of instructing attitudes or verbal information? (See Step #5).** When attitudes are taught that are not easily explained and instructed, the instructor must augment each possible medium. This usually occurs when the trainee must make significant interpretations of presented materials. The instructor can act as a model himself or explain the situations and messages being presented.

   When the SME has determined that a verbal training objective is too difficult for self-instruction and that instructor interpretation or interaction is required, media is employed only to aid the instructor. The differences between the employment of media alternatives will depend on the memorization component.

8. **Is significant memorization required? (See Step 6).** Instruction of verbal information that is challenging to the student in terms of complexity and difficulty requires that the instructor augment his instruction with appropriate media. The additional burden of significant memory demands will force the instructor to enhance classroom presentations, usually with visual cues. Any of a number of visually-based media can aid in such situations.

When memory is not a constraint, simple visual mediums can also aid in presenting verbal information. It should be noted that some mediums may be used in either case (e.g., charts). The difference between the high and low memory demand situation will be the sophistication of the medium employed; e.g., a number of charts with multi-colored surfaces for high memory demand versus a simplistic monochromatic chart representation for low memory demands.

9. **Individual or integrated system operation?** At various steps in media selection, job specific considerations should appear. Licensed operators are trained first, to operate individual systems and then integrated systems only at the more advanced stages of training. Earlier phases of training address generic and component aspects of system operation (e.g., pump designs and valve types). These types of objectives cross all systems. It is when a particular system is addressed that the term "systems" applies for this media selection model.

   The term "integrated systems" applies only to systems interactions, i.e., more than one system trained at one time. One could make a strong case for considering every system objective as an interactive one. This is, however, a reasonable distinction for media selection purposes since media vary greatly in their capabilities for systems description and modeling.

   Only a few mediums are possible alternatives for use in integrated systems operation training.

10. **Self-instruction? (See Step 4).** Self-instruction at the system level can be accomplished using a variety of sophisticated media. Additionally, some simple mediums (i.e., slides or printed text) can be used to accomplish single system training. Almost always, however, a combination of media will be used to accomplish training.

11. **Motor skill?** At the system level some smooth motor skills are necessary (e.g., use of throttling techniques to accomplish a desired effect) while others will be concerned with verbal objectives (e.g., principles of operation, problem solving, and decision making).

Once the appropriate media pool has been identified, the following additional considerations should be made before making a final selection of medium:

- Is more than one medium necessary to enable students to acquire each of the objectives?
- What are the comparative costs of the final candidate media and media combinations necessary to cover each objective?
- Can each medium meet your estimate in requirements for change and updating?

At the end of this media selection process or some similar process, the media analyst can be assured that a comprehensive set of decisions have been used in selecting a particular medium for training.

APPENDIX C

SEMI-STRUCTURED GUIDE FOR INTERVIEWS WITH OPERATOR TRAINING PERSONNEL

1. Subject: Structured selection criteria for selecting candidates for operator training

    Topics to be covered in discussion:

    ANS-3.1
    MMPI
    EEI operator test for nuclear, fossil, and hydro-electric
    Experience (Navy, etc.)
    Intelligence tests

2. Subject: Development and use of training objectives

    Topics to be covered in discussion:

    a. Standard practice
    b. Performance measures for training objectives
    c. INPO task analysis

3. Subject: Selection of training media

    Topics to be covered in discussion:

    a. Standard practice
    b. Front-end analysis
    c. Media selection models

4. Subject: Instructor selection process

    Topics to be covered in discussion:

    a. Standard practice
    b. Training of instructors
    c. Contractor instruction
    d. Instructor's role and responsibility

5. Subject: Structured training materials

    Topics to be covered in discussion:

    a. Standard practice
    b. Instructor guides
    c. Lesson plans
    d. Student guides
    e. Standardization

6. Subject: Internal evaluation

    Topics to be covered in discussion:

    a. Standard practice
    b. How often?
    c. How are the results used?
    d. Who performs the evaluation?

7. Subject: External Evaluation

Topics to be covered in discussion same as Item 6

8. Subject: Plant malfunctions which should be part of the simulator's simulation capability

Topics to be covered in discussion:

a. Standard practice
b. ANS-3.5
c. Use of consultants
d. Front-end Analysis
e. Who makes decisions?

9. Subject: Initial training vs. requalification training

Topics to be covered in discussion:

a. Standard practice
b. Differences in training content
c. Differences in structure of training
d. Team training

APPENDIX D

SAMPLE STUDENT EVALUATION FORMS

STUDENT EVALUATION OF COURSE

Name:

Instructor:

The following statements are to be rated on a scale of 1 to 5. A rating of 5 indicates complete agreement with the item while a 1 indicates that you do not agree at all. Ratings of 3 mean general agreement.

		COMPLETELY		GENERALLY		NOT AT ALL
1.	The objectives of the course were fully explained at the beginning of the course.	5	4	3	2	1
2.	Training objectives of the course are realistic and obtainable.	5	4	3	2	1
3.	Training objectives are proper for the stated content of the course.	5	4	3	2	1
4.	Course materials were organized in a clear and understandable manner.	5	4	3	2	1
5.	Tests were representative of the course content.	5	4	3	2	1
6.	The grading of tests and performance standards were explained at the beginning of the course.	5	4	3	2	1
7.	The instructors use of instructional aids and training devices were adequate for this course.	5	4	3	2	1
8.	I am satisfied with the course.	5	4	3	2	1
9.	This course will help me perform my job.	5	4	3	2	1
10.	I am aware of how this course fits with all of my previous and planned future training.	5	4	3	2	1

Fig. D-1. Student Evaluation of Course Form

STUDENT EVALUATION OF INSTRUCTOR

Name:

Instructor:

The following statements are to be rated on a scale of 1 to 5. A rating of 5 indicates complete agreement with the item while a 1 indicates that you do not agree at all. Ratings of 3 mean general agreement.

		COMPLETELY		GENERALLY		NOT AT ALL
1.	The instructor's presentations are clear.	5	4	3	2	1
2.	The instructor is prepared for class.	5	4	3	2	1
3.	I can communicate with the instructor.	5	4	3	2	1
4.	Questions that come up in class are always answered.	5	4	3	2	1
5.	The instructor has a good grasp of the course content.	5	4	3	2	1
6.	The instructor stimulates discussion.	5	4	3	2	1
7.	The instructor shows enthusiasm for his job during class sessions.	5	4	3	2	1
8.	All levels of student understanding are addressed by the instructor.	5	4	3	2	1
9.	At the end of each class the instructor summarizes what has been taught.	5	4	3	2	1
10.	The instructor uses class time efficiently.	5	4	3	2	1

Fig. D-2. Student Evaluation of Instructor.

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NRC FORM 335 (11-81)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER *(Assigned by DDC)*: ORNL/TM-8848--NUREG/CR-3414

4. TITLE AND SUBTITLE *(Add Volume No., if appropriate)*: Evaluation of Training Programs and Entry Level Qualifications for Nuclear Power Plant Control Room Personnel Based on the Systems Approach to Training

2. *(Leave blank)*

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S): P. M. Haas, D. L. Selby, M. J. Hanley, and R. T. Mercer

5. DATE REPORT COMPLETED

MONTH	YEAR
August	1983

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*

Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

DATE REPORT ISSUED

MONTH	YEAR
September	1983

6. *(Leave blank)*

8. *(Leave blank)*

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*

Nuclear Regulatory Commission
Washington, D.C.

10. PROJECT/TASK/WORK UNIT NO.

11. FIN NO.: B0466

13. TYPE OF REPORT: NUREG/CR

PERIOD COVERED *(Inclusive dates)*

15. SUPPLEMENTARY NOTES

14. *(Leave blank)*

16. ABSTRACT *(200 words or less)*

This report summarizes results of research sponsored by the U.S. Nuclear Regulatory Commission (NRC) Office of Nuclear Regulatory Research to initiate the use of the Systems Approach to Training in the evaluation of training programs and entry level qualifications for nuclear power plant (NPP) personnel. Variables (performance shaping factors) of potential importance to personnel selection and training are identified, and research to more rigorously define an operationally useful taxonomy of those variables is recommended. A high-level "model" of the Systems Approach to Training for use in the nuclear industry, which could serve as a model for NRC evaluation of industry programs, is presented. The model is consistent with current publically stated NRC policy, with the approach being followed by the Institute for Nuclear Power Operations, and with current training technology. Checklists to be used by NRC evaluators to assess training programs for NPP control-room personnel are proposed which are based on this model. In an appendix, a "typical" media selection model is illustrated which might be used in the design of training systems for NPP control-room personnel. Further assessment of the proposed checklists to assure practicality, utility and acceptability is recommended. In addition, other issues related to training-effectiveness evaluation are identified, and a comprehensive research approach to address them is outlined.

17 KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

Training
Job and Task Analysis
Media Selection
Performance Shaping Factors
Systems Approach to Training
Training Objectives
Instructional Delivery System
Training Evaluation
Training Effectiveness

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT

19. SECURITY CLASS *(This report)*: Unclassified

21. NO. OF PAGES: 130

20. SECURITY CLASS *(This page)*: Unclassified

22. PRICE: $

NRC FORM 335 (11 81)

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