SP-100 PROGRAM

SPACE REACTOR SYSTEM AND SUBSYSTEM INVESTIGATIONS

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**ASSESSMENT OF TECHNOLOGY ISSUES
FOR THE
REACTOR AND SHIELD SUBSYSTEM**

*Prepared for
the United States Department of Energy
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Rockwell International

Energy Systems Group

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System
of
Control
and
Automation

SP-100 PROGRAM

SPACE REACTOR SYSTEM AND SUBSYSTEM INVESTIGATIONS:

**ASSESSMENT OF TECHNOLOGY ISSUES
FOR THE
REACTOR AND SHIELD SUBSYSTEM,**

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1.0 INTRODUCTION

As part of Rockwell's effort on the SP-100 Program, we have completed a preliminary assessment of current nuclear technology as it relates to candidate reactor/shield subsystems for the SP-100 Program. The purpose of the assessment, as defined in Rockwell's scope of work, was as follows:

. . . assess and list the technology issues that will--in March 1984--establish whether the July 1985 'go/no-go' decision date for proceeding with a ground demonstration system test can be met.

The scope of the assessment was confined to the nuclear package (to the reactor and shield subsystems). The nine generic reactor subsystems presented in Rockwell's Subsystem Technology Assessment Report, ESG-DOE-13398, were addressed for the assessment.

The following guides were used in the assessment:

- The SP-100 Program specification applies.
- Requirements such as reliability, safety, survivability, and dormancy/restart can be met eventually, although design penalties may be associated with meeting these requirements.
- No significant advances in the current data base will be made by March of 1984, i.e., the existing data base applies for purposes of the technology assessment.
- Within the context of this assessment, a "technology issue" (an element or feature of a proposed reactor and/or shield subsystem, which in March of 1984 will have an impact on whether the July 1985 "go/no-go" decision date can be met) is defined as a factor having one or more of the following attributes:
 - 1) An inherent technical limit that is not amenable to engineering/design "fixes"

- 2) A gap in the existing data base of sufficient importance to question the technical viability of the March 1984/ July 1985 program decision dates
- 3) A lack of adequate design definition on which to base the "go/no-go" decision.

To assist in this assessment, we utilized our extensive SNAP Reactor Program experience in space reactor electric systems. We also carefully distinguished between "technical concerns" and "technology issues." Technical concerns relate to elements of the design and/or supporting data base, which may be ill-defined or uncertain at this point. Such concerns, however, would not prevent the project from making the decision in July 1985 to proceed with a ground demonstration system test. A technology issue, on the other hand, is sufficiently important that in — March 1984 — it would seriously impair a project decision in July 1985 to proceed with the ground demonstration test.

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2.0 SUMMARY

Three reactor subsystems have technology issues that in March 1984 would have an impact on the July 1985 go/no-go decision:

- The fixed-bed reactor
- The boiling-potassium fast reactor
- The heat-pipe reactor.

The technology issue for the fixed-bed reactor is its current preconceptual design stage. We believe that insufficient design information will exist in March 1984 for this concept to make a decision in July 1985 to proceed with a fixed-bed reactor for the ground demonstration test.

The boiling-potassium reactor has a technology issue associated with the liquid-vapor interface control in the microgravity environment. This technology issue cannot be resolved by March of 1984. This technical uncertainty should be resolved before this particular reactor subsystem is considered for a ground demonstration system test.

The heat-pipe reactor is an early conceptual design. In March 1984, the design features of the subsystem could be sufficiently well defined that it could satisfy the July 1985 go/no-go decision. However, although the novel fuel geometry in the heat-pipe reactor may be acceptable, we believe that a prototypic in-pile irradiation test should be performed to demonstrate its ability to meet the program requirements. We do not believe that these data can be available by March of 1984 to support the July 1985 go/no-go decision date.

The other six reactor subsystems also have technical concerns. For example, the NaK-cooled zirconium hydride reactor is known to be temperature limited. Fuel operating temperatures below 975K (1300°F) must be maintained for the reactor to achieve the design lifetime goal.

The high-temperature fast reactors, both gas cooled and liquid metal cooled, will probably require refractory metals for both the fuel cladding and the reactor structures. The data base available for behavior of refractory structural materials in a neutron environment at the temperatures anticipated for these fast reactors (1450K, or 2060°F) is very sparse (Table 1). However, in March 1984, this lack of a strong data base should not preclude meeting the July 1985 go/no-go decision date.

Thermionic reactors are known to be lifetime limited as a result of fuel swelling. This is a technical concern relative to achieving the 7-year, full-power operation design lifetime goal. However, we believe that the thermionic reactor is capable of achieving the initial lifetime goal. With additional development and testing, the thermionic reactor concept might be capable of achieving the ultimate design lifetime goal. Therefore, we believe that the thermionic reactor does not have inherent technology issues that in March 1984 would preclude making the July 1985 go/no-go decision for proceeding with a ground demonstration test.

The major technical concern associated with the shielding subsystems is the use of lithium hydride for the neutron shield. Lithium hydride is an excellent neutron shield but has a melting temperature of approximately 958K (1266°F). The high coolant outlet temperatures that would be used for several of the potential fast reactor systems might require active cooling of the shield. This cooling requirement can be readily addressed by engineering design and therefore does not represent a technology issue which in March 1984 would preclude making the July 1985 decision to proceed with a ground demonstration system test utilizing a lithium hydride neutron shield.

We do not foresee any technology issues associated with a heavy metal (e.g., tungsten) gamma shield.

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TABLE 1
EXISTING DATA BASE - STRUCTURAL MATERIALS

Item	316 Stainless Steel	D9	Hastelloy X	Inconel 718	Mo-Re	TZM	Nb-1 Zr	T-111
Fluence, N/cm ²	1.5×10^{23}	2.6×10^{22}	2×10^{21}	9.0×10^{21}	1×10^{21}	1×10^{22}	5×10^{21}	1×10^{20}
Spectrum	E 0.1 MeV	E 0.1 MeV	E > 1 MeV	E 0.1 MeV	E 0.1 MeV	E MeV	E 0.1 MeV	E > 0.1 MeV
Operating temperature	723K	923K	1033K	1020K	1400K	1400K	940K	1673K
Environment			Helium		Helium			Li UN

Data on Astar 811-C were not found.

3.0 DISCUSSION OF THE ASSESSMENT

In assessing technology issues for the reactor and shielding subsystems, the technical requirements of the SP-100 Program specification were used as a basis from which the specification requirements and goals are being evolved. Design goals, such as power level, mass and size constraints, dormancy and multiple restart requirements, survivability, and safety requirements must be considered in assessing and listing the technology issues for both the reactor and shielding subsystems, which in March of 1984 can have an impact on whether the July 1985 go/no-go decision date can be met.

As the SP-100 Program evolves, potential reactor and shielding subsystems designs are in the conceptual phase, making quantitative assessments of the ability of certain generic reactor subsystem designs to meet specific safety requirements, dormancy/restart requirements, or reliability requirements difficult. In assessing the ability of potential reactor and shielding subsystems to meet the design goals specified in the SP-100 Program, we have used our past experience from the SNAP Program. The assessment, therefore, relies heavily on our engineering judgment as to the ability of specific subsystems to meet the design goals and specifications.

3.1 ASSESSMENT OF ABILITY TO MEET OVERALL DESIGN GOALS AND REQUIREMENTS

Using the existing designs of the potential reactor and shield subsystem candidates, we assumed that requirements for such factors as reliability, dormancy, and survivability could be met by all subsystems. There probably would be penalties associated with meeting those requirements. For example, redundancy of certain components that might be required to achieve overall reliability goals would have a weight impact on the overall system.

We believe all of the subsystems can meet most of the design goals and requirements. Specific design features necessary to meet the requirements will be identified during future design activities. Three items — operating

temperature, lifetime, and safety — will present particular challenges to the project.

To meet the 100-kWe power-level requirement within the specified mass and size constraints, it will be necessary to increase reactor operating temperatures significantly higher than those forming the existing data base. If this temperature increase necessitates classifying it as a "technology issue" in March 1984, it is likely to preclude making the July 1985 go/no-go decision for proceeding with a ground demonstration system test. We do not believe that classification will be necessary, and that, in fact, this increase in operating temperatures may be one of the most important reasons for proceeding with the July 1985 decision to conduct a ground demonstration system test. Our reasoning is based on the fact that it is more cost and schedule effective to build and test a full-scale reactor subsystem, and thereby identify any design limits early, than to proceed with a sequential approach of extensive technology development followed by the subsystem test. Both approaches eventually identify design limits based on test data. The first approach — early full-scale subsystem testing — produces this end result sooner (and, therefore, at less cost to the project). We believe that our success with the approach we used in the 1960s and early 1970s with the SNAP reactor program would be applicable today.

Achieving the 7-year, full-power operation design lifetime goal for the reactor subsystem is questionable for the first-generation subsystems. The longest duration power run by a terrestrial nuclear power reactor is 1.8 years (achieved by the British Magnox Sizewell A2 in 1976-1977). The longest uninterrupted power run by a compact space nuclear reactor subsystem is 10,000 h (achieved by the SNAP-10A FS3 ground test in 1965-1966).

We believe the initial lifetime goal is achievable by first-generation reactor subsystems. For purposes of this technology assessment, we chose to regard the initial lifetime goal as the project requirement. We do not regard

meeting this requirement as a technology issue, which in March 1984 would preclude meeting the July 1985 go/no-go decision. Sufficient data exist on fuel performance (Table 2) to provide reasonable assurance of meeting the initial lifetime goal.

Safety requirements for the reactor and shielding subsystems were carefully considered. The requirement that the reactor remain subcritical during water flooding is the most demanding safety requirement for the reactor subsystem. For example, even the SNAP-2, -8, and -10A reactors, which were designed and tested by Rockwell in the 1960s and early 1970s would not meet the water flooding subcriticality requirement imposed by the SP-100 Program specification. The current trend of using fast reactors with higher fuel loadings makes the water flooding subcriticality requirement more difficult to satisfy. The safety requirement for dispersal of the reactor subsystem during re-entry will also present difficult design challenges, particularly for the high-temperature gas-cooled reactor with its thick reactor pressure vessel.

At present, the design definition of potential reactor subsystems is insufficient to make quantitative assessments of the ability of given subsystems to meet the safety requirements. The safety issues apply across the board to all potential reactor subsystems. It will take time and money to resolve these safety issues. However, we do not believe these requirements should preclude going ahead with the ground demonstration test.

3.2 ASSESSMENT OF SPECIFIC REACTOR AND SHIELD SUBSYSTEMS

Nine specific reactor subsystems (the same subsystems addressed in Rockwell's Subsystem Technology Assessment Report, ESG-DOE-13398) were considered in the technology issues assessment:

- NaK-cooled zirconium hydride reactor
- High-temperature gas-cooled reactor
- Gas-cooled fast reactor

TABLE 2
EXISTING FUEL TECHNOLOGY DATA BASE

Item	SP-100 Requirements	Oxides		Carbides		Nitrides		Coated Particles	UZrH
		UO ₂	(U + Pu) O ₂	UC	(U + Pu) C	UN	(U + Pu) N		
No. Pins Irradiated in LMFBRs	-	~250,000	~250,000	~1500	~600		~100		
Principal Locations	-	USSR, France	France, UK	USSR BR-5	U.S. EBR-II	Japan	U.S. EBR-II	U.S. HTGR	U.S. SNAP
Peak Burnup (MWD/MT) (Heavy Metal)	60,000	70,000	200,000	50,000	150,000	16,000	60,000		0.1 Metal a/o
Well Demonstrated Burnup (MWD/MT) (Heavy Metal)	-	50,000	100,000	N/A	N/A	N/A	N/A	30,000	
Peak Linear Power Rating (kW/m)					130		107		
Well Demonstrated Peak Linear Power (kW/m)	-	~46	46		~75	N/A	N/A		
Smear Density (% TD)		80	80		80		80		
Failure Rates	-	<0.01%	<0.01%		>5%		>10%		
Spectrum	Fast E > 0.1 MeV	Fast E > 0.1 MeV	Fast E > 0.1 MeV	Fast E > 0.1 MeV	Fast E > 0.1 MeV		Fast E > 0.1 MeV	Thermal	

- Na- or K-cooled fast reactor
- Lithium-cooled fast reactor
- Fixed-bed reactor
- Boiling potassium fast reactor
- Thermionic reactor
- Heat-pipe reactor.

For all these potential reactor subsystem candidates, a heavy metal gamma shield (probably tungsten) and a lithium hydride neutron shield would be used. These shielding subsystems are common to all reactor subsystems considered in the technology issues assessment. Here again, it is important to distinguish between technical concerns and technology issues (see Section 1.0).

A discussion of the technology issues and considerations associated with each of the nine reactor subsystems is presented below.

3.2.1 NaK-Cooled Zirconium Hydride Reactor

Figure 1 summarizes our assessment of the NaK-cooled zirconium hydride reactor subsystem. Entries in the figure illustrate our assessment of this reactor subsystem.* The concerns associated with the NaK-cooled zirconium hydride reactor relate to the fuel pin performance. Our previous experience with the UZrH type of SNAP reactor has indicated that the fuel is temperature limited and operating fuel temperatures should be maintained below 980K (1300°F) for long lifetime designs. In addition, the hydrogen barrier which restricts loss of the hydrogen from the fuel, and therefore reduces reactivity losses, is also a concern.

*The dashed boxes indicate items which we believe represent technical concerns. Solid boxes indicate items that we believe represent technology issues as defined for this assessment.

NUCLEAR PACKAGE COMPONENT	PROBABLE DESIGN	PERFORMANCE ISSUES	MATERIAL ISSUES	OPERATIONAL AND ENVIRONMENTAL ISSUES	DESIGN ISSUES	PRODUCIBILITY	SAFETY
<u>FUEL PINS</u>	HASTELLOY N CLAD UZrH	LIFETIME $\leq$ 2 YRS AT 980K (1300°F)		NONE - SNAP TECHNOLOGY	TIGHT TOLERANCE FUEL PIN DESIGN	REESTABLISH SNAP FUEL PRODUCTION CAPABILITY	LAUNCH ABORT WATER CRITICALITY AND RE-ENTRY DISPERSAL
FUEL	U-ZrH	FUEL IS TEMPERATURE LIMITED	FUEL GROWTH LIMITS LIFETIME	↓			
CLADDING	HASTELLOY N WITH H ₂ BARRIER	BARRIER PERFORMANCE CRITICAL TO LONG LIFE (I.E., HYDROGEN DETENTION)	CLADDING/BARRIER INTEGRITY ASSOCIATED WITH FULL GROWTH	↓		REESTABLISH SNAP CLADDING, AND IN PARTICULAR, BARRIER PRODUCTION CAPABILITY	
<u>REACTOR STRUCTURE</u>	STAINLESS STEEL, 920K 980K	NONE - LARGE LMFBF DATA BASE	NONE - LARGE LMFBF AND SNAP DATA BASE	NONE - SNAP TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	NONE - LARGE LMFBF DATA BASE	
CORE SUPPORT		↓	↓	↓	↓	↓	
VESSEL							
COOLANT PIPING							
<u>CONTROL MECHANISMS</u>	REFLECTOR DRUMS WITH SNAP-8 DRIVES	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	REESTABLISH SNAP PRODUCTION CAPABILITY	
CONTROL ELEMENTS		↓	↓	↓	↓	↓	
DRIVES							
<u>SHIELDS</u>	HEAVY METAL GAMMA SHIELD, L/H NEUTRON SHIELD	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	
GAMMA	HEAVY METAL	↓	↓	↓	↓	↓	
NEUTRON	LITHIUM HYDRIDE						
<u>COOLANT</u>	NaK 920-980K	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	DORMANCY/RESTART	NONE - SNAP 8 TECHNOLOGY	NONE	

Figure 1. NaK-Cooled ZrH Reactor

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The producibility concern is associated with reestablishing the production capability for producing SNAP cladding and, in particular, the hydrogen barrier. While we believe this technology can be reestablished, we have categorized it as a concern at this point.

As previously noted, water flooding subcriticality of the reactor cannot be demonstrated with the UZrh designs which existed in the 1960s and early 1970s. Design provisions for maintaining subcriticality under water flooding conditions and features to provide for reentry dispersal would need to be incorporated in an SP-100 Program reactor subsystem in order to satisfy the safety requirements.

Although there are several concerns associated with the NaK-cooled zirconium hydride reactor, they are not of sufficient magnitude that in March 1984 they would impact a July 1985 project go/no-go decision.

3.2.2 High-Temperature Gas-Cooled Reactor

Figure 2 illustrates the results of our assessment of technology issues associated with the high-temperature gas-cooled reactor concept. We do not foresee any technology issues associated with the use of an HTGR for SP-100. (Concern for impurities in the system when coupled to a refractory Brayton PCS was expressed at the Refractory Materials Symposium at Oak Ridge in August 1983. The assessment herein is confined to the nuclear package (reactor/shield) and, therefore, does not address this concern.) As with the NaK-cooled zirconium hydride reactor, there are some concerns that will need to be addressed if an HTGR is chosen for SP-100. These concerns relate to the fact that HTGRs in the power range anticipated for SP-100 tend to be large with heavy core support structures and the pressure vessel required to contain the high-pressure/high-temperature gas coolant. Compatibility of the graphite particle fuel with potential superalloy core structures is also a concern, along with the need for high integrity pressure boundary seals which would be required to contain the helium or helium/xenon coolant. As with the zirconium

NUCLEAR PACKAGE COMPONENTS	PROBABLE DESIGN	PERFORMANCE ISSUES	MATERIAL ISSUES	OPERATIONAL AND ENVIRONMENTAL ISSUES	DESIGN ISSUES	PRODUCIBILITY	SAFETY
<u>FUEL PINS</u>	N A	N A	N A	N A	N A	N A	<div>GRAPHITE COATED FUEL RESISTANT TO RE-ENTRY BURNUP</div> <div>POROUS CORE MORE SUSCEPTIBLE WITH LAUNCH ABORT CRITICALLY</div> <div>HEAVY CORE STRUCTURES RESISTANT TO RE-ENTRY DISASSEMBLY</div>
FUEL	GRAPHITE/PARTICLE FUEL	FUEL CAPABLE OF HIGH BURN UP	NONE LARGE HTGR DATA BASE	NONE LARGE HTGR DATA BASE	NONE LARGE HTGR DATA BASE	NONE USE HTGR TECHNOLOGY (TRISO COATING PROCESS)	
CLADDING	N A	N A	N A	N A	N A	N A	
<u>REACTOR STRUCTURE</u>	SUPERALLOY STRUCTURES VESSEL AND PIPING	LARGE HEAVY CORE STRUCTURES TO SUPPORT HIGH PRESSURE/TEMPERATURE CORE PERFORMANCE	COMPATABILITY OF GRAPHITE PARTICLE FUEL WITH SUPERALLOY CORE STRUCTURES	NONE LARGE HTGR DATA BASE	REACTOR STRUCTURES TEND TO BE HEAVY TO WITHSTAND HIGH PRESSURE/TEMPERATURES	MATERIALS AVAILABILITY	
CORE SUPPORT	↓	↓	↓	↓	↓	↓	
VESSEL							
COOLANT PIPING							
<u>CONTROL MECHANISMS</u>							
CONTROL ELEMENT	POISON BACKED REFLECTOR DRUMS	NONE LARGE HTGR DATA BASE	NONE LARGE HTGR DATA BASE	NONE LARGE HTGR DATA BASE	NONE LARGE HTGR DATA BASE	NONE LARGE HTGR DATA BASE	
DRIVES	SNAP 8 TYPE ACTUATORS	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	ACTUATORS MAY REQUIRE ACTIVE COOLING	ACTUATORS MAY REQUIRE ACTIVE COOLING		
<u>SHIELDS</u>		LARGE PIPING DUCTS WILL INCREASE RADIATURE SCATTERING			LARGE PIPING DUCTS WILL INCREASE RADIATION SCATTERING		
GAMMA	HEAVY METAL	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY		
NEUTRON	LITHIUM HYDRIDE ACTIVELY COOLED	SHIELD WILL REQUIRE ACTIVE COOLING	NONE WITH ACTIVE COOLING	SHIELD WILL REQUIRE ACTIVE COOLING	SHIELD WILL REQUIRE ACTIVE COOLING		
<u>COOLANT</u>	HELIUM OR HELIUM + XENON	NONE LARGE HTGR DATA BASE	COOLANT PURITY MUST BE CONTROLLED	NONE GAS COOLANT AMENABLE TO DORMANCY/RESTART REQUIREMENTS	PRESSURE BOUNDARY SEALS PARTICULARLY IMPORTANT IN HELIUM SYSTEMS	↓	

Figure 2. HTGR Reactors

hydride reactor, there are safety concerns, but we believe these concerns can be addressed by design features if an HTGR were to be chosen.

In summary, we do not believe that there are any technology issues associated with the HGTR which, in March 1984, would impact the selection of an HTGR in July 1985 for subsequent ground demonstration system testing.

3.2.3 Gas-Cooled Fast Reactors

Figure 3 summarizes our assessment of technology issues associated with the gas-cooled fast reactor concept. There are three technical concerns that we believe are associated with this concept, specifically, demonstration of long lifetime and the water subcriticality and reentry dispersal safety requirements. We believe the concerns will be resolved through a natural evolution of the design during the program.

Again, we do not see these as technology issues which would prevent selection of a gas-cooled fast reactor in July 1985 for subsequent ground demonstration system testing.

It is important to note that we have chosen not to identify the use of superalloys as a technical concern. We believe, based upon admittedly sparse data, that superalloys should be readily amenable to use in the gas-cooled reactor environment. We believe that this technical consideration is readily addressed in either component testing programs or, more directly, in the ground demonstration system test itself. This technical feature certainly is not of a magnitude to preclude a July 1985 go/no-go decision on the gas-cooled fast reactor for ground demonstration system testing.

3.2.4 Liquid-Metal-Cooled Fast Reactors

Figure 4 summarizes our assessment of Na- or -K-cooled fast reactors for the SP-100 Program. As with the gas-cooled fast reactors, the prime technical

NUCLEAR PACKAGE COMPONENTS	PROBABLE DESIGN	PERFORMANCE ISSUES	MATERIAL ISSUES	OPERATIONAL AND ENVIRONMENTAL ISSUES	DESIGN ISSUES	PRODUCIBILITY	SAFETY
<u>FUEL PIN</u>	HASTELLOY X CLAD UO ₂ FUEL	LIFETIME CAPABILITY MUST BE DEMONSTRATED					
FUEL	UO ₂	FUEL GROWTH	NONE	NONE	NONE	NONE	<div>LAUNCH ABORT WATER CRITICALITY AND RE-ENTRY DISPERSAL</div> <div>HEAVY CORE STRUCTURES RESISTANT TO RE-ENTRY DISASSEMBLY</div>
CLADDING	HASTELLOY X	BEHAVIOR OF HASTELLOY X SUPERALLOY AT HIGH FLUENCES NEEDS TO BE ESTABLISHED	DATA BASE IS SPARSE FOR FLUENCES ANTICIPATED	NONE	NONE	NONE	
<u>REACTOR STRUCTURE</u>	SUPERALLOY STRUCTURE VESSEL AND PIPING	HEAVY CORE STRUCTURES TO SUPPORT HIGH PRESSURE/ TEMPERATURE	DATA BASE IS SPARSE FOR FLUENCES ANTICIPATED	NONE	STRENGTH PROPERTIES AS A FUNCTION OF FLUENCE DOES NOT HAVE A LARGE DATA BASE	MATERIALS AVAILABILITY AND FABRICATION	
CORE SUPPORT	↓	↓	↓	↓	↓	↓	
VESSEL							
COOLANT PIPING							
<u>CONTROL MECHANISMS</u>							
CONTROL ELEMENT	POISON BACKED REFLECTOR DRUMS	NONE LARGE LMFBR DATA BASE	NONE LARGE LMFBR DATA BASE	NONE LARGE LMFBR DATA BASE	NONE LARGE LMFBR DATA BASE	NONE	
DRIVES	SNAP 8 ACTUATORS	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY (ACTIVE COOLING OF ACTUATORS MAY BE REQUIRED)	NONE	
<u>SHIELDS</u>							
GAMMA	HEAVY METAL	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE	
NEUTRON	LITHIUM HYDRIDE	SHIELD WILL PROBABLY REQUIRE ACTIVE COOLING	SHIELD WILL REQUIRE ACTIVE COOLING	ACTIVE COOLING REQUIRED	ACTIVE COOLING OF SHIELD REQUIRED	NONE	
<u>COOLANT</u>	HELIUM OR HELIUM + XENON	NONE LARGE HTGR DATA BASE	COOLANT PURITY REQUIRES CLOSE CONTROL	NONE GAS COOLANT AMENABLE TO DORMANCY/RESTART REQUIREMENT	NONE	NONE	

Figure 3. Gas-Cooled Fast Reactors

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NUCLEAR PACKAGE COMPONENTS	PROBABLE DESIGN	PERFORMANCE ISSUES	MATERIAL ISSUES	OPERATIONAL AND ENVIRONMENTAL ISSUES	DESIGN ISSUES	PRODUCIBILITY	SAFETY
<u>FUEL PINS</u>	920 K	LIFETIME NEEDS TO BE DEMONSTRATED	NONE LARGE LMFBF DATA BASE	NONE LARGE LMFBF DATA BASE	NONE LARGE LMFBF DATA BASE	NONE LARGE LMFBF DATA BASE, AND SNAP 8 TECHNOLOGY BASE	LAUNCH ABORT WATER CRITICALITY AND RE-ENTRY DISPERSAL
FUEL	UO ₂	FUEL GROWTH	↓	↓	↓	↓	
CLADDING	STAINLESS STEEL	IRRADIATION BEHAVIOR	↓	↓	↓	↓	
<u>REACTOR STRUCTURE</u>	STAINLESS STEEL	NONE LARGE LMFBF DATA BASE	NONE LARGE LMFBF DATA BASE	NONE LARGE LMFBF DATA BASE	NONE LARGE LMFBF DATA BASE		
CORE SUPPORT	↓	↓	↓	↓	↓		
VESSEL							
COOLANT PIPING	↓	↓	↓	↓	↓		
<u>CONTROL MECHANISMS</u>							
CONTROL ELEMENT	POISON BACKED REFLECTOR DRUMS	NONE LARGE LMFBF DATA BASE	NONE LARGE LMFBF DATA BASE	NONE LARGE LMFBF DATA BASE	NONE LARGE LMFBF DATA BASE		
DRIVES	SNAP 8 ACTUATORS	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY		
<u>SHIELDS</u>							
GAMMA	HEAVY METAL	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY		
NEUTRON	LITHIUM HYDRIDE (PASSIVE COOLING)	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY		
<u>COOLANT</u>	Na OR K	NONE LARGE LMFBF DATA BASE	NONE LARGE LMFBF DATA BASE	DORMANCY/RESTART	DESIGN OF SUBSYSTEM TO KEEP COOLANT LIQUID	↓	

Figure 4. Na- or K-Cooled Fast Reactors

concerns appear to be the demonstration of the design lifetime goal for the reactor subsystem and the satisfaction of the water flooding subcriticality safety requirement. In addition, for the liquid-metal-cooled fast reactors, the operational requirement for dormancy and multiple restarts will need to be addressed during detailed design of this particular type of subsystem.

We believe that these technical concerns can be addressed during the life of the program and that they are not of sufficient magnitude to be classed as technology issues. We believe that the existing data base for LMFBRs supports the July 1985 go/no-go decision relative to either Na- or -K-cooled fast reactors.

Figure 5 summarizes our assessment of the lithium-cooled fast reactor. The technical concerns associated with the lithium-cooled fast reactor subsystem are, again, demonstration of achievable lifetime and satisfaction of the water flooding subcriticality and reentry dispersal safety requirement. In addition, certain technical concerns associated with the use of refractory metals for reactor structures, including the fuel pin cladding, will need to be addressed, and mass transfer and compatibility effects verified. The lithium-cooled fast reactor system is a high-temperature system and may require active cooling of the lithium hydride shield as well as active cooling of the control drum actuators if it is desired to utilize the SNAP-8 actuator technology. As with the sodium- or potassium-cooled fast reactors, the dormancy restart requirement will need to be addressed, but we believe this concern can be satisfactorily resolved.

None of these concerns would, in our judgment, preclude a July 1985 selection of a lithium-cooled fast reactor for ground demonstration system testing.

3.2.5 Fixed-Bed Reactor

Figure 6 summarizes our assessment of the fixed-bed reactor subsystem. In Figure 6, the solid boxes around two performance factors illustrate what we

believe to be the technology issue associated with this concept which, in March 1984, could impact the ability to meet the July 1985 decision date relative to proceeding with a ground demonstration system test of a fixed-bed reactor design. Our assessment of the current design status of the fixed-bed reactor indicates that the design is in a preconceptual stage. Insufficient design definition exists at this time to permit the project, in our judgment, to select in July 1985, a fixed-bed reactor for proceeding with the ground demonstration system test. However, the fixed-bed reactor might be a candidate for far-term missions. Its ability to produce very high power outputs is one of its strong features and a highly desirable performance objective for future missions. But, we believe that insufficient design detail in March of 1984 will definitely impact the July 1985 go/no-go decision relative to the fixed-bed reactor concept.

3.2.6 Boiling-Potassium Fast Reactor

Figure 7 summarizes our assessment of the boiling-potassium reactor subsystem. We have identified the behavior and control of the liquid-vapor interface under microgravity conditions as being a technology issue which, in March 1984, we believe would impact the the July 1985 project go/no-go decision. There are limited, short-time data on the behavior of the liquid-vapor interface in a boiling system for space application. The data came from drop tests and suborbital airplane flight tests. However, the acceptability of the boiling-potassium fast reactor depends on long-term data relative to the behavior and control of the liquid/gas interface in this concept. We believe the current uncertainties associated with this technology issue could prevent its selection in July 1985.

It is possible that vapor/liquid interface control and behavior of the two-phase fluid under microgravity conditions are not technical hurdles. However, we believe that appropriate demonstration will not be possible by March 1984, that is, in a time frame consistent with the July 1985 go/no-go decision.

NUCLEAR PACKAGE COMPONENTS	PROBABLE DESIGN	PERFORMANCE ISSUES	MATERIAL ISSUES	OPERATIONAL AND ENVIRONMENTAL ISSUES	DESIGN ISSUES	PRODUCIBILITY	SAFETY
<u>FUEL PINS</u>	Mo-Re CLAD UO ₂ FUEL	DEMONSTRATE ACHIEVEABLE LIFETIME			FUEL PIN INTEGRITY REQUIRED TO LIMIT OXYGEN AVAILABILITY TO COOLANT		LAUNCH ABORT WATER CRITICALITY AND RE-ENTRY DISPERSAL
FUEL	UO ₂	NONE	OXYGEN STOICHIOMETRY MUST BE CONTROLLED TO PREVENT REACTION WITH CLADDING	NONE	NONE	CONTROL OF FUEL STOICHIOMETRY	
CLADDING	Mo-Re	NONE	PERFORMANCE OF Mo-Re UNDER LONG TERM IRRADIATION	NONE	NONE	NONE	
<u>REACTOR STRUCTURE</u>							
CORE SUPPORT	Mo-Re	NONE	SEE "COOLANT"	NONE	POSITIVE POSITIONING OF FUEL PINS MAY BE REQUIRED	MATERIAL AVAILABILITY PRESSURE VESSEL FORMING AND WELDING	
VESSEL	Mo-Re	↓	↓	↓	VESSEL SURVIVABILITY/ FUEL DISPERSAL ON REENTRY	MATERIAL AVAILABILITY PIPING FORMING, WELDING	
COOLANT PIPING	Mo-Re				NONE		
<u>CONTROL MECHANISMS</u>							
CONTROL ELEMENT	B ₄ C/BeO BACKED	NONE - LARGE LMFBR DATA BASE	NONE - LARGE LMFBR DATA BASE	NONE	NONE	NONE	
DRIVES	SNAP-8 TYPE	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	ACTIVE COOLING OF ACTUATORS MAY BE REQUIRED TO MAINTAIN SNAP 8 CONDITIONS	NONE - SNAP 8 TECHNOLOGY	
<u>SHIELDS</u>							
GAMMA	HEAVY METAL	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	
NEUTRON	LITHIUM HYDRIDE (ACTIVE COOLING)	ACTIVE COOLING MUST BE MAINTAINED	NONE WITH ACTIVE COOLING MAINTAINED	ACTIVE COOLING MANDATORY	ACTIVE COOLING CIRCUIT REQUIRED	NONE - SNAP 8 TECHNOLOGY	
<u>COOLANT</u>	Li	NONE	MASS TRANSFER AND COMPATIBILITY WITH PIPING AND CLADDING MUST BE VERIFIED	DORMANCY/RESTART	SPECIAL LOADING PROCEDURES REQUIRED TO LIMIT OXYGEN LEVEL IN COOLANT	NONE	

Figure 5. Li-Cooled Fast Reactors

NUCLEAR PACKAGE COMPONENTS	PROBABLE DESIGN	PERFORMANCE ISSUES	MATERIAL ISSUES	OPERATIONAL AND ENVIRONMENTAL ISSUES	DESIGN ISSUES	PRODUCIBILITY	SAFETY
<u>FUEL PINS</u>	N A	N A	N A	N A	N A	N A	
FUEL	PARTICULATE FUEL TRISO COATED	NONE - LARGE HTGR DATA BASE	NONE - LARGE HTGR DATA BASE	NONE	CONCEPT APPEARS TO BE AT PRE CONCEPTUAL DESIGN PHASE. POTENTIAL TECHNOLOGY ISSUES NEED TO BE ADDRESSED AFTER DESIGN PROGRESSES FURTHER	NONE - LARGE HTGR DATA BASE	COATED FUEL RESISTANT TO RE-ENTRY BURNUP
CLADDING	FRIT LINERS INNER INCONEL OUTER Zr	CONCEPT NEEDS TO BE DEMONSTRATED	NONE - LARGE LWR DATA BASE AND SOME LMFBR DATA	NONE		FRIT LINER PRODUCTION DEVELOPMENT REQUIRED	
<u>REACTOR STRUCTURE</u>							
CORE SUPPORT	FRITS	CONCEPT NEEDS TO BE DEMONSTRATED	(SEE ABOVE)	(SEE DESIGN ISSUES)	THERMAL HYDRAULICS PLUGGING CHARACTERISTICS AND MECHANICAL RESPONSE OF FRITS NEEDS TO BE DETERMINED	NONE	
VESSEL	SUPERALLOY ↓	NONE - ALTHOUGH DATA BASE IS SPARSE AND OPERATING PRESSURE IS HIGH (~ 70 ATMS) ↓	DATA BASE IS LIMITED BUT PROBABLY ACCEPTABLE ↓	NONE	STRUCTURAL BEHAVIOR OF VESSEL AND PIPING UNDER HIGH PRESSURE/ IRRADIATION NEEDS TO BE DETERMINED	NONE	
COOLANT PIPING				NONE			
<u>CONTROL MECHANISMS</u>							
CONTROL ELEMENTS	POISON BACKED REFLECTOR DRUMS	NONE - LARGE LMFBR DATA BASE	NONE - LARGE LMFBR DATA BASE	NONE - LARGE LMFBR DATA BASE	NONE - LARGE LMFBR DATA BASE (COOLING OF Be BOTTOM REFLECTOR MAY BE REQUIRED)	NONE	REFLECTORS MAY SHIELD FUEL DURING RE-ENTRY
DRIVES	SNAP 8 ACTUATORS	NONE - SNAP TECHNOLOGY (ACTIVE COOLING MAY BE REQUIRED)	NONE - SNAP 8 TECHNOLOGY (ACTIVE COOLING MAY BE REQUIRED)	NONE - SNAP 8 TECHNOLOGY (ACTIVE COOLING MAY BE REQUIRED)	ACTIVE COOLING OF ACTUATORS MAY BE REQUIRED	NONE	
<u>SHIELDS</u>							
GAMMA	HEAVY METAL	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY	NONE - SNAP 8 TECHNOLOGY		
NEUTRON	LITHIUM HYDRIDE (ACTIVELY COOLED)	ACTIVE COOLING WILL BE REQUIRED	ACTIVE COOLING OF SHIELD WILL BE REQUIRED	ACTIVE COOLING OF SHIELD WILL BE REQUIRED	ACTIVE COOLING OF SHIELD WILL BE REQUIRED	NONE	
<u>COOLANT</u>	HELIUM		CONTROL OF TRAMP IMPURITIES	GAS COOLANT IS AMENABLE TO DORMANCY/RESTART REQUIREMENT	NONE	NONE	

Figure 6. Fixed-Bed Reactors

NUCLEAR PACKAGE COMPONENTS	PROBABLE DESIGN	PERFORMANCE ISSUES	MATERIAL ISSUES	OPERATIONAL AND ENVIRONMENTAL ISSUES	DESIGN ISSUES	PRODUCIBILITY	SAFETY
<u>FUEL PINS</u>	UO ₂ STAINLESS STEEL CLAD	LIFETIME NEEDS TO BE DEMONSTRATED					
FUEL	UO ₂	FUEL GROWTH	NONE - LARGE LMFBR DATA BASE	NONE	NONE	NONE	LAUNCH ABORT WATER CRITICALITY AND RE-ENTRY DISPERSAL
CLADDING	STAINLESS STEEL	IRRADIATION BEHAVIOR AND HIGH CLADDING TEMPERATURES	TEMPERATURES VERY HIGH FOR STAINLESS STEEL	↓	HIGH CLADDING TEMPERATURES	↓	
<u>REACTOR STRUCTURE</u>	STAINLESS STEEL	TEMPERATURES VERY HIGH FOR STAINLESS STEEL	TEMPERATURES VERY HIGH FOR SS; STRESS ALLOWABLES LOW AT THESE TEMPS	NONE	HIGH STRUCTURAL TEMPERATURES AND PIPING TEMPERATURES	NONE	
CORE SUPPORT		↓	↓	↓	↓	↓	
VESSEL	BORON STAINLESS STEEL						
COOLANT PIPING	STAINLESS STEEL						
<u>CONTROL MECHANISMS</u>							
CONTROL ELEMENT	POISON - BACKED REFLECTOR DRUMS	LARGE LMFBR DATA BASE	LARGE LMFBR DATA BASE	NONE	NONE		
DRIVES	SNAP - 8 ACTUATORS	NONE - SNAP - 8 TECHNOLOGY (ACTIVE COOLING MAY BE REQUIRED)	NONE - SNAP - 8 TECHNOLOGY (ACTIVE COOLING MAY BE REQUIRED)	↓	REQUIRE ACTIVE COOLING OF ACTUATORS OR LOCATION BEHIND SHIELD	NONE	
<u>SHIELDS</u>							
GAMMA	HEAVY METAL	NONE - SNAP - 8 TECHNOLOGY	NONE - SNAP - 8 TECHNOLOGY	NONE	NONE	NONE	
NEUTRON	LITHIUM HYDRIDE (ACTIVELY COOLED)	NONE - SNAP - 8 TECHNOLOGY BUT ACTIVE COOLING REQUIRED	NONE - SNAP - 8 TECHNOLOGY BUT ACTIVE COOLING REQUIRED	↓	ACTIVE COOLING OF SHIELD WILL BE REQUIRED	NONE	
<u>COOLANT</u>	BOILING POTASSIUM	VAPOR - LIQUID INTERFACE BEHAVIOR UNDER MICROGRAVITY CONDITIONS	LONG TERM K - SS COMPATIBILITY MUST BE DEMONSTRATED	DORMANCY/RESTART OPERATION OF 2 PHASE SYSTEM IN MICROGRAVITY	MAY REQUIRE SPECIAL DESIGN PROVISIONS FOR TWO PHASE FLUID IN MICROGRAVITY		

Figure 7. Boiling K-Fast Reactors

3.2.7 Thermionic Reactor

Figure 8 summarizes our assessment of the in-core thermionic reactor. There are several concerns associated with this subsystem, mainly related to demonstration of achievable lifetime as it may be restricted by fuel growth and degradation of the insulator seals in the irradiation environment. Also, since it is a liquid-metal-cooled system, the dormancy/multiple restart requirements will need to be addressed. The use of doubly encapsulated refractory alloys in the converter design may impact reentry dispersal. However, we believe these issues can be satisfactorily resolved.

At present, we cannot foresee achievement of the ultimate design lifetime by the thermionic reactor. However, the initial lifetime would appear achievable based on the existing data base for thermionic elements. We do not foresee any technology issues associated with in-core thermionics that in March 1984 would have an impact on the ability to meet the July 1985 go/no-go decision, if the project is willing to accept the initial lifetime goal.

3.2.8 Heat-Pipe Reactor

Our assessment of the heat-pipe reactor subsystem, summarized in Figure 9, indicates that the heat-pipe reactor is at a somewhat more advanced preconceptual design stage than the fixed-bed reactor. We decided that the current design definition of the heat-pipe reactor would be adequate in March 1984 and would not impact the July 1985 go/no-go decision for proceeding with a ground demonstration test.

However, we have sufficient concern about the behavior of the fuel tile geometry with respect to achieving lifetime goals for the SP-100 to classify it as a technology issue. It has been our experience that "inside-out" fuel geometries present major technical problems relative to predicting fuel behavior. We have identified this fuel geometry feature as a technology issue, i.e., a technical concern of sufficient magnitude that, in March 1984,

NUCLEAR PACKAGE COMPONENTS	PROBABLE DESIGN	PERFORMANCE ISSUES	MATERIAL ISSUES	OPERATIONAL AND ENVIRONMENTAL ISSUES	DESIGN ISSUES	PRODUCIBILITY	SAFETY
<u>FUEL PINS</u>	UO ₂ /W EMITTER Nb COLLECTOR NaK COOLED	POWER DEGRADATION DUE TO FUEL GROWTH, FISSION GAS RELEASE TO GAP <div>LIFETIME < 2 YRS.</div>	<div>FUEL GROWTH LIMITS LIFETIME</div> FUEL GROWTH/FISSION GAS RELEASE TO GAP	<div>FAST NEUTRON DAMAGE OF INSULATOR SEALS. DEVELOPMENT OF IRRADIATION RESISTANT CERAMICS, E.G., Y₂O₃</div> NONE	<div>COMPLEX, TIGHT TOLERANCE DESIGN</div> NONE - LARGE LMFB DATA BASE	NONE - LARGE UMFB DATA BASE <div>CONTROL OF FUEL STOICHIOMETRY CRITICAL TO PROTECT EMITTER</div> INDUSTRIAL PRODUCTION BASE NEEDS TO BE REESTABLISHED	<div>FUEL PROTECTED BY REFRACTORY ALLOYS DURING RE-ENTRY</div>
FUEL							
CLADDING		NONE	NONE	NONE	TIGHT TOLERANCES POWER FEEDS THROUGH		
<u>REACTOR STRUCTURE</u>	STAINLESS STEEL, T<950K	NONE	LARGE LMFB DATA BASE	NONE	NONE - LARGE LMFB DATA BASE	NONE - LARGE LMFB DATA BASE	
CORE SUPPORT		↓	↓	↓	↓	↓	
VESSEL							
COOLANT PIPING		↓	↓	↓	↓	↓	
<u>CONTROL MECHANISMS</u>	REFLECTOR DRUMS W/SNAP 8 DRIVES	NONE	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	REESTABLISH SNAP PRODUCTION CAPABILITY	
CONTROL ELEMENTS		↓	↓	↓	↓	↓	
DRIVES		↓	↓	↓	↓	↓	
<u>SHIELDS</u>		NONE	NONE	NONE	NONE	NONE	
GAMMA SHIELD	HEAVY METAL	↓	NONE	NONE	NONE	NONE	
NEUTRON SHIELD	LITHIUM HYDRIDE	↓	NONE T < T _{MELT} , LiH	NONE T < T _{MELT} , LiH	NONE SOLID SHIELD	NONE SNAP 8 TECHNOLOGY	
<u>COOLANT</u>	NaK 920K	NONE	NONE	<div>DORMANCY/RESTART</div>	NONE	NONE	

Figure 8. In-Core Thermonic Reactors

NUCLEAR PACKAGE COMPONENTS	PROBABLE DESIGN	PERFORMANCE ISSUES	MATERIAL ISSUES	OPERATIONAL AND ENVIRONMENTAL ISSUES	DESIGN ISSUES	PRODUCIBILITY	SAFETY
<u>FUEL PINS</u>	N A	N A	N A	N A	N A	N A	
FUEL	UO ₂ TILES	ACHIEVABLE LIFETIME FOR FUEL TILE GEOMETRY MUST BE DEMONSTRATED	FUEL GROWTH FOR TILE GEOMETRY	LAUNCH VIBRATION LOADS ON UO ₂ FUEL TILES	NOVEL FUEL GEOMETRY TIGHT TOLERANCES MO RE SPACERS CRITICAL	CONTROL OF UO ₂ STOICHIOMETRY AND PRODUCTION OF THOUSANDS OF CLOSE TOLERANCE FUEL TILES	RE ENTRY DISPERSAL CAUSED BY CONSTRAINTS OFFERED BY MULTIPLE HEAT PIPES
CLADDING	N A	N A	N A	N A	N A	N A	
<u>REACTOR STRUCTURE</u>							
CORE SUPPORT	Mo Re INTERLAYERS	NONE	NONE CORE STRUCTURE HAS MINIMAL FUNCTIONAL REQUIREMENTS		NONE	MINIMAL FABRICATION DEVELOPMENT REQUIRED	
VESSEL	Mo Re	↓	↓		↓	↓	VESSEL SURVIVABILITY AND FUEL DISPERSAL DURING RE ENTRY
COOLANT PIPING	HEAT PIPES (SEE COOLANT)	(SEE COOLANT)	(SEE COOLANT)	(SEE COOLANT)		(SEE COOLANT)	
<u>CONTROL MECHANISMS</u>							
CONTROL ELEMENT	B ₄ C/BEO BACKED	NONE LARGE LMFBR DATA BASE	NONE LARGE LMFBR DATA BASE	REMOVAL OF B ₄ C PLUG	PLUG EJECTION DEVICE (IF USED)		
DRIVE	SNAP 8 ACTUATORS	TEMPERATURES MUST BE KEPT TO SNAP 8 LEVELS	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	MUST MAINTAIN SNAP 8 TEMPERATURE LEVELS	NONE SNAP TECHNOLOGY	LAUNCH ABORT WATER CRITICALITY PREVENTED BY B ₄ C PLUG
<u>SHIELDS</u>							
GAMMA	HEAVY METAL	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE SNAP 8 TECHNOLOGY	NONE	NONE SNAP 8 TECHNOLOGY	
NEUTRON	LITHIUM HYDRIDE (ACTIVELY COOLED)	ACTIVE COOLING MUST BE MAINTAINED	↓	ACTIVE COOLING OF SHIELD	ACTIVE COOLING CIRCUIT REQUIRED	↓	
<u>COOLANT</u>	Li/Mo Re HEAT PIPES	DYNAMIC (START UP/LOAD CHANGE) RESPONSE NEEDS TO BE DEMONSTRATED	VERY LOW OXYGEN CONTENT REQUIRED FOR LITHIUM WORKING FLUID	NONE HEAT PIPES SELF STARTING	HEAT PIPE DESIGN AND GEOMETRY	8 M LONG, CURVED MO RE HEAT PIPES WITH FINNED SECTIONS IN CORE	

Figure 9. Heat Pipe Reactor

would present serious reservations to the project regarding selection in July 1985 of the current heat-pipe reactor subsystem design for subsequent ground demonstration testing.

Again, as with other technology issues associated with both the fixed-bed and boiling-potassium fast reactors, it is not definite that the design will not work, but an irradiation "proof-of-principle" test should be conducted. Availability of data from such a test will not be available in March 1984, and therefore would have an impact on the July 1985 go/no-go decision.

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