ITER Test Program

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Presented at the US Home Team Meeting
Boston, May 11, 1994

Introductory Remarks

- We are making great PROGRESS

  - The parties have developed the larger part of their test programs.

  - The parties are working together (through TPWG) and have agreed on the key guidelines for one international test program on ITER. Coordinators from various parties are already working on integration.

  - JCT has assigned six ports for the test program.

  - JCT is beginning to appreciate the importance and complexity of the test program and the need for early integration into the device.

- But, we need help solving some problems:

  - We have good suggestions for improving the efficiency of the international effort among the parties and within JCT.

    - We need help from US management in implementing these suggestions.

ITER Test Port Allocation and Responsible Coordinators

- The coordinators have the responsibility of working with the home teams and with JCT to develop the test program for the particular port or technical area they are coordinating. The coordinator will provide the final proposal for:

  1. Test port utilization and integration issues
  2. Test matrix and schedule

- Port 1: Solid Breeder/Helium Cooled
  Coordinator: Mario Dalle Donne (KfK)

- Port 2: Solid Breeder/Water Cooled
  Coordinator: Japan (Takatsu to name)

- Port 3: Liquid Metal/Self Cooled
  Coordinators: Richard Mattas (ANL) and Siegfried Malang (KfK)

- Port 4: Liquid Metal/Separately Cooled (He, H_2O)
  Coordinator: Luciano Giancarli (CEA/Saclay)

- Port 5: Materials
  Coordinator: Yuri Strebkov (ENTEK)

- Port 6: Special Purpose and Plasma Facing Components (rf antenna, divertors, etc.)
  Coordinator: Mark Tillack (UCLA)

Additional Areas of Testing

A. Neutronics Tests and Self Sufficiency Tests
Coordinator: M. Youssef (UCLA)

B. Safety Tests
Coordinator: (Need Volunteer?!)

C. Tritium Processing Tests
Coordinator: (Need Volunteer?!)

D. Other Areas? (Please suggest as needed)

ITER Test Program Schedule

May 15:	Principal Coordinators (Dalle Donne, Takatsu, Strebkov, Abdou) are to send names of persons in their parties who would be directly responsible for each port/technical area. Coordinator issues additional clarifications/requests to the parties if needed.
June 1:	Parties send coordinators test program information for the specific ports (i.e. send design concepts, suggestions for design of test port; size, number and testing schedule for the specific concepts in the particular test port, etc.)
July 1:	Coordinator circulates his/her final proposal for test program to members of the parties responsible for his/her test port.
July 15:	Members of parties send comments to coordinators suggesting modifications or alternatives to the coordinator's proposal.
August 1:	Coordinator sends final draft of the modified proposal to the parties
August 29 - September 2	Workshop Meeting at Garching. The purpose of the meeting is to discuss the proposals for the test program on each port/technical area, integrate various areas/ports into international test program on ITER. A crucial aspect of the meeting is to work with JCT to ensure that: a) the test program is consistent with ITER constraints, b) the needs of the test program are effectively met.

Plasma Burn Cycle / Dwell Time Issue

- Very Complex Issue
  - -Needs large resources and a long time to address.
  - -Involves transient/time dependent analysis of many technical areas.
  - -Very little had been done previously on time-dependent analysis for fusion systems.

- Effort at UCLA
  - Modest effort.
  - It shows that obtaining meaningful testing information in many areas will be difficult.

Desirable	< 50 S
Acceptable	<200 S
ITER	~1200 S

- Conclusions of EU, Japan and Russia (April '94)
  - 1200 S dwell is too long to achieve even thermal equilibrium.
  - Requested dwell time to be reduced to 200S.

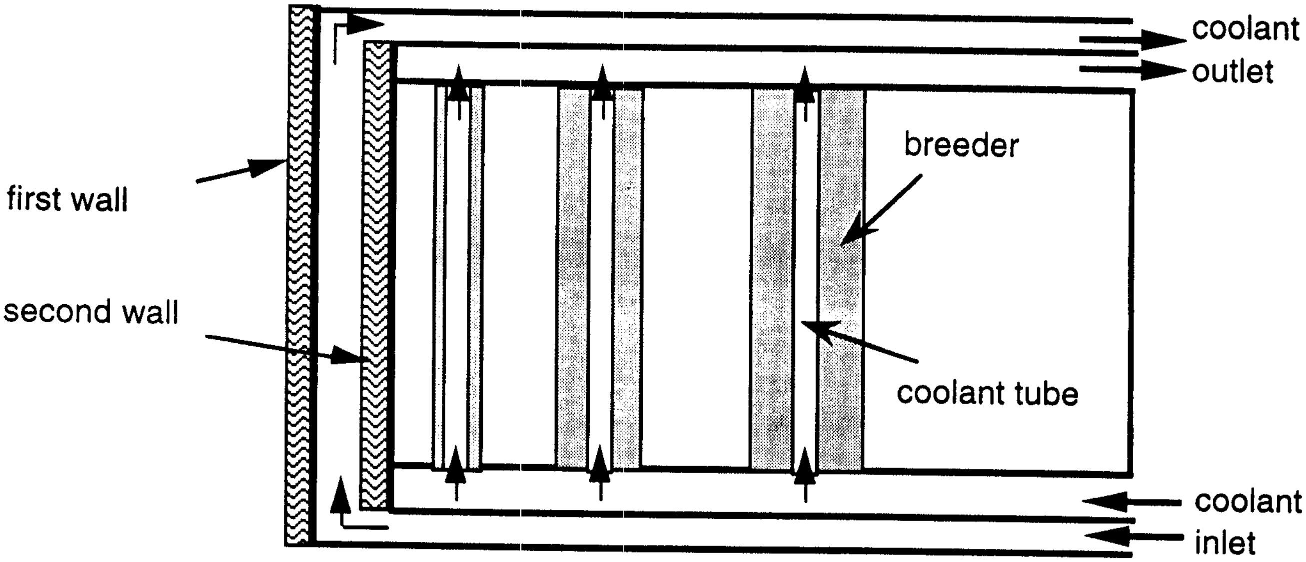
- Suggested Resolution
  - Work on prolonging the burn time to obtain duty cycle of ~ 80%.
  - Work on reducing dwell time.
  - Explore innovative ideas to do testing with these difficult conditions.

Table 2. Characteristic Time Constants In Solid Breeder Blankets

Process	**Time Constant**
Flow	
solid breeder purge residence time	6 s
coolant residence time	~ 1 s
Thermal	
structure conduction	
austenitic steel(5 mm)	~ 2 s
ferritic steel (5 mm)	~ 1 s
structure bulk temperature rise	
5 mm austenitic steel/water coolant	~ 1 s
5 mm ferritic steel/helium coolant	~ 1 s
solid breeder conduction	
Li2O (400-800 C)	
10 MW/m3	30-100 s
1 MW/m3	300-900 s
LiAlO2 (300- 1000 C)	
10 MW/m3	20-100 s
1 MW/m3	180-700 s
Solid Breeder Bulk Temperature Rise	
Li2O (400-800 C)	
10 MW/m3	30-70 s
1 MW/m3	80-220 s
LiAlO2 (300- 1000 C)	
10 MW/m3	10- 30 s
1 MW/m3	40- 100 s
Tritum	
Diffusion through SS316	
500 C	10 days
300 C	150 days
Inventory & Release in the breeder	
Li2O 400- 800 C	20 - 30 hrs
LiAlO2 300- 1000 C	20 - 30 hrs

Characteristic Time Constants In Liquid Metal Breeder Blankets

Process		Time Constant
Flow		
coolant residence time		
first wall (V= 1 m/sec)		~30 s
back of blanket (V= 1 cm/sec)		~100 s
Thermal		
structure conduction		
ferritic steel (5 mm)		~ 1 s
vanadium (5 mm)		~1 s
structure bulk temperature rise		
5 mm ferritic steel/Li coolant		~ 4 s
5 mm vanadium/Li coolant (h= 5000 W/m2-K)		~ 4 s
liquid breeder conduction		
Li		
blanket front		~ 1 s
blanket back		20 s
LiPb		
blanket front		4 s
blanket back		300 s
liquid Breeder Bulk Temperature Rise		
Li		
blanket front		4 s
blanket back		20 s
LiPb		
blanket front		4 s
blanket back		36 s
Corrosion		
dissolution of Fe in Lithium		40 days
Tritum		
Diffusion through		
Ferritic Steel	300 C	2230 days
	500 C	62 days
Vanadium	500 C	2810 s
	700 C	2464 s
Inventory & Release in the breeder		
Li		30 days
LiPb		30 min



Test Module Cross Section Used For Analysis

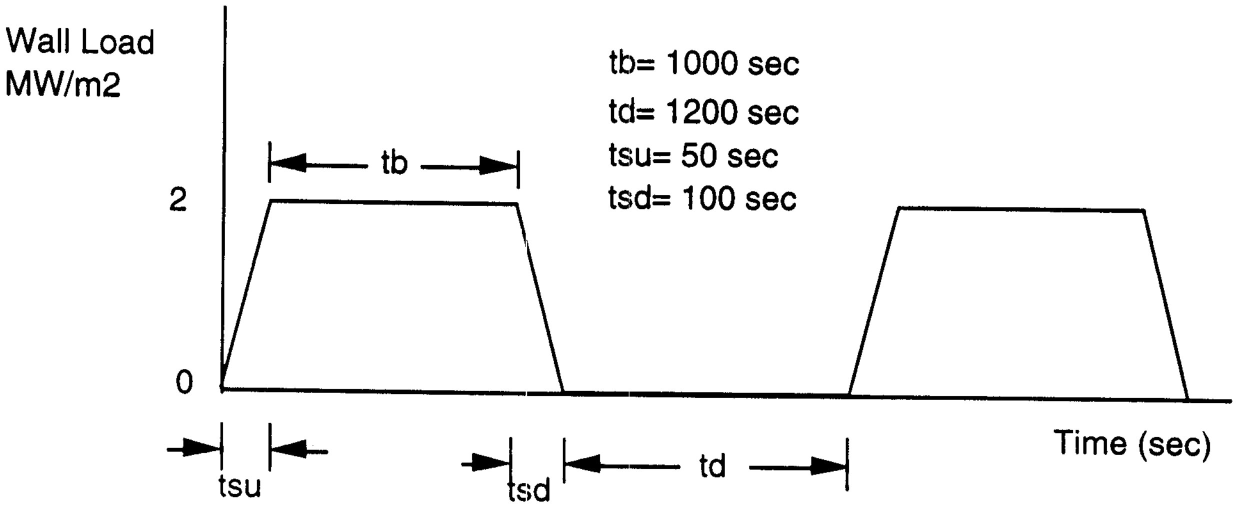
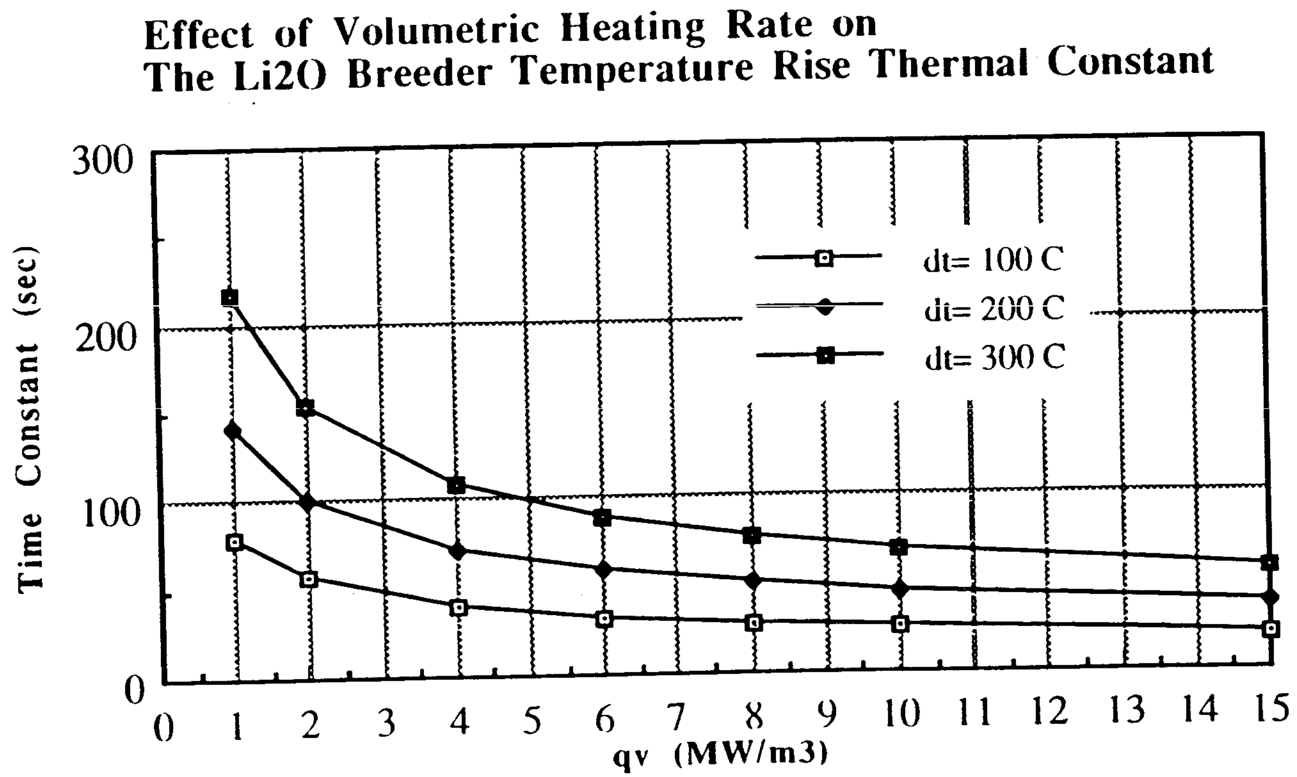
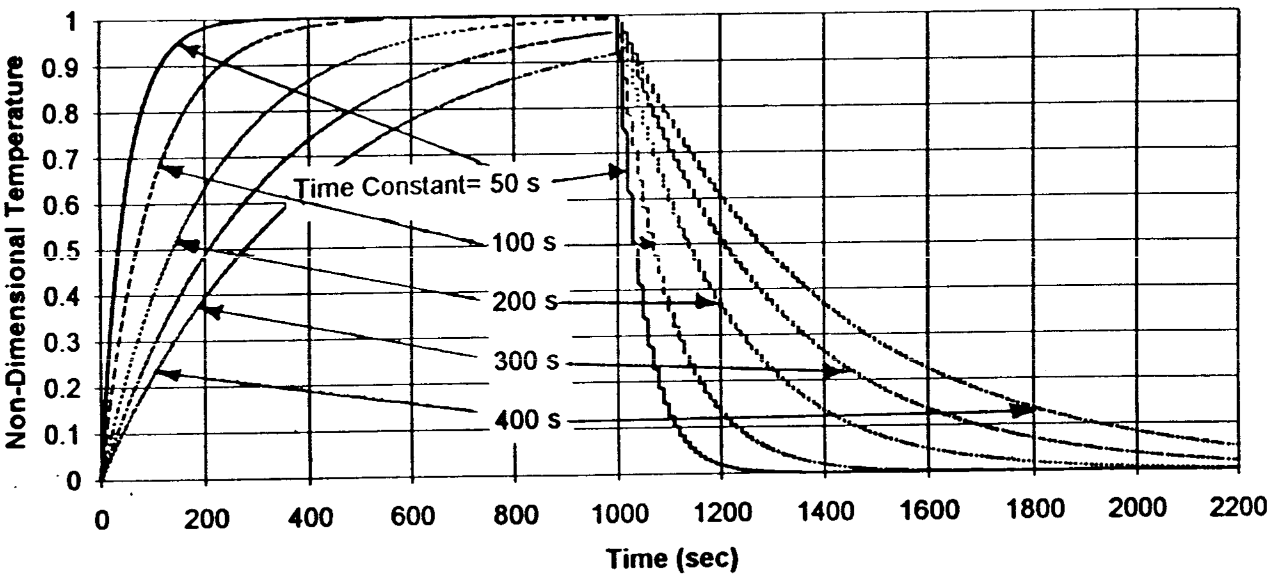


Figure 2. ITER Pulse Shape

Effect of Volumetric Heating Rate on Breeder time constants

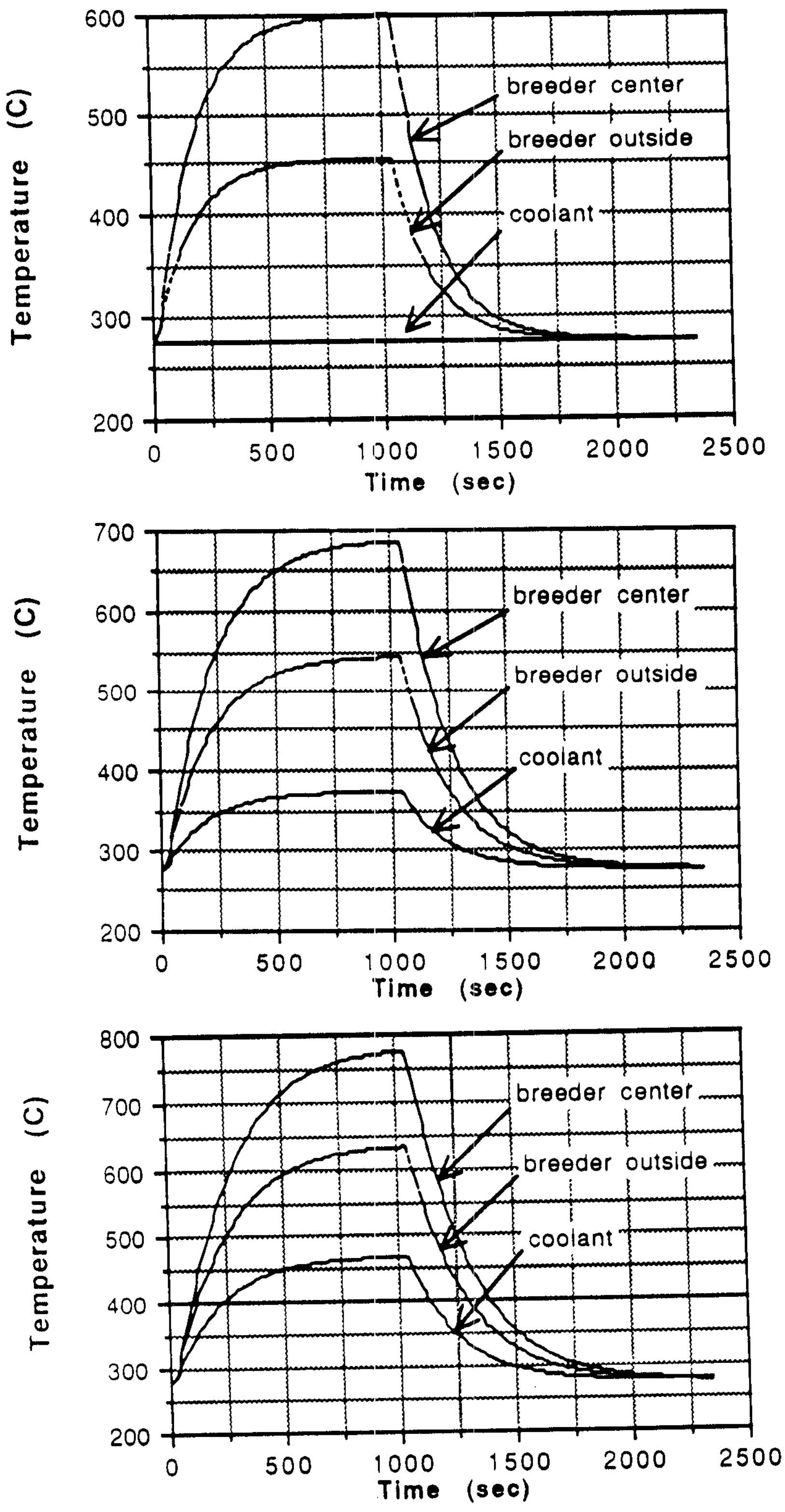


The Effect of Thermal Time Contant on Temperature Transient



Breeder Temperature Response To ITER Pulse Heating

Blanket Front, Volumetric Heating Rate= 9.2 MW/m3



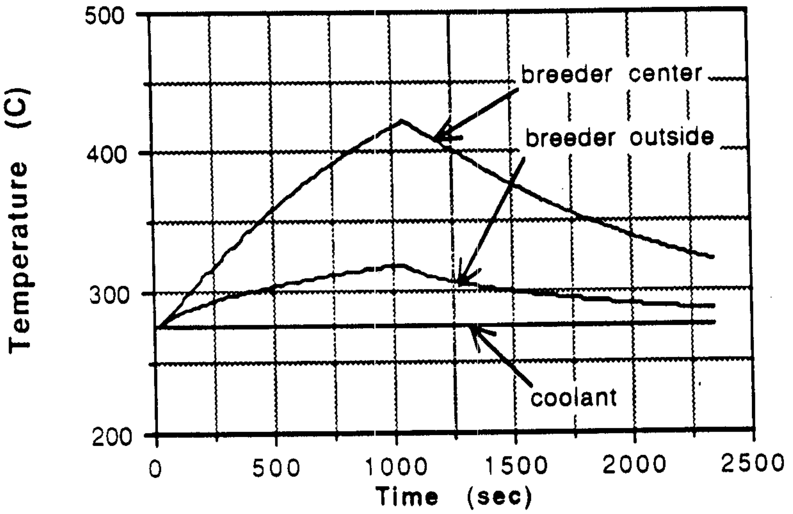
a. inlet position

b. middle position

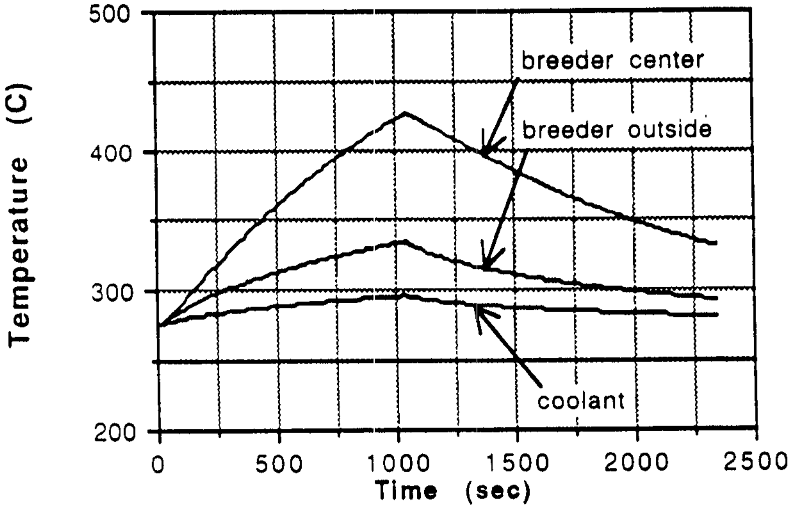
c. end position

Breeder Temperature Response To ITER Pulse Heating

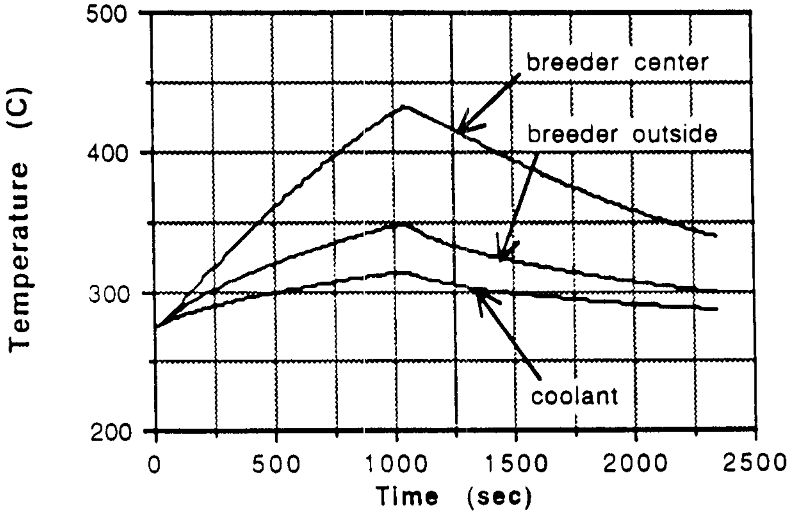
Blanket back, Volumetric Heating Rate= 1 MW/m3



a. inlet position



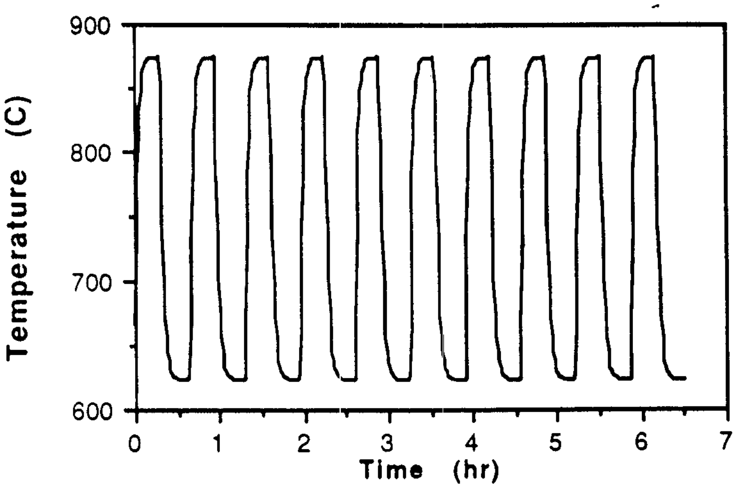
b. middle position



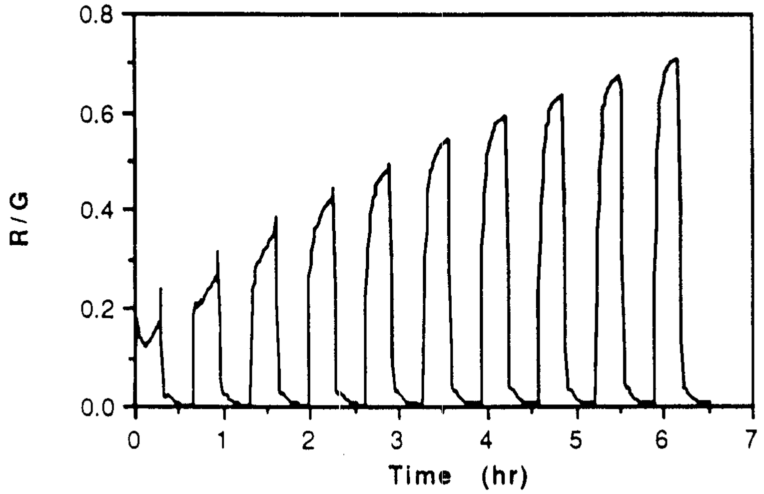
c. end position

Tritium Inventory and Release Histories in Li2O Breeder Under Pulsed Reactor Operation

volumetric heating Rate= 9.2 MW/m3

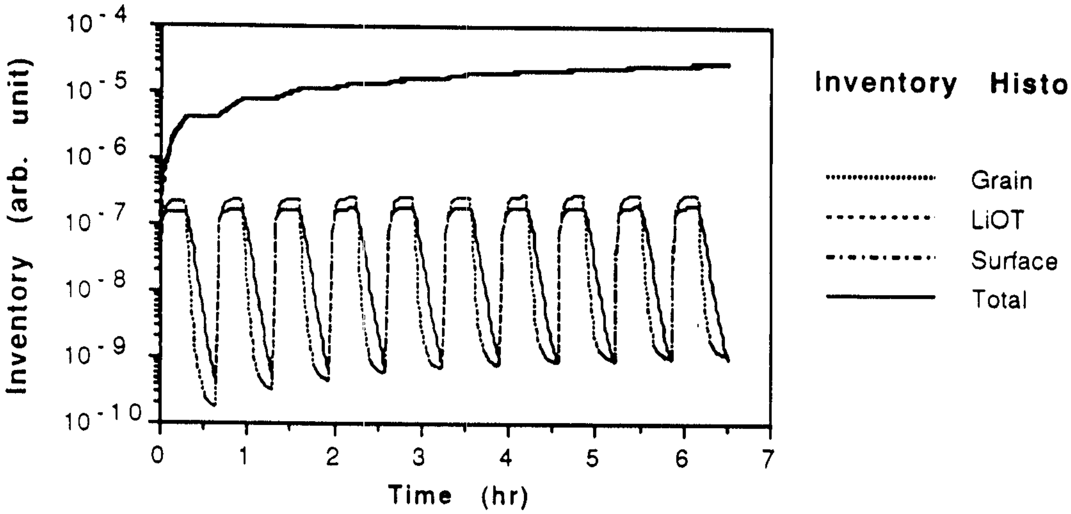


Temperature History



Release Rate History

Inventory History



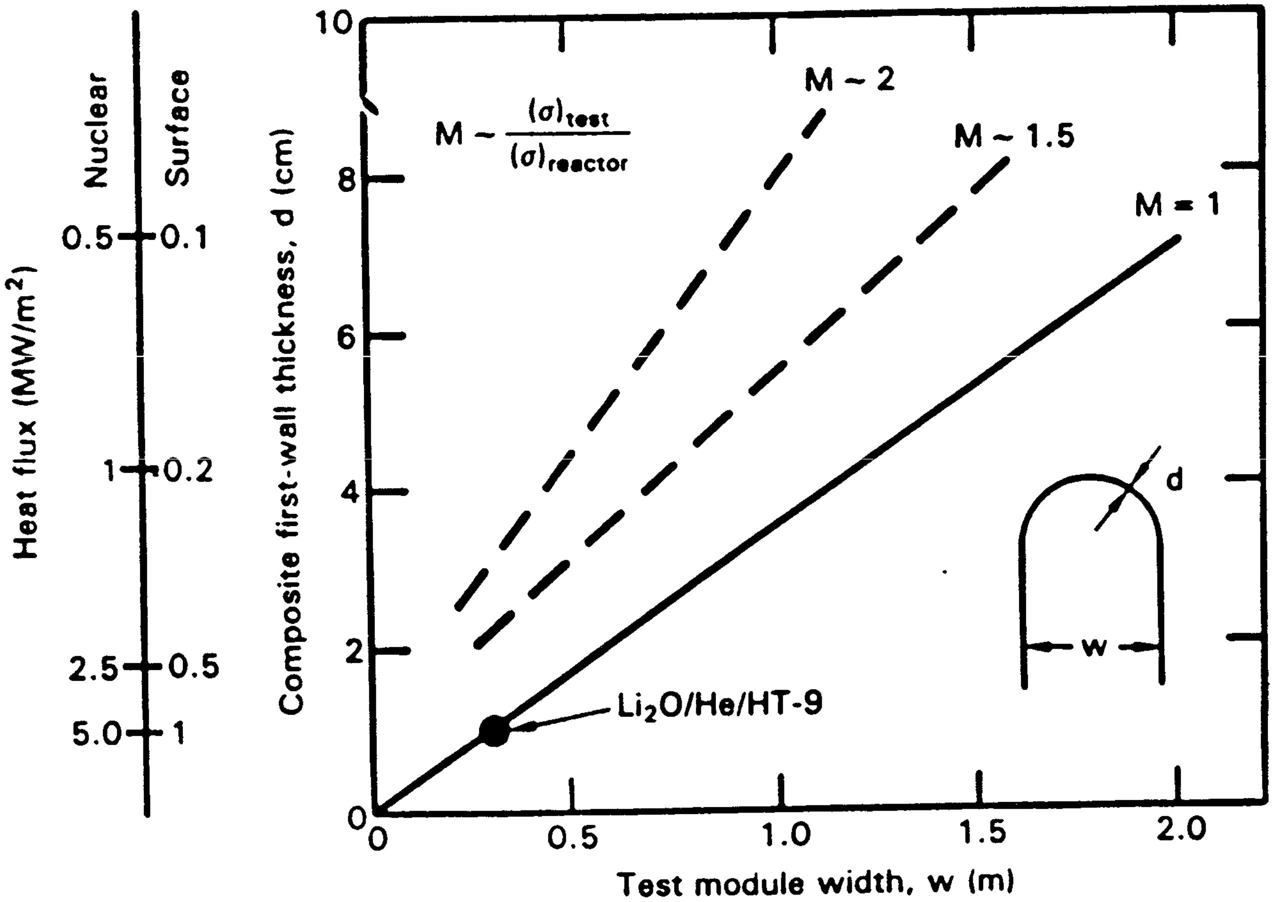


Fig. 9. Test module width and device heat source trade-off for preserving Li_2O/He/HT-9 tokamak first-wall thermal plus pressure stresses. Here, *M* is a qualitative measure of the (multiplicative) change in first-wall stress profile.

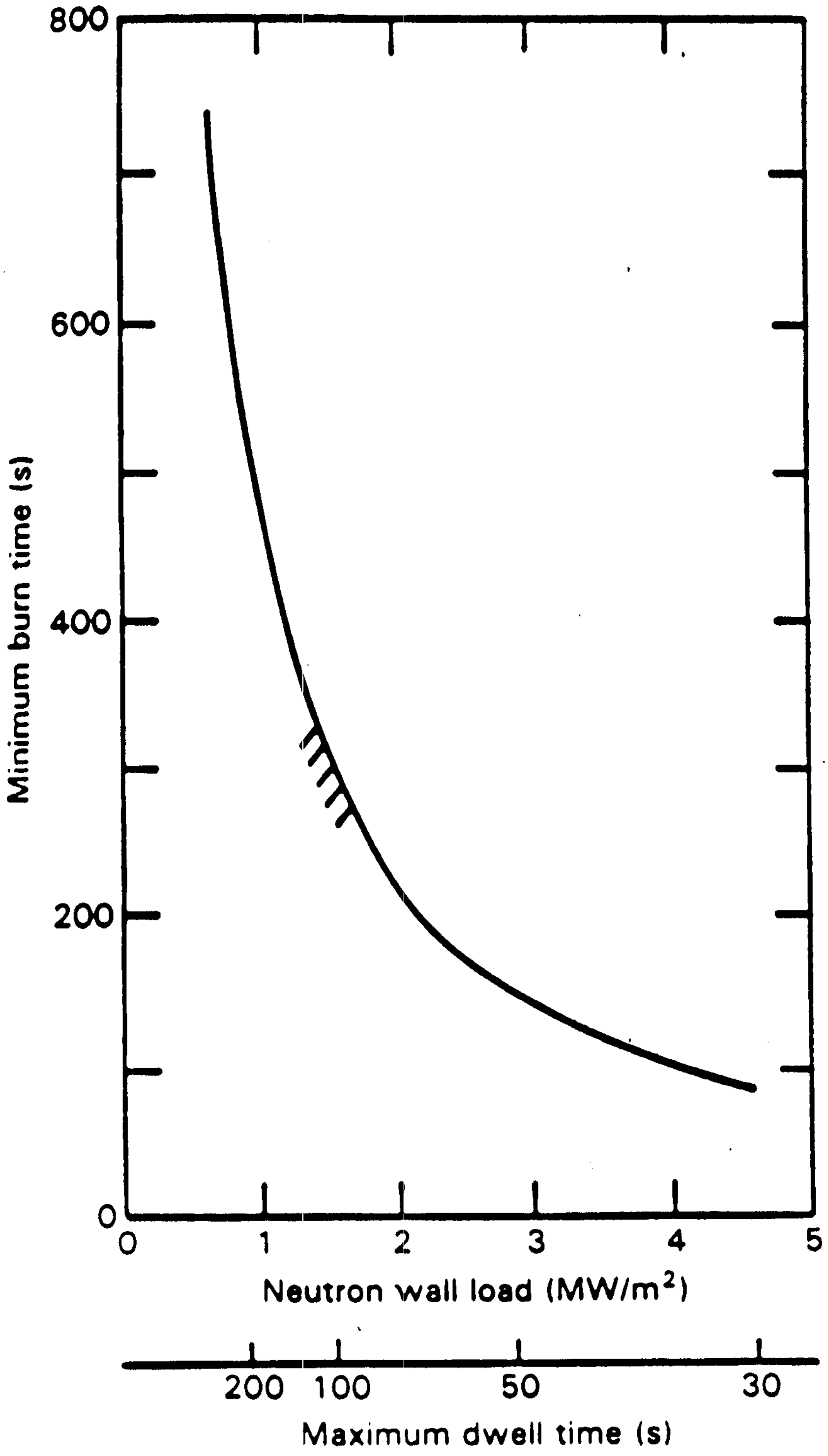


Fig. 10. Relation between minimum burn time, maximum dwell time, and neutron wall load for breeder thermal equilibrium in the Li_2O/He/HT-9 test module. Breeder dimensions are changed to keep the breeder within the reactor temperature limits.