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QUALITY ASSURANCE IN TECHNOLOGY DEVELOPMENT
FOR
THE CLINCH RIVER BREEDER REACTOR PLANT PROJECT

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ABSTRACT

The Clinch River Breeder Reactor Plant Project is the nation's first large-scale demonstration of the liquid Metal Fast Breeder Reactor (LMFBR) concept. The Project has established an overall program of plans and actions to assure that the plant will perform as required. The program has been established and is being implemented in accordance with Department of Energy Standard RDT F 2-2. It is being applied to all parts of the plant, including the development of technology supporting its design and licensing activity. A discussion of the program as it is applied to development is presented.

INTRODUCTION

The Clinch River Breeder Reactor Plant (CRBRP) Project is the nation's first large-scale demonstration breeder nuclear power plant. The plant will have an electric generating capacity of 375 megawatts. The plant is to be located on a 1300 acre site adjacent to the U.S. Government reservation on the Clinch River in Oak Ridge, Tennessee. The plant will operate as part of the Tennessee Valley Authority System. The Project is a joint effort of government and private industry.

CRBRP was established to demonstrate that the breeder can operate reliably and safely in a utility environment and to serve as a major step in the successful transition from technology development efforts to large-scale commercial LMFBR plants.

A chief goal of the Project is to demonstrate the licensability of LMFBR's in a utility environment. The Clinch River Plant will be licensed under the same Federal regulations that apply to all commercial nuclear power facilities.

To support licensing and other principal objectives of the Project, an overall integrated quality assurance program has been established and is being implemented to assure that required quality is achieved in the Project.

PROJECT PARTICIPANTS

The U.S. Department of Energy (DOE) has lead responsibility for managing the CRBRP Project. Day-to-day management is carried out by a single integrated organization in which the DOE people work closely with representatives of other major Project partners -- the Tennessee Valley Authority (TVA), Commonwealth Edison Company (CeCo) and Project Management Corporation (PMC).

Westinghouse Electric Corporation is the lead reactor manufacturer, responsible for designing and furnishing the nuclear steam supply system for the Clinch River Plant. Westinghouse is supported by the General Electric Company (Intermediate Heat Transport, Steam Generator Systems) and the Atomic International Division of Rockwell International, Energy Systems Group (Refueling, Auxiliary, and Maintenance Systems) as subcontractors.

Burns and Roe, Incorporated, is the architect-engineer. Stone and Webster Engineering Corporation is the general contractor for constructing the Clinch River Plant. TVA will operate and maintain the plant for the five year demonstration period.

Research and development in support of the Project is performed by the designer organizations and the national laboratories.

THE PROJECT QUALITY ASSURANCE PROGRAM

The Project's Quality Assurance Program was established in 1973, soon after the Project was authorized by Public Law 91-273. Participation in the program was organized in a three-level structure as shown in Figure 1. Details of the program have previously been reported.¹

One of the major areas of activity at the first level of the Project's Quality Assurance Program is that related to technology development. The development performed by the Project in support of plant design and licensing is divided into two basic categories. If the development task is specific to the plant design or equipment it is categorized as applied technology and is performed in what is referred to as the Applied Base Technology Program. If the task is of a more generic nature and not specific to plant design or equipment, it is categorized as contributing technology and is performed in what is referred to as the Contributing Base Technology Program.

Tasks of the Applied Base Program are performed primarily by the architect-engineer and the reactor manufacturers. Tasks of the Contributing Base Program are performed primarily by the national laboratories.

The Project's Quality Assurance Program has been applied to the development work using the same requirements for applicable quality assurance activities as used for the rest of the Project. These requirements are defined in the Department of Energy Standard RDT F 2-2.

¹ ASQC Eighth Annual Eastern Energy Conference, "The Clinch River Breeder Reactor Plant Project Quality Assurance Program," March 27, 1980.

THE QUALITY ASSURANCE PROGRAM FOR DEVELOPMENT

The Project's management system for development includes participation in each task by several of the Project organizations. In this system the organization with assigned design responsibility is responsible for identifying development requirements in its assigned area and for monitoring development results to assure that it is responsive to the identified need. These organizations are referred to in the Project as Requestors.

Development requirements are defined in a Development Requirements Specification (DRS) by the Requestor. The DRS is reviewed and approved by the cognizant customer organizations and then assigned by DOE to one or more of the Project organizations or a national laboratory for implementation. These organizations are referred to in the Project as Performers.

A standard format for Development Requirements Specifications shown in Figure 2 has been adopted by the Project.

The DRS also serves as a vehicle by which the appropriate activities to be implemented by the Performer to assure requisite quality in the development results are defined. To clearly define which quality assurance program activities are to be implemented on each development task, the Project developed a technique of identifying and organizing the major program activities and assigning them to appropriate development Performers commensurate with the scope and objective of the development task. The important quality engineering function is to select the appropriate combination of activities to match and apply to the development task being covered and then prepare the appropriate specification statement for inclusion in the DRS.

To provide guidance in the selection and application of requirements for quality assurance program activities being implemented by a development Performer, the Project developed a set of guidelines for choosing the appropriate programmatic requirements for each development task.

The guidelines are based on the premise that each development task can be characterized in terms of its purpose or objective and the scope of activities that must be executed to accomplish the objective. It is further assumed that for each task there is a group of quality assurance activities that should be delegated to the Performer for implementation. The scope of these activities and the requirements for them may vary widely based on the objective and scope of the development task. However, a carefully structured set of activity groupings can be devised, such that one of the groups of activities is generally appropriate for any of the development tasks. Each group of activities results in a particular type of quality assurance program. Once the baseline group of activities or type of quality assurance program has been identified, it can be customized for the specific development task and the requirements for those activities can be defined in the DRS.

The selection of the appropriate type of program for a particular development task begins in the Project's system with the identification of the task objective. Standard definitions of task objectives that have been adopted by the Project are provided in Table 1.

The second step is to identify the scope of the development task. A set of definitions of task scopes have also been adopted by the Project and these are provided in Table 2.

The third step is to identify the appropriate baseline group of quality assurance activities or type of quality assurance program. Table 3 provides an identification of the program type. Using the results from the preceding two steps of selection, a number from 1 through 5 is found in Table 3 at the appropriate line-column intersection. The number identifies the quality assurance program type that is generally applicable to the development task.

The final step in the selection process is completed by taking the program type number found in the preceding step and entering Table 4, which provides identification of the baseline group of quality assurance activities and the requirements for those activities.

Following selection of the baseline program requirements, the requirements are then customized to fit the specifics of the individual development task. It may be appropriate to select a more rigorous type of program based on considerations for use and integrity of results, or it may be appropriate to select a less rigorous type of program based on previous experience with the Performer and its facilities and standard operating practices and procedures. In addition, there may be unique or special features about the development task or its objective and scope which dictates that specific quality assurance activities be added, altered or deleted altogether from the program. Other considerations may also include:

- a) Access to Performer facilities,
- b) Approval of documents,
- c) Documentation submittal,
- d) Records requirements, or
- e) Quality Status Reports.

After all considerations have been factored into the selection and customizing of the program activities, the requirements for those activities are worded into the DRS. Typical program requirement specifications are illustrated in Table 5.

CONCLUSIONS

The Project's system for selecting and defining quality assurance activities for development tasks has worked quite well to date. There have been over 300 development tasks defined in the Project at an estimated cost of about \$350 million dollars.

To date, with about 90% of the development work completed, the results from program implementation have been good. The Project organizations have worked closely and in a very disciplined and coordinated way. There have been few failures in the program or deficiencies in results. The program is well on its way to achieving its objectives.

CRBRP QUALITY ASSURANCE PROGRAM FUNCTIONAL ORGANIZATION OF PROGRAM RESPONSIBILITY

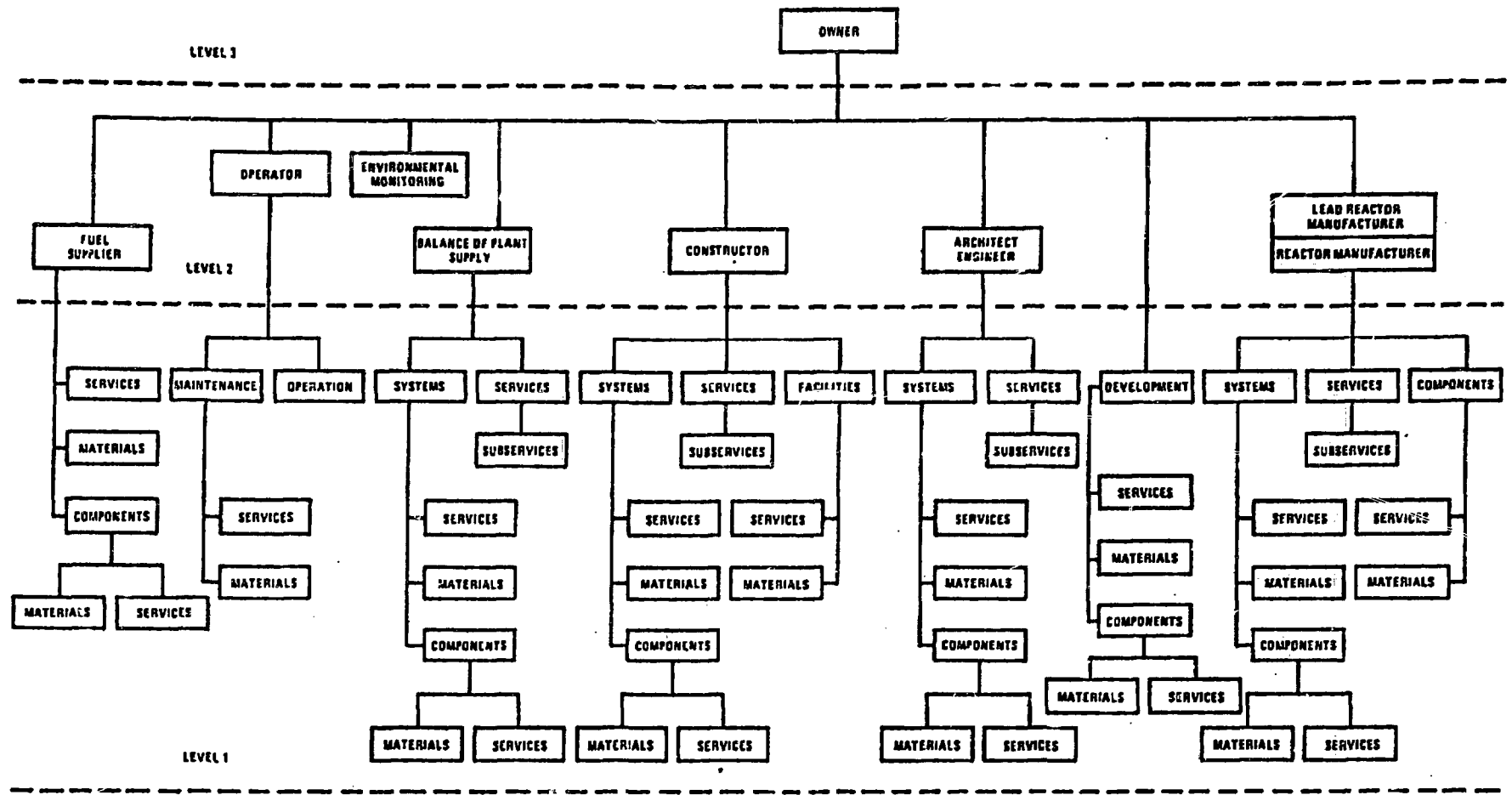


Figure 1

CLINCH RIVER BREEDER REACTOR PLANT PROJECT
DEVELOPMENT REQUIREMENTS SPECIFICATION

CONTENTS

1. Development Task Number
2. Development Title
3. Objectives
4. Justification
5. Description of Development Program (Scope)
6. Schedule
7. Test Facility Requirements
8. Data Requirements
9. Acceptance Criteria or Limits
10. Interim and Final Reports
11. Quality Assurance
12. Drawings
13. Document Review
14. References
15. Estimated Cost

TABLE 1
DEVELOPMENT TASK
DEFINED AS TO OBJECTIVE

1. DATA

The objective of a task to identify or establish information or methods for use in design.

- a) Design Data: The objective of a task to identify, establish, assemble or correlate information and data for use in or to provide the basis for a design.
- b) Design Technique: The objective of a task to prepare methodology for use in designing. Such methodology may include empirical, analytical, or numerical methods and technical data for use in developing a design or performing design verification.

2. DESIGN

The objective of a task to provide a design which will satisfy an identified need which can be characterized by a set of requirements or criteria.

- a) Design Development: The objective of a task to produce a design which meets a set of requirements that characterize a special need.
- b) Design Verification: The objective of a task to determine through methods other than those used in the design development process that the design satisfies the design requirements.

3. PRODUCT

The objective of a task to demonstrate that a given end item of either software or hardware meets the requirements defined for it.

- a) Qualified Design: The objective of a task to demonstrate through appropriate performance demonstration and evaluation, that a design meets requirements and will result in satisfaction of the identified need each time it is employed to produce an end item. Ordinarily, this type of objective would be present in the task of establishing a new product for multiple production.
- b) Qualified Item: The objective of a task to demonstrate through appropriate performance demonstration and evaluation, that an object will perform as required when placed in service. Ordinarily, this type of objective is present in a task to prove performance capability of items to be installed for actual operation.

TABLE 2
DEVELOPMENT TASK
DEFINED AS TO SCOPE OF TASK

1. SURVEY

A task involving a search for information related to a specific subject or the investigation, correlation and identification of properties or other characteristics of materials, items, methods and techniques to provide feasibility of a design feature. (Example: scoping analyses, feasibility evaluations.)

2. STUDY

A task involving a disciplined and systematic analysis or investigation of solutions to problems. Included are analyses such as mathematical analysis of a design feature for its application or probabilistic predictions of success or failure under various conditions. A study task may be extensive and complex when it is used to establish that a design: meets criteria; is based on proven practice; and is adequate for intended service. (Example: analysis used in design, preliminary analyses, design data.)

3. TEST

A task involving a determination or verification of the capability of an item to meet specified requirements by subjecting the item to a test of physical, chemical, environmental or operating conditions. A test may provide data for surveys, studies, design verification and item qualification.

A task involving a test article provided by others to be subjected to a test or series of tests in an existing facility will normally include: designing the test article installation, installing the test article; performing the tests; evaluating test results; and preparing and issuing reports.

NOTE: There may be occasions in which a test is required in which the necessary test articles or test facilities or both are not provided. The providing of such articles and facilities are considered to be separate tasks or projects and are to be accomplished under quality assurance programs defined in accordance with Project guidance for the overall program.

**SELECTION OF QUALITY ASSURANCE PROGRAM TYPE
BASED ON DEVELOPMENT TASK SCOPE AND OBJECTIVE**

OBJECTIVES						
TASK OBJECTIVE TASK SCOPE	DATA		DESIGN		PRODUCT	
	DESIGN DATA	DESIGN TECHNIQUES	DESIGN DEVELOPMENT	DESIGN VERIFICATION	QUALIFIED DESIGN	QUALIFIED ITEM
SURVEY	1 (See Note 1)	1	N/A	N/A	N/A	N/A
STUDY	1	1	2	2	2	N/A
TEST (See Notes 2 and 3)	3	3	4	4	5	5

Notes:

1. The numbers identify the type of quality assurance program to be specified in the development specification.
2. Test articles shall be provided under quality assurance programs developed in accordance with overall program guidance.
3. Test facilities shall be provided under quality assurance programs developed in accordance with overall program guidance.

TABLE 4
QUALITY ASSURANCE PROGRAMS
DEFINED BY TYPE

TYPE 1

Program in accordance with Project or company specification. This means any combination of program requirements specified through the invoking of a standard company specification or written directly into the Development Requirements Specification.

TYPE 2

Program in accordance with RDT F 2-2 containing the following activities:

- Program planning,
- Program index,
- Defined responsibility and authority,
- Documentation,
- Engineering studies,
- Document review and approval, and
- Program audits.

TYPE 3

Program in accordance with RDT F 2-2 containing the following activities:

- Program planning,
- Program index,
- Defined responsibility and authority,
- Documentation,
- Engineering studies,
- Development and qualification testing,
- Test article control, and
- Program audits.

TYPE 4

Program in accordance with RDT F 2-2 containing the following activities:

- Program planning,
- Program index,
- Defined responsibility and authority,
- Documentation,
- Unusual occurrence reporting,
- Engineering studies,
- Development control,
- Failure reporting and corrective action,
- Quality records, and
- Program audits.

Table 4 (Continued)

TYPE 5

Program in accordance with RDT F 2-2 containing the following activities:

- Program planning,
- Program index,
- Defined responsibility and authority,
- Documentation,
- Management reviews,
- Unusual occurrence reporting,
- Engineering studies,
- Acceptance criteria,
- Development control,
- Failure reporting and corrective action,
- Quality records, and
- Program audits.

TABLE 5

QUALITY ASSURANCE PROGRAM
REQUIREMENTS SPECIFICATIONS
FOR DEVELOPMENT TASKS

Tabulated herein are typical specification statements that may be used in preparing the quality assurance requirements section of a DRS based on the applicable type of program selected.

A. A Type 1 Program Statement for Survey, Scoping Analysis, or Feasibility Evaluations.

"To assure that the required quality of the results from this development task is achieved, a program of plans and actions shall be implemented to control and verify quality attainment.

This program shall establish measures and documentations to assure that:

1. The data identified is reviewed and evaluated systematically to verify completeness, correctness and adequacy with respect to the task requirements.
2. The methods used for verification are identified and the comparative results documented.
3. The compilation of data and the results of analyses are verified by individuals who are responsible for verifying that the work has been performed satisfactorily."

B. A Type 1* Program Statement for Computer Programs in Development Tasks.

"To assure that the required quality of the results from this development task is achieved, a program of plans and actions shall be implemented to control and verify quality attainment.

This program shall provide that mathematical models and computer programs which have been developed shall be verified for accuracy by either of the following methods:

1. The computer program solutions to a series of test problems with accepted results have been demonstrated to be substantially identical to those obtained by a similar program which is recognized and widely used, with a sufficient history of successful use to justify its applicability and validity without further demonstration. The dated program version that will be used, the software or operating system, and the hardware configuration must be specified to be accepted by virtue of its history of use. The test problems shall be demonstrated to be similar to or within the range of applicability for the problems analyzed by the computer program to justify acceptance of the program.

Table 5 (Continued)

2. The program solutions to a series of test problems are substantially identical to those obtained by hand calculations or from accepted experimental tests or analytical results published in technical literature. The test problems shall be demonstrated to be similar to the problems analyzed to justify acceptance of the program.

The methods used for verification shall be identified and the comparative results documented. Validation of developed models or programs shall be accomplished using available experimental data."

C. A Type 2 Program Statement:

"To assure that the required quality of the results from this development task is achieved, a program of plans and actions shall be implemented to control and verify quality attainment. This program shall conform to the requirements and produce the action specified in Sections 1, 2.2, 2.3.1, 2.4, 3.3.3, 3.4.1, and 8 of RDT F 2-2, 1973, Quality Assurance Program Requirements, including Amendments 1, 2, and 3.

A test Plan and Quality Assurance Program Index shall be submitted by the test Performer to the Requestor organization, LRM and the CRBRP Project Office. Quality Status Reports in accordance with Paragraph 2.4.3 of RDT F 2-2 shall be submitted to the Requestor, LRM, and the CRBRP Project Office by the Performer on a quarterly basis."

D. A Type 3 Program Statement:

"To assure that the required quality of the results from this development task is achieved, a program of plans and actions shall be implemented to control and verify quality attainment. This program shall conform to the requirements and produce the action specified in Sections 1, 2.2, 2.3.1, 2.4, 3.3.3, 3.6.2, 3.6.3, and 8 of RDT F 2-2, 1973, Quality Assurance Program Requirements, including Amendments 1, 2, and 3.

A Test Plan and Quality Assurance Program Index shall be submitted by the test Performer to the Requestor organization, LRM, and the CRBRP Project Office. Quality Status Reports in accordance with Paragraph 2.4.3 of RDT F 2-2 shall be submitted to the Requestor, LRM, and the CRBRP Project Office by the Performer on a quarterly basis."

E. A Type 4 Program Statement:

"To assure that the required quality of the results from this development task is achieved, a program of plans and actions shall be implemented to control and verify quality attainment. This program shall conform to the requirements and produce the action specified in Sections 1, 2.2, 2.3.1, 2.4, 2.8, 3.3.3, 3.3.8, 3.6, 3.7, 3.8, 3.9, and 8 of RDT F 2-2, 1973, Quality Assurance Program Requirements, including Amendments 1, 2, and 3.

Table 5 (Continued)

A Test Plan and Quality Assurance Program Index shall be submitted by the test Performer to the Requestor organization, LRM and the CRBRP Project Office. Quality Status Reports, in accordance with Paragraph 2.4.3 of RDT F 2-2 shall be submitted to the Requestor, LRM and the CRBRP Project Office by the Performer on a quarterly basis."

F. A Type 5 Program Statement:

"To assure that the required quality of the results from this development task is achieved, a program of plans and actions shall be implemented to control and verify quality attainment. This program shall conform to the requirements and produce the action specified in Sections 1, 2.2, 2.3.1, 2.4, 2.5, 2.8, 3.3.3, 3.3.8, 3.6, 3.7, 3.8, 3.9, and 8 of RDT F 2-2, 1973, Quality Assurance Program Requirements, including Amendments 1, 2, and 3.

A Test Plan and Quality Assurance Program Index shall be submitted by the test Performer to the Requestor organization, LRM and the CRBRP Project Office. Quality Status Reports in accordance with Paragraph 2.4.3 of RDT F 2-2 shall be submitted to the Requestor, LRM and the CRBRP Project Office by the Performer on a quarterly basis."