FINESSE OVERVIEW

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FINESSE Project Meeting
August 13-14, 1984
Jackson Hole, Wyoming

AGENDA FOR
FINESSE PROJECT MEETING

August 13-14, 1984
Jackson Hole, Wyoming

(Revised 8/10/84)

Monday, August 13

7:00	Advisory Committee (plus Haas/Berk, Abdou, Conn, Berwald) Meets for Breakfast	
8:15 - 8:30	OFE Opening Remarks	Haas
8:30 - 9:30	Overview	Abdou
9:30 - 9:45	Discussions	
9:45 - 10:15	Summary of Issues (plus Description of Critical Issues)	Tillack
10:15 - 10:30	Coffee Break	
10:30 - 11:00	Summary of Survey of Testing Needs	Gierszewski
11:00 - 11:30	Discussions on Issues and Testing Needs	

Testing Requirements and Engineering Scaling*

11:30 - 12:30	Summary and Conclusions/Solid Breeders	Gierszewski
12:30 - 1:30	Lunch	
1:30 - 2:15	Summary and Conclusions/Liquid Metals	Tillack
2:15 - 2:45	Thermal, Burn Cycle	Taghavi
2:45 - 3:15	Tritium Recovery	Billone/Hollenberg
3:15 - 4:00	Liquid Metal Fluid Flow and MHD Effects	Madarame
	(Coffee Break around 3:30)	
4:00 - 4:30	Fluence Goals	Straalsund/Puigh
4:30 - 5:00	Failure Modes and Subscale Tests	Davis
5:00 - 5:30	Test Module Designs	Garner
5:30 - 6:00	Test Matrix	Straalsund/Opperman

*Time indicated includes presentation and discussion.

Tuesday, August 14

8:00 - 8:45	Fission Reactor Utilization	Deis
8:45 - 9:45	Mirror Test Facilities	Thomassen, Berwald, et al
9:45 - 10:30	Point Neutron Sources	Holmes
	(Coffee Break around 10:00)	
10:30 - 11:10	Development Scenarios	Berwald/Abdou
11:10 - 11:30	Plant Availability	Whitley
11:30 - 12:00	Discussion on Test Facilities and Scenarios	
12:00 - 1:30	Lunch (Advisory Committee Meets)	
1:30 - 1:45	RTNS-II Upgrade	Henning, et al
1:45 - 2:05	Neutronics Testing	Oyama
2:05 - 2:35	Instrumentation and Control	Grover
2:35 - 3:15	Aerospace Experience	Davis
3:15 - 3:30	Coffee Break	
3:30 - 4:30	Plans for November Workshop	
4:30 - 6:00	Project Meeting	

PURPOSE OF MEETING

- MOST OF THE MEETING TIME IS TAILORED TO MAXIMIZE THE BENEFITS OF THE PRESENCE OF THE ADVISORY COMMITTEE.
  - REVIEW PROGRESS SINCE LAST APRIL
  - COVER MANY TECHNICAL AREAS
  - CONDENSED SCHEDULE, LIMITED TIME ALLOTTED FOR EACH TOPIC

PROCEDURE

- TIME IS LIMITED!
- CANNOT POSSIBLY DISCUSS OR RESOLVE ALL THE TECHNICAL DETAILS DURING THE MEETING
- QUESTIONS/COMMENTS SHOULD BE CONCISE AND FOCUSED ON KEY AREAS
- MORE TIME FOR QUESTIONS/COMMENTS FROM THE ADVISORY COMMITTEE; LESS TIME FOR DISCUSSIONS AMONG FINESSE TECHNICAL PARTICIPANTS
- TUESDAY NOON MEETING FOR THE ADVISORY COMMITTEE PLUS A BRIEF WRITTEN REPORT ARE ADDITIONAL MECHANISMS TO GET ADVISORY COMMITTEE INPUT

FINESSE STATUS (AUGUST 13, 1984)

- Most of the technical work planned for Year 1 has been completed

- August 15 through October 1, 1984:
  - Complete the remainder of technical work
  - Sharpen, focus conclusions
  - Write Interim Report

- Interim Report schedule:
  - Camera-ready copy by October 1
  - Mail to workshop participants by October 22

- Community workshop:
  - Reschedule from October 11 to November 13-15
  - Scope: U.S. or international?

FINESSE
FUSION NUCLEAR TECHNOLOGY DEVELOPMENT STUDY

- OBJECTIVE:
  - INVESTIGATE THE TECHNICAL AND PROGRAMMATIC ISSUES IN THE DEVELOPMENT OF FUSION NUCLEAR COMPONENTS

- TWO-YEAR STUDY (STARTED IN NOVEMBER, 1983)

- MAJOR PARTICIPATION BY KEY U.S. ORGANIZATIONS:
  - UCLA, ANL, EG&G, HEDL, MDAC, TRW
  - LLNL, PPPL
  - COORDINATION WITH OTHER DOE AND EPRI PROGRAMS

- BROAD PARTICIPATION BY FUSION COMMUNITY: ADVISORY COMMITTEE, WORKSHOPS

- SIGNIFICANT INTERNATIONAL PARTICIPATION
  - GERMANY (KFK), JAPAN (JAERI, UNIVERSITIES), CANADA
  - IMPORTANCE:
    - * ALL WORLD PROGRAMS FACE THE SAME ISSUES
    - * INTERNATIONAL COOPERATION ON NT: VIABLE, ECONOMICAL

FINESSE INTERIM REPORT OUTLINE

1. Introduction
2. Summary
3. Fusion Nuclear Issues
4. Survey of Testing Needs
5. Analysis and Engineering Scaling of Solid Breeder Blankets
6. Analysis and Engineering Scaling of Liquid Metal Blankets
7. Neutronics Tests
8. Fluence Considerations
9. Testing Requirements
10. Non-Neutron Test Stands
11. Accelerator-Based Neutron Sources
12. Fission Reactor Utilization
13. Mirror Fusion Test Facilities
14. Tokamak Fusion Test Facilities
15. Device Availability Analysis
16. Fusion Development Scenarios: Preliminary Definition

Appendices

Appendix A: Evaluation of Experience from Fast Breeder Reactor Development

Appendix B: Survey of Opinions of Some Experts from Fission Field

Appendix C: Evaluation of Experience from Aerospace Industry

Appendix D: Characterization of Fusion Nuclear Systems Operating Environment

Appendix E: Failure Modes and Subscale Testing

FINESSE PRINCIPAL TECHNICAL TASKS

I. Identification of Issues

II. Investigation of Testing Needs
- A. Survey of Testing Needs
- B. Quantifying Key Testing Requirements
- C. Test Matrix
- D. Summary of Test Requirements and Priorities

III. Evaluation of Experience from Other Technologies
- A. Fission
- B. Aerospace

IV. Survey and Evaluation of Neutron-Producing Facilities
- A. Non-Fusion Facilities (Point Neutron Sources, Fission Reactors)
- B. Fusion Devices (Mirrors, Tokamaks)

V. Benefits and Applications of a Fusion Neutron-Producing Facility (e.g., Medicine, Science, Technology)

VI. Comparative Evaluation of Facilities and Development Scenarios

VII. Recommendations on Fusion Nuclear Technology Development

NUCLEAR COMPONENTS AND COMPONENTS AFFECTED BY THE NUCLEAR ENVIRONMENT

Blanket

Shield

Plasma Interactive and High Heat Flux Subsystems:
- First Wall
- Impurity Control
- RF Antennas, Launchers, and Waveguides

Tritium and Vacuum Systems

Instrumentation and Control

Magnets

Remote Maintenance

Heat Transport and Power Conversion

STATUS AND SCHEDULE OF FINESSE TECHNICAL EFFORT

Task	Year 1 November 1983 to October 1984	Year 2 November 1984 to October 1985
Task I: Issues	Completed.	Minor effort.
Task II: Investigation of Testing Needs		
A. Survey of Testing Needs	Completed.	Minor effort.
B. Quantification of Test Requirements	Analysis of component behavior performed. Approach to engineering scaling developed and applied to key cases.	- Continue investigation and application of engineering scaling. - Conceptual designs of act-alike test modules, check suitability for providing the needed information.
C. Test Matrix	Approach developed.	Develop the details of the test matrix; prioritize testing needs.
Task III: Evaluation of Experience from Other Technologies	A. Fission: completed. B. Aerospace: completed.	No further effort is planned.

STATUS AND SCHEDULE OF FINESSE TECHNICAL EFFORT (CONT.)

TASK	YEAR 1 NOVEMBER 1983 TO OCTOBER 1984	YEAR 2 NOVEMBER 1984 TO OCTOBER 1985
TASK IV: EVALUATION OF NEUTRON-PRODUCING FACILITIES		
A. NON-FUSION FACILITIES	POINT NEUTRON SOURCES: COMP. FISSION REACTORS: COMP.	NO FURTHER EFFORT IS PLANNED.[A]
B. FUSION FACILITIES	BRIEF SURVEY OF POSSIBLE OPTIONS FOR MIRRORS AND TOKAMAKS.	- INTENSIVE EFFORT ON EXPLORING OPTIONS AND INNOVATIVE IDEAS FOR FUSION TEST FACILITIES TO MINIMIZE COST AND MAXIMIZE TEST BENEFITS CONSISTENT WITH ACCEPTABLE PHYSICS AND TECHNOLOGY RISKS. - CONCEPTUAL DESIGN OF THE MOST PROMISING OPTION FOR A TEST FACILITY (INTERACTIVE WITH TASK VI). DESIGN DETAILS AS APPROPRIATE TO ENSURE SATISFYING THE REQUIREMENTS DEFINED IN TASK II AND TO PROVIDE REALISTIC ESTIMATES OF COST AND RISK.

[A]RECENT EVENTS MAY MAKE SOME ADDITIONAL EFFORT ON POINT NEUTRON SOURCES NECESSARY.

STATUS AND SCHEDULE OF FINESSE TECHNICAL EFFORT (CONT.)

TASK	YEAR 1 NOVEMBER 1983 TO OCTOBER 1984	YEAR 2 NOVEMBER 1984 TO OCTOBER 1985
TASK V: BENEFITS AND APPLICATIONS OF A FUSION NEUTRON-PRODUCING FACILITY	NO EFFORT.	INVESTIGATE THE ADDITIONAL BENEFITS AND APPLICATIONS OF A FUSION NEUTRON-PRODUCING FACILITY TO OTHER AREAS OF SCIENCE AND TECHNOLOGY.
TASK VI: COMPARATIVE EVALUATION OF FACILITIES AND DEVELOPMENT SCENARIOS	TASK INITIATED.	- COMPARE THE CAPABILITIES, COST AND RISK OF VARIOUS NON-FUSION AND FUSION FACILITIES. - DEVELOP A NUMBER OF SCENARIOS FOR FUSION DEVELOPMENT. - DEVELOP SEVERAL POSSIBLE PATHS OF FUSION NUCLEAR TECHNOLOGY DEVELOPMENT. - COMPARE AND EVALUATE SCENARIOS AND PATHS.
TASK VII: RECOMMENDATIONS ON FUSION NUCLEAR TECHNOLOGY	NO EFFORT.	TRANSLATE ALL RESULTS FROM FINESSE INTO A SET OF RECOMMENDATIONS ON TECHNOLOGY DEVELOPMENT.

Task I: Identification and Characterization of Issues
Task II.A: Survey of Testing Needs

Purposes of Tasks I and II.A

- Part of FINESSE effort to provide a "clear statement of needs for fusion nuclear technology"
- Necessary prerequisite to identifying, quantifying and prioritizing testing requirements in Tasks II.B and II.C

Time Frame

- Now to DEMO
- More emphasis on after 1995

Approach/Status

- Subgroups of experts in various technical areas identified and characterized the issues and surveyed testing needs
- Two persons (Tillack/Morgan and Gierszewski/Opperman) integrated the work of the subgroups into a single document with a common format
- The entire document is being reviewed by the entire project
- The document (Chapters 3 and 4 of the Interim Report) will be mailed soon to selected experts from the community prior to publication in the Interim Report

TEST TYPES FOR SINGLE COMPONENT DEVELOPMENT

BASIC TEST

- BASIC PROPERTY DATA
- SINGLE MATERIAL SPECIMEN
- GENERALLY SINGLE DOMINANT ENVIRONMENTAL CONDITION (E.G., RADIATION FIELD); OTHER ENVIRONMENTAL CONDITIONS ARE SOMETIMES NEEDED TO PROVIDE STATE CONDITIONS (E.G., TEMPERATURE)
- EXAMPLES: CONDUCTIVITY, CROSS SECTION, SWELLING

ELEMENT TEST

- AIMED AT A SINGLE ISSUE (EITHER A SINGLE PHENOMENON OR THE INTERACTION OF A LIMITED NUMBER OF PHENOMENA)
- GENERALLY, COMPOSITE MATERIAL ARTICLE IN A "CLEAN" GEOMETRY
- VERIFY UNDERSTANDING AND PREDICTION CAPABILITY
- EXAMPLES:
  1) ISOTHERMAL PELLET-IN-CAN TEST OF THE THERMAL STRESS/CREEP INTERACTION BETWEEN SOLID BREEDER AND CLAD;
  2) ELECTROMAGNETIC RESPONSE OF BONDED MATERIALS TO A TRANSIENT MAGNETIC FIELD
  3) TRITIUM PRODUCTION RATE IN A SLAB OF HETEROGENEOUS MATERIALS EXPOSED TO A POINT NEUTRON SOURCE

TEST TYPES FOR SINGLE COMPONENT DEVELOPMENT
(CONTINUED)

MULTIPLE INTERACTION TEST

- AIMED AT MULTIPLE INTERACTIONS AMONG PHYSICAL ELEMENTS OF ONE OR MORE UNIT CELLS, AND MULTIPLE ENVIRONMENTAL CONDITIONS
- TEST ARTICLE HAS A MORE REALISTIC GEOMETRY
- VERIFY UNDERSTANDING AND PREDICTION CAPABILITIES FOR INTERACTIONS. IN SOME CASES, DIRECTLY MEASURE SPECIFIC GLOBAL PARAMETERS THAT CANNOT BE CALCULATED. ALSO, DISCOVER "UNKNOWNS." HOWEVER, VERIFICATION IS ONLY FOR THE NET INTERACTIONS NOT FOR INDIVIDUAL CONTRIBUTIONS
- EXAMPLE: TESTING OF AN INTERNALLY COOLED FIRST WALL SECTION UNDER A STEADY SURFACE HEAT LOAD AND A TIME-DEPENDENT MAGNETIC FIELD

PARTIALLY INTEGRATED TEST

- ALL KEY PHYSICAL ELEMENTS OF THE COMPONENT WITH ALMOST ALL KEY ENVIRONMENTAL CONDITIONS; NOT NECESSARILY FULL SCALE
- ATTEMPTS TO OBTAIN "INTEGRATED TEST" INFORMATION WITHOUT SOME CONDITION, USUALLY PERFORMED WHEN THERE ARE LARGE (ORDER OF MAGNITUDE OR MORE) COST SAVINGS IN ELIMINATING A SPECIFIC ENVIRONMENTAL CONDITION
- EXAMPLE: LIQUID METAL BLANKET TEST IN A FACILITY THAT SIMULATES ALL ENVIRONMENTAL CONDITIONS EXCEPT NEUTRONS

TEST TYPES FOR SINGLE COMPONENT DEVELOPMENT
(CONTINUED)

INTEGRATED TEST

- ALL KEY PHYSICAL ELEMENTS OF THE COMPONENT WITH ALL KEY ENVIRONMENTAL CONDITIONS; NOT NECESSARILY FULL SCALE
- "PROOF-OF-PRINCIPLE" PERFORMANCE DATA AND THE DISCOVERY OF "UNKNOWNS"
- EXAMPLE: BLANKET MODULE TEST IN A LOW-POWER FUSION DEVICE

COMPONENT TEST

- FULL-SIZE COMPONENT
- PROTOTYPICAL OPERATING CONDITIONS
- DESIGN VERIFICATION AND RELIABILITY DATA
- INCLUDES DIFFERENT STAGES FOR DESIGN VERIFICATION AND RELIABILITY GROWTH, FROM AN ISOLATED BLANKET MODULE IN A FUSION TEST REACTOR WITH ITS OWN SIMPLE COOLING SYSTEM TO A FULLY INTEGRATED BLANKET IN A DEMONSTRATION POWER REACTOR

COMPONENT INTERACTION TEST

- PROTOTYPICAL COMPONENTS, BUT NOT NECESSARILY FULL SCALE
- COMPONENT INTERACTION AND COMBINED PERFORMANCE DATA
- EXAMPLES: TSTA; BLANKET AND COOLANT LOOP TEST OF CORROSION TRANSPORT

NEUTRON-PRODUCING FACILITIES

- ACCELERATOR-BASED "POINT" SOURCES
- FISSION REACTORS
- FUSION REACTORS

POINT NEUTRON SOURCES (PART OF TASK IV)

- NECESSARY/USEFUL FOR SPECIFIC PURPOSES
  - RADIATION EFFECTS IN CAPSULES (FLUENCE)
  - NEUTRONICS (TRITIUM BREEDING, SHIELDING)
- NOT SUITABLE FOR MULTIPLE-EFFECT/INTEGRATED TESTS

FISSION REACTORS (PART OF TASK IV)

- LARGER (BUT LIMITED) VOLUME THAN POINT SOURCES
- SUITABLE FOR CAPSULE AND SOME SUBMODULE TESTS
- ARE BEING USED AND WE NEED TO CONTINUE TO USE THEM
- GENERALLY MORE USEFUL FOR SOLID BREEDER THAN LIQUID METAL BLANKETS
- BUT, THEY CANNOT SUBSTITUTE FOR FUSION TESTING
  - LIMITATIONS ON VOLUME (SIZE OF TEST ELEMENT, NUMBER OF TEST LOCATIONS)
  - LIMITATIONS ON SIMULATING ENVIRONMENTAL ELEMENTS (E.G., ELECTROMAGNETIC)
  - LIMITATIONS ON SIMULATING ENVIRONMENTAL PARAMETERS (E.G., SURFACE HEAT FLUX, POWER DENSITY, SPATIAL/TIME DEPENDENCE, ETC.)
  - SPECTRAL DIFFERENCES FROM FUSION NEUTRONS

FUSION FACILITIES FOR TESTING NUCLEAR COMPONENTS

ARE THEY NEEDED: YES

WHY?

- WE HAVE NOT YET FOUND AN ALTERNATIVE TO SATISFYING THE IDENTIFIED CRITICAL TESTING NEEDS

- VOLUME/SURFACE AREA OF TEST ELEMENT/MODULE
  SOME TESTS REQUIRE: ~ 1 M X 1 M X 0.5 M
  OBTAINABLE ONLY IN FUSION TEST DEVICE

- TOTAL VOLUME/SURFACE AREA OF TEST MATRIX
  NEED: UNIFORM STEADY NEUTRON SOURCE WITH 2×10^{18}-10^{19} N/S
  OBTAINABLE ONLY IN FUSION REACTOR

- SIMULATION OF ALL ENVIRONMENTAL CONDITIONS
  - NEUTRONS
  - ELECTROMAGNETICS
  - PLASMA PARTICLES
  - TRITIUM
  - VACUUM

- NEUTRON SPECTRUM
  - 14 MEV SOURCE NEUTRONS
  - COMPLEX "SLOWING DOWN/BACKSCATTERING" SPECTRUM

GENERAL QUESTIONS ON FUSION TEST FACILITY

CONCLUSION: A FUSION FACILITY IS NEEDED FOR TESTING NUCLEAR COMPONENTS AS PART OF FUSION DEVELOPMENT

QUESTION 1: WHAT ARE THE FACILITY PERFORMANCE REQUIREMENTS (E.G., WALL LOAD, FLUENCE, MAGNETIC FIELD) TO SATISFY THE NUCLEAR TECHNOLOGY DEVELOPMENT NEEDS?

ANSWER: BEING DEVELOPED IN TASK II.B (EMPHASIZED IN FY 1984)

QUESTION 2: WHAT TYPE OF FUSION FACILITY IS BEST IN SATISFYING THE REQUIREMENTS AT A MINIMUM COST AND RISK (E.G., TOKAMAK, MIRROR)? SHOULD IT BE DEDICATED OR PART OF A COMBINED PHYSICS/TECHNOLOGY FACILITY?

ANSWER: BEING DEVELOPED IN TASKS IV AND VI (WILL BE EMPHASIZED IN FY 1985)

QUESTION 3: ARE THERE INCENTIVES TO BUILDING A FUSION NUCLEAR TECHNOLOGY (NEUTRON-PRODUCING) FACILITY OTHER THAN THOSE OF FUSION DEVELOPMENT?

ANSWER: PROBABLY. WILL DEVELOP THE ANSWER IN FY 1985 (TASK V)

TASK II.B: QUANTIFICATION OF TEST REQUIREMENTS

DESCRIPTION OF PROBLEM

- THE COST OF A FUSION DEVICE INCREASES WITH THE MAJOR DEVICE PARAMETERS (WALL LOAD, FLUENCE, ETC.)
- REALISTIC COST CONSTRAINTS DICTATE THAT FUSION TESTING MUST BE PERFORMED UNDER SCALED-DOWN CONDITIONS
- "LOOK ALIKE" TEST MODULES UNDER SCALED-DOWN CONDITIONS ARE USELESS IN MOST CASES

SCOPE OF TASK II.B

- DEVELOP ENGINEERING SCALING APPROACH
- INVESTIGATE "ACT-ALIKE" DESIGNS
- PROVIDE QUANTITATIVE GUIDANCE TO REQUIRED DEVICE PARAMETERS
  - MINIMUM VALUES IF ANY
  - TRADEOFFS AMONG PARAMETERS

APPROACH TO TASK II.B

BECAUSE OF THE DIFFICULTY AND COMPLEXITY OF PROBLEMS INVOLVED, WE PURSUED TWO DIFFERENT APPROACHES (TO BE DESCRIBED LATER) FOR SOLID BREEDERS AND LIQUID METALS

TASK II.B: QUANTIFICATION OF TEST REQUIREMENTS (CONT.)

General Observations on Results

- In many cases, a true integrated test in the strictest sense cannot be performed under significantly scaled-down conditions for certain parameters (e.g., power density, surface heat load, geometry)

- Under scaled-down environmental conditions, the function of an integrated test module has to be divided into two or more "act-alike tests. Each act-alike test emphasizes a group of issues/phenomena.

- While an overlap among the various act-alike tests can be included to account for certain interfaces, a concern about possibly missing some phenomena remains

- Perfect quantitative engineering scaling is not possible because it requires complete quantitative models for all (including interactive) phenomena

- If fusion testing will have to be carried out under scaled-down conditions, as appears now to be the case, then:
  - Engineering scaling needs to continue to be nourished as a key technical discipline in fusion
  - The need for a more thorough understanding of phenomena and more analytical modeling will become more critical

TASK II.B: QUANTIFICATION OF TEST REQUIREMENTS (CONT.)

PRELIMINARY REQUIREMENTS OF FUSION DEVICE PARAMETERS

- MOST DESIRABLE: AS CLOSE AS POSSIBLE TO DEMONSTRATION/ COMMERCIAL "LOCAL" CONDITIONS
- IN MOST CASES, BENEFITS ARE CONTINUOUS (INCREASING) FUNCTION OF DEVICE PARAMETERS (NO SHARP THRESHOLDS OR DISCONTINUITIES)
- IN SOME CASES, THERE ARE TRADEOFFS IN THE TEST REQUIREMENTS (E.G., TRADEOFF BETWEEN WALL LOAD AND TEST TIME FOR SPECIFIC PHENOMENA)
- RECOMMENDED PARAMETERS WILL EVOLVE AS PART OF TRADEOFFS WITH FUSION DEVICE COST AND RISK
- WE CAN NOW PROVIDE PRELIMINARY REQUIREMENTS TO BE USED FOR GUIDANCE OF FUSION TEST FACILITY DESIGN EFFORT

TASK II.B: QUANTIFICATION OF TEST REQUIREMENTS (CONT.)

EXAMPLES OF PRELIMINARY REQUIREMENTS

- WALL LOAD
  - MINIMUM: > 1 MW/m^2
  - SUBSTANTIAL BENEFITS: 2-3 MW/m^2
  - MUCH HIGHER WALL LOADS CAN BE EXTREMELY BENEFICIAL AND WILL ALTER STRATEGY (ACCELERATED TESTING, MORE AMBITIOUS TECHNOLOGY PERFORMANCE GOALS FOR FUSION, ETC.)

- SURFACE HEAT LOAD
  - CRITICAL FOR TESTS OF FIRST WALL, SOLID BREEDER BLANKETS, LIQUID METAL BLANKETS
  - NEEDED IN TEST FACILITY: > 20 W/cm^2
  - NON-STANDARD MEANS REQUIRED TO ENHANCE SURFACE HEAT FLUX IN FUSION TEST FACILITIES, PARTICULARLY MIRRORS

- PLASMA BURN CYCLE
  - PULSING SHARPLY REDUCES THE VALUE OF MANY TESTS
  - PREFER STEADY STATE
  - BURN TIME: > 1000 s
  - DWELL TIME: ?

- MINIMUM CONTINUOUS TIME
  - MANY PERIODS WITH 100% AVAILABILITY
  - DURATION OF EACH PERIOD: SEVERAL WEEKS

TASK II.B: QUANTIFICATION OF TEST REQUIREMENTS (CONT.)

- FLUENCE
  - FLUENCE REQUIREMENTS WILL DEPEND ON WHETHER A POINT NEUTRON SOURCE, OR OTHER MEANS, IS AVAILABLE FOR HIGH FLUENCE MATERIAL TESTING
  - IN GENERAL, COMPONENT TESTS IN THE EARLY STAGES OF DEVELOPMENT ARE CARRIED OUT TO FLUENCES LOWER THAN THOSE FOR SPECIMEN TESTS
  - IN ALL CASES, HIGHER FLUENCES ARE DESIRABLE BUT COSTLY; MODEST FLUENCES ARE STILL EXTREMELY VALUABLE
  - FOR COMPONENT TESTS:
    CRITICAL: 1-2 $MW \cdot Y/M^2$
    VERY IMPORTANT: 2-4 $MW \cdot Y/M^2$
    IMPORTANT: 4-10 $MW \cdot Y/M^2$
  - AGGRESSIVE GOALS FOR BETTER FUSION PRODUCT WILL BENEFIT FROM HIGHER FLUENCE

- LARGEST SIZE OF TEST ELEMENT
  - INTERACTIVE TESTS (SUBMODULE): ~ 0.2 M X 0.2 M X 0.1 M
  - INTEGRATED TESTS (MODULE): 1 M X 1 M X 0.5 M
    (LIQUID METALS TEND TO REQUIRE LARGER SIZE, SECTOR SCALE?)

- TEST SURFACE AREA:
  - CRITICAL: > 5 M^2
  - VERY IMPORTANT: > 10 M^2
  - IMPORTANT: 15-20 M^2

TASK II.C: TEST MATRIX AND PRIORITIES

SCOPE

- ANALYZE THE TESTING NEEDS DEFINED IN VARIOUS TECHNICAL AREAS AND CATEGORIZE ACCORDING TO REQUIREMENTS FOR SIZE, SURFACE AREA, FLUX, POWER DENSITY, ETC.

- INVESTIGATE "IN-FACILITY" TEST PLAN:
  - PARALLEL TESTS (NUMBER OF LOCATIONS AT THE SAME TIME) VS. SEQUENTIAL TESTS (SAME LOCATION USED FOR DIFFERENT TESTS ONE AFTER THE OTHER)
  - NEED FOR DUPLICATION:
    * STATISTICS
    * DATA AT TIME INTERVALS FOR FLUENCE TESTS
    * VARIATIONS IN TEST CONDITIONS

- WORK WITH SUBGROUPS TO NORMALIZE TESTING PRIORITIES

- SUMMARIZE TEST REQUIREMENTS:
  - NUMBER, SIZE, GEOEMTRY, ETC.
  - PRIORITIES

STATUS

- INFORMATION FROM VARIOUS GROUPS OF TASKS I AND II PERMIT THIS SUBTASK TO START NOW

- MORE EFFORT IS PLANNED IN THIS AREA OVER THE NEXT TWO MONTHS

FUSION DEVELOPMENT SCENARIOS AND NUCLEAR TECHNOLOGY DEVELOPMENT PATHS

- THE ISSUES AND TESTING NEEDS EFFORT IN FINESSE UNTIL NOW HAS FOCUSED ON THE TOTAL REQUIREMENTS, WHICH ARE FAIRLY INDEPENDENT OF SPECIFIC SCENARIOS

- NOW, WE BEGIN EXAMINING THE PARTIALS, I.E., WHERE AND WHEN WE DO THE DIFFERENT PARTS; NEED TO CONSIDER SPECIFIC SCENARIOS

- AN EFFORT HAS BEEN INITIATED TO SELECT A NUMBER OF SCENARIOS FOR FUSION DEVELOPMENT AS A FRAMEWORK FOR FINESSE IN FY 1985

- PART OF THE EFFORT WILL INVOLVE EXAMINING THE LIKELY NATURE OF THE NUCLEAR TECHNOLOGY DEVELOPMENT PATH? CHARACTERISTICS?

  - FOR EXAMPLE, FOR BLANKET, BY 1995, WOULD WE HAVE SELECTED LIQUID METALS OR SOLID BREEDERS?

    * THE ANSWER (WHICH CAN BE ONLY A GUESS AT PRESENT) WILL SUBSTANTIALLY AFFECT THE TEST REQUIREMENTS (SURFACE AREA, VOLUME, SURFACE HEAT LOAD, MAGNETIC FIELD, ETC.) AND, HENCE, THE COST AND POSSIBLY EVEN THE TYPE OF THE REQUIRED FUSION FACILITIES

    * NOTE HOW MANY BENEFITS CAN BE REALIZED FROM ANALYTICAL AND EXPERIMENTAL WORK ON NUCLEAR TECHNOLOGY NOW

GENERIC FUSION FACILITIES SEQUENCES AND TYPICAL CASES

A) SFE/SFE-U → ETR → DEMO

- I: TFTR/TFTR-U → INTOR → DEMO*
- M: MFTF-B/MFTF-U → ETR → DEMO

B) SFE → BCX → ETR → DEMO

- I: TFTR → TFCX → ETR → DEMO*
- M: MFTF-B → MFTF-α → ETR → DEMO

C) SFE → BCX/BCX-U → ETR/DEMO

- I: TFTR → TFCX/TFCX-U → ETR/DEMO
- M: MFTF-B → MFTF-α+T → ETR/DEMO

D) SFE/SFE-U, NTF → ETR → DEMO

- I: TFTR/TFET, MFTF-α+T → ETR → DEMO
- I: TFTR/TFET, TDF → ETR → DEMO*
- M: None

GENERIC FUSION FACILITIES SEQUENCES AND TYPICAL CASES (continued)

E) SFE → BCX / NTF → ETR → DEMO

- I: TFTR → TFCX / MFTF-α+T → ETR → DEMO
- I: TFTR → TFCX / TDF → ETR → DEMO*
- M: None

F) SFE → BCX / NTF → DEMO

- I: TFTR → TFCX / MFTF-α+T → ETR/DEMO
- I: TFTR → TFCX / TDF → ETR/DEMO*
- I: TFTR → TFCX / NTF(TOK) → ETR/DEMO
- M: MFTF-B → MFTF-α / TDF → ETR/DEMO*

GENERIC FUSION FACILITIES SEQUENCES AND TYPICAL CASES (continu

G) SFE → BCX, NTF → DEMO

- I: TFTR → TFCX, NTF(TOK) → DEMO
- M: MFTF-B → MFTF-α, TDF → DEMO

GENERAL FRAMEWORK FOR FUSION NUCLEAR TECHNOLOGY DEVELOPMENT

Now to Mid-1990's

- Utilize existing facilities (test stands, point neutron sources, fission reactors)
- Build a number of small-scale test stands
- There may be a need for a Partially Integrated Test Facility (PITF), e.g., facility for testing liquid metal blanket and transport loop in all relevant environmental conditions (vacuum, tritium, magnetic field) except neutrons

After Mid-1990's

- Continue non-fusion testing
- Testing in a fusion facility (possibly dedicated to nuclear technology)

PRELIMINARY OBSERVATIONS ON FUSION DEVELOPMENT SCENARIOS

- COMBINING PHYSICS AND TECHNOLOGY MISSIONS IN A SINGLE TOKAMAK
  - PHYSICS TESTING REQUIRES LARGE DEVICE POWER, LOW FLUENCE (TOKAMAK)
  - NUCLEAR TESTING REQUIRES LOW DEVICE POWER, HIGH FLUENCE
  - COMBINING LARGE DEVICE POWER AND HIGH FLUENCE IN A SINGLE DEVICE INTRODUCES SERIOUS DEMAND FOR LARGE TRITIUM SUPPLY
  - SUPPLYING TRITIUM REQUIRES LARGE-COVERAGE BREEDING BLANKET

- INSTALLING A LARGE-COVERAGE BREEDING BLANKET WITHOUT PRIOR FUSION TESTING RAISES MANY DIFFICULT ISSUES:
  - LOW DEVICE AVAILABILITY LIKELY
    LONGER TO ACHIEVE FLUENCE GOALS
  - HIGHER RISK IN ACHIEVING MISSION?
  - HIGHER COST

- THERE ARE CONSIDERABLE INCENTIVES TO EXAMING THE SCENARIO OF TWO PARALLEL DEVICES, ONE FOR PHYSICS AND THE OTHER FOR NUCLEAR TECHNOLOGY
  - CAN WE DESIGN A LOW POWER (< 50 MW), HIGH WALL LOAD DEVICE?
  - TMR?
  - SMALL TOKAMAK (WITH COPPER COILS, DRIVEN PLASMA)?

GENERAL/ADMINISTRATIVE/PROGRAMMATIC QUESTIONS

SEPTEMBER 11-12 MEETING

- THE TIME CAN BE USED MORE EFFECTIVELY FOR WRITING
- SUGGESTION: LIMITED-ATTENDANCE MEETING (ONE PERSON PER ORGANIZATION); REVIEW STATUS AND RESOLVE PROBLEMS RELATED TO INTERIM REPORT; NO PRESENTATIONS

FINESSE WORKSHOP

- CHANGE DATE AND SCOPE OF THE WORKSHOP
- ORIGINALLY SCHEDULED FOR OCTOBER 10-11
- SUGGESTION: DIVIDE INTO TWO WORKSHOPS
  - U.S. WORKSHOP: NOVEMBER 13-15, 1984
  - INTERNATIONAL WORKSHOP: FEBRUARY 26-28, 1985 OR MARCH 12-14, 1985
- U.S. WORKSHOP (NOVEMBER, 1984)
  - LIMIT TO THE U.S. FUSION COMMUNITY
  - REPORT TECHNICAL WORK FROM FINESSE
  - DISCUSS THE FUSION NUCLEAR DEVELOPMENT, DEVELOP CONSENSUS WITHIN U.S. COMMUNITY OR STRATEGY OPTIONS, ROLE OF INTERNATIONAL COOPERATION

GENERAL/ADMINISTRATIVE/PROGRAMMATIC QUESTIONS (CONT.)

- INTERNATIONAL WORKSHOP (FEBRUARY OR MARCH, 1985)
  - INVITE SENIOR PEOPLE (OVERALL FUSION, NUCLEAR, MATERIALS) FROM U.S. AND THE INTERNATIONAL COMMUNITY (CANADA, VARIOUS EUROPEAN COUNTRIES, JAERI, JAPANESE UNIVERSITIES)
  - 50% TECHNICAL, 50% PROGRAMMATIC
  - SCOPE:
    * NUCLEAR ISSUES AND TESTING NEEDS (FINESSE, OTHER COUNTRIES)
    * FROM EACH COUNTRY:
      1) PRESENT AND PLANNED FACILITIES
      2) HOW WELL THEY SATISFY THE OVERALL DEVELOPMENT NEEDS
      3) HOW DOES NUCLEAR TECHNOLOGY FIT INTO OVERALL FUSION DEVELOPMENT STRATEGY
    * ROLE OF INTERNATIONAL COOPERATION
    * HOPEFULLY, AGREE ON PLANS TO MAKE JOINT INITIATIVES POSSIBLE
  - COORDINATION OF INTERNATIONAL WORKSHOP WITH BLANKET TECHNOLOGY INTERNATIONAL INFORMATION EXCHANGE

GENERAL/ADMINISTRATIVE/PROGRAMMATIC QUESTIONS (CONT.)

- IMPORTANCE OF MATERIALS TESTING AS PART OF FUSION NUCLEAR DEVELOPMENT AND THE IMPLICATIONS OF THE PRESENT SITUATION WITH FMIT
  - HOW DO WE ENHANCE THE PARTICIPATION OF THE U.S. MATERIALS COMMUNITY?
  - HOW DO WE ENHANCE THE INTERNATIONAL PARTICIPATION IN FINESSE EXPLICITLY IN THE MATERIALS AREA?
  - POINT NEUTRON SOURCES: WHAT NEW GROUND RULES DO WE ASSUME?

- ASSUMPTIONS ABOUT FUSION DEVELOPMENT SCENARIOS TO BE CONSIDERED IN FINESSE

- DISTRIBUTION OF EFFORT AND AREAS OF EMPHASIS IN FINESSE IN FY 1985