COO-4184-5

MASTER

DEVELOPING MAINTAINABILITY IN CONTROLLED THERMONUCLEAR REACTORS

Progress Report

for Period October 1, 1977 - April 30, 1978

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May 1977

Prepared For

THE U.S. DEPARTMENT OF ENERGY

UNDER CONTRACT NO. EG-77-C-02-4184.A001

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ABSTRACT

It is the purpose of this study to examine maintainability, particularly for the tokamak reactor conceptual designs, and to define design guidelines as an aid toward developing maintainability in this type of reactor. This continuing study is designed to incorporate the impacts of maintenance actions required by several critical subsystems other than the first wall/blanket and of unscheduled maintenance actions.

During the period 1 October 1977 through 30 April 1978 the study has completed work on Task 6, Candidate Reference Systems, except for writing the task report and has conducted effort on Task 7, Maintenance Plans. Four candidate reference systems have been defined. These are based on the conceptual designs of the UWMAK-III, the General Atomic Company Demonstration Power Reactor, the Oak Ridge National Laboratory Cassette defined in the Demonstration Power Study and the Culham Laboratory Mark II Reactors. These reactor concepts are normalized to 3000 MW_{th} and near minimum cost of electricity. In addition, designs of four major subsystems have been selected and defined for application to these reactors. These include a primary coolant system, primary and secondary vacuum zone systems, the neutral beam injection system and the magnetic field system. These magnet systems are unique to each reactor.

The cases for which maintenance plans are being developed in Task 7 have been selected to allow evaluation of design features, particularly the vacuum wall locations, and the impacts of unscheduled and contact maintenance of subsystems on the cost of electricity. Other accomplishments during this period include a preliminary evaluation of the maintainability of a demountable, externally anchored, low stress, superconducting magnet as applied to an ignition test reactor, the publishing of the revised Phase I study report, the revision of the threshold goal and economic breakeven point of fusion plants with coal fired plants to 55% and 53.9 mils/kWh in 1977 $, respectively, and the development of a revised plan for completion of this part of the maintainability studies within the remaining period, i.e., before September 30, 1978.

1.0 INTRODUCTION

Today's fusion reactor design concepts represent such an advance in the technology required for power generating systems that the practical aspects of maintenance of these reactors tend to receive relatively little recognition. To develop a design with a high degree of maintainability requires singular attention to this characteristic. It is the purpose of this study to examine maintainability, particularly for the tokamak reactor conceptual designs and to define design guidelines as an aid toward developing maintainability in this type of reactor.

The initial part of this study primarily considered scheduled maintenance activities for the first wall /blanket exchange of five conceptual designs for demonstration, or first generation, commercial power reactors. These designs included the UWMAK-I, UWMAK-III, General Atomic Demonstration, ORNL Demonstration Study and the Culham Laboratory Mark II reactors. The results were based on assumed maintenance impacts of other subsystems and of unscheduled maintenance requirements.

This continuing study is designed to incorporate the impacts of maintenance actions required by several critical subsystems other than the first wall/blanket and of unscheduled maintenance actions. Through this effort a set of guidelines for maintainable design features will be identified.

In this part of the study the four reactor concepts which are retained are the UWMAK-III, General Atomic Demonstration, ORNL Demonstration Study and the Culham Mark-II reactors. These designs are defined in References 1 thru 5, but normalization to common design and performance parameters, insofar as possible, is essential to attain a set of comparable results. From these four concepts, alternative design features will be selected to define a concept that incorporates the most desirable features of maintainability, balanced in emphasis to minimize the cost of electricity.

During this reporting period the selected reference design concepts, Task 6, have been defined and normalized. This effort includes defining selected arrangements for the plasma chamber, vacuum system, primary coolant system, plasma heating system and the magnet system. In addition, the evaluation of the impact on maintainability of the Demountable Externally Anchored Low Stress (DEALS) Magnet on the maintenance of an Ignition Test Reactor (ITR) was completed. This evaluation will be extended to the commercial reactor concepts later in the study. Initial work has been conducted on the development of the maintenance plans, Task 7, required to evaluate the impact of unscheduled maintenance and of the several subsystem arrangements.

2.0 PROGRESS DURING THIS REPORTING PERIOD

2.1 Administrative Activity

This initial progress report covers the period through 30 April 1978 instead of the first three months as required by the contract extension.

A request for evaluation of the DEALS magnet concept was received from the U.S. Department of Energy dated 10 March 1978. This evaluation was completed and forwarded to the DOE on 18 April 1978.

To complete the study in the remaining time the schedule for submittal of reports and completion of the tasks has been revised as shown in Figure 1.

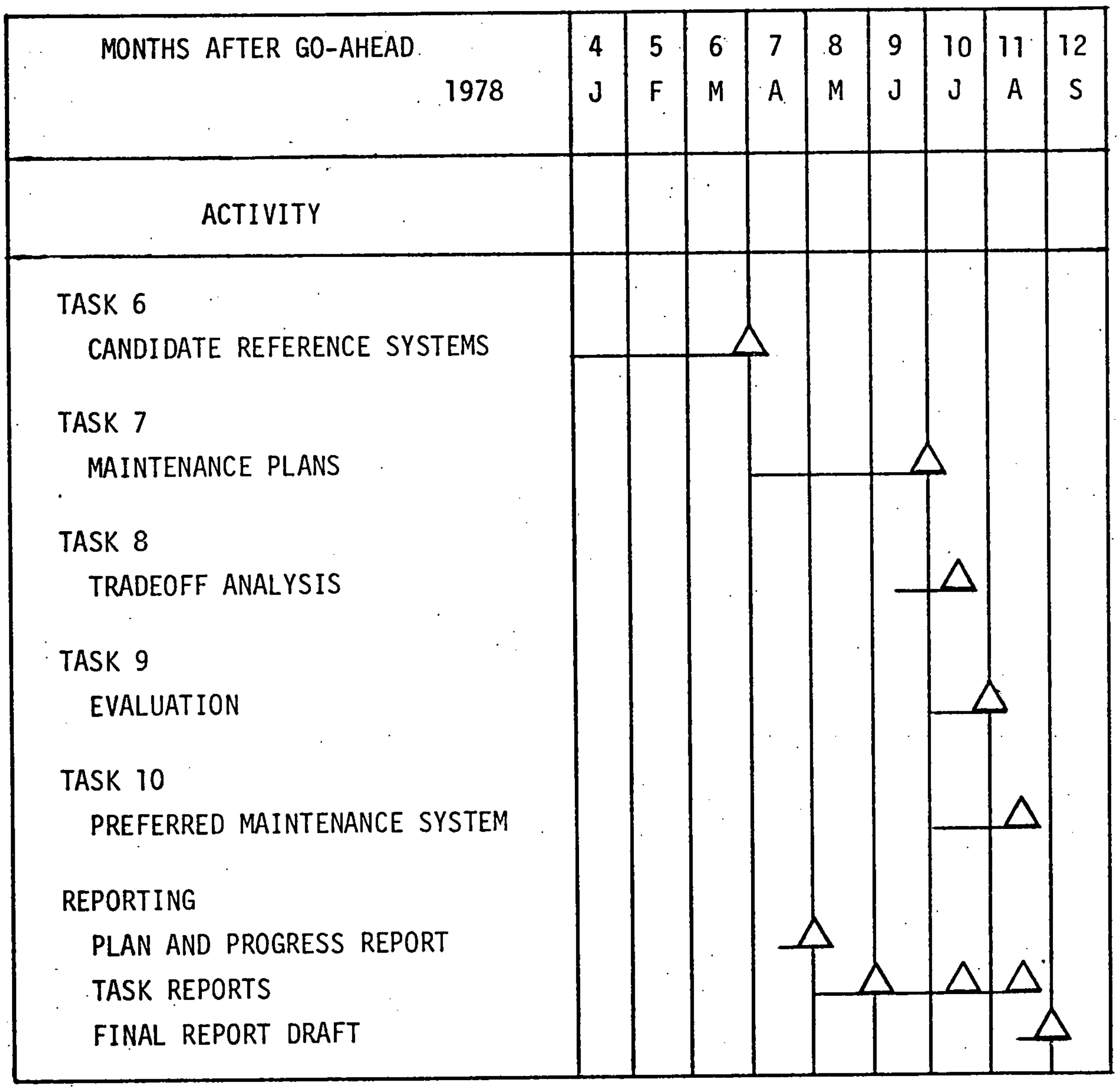
The Phase 1 report, dated October 1977, was revised in accordance with comments received and distributed in final form during this period.

2.2 Technical Activity

During this period the principal technical activities included:

- o The development of normalized configurations for selected tokamak reactor concepts, including the selection and resizing of design concepts for the principal subsystems interfacing with the reactor room. These configurations will be used as reference designs for evaluating the maintainability of design features.
- o Evaluation of the maintainability of the DEALS magnet concept when applied to an ITR conceptual design.
- o The definition of the maintenance plans for the reference concepts required for the study evaluation and initial work on these plans. These plans will include estimates of time-to-repair or replace for selected maintenance actions, and estimates of maintenance equipment, facilities and personnel requirements.

FIGURE 1. STUDY SCHEDULE



These technical efforts are a continuation of the study reported in the first phase report of October, 1977 and utilize the work accomplished in that portion of the study as a base for design concepts and maintenance plans.

2.2.1 Candidate Reference Systems - Task 6

2.2.1.1 Reactor Concept Sizing - The four more promising reactor concepts from the first phase of the study have been selected for use as reference designs to complete the evaluation. These concepts are the UWMAK-III, the General Atomic Demonstration Power Reactor, the Oak Ridge National Laboratories Cassette concept and the Culham Laboratory Mark II. It is desired that the designs used for this evaluation be normalized to common performance and design characteristics wherever possible. Therefore, the characteristics shown in Table 1 as independent parameters have been selected. All other parameters in Table 1 are computed values. The objective of the normalization process is to define reactors that are of a uniform power output and near minimum cost of electricity for that power and reactor concept. To accomplish this, several of the sizing parameters are varied.

Some of the more significant variations in the values of various parameters, both selected and computed, and other than the parameters which directly reflect the characteristics of the design concepts, include the following:

- For the Culham Mark II and the ORNL concepts the selected major radius is increased by the requirement for an actively cooled, breeding, inner blanket. A constant value of major radius for all reactors has not been maintained since this results in a design that is too far removed from the minimum cost point for some concepts.
- The poloidal beta has been set by General Atomic for their DPR at a value of one half of the aspect ratio. For all of the other concepts, a value of poloidal beta equal to the aspect ratio is applied in the sizing analysis.
- The parameters affecting wall loading are selected to produce approximately the same average wall loading for all concepts but some deviation occurs as a result of the blanket design concept. For example, the average neutron wall loading of the ORNL concept is significantly

TABLE 1. REFERENCE REACTOR CONCEPT CHARACTERISTICS

	UWMAK-III	GA-DPR	CULHAM	ORNL
* POWER, MW_{th}	3000	3000	3000	3000
* FIRST WALL/BLANKET CONFIGURATION	UWMAK-III	GA-DPR	CULHAM	CASSETTE
* FIRST WALL COOLANT	LITHIUM (OUTER WALL) HELIUM (INNER WALL)	HELIUM	HELIUM	HELIUM
* DIVERTER COOLANT	LITHIUM	-	LITHIUM	LITHIUM
* AUXILIARY HEATING	NBI	NBI	NBI	NBI
* VACUUM SYSTEM	UWMAK-III	GA-DPR	UWMAK-III TYPE	UWMAK-III TYPE
* DIVERTER	UWMAK-III (DOUBLE NULL)	FLOWING PLASMA BOUNDARY	SINGLE NULL	UWMAK-III TYPE (SINGLE NULL)
* T. F. MAGNETS, NUMBER	16	16	16	16
* MAX. TOROIDAL FIELD STRENGTH (B_m), TESLA	8.66	8.66	8.66	8.66
FIELD STRENGTH ON AXIS (B_o) TESLA	4.109	4.717	3.871	3.871
* PLASMA STABILITY FACTOR	2.5	2.5	2.5	2.5
* PLASMA BURN TIME, SEC	3600	3600	3600	3600
* PLASMA REJUVENATION TIME, SEC	100	100	100	100
* PLASMA ECCENTRICITY	2	3 (DOUBLET)	2	2
* PLASMA MAJOR RADIUS, m	6.5	6.5	7.5	7.5
PLASMA MINOR RADIUS, m	1.75	1.405	1.92	1.92
PLASMA VOLUME, m^3	785.87	796.98	1091.50	1091.50
WALL AREA, m^2	781.02	884.88	988.72	1179.00
POLOIDAL BETA	3.714(A)	2.315(A/2)	3.906(A)	3.906(A)
NEUTRON WALL LOADING, MW/m^2	2.74	2.364	2.121	1.780
ION TEMPERATURE, T_i, KeV	12.7726	16.218	12.9298	12.9298
ELECTRON TEMPERATURE, T_e, KeV	13.8118	16.148	13.8176	13.8176
DENSITY, n_i PARTICLES/m^3	1.572×10^{20}	1.234×10^{20}	1.3144×10^{20}	1.3144×10^{20}
CONFINEMENT TIME, τ_p, SEC	2.316	2.808	2.72	2.72
$N_i\tau_p$, PARTICLE-SEC/m^3	3.642×10^{20}	3.466×10^{20}	3.575×10^{20}	3.575×10^{20}
FUSION REACTION RATE, $\langle\sigma v\rangle$ m^3/SEC	2.0×10^{-22}	3.11×10^{-22}	2.05×10^{-22}	2.05×10^{-22}
THRUPUT, TORR-L/SEC	2125.58	5174.73	2103.09	2103.09
CRYO PANEL AREA, m^2 (ACTIVE OPERATING)	423.6	1031.2	419.1	419.1

* Independent Selected Parameters
A = Aspect Ratio

lower than for the other concepts because the polygonal cross section of the plasma chamber increases the total area for a given size of plasma and thus reduces the average neutron wall loading. Where the wall loading at some modules is significantly higher than the average and the conceptual blanket design allows an increase in maintainability with earlier replacement of these modules, such as in the case of the UWMAK-III, this capability is used in the analysis.

Cross section layouts of each configuration are generally complete for the reactor plasma chamber and attached equipment. Some minor work is required to complete a comprehensive view of the equipment arrangement.

One of the most significant design problem areas is the diverters and the means to conduct the gases to the cryosorption pumps. Since the UWMAK-III diverter system definition is the most complete, this system is applied in concept to the Culham Mark-II and to the ORNL Cassette designs. These designs do employ, however, single null poloidal diverters instead of the double null used by UWMAK-III. Bombardment plate areas are sized to accommodate the increased thermal load and it is assumed that the magnetic flux surfaces can be spread over this area. Insufficient information is available to define bundle diverters for the ORNL design and some question exists whether there is sufficient space to absorb the energy from the diverted particles in this type of diverter. For the ORNL design, the single null poloidal diverter necessitates the use of a single module for the diverter island instead of the multizone blanket employed for all other blanket modules. Connections are made from the back surface of the module in a manner similar to that required by the Culham Mark-II design.

The only other major revisions are to define structural support to the ORNL cassette designs and to incorporate the modified first wall/blanket module recently presented by General Atomic for the GA-DPR concept, Reference 6. In general, no other significant additional design problems have been encountered.

2.2.1.2 Subsystem Sizing - The impact of subsystem maintenance is to be evaluated. For this purpose the normalized reactor plant designs are defined to incorporate subsystems that are common in design principle and arrangement insofar as possible, but are sized to meet the performance requirements of the reactor concept. This normalization has been conducted for four critical subsystems which interface with the reactor. These are the vacuum system, primary coolant system, magnet system and plasma heating system. In addition to the principal conceptual design documents, data for the subsystem designs was extracted from Reference 7 through 13 and by contact with various manufacturers.

Failure modes and the required maintenance actions will be selected from these four subsystems for definition of their impact on the maintenance plans. For each subsystem some alternative designs and arrangements are defined to provide a "standardized" nominal design and arrangement for each reactor concept.

The subsystem characteristics and alternatives that are defined include:

o Primary coolant system - For this system two designs have been defined, one for lithium and one for helium coolant. The lithium system will be used with the UWMAK-III concept and the helium system for the other three concepts. Since the diverter and shield coolant systems require different thermal cycles, these are defined as separate loops. All diverter systems use lithium as the coolant and the shield systems use helium. The primary coolant and diverter systems both use a sodium secondary system to generate steam and store energy during the reactor 100 second downtime between burns.

  The tritium reclamation and handling system has not been considered except that, in all cases except the ORNL concept, the tritium from the breeder blanket is primarily carried from the reactor room with the primary coolant.

o The vacuum system cryosorption pump and roughing pumps have been sized for all systems. The principal variation among the reactor concepts is the sizing and arrangement of the cryosorption pump panels. For the UWMAK-III, Culham Mark-II and ORNL concepts the UWMAK-III general arrangement is used except that the size is varied when the single null poloidal diverter is used. The cryosorption pump area required for the GA-DPR is sized for the flowing plasma boundary requirements and apportioned in accordance with the requirements of References 2 and 7. The UWMAK-III arrangement is used as a "standard" since it is reasonably well defined in Reference 1 and the conductance from the bombardment plates to the cryosorption panels appears to be as close to a maximum as practical.

The roughing pump arrangements are common for all reactors and are sized to accommodate both the neutral beam injectors and the primary vacuum chamber. These require a size variation as the primary chamber wall is varied in its location among the concepts. A separate roughing pump system is defined for the secondary vacuum chamber, when one is used, and is also varied in size with the size of the chamber.

- o The magnet systems use superconducting magnets in the configuration defined by each reactor concept. The alternative system uses the DEALS magnet concept as defined in References 12 and 13.

- o The plasma heating system uses the ohmic heating coils (E coils, induction coils) as defined by each concept and neutral beam injectors. These injectors will use three neutral beams in each assembly and employ the design being developed for the tokamak fusion test reactor (TFTR) as defined in Reference 11. All injectors are installed with the beams normal to the plasma toroidal axis and a total of 12 - 7.5 MW units are used for each reactor.

The detailed data for these subsystems will be included in the Task 6 progress report. This data includes heat balances, principal characteristics, arrangement and sizing sketches. Data on other subsystems from various sources was compiled prior to the selection of the four subsystems discussed above. This data also will be summarized for the Task 6 report. The first wall blanket data used for the report of the first phase of this study is also used except that greater definition of the ORNL and Culham Mark-II concepts is used. Since a blanket study by ORNL is in progress, this first wall blanket concept may be further modified as required in this study. The Culham Mark-II definition was forwarded from Culham Laboratory.

2.2.2 Maintenance Plans - Task 7

2.2.2.1 DEALS Magnet Evaluation - The evaluation of the Ignition Test Reactor (ITR) employing the DEALS magnet design concept has been conducted by comparing the maintainability of this concept, Reference 13, with the GA-ITR design as presented in Reference 14. The GA-ITR is used as a comparison baseline both because the replacement of a toroidal field magnet is made feasible by the use of normal poloidal field coils which are reasonably accessible and because sufficient design detail exists.

Downtime estimates have been made for a magnet failure mode in which an internal short has destroyed the integrity of one toroidal field coil without distorting the coil case to the extent that other components of the reactor are damaged or that the magnet removal is made more difficult. This failure mode is chosen since it permits replacement of only a portion of the TF magnet in the DEALS concept and thus indicates the greatest difference in downtimes for the DEALS versus the unitary design magnet. The failure is assumed to be in the inside lower leg of the TF DEALS magnet since this is the most difficult location for maintenance access.

Alternate maintenance procedures have been devised for this maintenance requirement depending upon several major assumptions that can be made. These alternative cases are briefly defined in Table 2 and the downtime estimates are given. Since the study is intended only as a preliminary evaluation these estimates are considered order of magnitude estimates but are based on the estimates derived in the Phase I study insofar as possible.

Downtime estimates have been made for only the simplest maintenance action involving the DEALS magnet (i.e., the first listed in Table 2) but estimates have been made for both of the alternatives for removal of a GA-ITR toroidal field magnet. Both estimates are made for the GA-ITR because the present design indicates that the inner poloidal field coils are not sectionalized (the fourth case listed), but significant advantages are attained when all inner poloidal field coils are sectionalized (the fifth case listed). It is desired to show the effects of this improvement to present the best possible situation for the GA-ITR concept.

TABLE 2. MAINTAINABILITY COMPARISON OF DEALS MAGNET WITH UNITARY DESIGN TF MAGNET.

	Reactor	Failure	Consequence	Design Assumption	Estimated Downtime Days*
1.	DEALS-ITR	Short in TF coil conductor	No damage to adjacent joints	Plasma chamber can be raised to provide clearance at inner leg of magnet	17
2.	DEALS-ITR	Short in TF coil conductor	Joint between inner lower leg and inner vertical leg are welded together	Same as 1 above	No estimate
3.	DEALS-ITR	Short in TF coil conductor	No damage to adjacent joints	No clearance is available to raise plasma chamber	No estimate
4.	GA-ITR	Short in TF coil conductor	Complete magnet must be replaced	Upper, lower and inner "F" coils are not segmented	962
5.	GA-ITR	Short in TF coil conductor	Complete magnet must be replaced	Upper, lower and inner "F" coils are segmented	285

* 3 Shift days adjusted for 75% manpower utilization factor.

The comparison between the DEALS-ITR and the GA-ITR shows that there is a potential savings for demountable magnets in downtime in the ratio of 17/1 when compared to the downtime requirements for the conventional unitary magnet design. This allows for 17 failures with the demountable magnet before the total downtime exceeds that required to repair one failure in the unitary magnet system. If the nonsectionalized inner poloidal field coils are used in the GA-ITR design, this ratio increases to 57/1 in favor of the demountable magnet.

The major cause for the difference in downtimes is the need, in the case of the GA-ITR, to disassemble the poloidal field coils located inside of the TF coils and also to remove the plasma chamber and associated shielding for access to these coils. The poloidal field coils and plasma chamber must then be reassembled or rebuilt, depending upon their design. If the poloidal field coils are built up from 6 sections for each coil, only three sectors of the 12 used for the reactor need be removed and reassembly is simplfied. Non-sectionalized coils require removal and rebuilding of almost the entire inner torus. Almost all of these maintenance operations must be accomplished by remote means. In contrast, the DEALS magnet configuration requires no disassembly of poloidal field coils or the plasma chamber and all functions can be performed by use of contact maintenance operations.

The application of the DEALS magnet concept to commercial tokamak reactors may require the extension of the demountable superconducting magnet technology to poloidal field coils. In addition, the impact of diverters must be determined. For all applications the reliability of the joints in the DEALS magnet concept is critical in determining the effectiveness of this design. A number of other observations and cautions are included in the letter reporting this preliminary comparison. This data will be included in the task reports as appropriate.

2.2.2.2 Maintenance Action Time Estimates - Work on the functional flow and downtime estimates for the selected, normalized, reactor design concepts has been initiated. Table 3 indicates the scope of the reactor maintenance actions used in planning the development of maintenance plans and in the evaluation of the design features and maintenance modes (i.e., contact or remote modes). Time estimates for maintenance of single reactor sectors are completed for 13

TABLE 3. MAINTENANCE ACTION CASES ESTIMATED

UNSCHEDULED CONTACT

1st Wall U-III	1st Wall ORNL	1st Wall GA-DPR	1st Wall Culham	Subsystem A	Subsystem B
Vac. #1	Vac. #1	Vac. #1	Vac. #1	Vac. #1	Vac. #1
Vac. #2	Vac. #2	Vac. #2	Vac. #2	Vac. #2	Vac. #2
Vac. #3	Vac. #3		Vac. #3	Vac. #3	Vac. #3

UNSCHEDULED REMOTE

1st Wall U-III	1st Wall ORNL	1st Wall GA-DPR	1st Wall Culham	Subsystem A	Subsystem B
Vac. #1	Vac. ?	Vac. ?	Vac. ?	Vac. #1	Vac. #1
Vac. #2				Vac. #2	Vac. #2
Vac. #3				Vac. #3	Vac. #3

SCHEDULED CONTACT

1st Wall U-III	1st Wall ORNL	1st Wall GA	1st Wall Culham	Subsystem A	Subsystem B
Vac. ?	Vac. ?	Vac. ?	Vac. ?	Vac. ?	Vac. ?
Vac. ?				Vac. ?	Vac. ?

SCHEDULED REMOTE

1st Wall U-III	1st Wall ORNL	1st Wall GA	1st Wall Culham	Subsystem A	Subsystem B
Vac. ?	Vac. ?	Vac. ?	Vac. ?	Vac. ?	Vac. ?
Vac. ?				Vac. ?	Vac. ?

Vac. = Vacuum Wall Location

of the 47 cases identified in this table. The most suitable vacuum wall locations for evaluation of each case identified with a question mark in Table 3 and the subsystem failure modes to be analyzed will be selected as the study proceeds. The most suitable combination of subsystem and reactor will also be selected.

The subsystem failure modes to be evaluated will be selected from

- o the primary coolant system,
- o the vacuum system,
- o the neutral beam injector system, or
- o the magnet system.

The DEALS magnet evaluation will be extended to determine its impact on the maintainability of commercial reactors.

As indicated by Table 3, the plans for unscheduled maintenance actions using either contact or remote operations are derived for all four concepts in addition to revising the Phase I study scheduled maintenance data to reflect the impact of the smaller 3000 MW_{th} and of the normalized reactors. These revised plans are being formulated for maintenance actions involving first wall/blanket failure modes and scheduled replacement.

Specific design features that are being evaluated during this study include the vacuum wall location and the DEALS magnet. The variations in maintenance plans with vacuum wall location are to be determined for each concept. The number of practical locations vary with the reactor concepts and involve the addition of a secondary vacuum chamber with varying vacuum seal requirements between the primary and secondary chambers. While the UWMAK-III, the ORNL and the Culham Mark-II concepts have three potential vacuum wall arrangements to be investigated, the GA-DPR module design, Reference 6, is basically a double vacuum wall design and only one alternative location of the secondary wall appears reasonable. Therefore, only two vacuum wall locations are to be investigated for the GA-DPR concept. The UWMAK-III is considered to be the baseline for evaluation of the vacuum wall location impact variations arising from remote maintenance and scheduled maintenance operations. Unless additional impacts from the other reactor concepts indicate a need for further estimates of the vacuum wall location variations, the UWMAK-III estimates will allow selection of the most suitable location for estimating the impact of remote maintenance for all concepts being considered. For scheduled maintenance, the two most beneficial vacuum wall locations will be selected.

In addition to the first wall/blanket analysis, maintenance plans for the other subsystems will be defined and incorporated into the evaluations of vacuum wall location, and unscheduled and contact maintenance impacts on the total maintenance plan.

2.2.3 Availability and Cost of Electricity Goals

The goals established for the first phase of the maintainability study have been revised. The new basis for comparison of the cost of electricity (COE) from coal fired plants and fusion reactors are estimates reported in a study for EPRI (Reference 15) which compares the COE for coal fired plants and fission plants brought on line in 1986. These costs reflect the latest environmental requirements and represent a more realistic basis for comparison with the COE from fusion reactors than the average COE data for coal fired plants previously available.

The COE of a coal fired plant brought on line in 2000 is expected to be 53.9 mills/kWh, in 1977 dollars. This is based on extrapolating the 1986 estimates to 2000 at 6% for the capital and O&M costs and 8% for fuel costs. The availability of a fusion plant which will produce a breakeven COE in 2000 is 55%. The fusion plant COE is based on current unpublished MDAC study estimates for minimum COE from fusion plants of 35 mills/kWh at an availability of approximately 80%.

The above revisions are being made in the Phase I maintainability study report.

2.3 Contacts

The following contacts have been made during this period for the purposes stated. All contacts are by telephone or letter.

Contact	Date	Purpose
Charles Head Office of Fusion Energy Department of Energy Washington, D.C.	Several Contacts	Study Coordination
J. Neff Office of Fusion Energy Department of Energy Washington, D.C.	4/21/78	Revised Coal Economic Data
M. Murphy Office of Fusion Energy Department of Energy Washington, D.C.	4/20/78	Use of total beta in reactor normalization
Thomas E. Shannon Oak Ridge National Lab. Oak Ridge, TN	1/11/78	ORNL Demonstration Study Progress
John T. D. Mitchell Culham Laboratory Abingdon, Oxfordshire England	2/2/78	Culham Mk-II blanket and manifold detail

2.4 Quantitative Estimate of Overall Progress

Table 4 provides the estimated completion percentage accomplished through this first reporting period for each study task covered by the contract extension .A001. Tasks 1 through 5 were completed in FY 1977.

TABLE 4. COMPLETION PERCENTAGE BY TASK

Task		Completion Percentage		
Number	Title	Prior Periods	This Period	Total
6	Candidate Reference Systems	0	92	92
7	Maintenance Plans	0	47	47
8	Tradeoff Analysis	0	0	0
9	Evaluation	0	0	0
10	Preferred Maintenance System	0	0	0
	Total:	0	39	39

3.0 WORK PLANNED FOR THE NEXT REPORTING PERIOD

Succeeding progress reports will cover each task at its approximate completion. Since the tasks of this study have interacting effects, these reports are subject to revision in the final report but the intent is to make each task report in the form of its part of the final report. A top level outline of the proposed final report is shown in Table 5.

3.1 Task 6 - Candidate Reference Systems

This task is essentially completed with only the task report and associated summary work to be completed.

3.2 Task 7 - Maintenance Plans

Concurrently with the writing of the Task 6 report, work will continue on the functional flow, time estimates and maintenance support definitions required for the maintenance plans.

TABLE 5 - FINAL REPORT OUTLINE

DEVELOPING MAINTAINABILITY FOR TOKAMAK FUSION POWER SYSTEMS

1.0 INTRODUCTION

2.0 SUMMARY

3.0 TASK 6 - CANDIDATE REFERENCE SYSTEMS

- 3.1 SYSTEM SELECTION
- 3.2 SUBSYSTEM DEFINITION
- 3.3 REFERENCE SYSTEM DEFINITIONS

4.0 TASK 7 - MAINTENANCE PLANS

- 4.1 MAINTENANCE REQUIREMENTS
- 4.2 SCHEDULED MAINTENANCE
- 4.3 UNSCHEDULED MAINTENANCE
- 4.4 VACUUM WALL ALTERNATIVES
- 4.5 DEMOUNTABLE MAGNET ALTERNATIVES
- 4.6 MAINTENANCE EQUIPMENT REQUIREMENTS

5.0 TASKS 8 AND 9 - DESIGN FEATURE TRADEOFFS AND EVALUATION

- 5.1 FIRST WALL/BLANKET MODULE SIZE
- 5.2 VACUUM WALL LOCATION
- 5.3 DEMOUNTABLE MAGNETS
- 5.4 UNSCHEDULED MAINTENANCE
- 5.5 CONTACT AND REMOTE MAINTENANCE COMPARISON
- 5.6 OPTIMUM COST COMPARISONS
- 5.7 MAINTENANCE EQUIPMENT DEVELOPMENT RISK
- 5.8 MAINTAINABILITY DESIGN GUIDELINES

6.0 TASK 10 - PREFERRED MAINTENANCE SYSTEM

- 6.1 SELECTED REACTOR SYSTEM DESIGN
- 6.2 MAINTENANCE PLAN
- 6.3 BALANCE OF PLANT
- 6.4 COST AND AVAILABILITY ESTIMATES

7.0 CONCLUSIONS

4.0 REFERENCES

1. "UWMAK-III, A Noncircular Tokamak Power Reactor Design," Nuclear Engineering Department, University of Wisconsin, sponsored by the Electric Power Research Institute, Report UWFDM-150, July 1976.
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