IAEA Vol IV

(USA) **SRE**

SODIUM REACTOR EXPERIMENT

PURPOSE: Power Production

DATE OF INFORMATION: June 1961

GENERAL

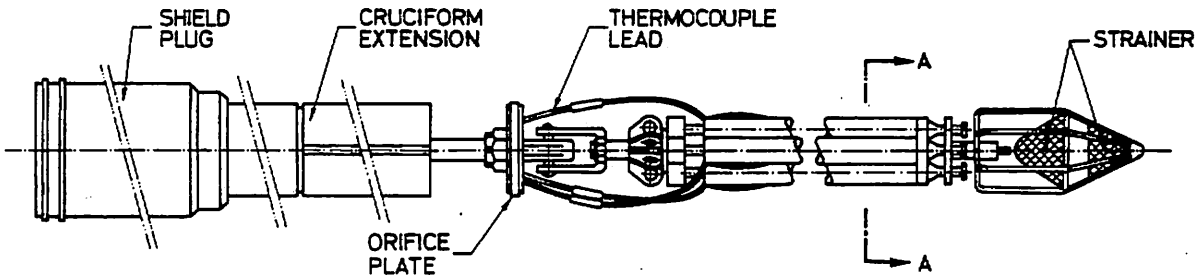
1. Reactor type	Fully enriched (93%) uranium, and thorium, graphite moderated, Na cooled
2. Number of reactors in plant	1
3. Rated output per reactor	Gross heat 20 MW (see Remarks) Gross electric 6.0 MW Net. elect. 5.7 MW Self-consumption 5%
4. Net efficiency	28.5%
5. Location	Santa Susana, California, USA
6. Owner and operator	Owned by United States Atomic Energy Commission Operated by Atomics International & Southern California Edison Co.
7. Designers	Atomics International
8. Main contractors	Atomics International
9. Present status	In operation
10. Construction schedule	Start of construction April 1955 Reactor critical April 1957 Full power operation May 1958

REACTOR PHYSICS

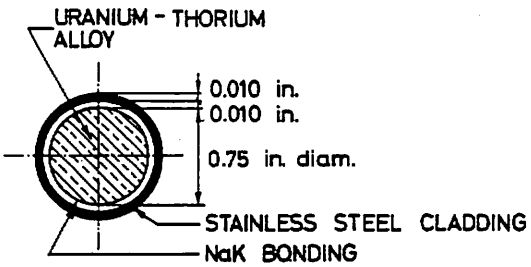
11. Neutron energy and lifetime	0.06 eV (mean, prompt)
12. Core parameters	$\eta_i = 1.818$ $\varepsilon = 1.010$ $f = 0.836$ $p = 0.879$ $k_{\infty} = 1.35$ $L^2 = 149\ cm^2$ $\tau = 374\ cm^2$
13. Conversion ratio	0.4 (initial)
14. Neutron flux	Thermal av. (reactor) 5×10^{13} n/cm² sec Thermal av. (fuel) 1×10^{13} n/cm² sec Fast av. (reactor) 1×10^{14} n/cm² sec
15. Excess reactivity to compensate for	Temperature 0.6% Xe and Sm at rated power, Xe 1.58% Sm 0.7% Burnup (10000 MWd/t) 3.5%
16. Maximum excess reactivity	4.22%

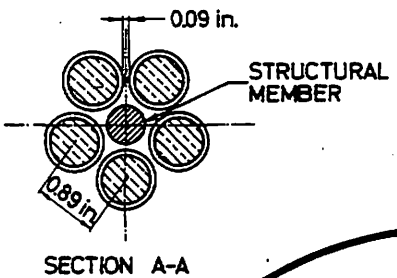
CORE

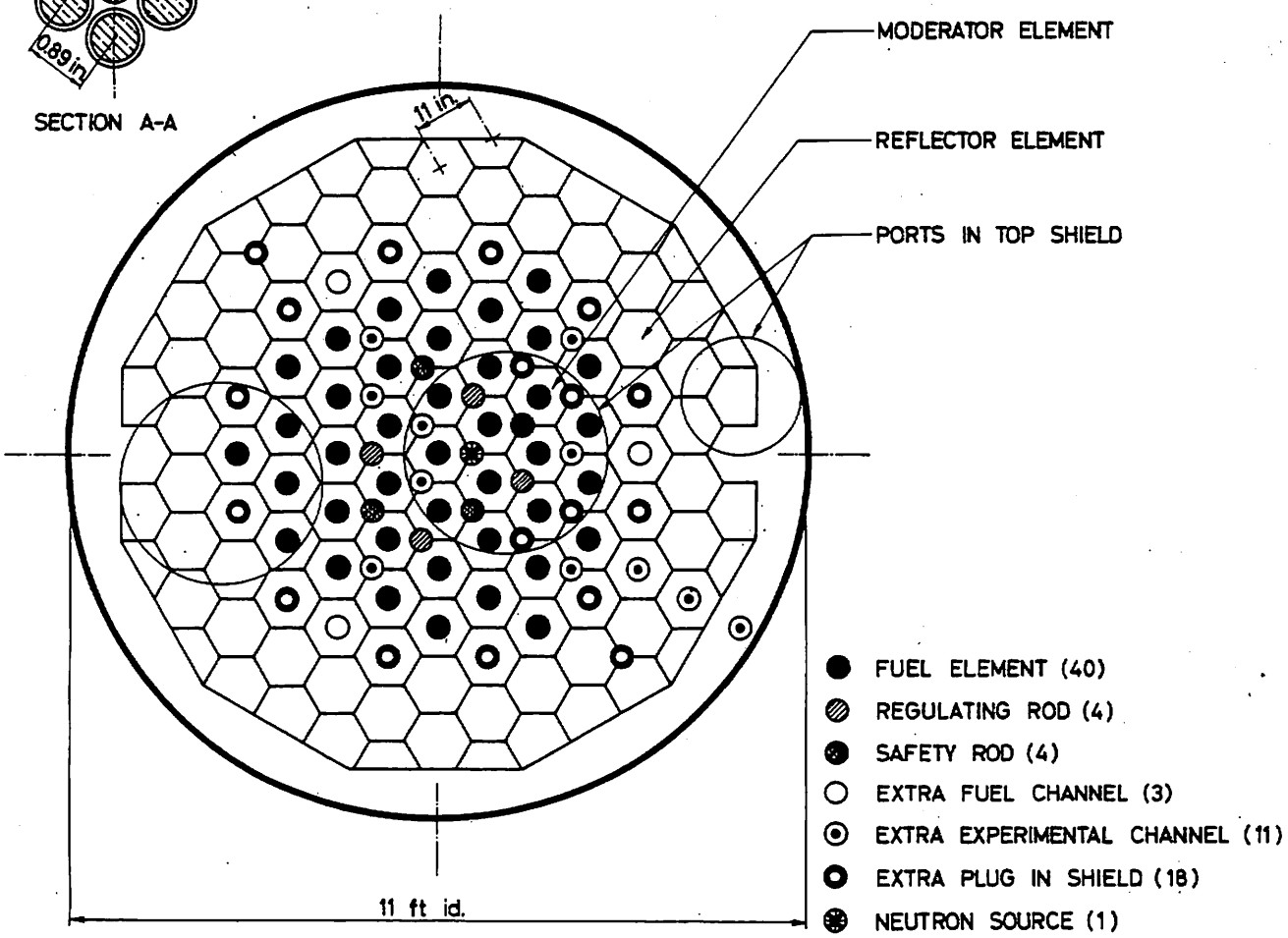
17. Shape and dimensions	Right cylinder diam. 6 ft (183 cm) height 6 ft (183 cm)
18. No. of channels & subassemblies	43 fuel channels of which 40 are loaded Fuel channel is a Zirconium tube 2.8 in. (7.1 cm) id. with a 0.035 in. (0.089 cm) wall thickness
19. Lattice	Triangular Pitch 11 in. (27.5 cm)
20. Critical mass	62 kg U^{235} in thorium alloy
21. Core loading at rated power	81 kg U^{235} and 1160 kg thorium
22. Average specific power in fuel	Approx. 250 kW/kg U^{235}
23. Average power density in core	4.2 kW/liter
24. Burnup	10000 MWd/t estimated
25. Fuel loading and unloading	After shut-down, lead fuel cask is positioned over the element. A latch mechanism engages the top plug and lifts element into the lead shielded cask of the handling machine. It is removed to storage pit
26. Irradiated fuel storage	Storage pit has 99 cells (steel tubes 4 in. diam., 21.5 ft long) with inert atmosphere. 80 cells cooled by kerosene
27. Refuelling schedule	After 10 hr cooling period, refuelling *downtime is* about 2 hr per element
28. Moderator	31 000 lb of hexagonal graphite logs: 10.76 in. across flats, 10 ft long. Clad with 0.035 in. Zr. Each has a central channel for fuel element. Av. temp. 420° C, max. 535° C; cooled by primary Na
29. Blanket gas	Helium



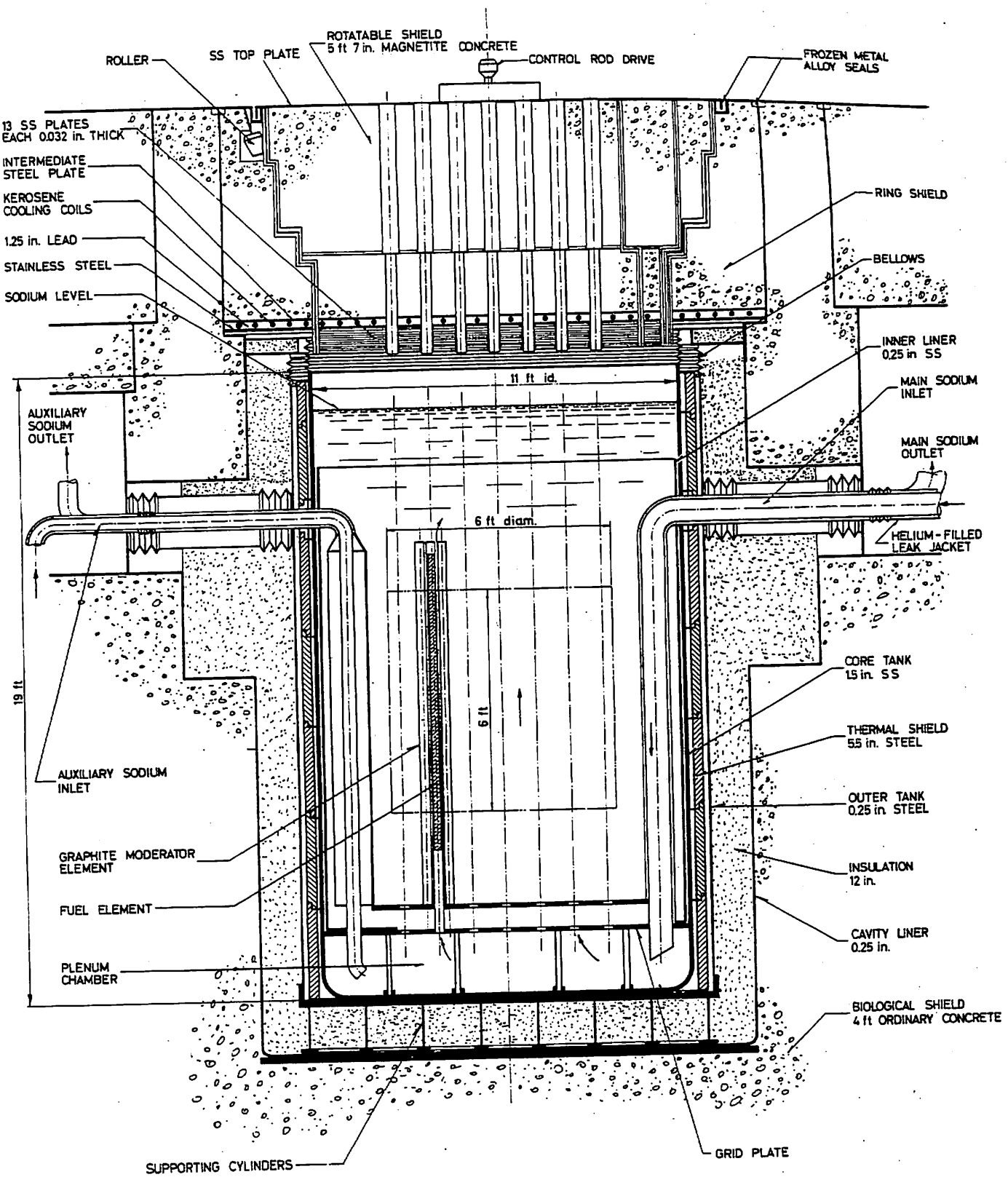
FUEL ELEMENT







HORIZONTAL SECTION REACTOR SRE



VERTICAL SECTION REACTOR SRE

FUEL ELEMENT

30. Form and composition	12 slugs, each 0.75 in. diam., 6 in. long, form a rod. 5 rods are spaced equally on a 1.51 in. diam. circle around a 0.375 in. diam. central tie rod of type 304 stainless steel Enrichment 93%; uranium metal alloyed with 92.4 wt. % thorium metal	31. Cladding	0.01 in. type 304 stainless steel cladding, 0.79 in. od. 0.01 in. NaK bonding Each tube has a spiral spacer wire of 0.091 in. diam.
		32. Subassemblies	5-rod cluster (see No. 30)

CORE HEAT TRANSFER

33. Heat transfer area	5.89 ft² (5475 cm²) per element 235 ft² (21.9 m²) total	40. Coolant mass flow rate	485000 lb/hr (220000 kg/hr)
34. Heat flux	Av. 289000 BTU/ft² hr (21.8 cal/cm² sec) Max. 419000 BTU/ft² hr (31.6 cal/cm² sec)	41. Coolant temperatures	Inlet 500° F (260° C) Outlet 960° F (515° C)
35. Film temperature drop	45° F (25° C) design	42. Coolant pressures	Inlet 10 psig (5.7 psig of which is due to static head) Outlet 4 psig (2.3 psig of which is due to static head)
36. Fuel element temperatures	Max. fuel 1168° F (620° C) Max. clad 997° F (536° C)	43. Hot channel factors	Not available
37. Coolant flow area	Per element 3.56 in.² (23 cm²) Total 143 in.² (920 cm²)		
38. Channel velocity	3.2 ft/sec (0.98 m/sec)	44. Shut-down heat removal	1 MW (thermal) auxiliary sodium loop, air cooled
39. Heat transfer coefficient	1031 BTU/ft² hr °F (0.14 cal/cm² sec °C)		

CONTROL

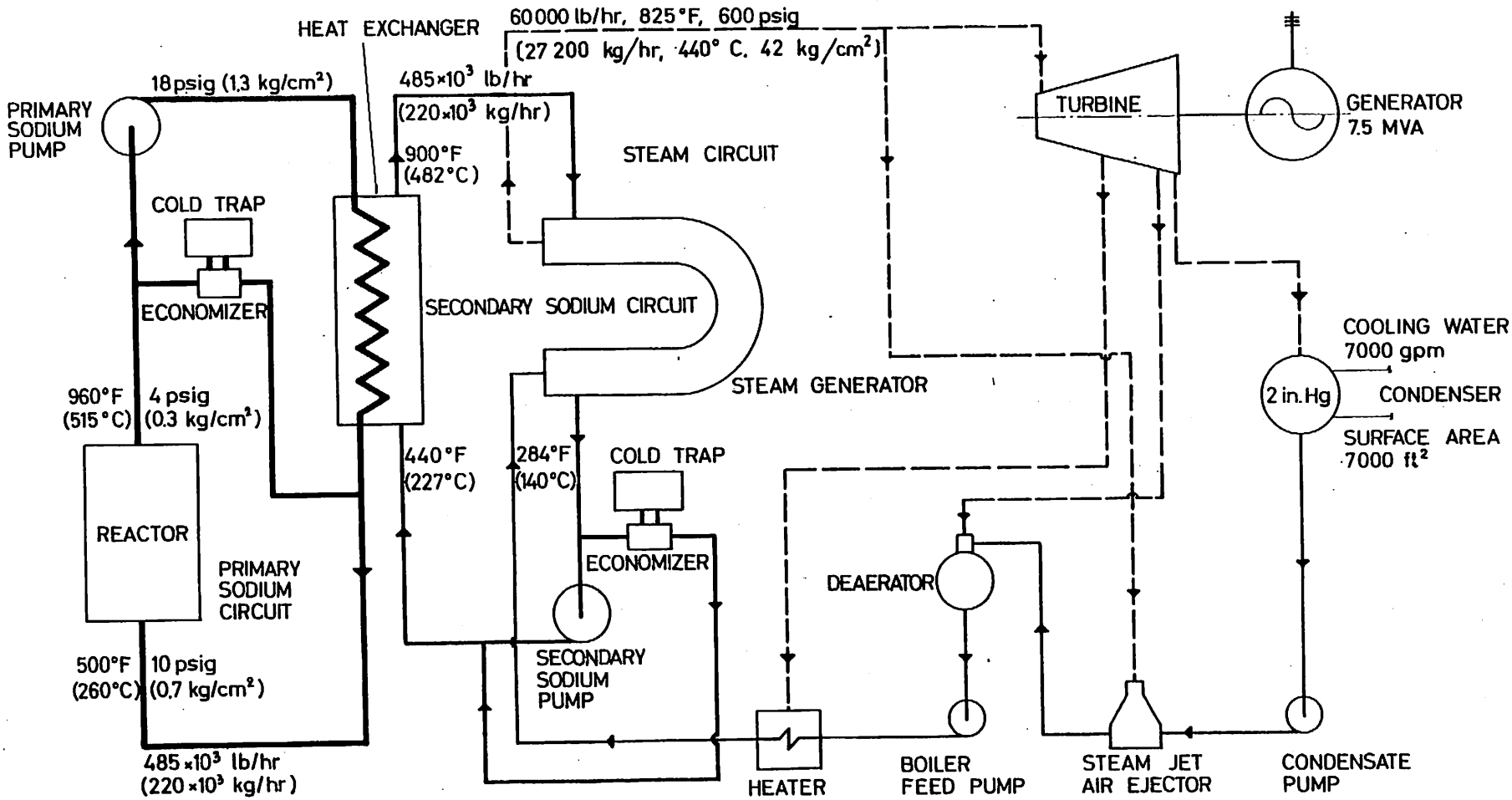
45. Control, regulating and safety rods	8 hollow cylindrical control rods: 4 safety and 4 regulating Poison material is nickel with 1.5 wt.% boron Rods operate in thimbles with He atmosphere 4 safety rods, 142 cm absorber section Total worth 6.6% $\frac{\Delta k}{k}$ Speed 9% $\frac{\Delta k}{k}$/sec 4 regulating rods, 183 cm absorber-section Total worth 8.8% $\frac{\Delta k}{k}$ Speed: fast 1.03 cm/min, or 1.9×10^{-3} % $\frac{\Delta k}{k}$/sec slow 0.91 cm/min, or 1.7×10^{-3} % $\frac{\Delta k}{k}$/sec	47. Reactivity addition rate	Max. 0.0136% $\frac{\Delta k}{k}$/sec
		48. Scram time and mechanism	Drop time 0.7 sec Magnetic latch release mechanism
		49. Sensitivity of auto. control	Not available
		50. Temperature coefficients	Fuel (prompt) -4×10^{-5} % $\frac{\Delta k}{k}$/°C Moderator (delayed) $+4.5\times10^{-5}$ % $\frac{\Delta k}{k}$/°C at 400° C
		51. Burnable poison	None
46. Other control features	None	52. Other shut-down provisions	None

REACTOR VESSEL AND OVERALL DIMENSIONS

53. Form, material and dimensions	Type 304 stainless steel cylindrical vessel with 11 ft (334 cm) id., 18.8 ft (572 cm) high with a 1.5 in. (3.8 cm) thick wall This is contained in an outer tank of carbon steel, with open top, 19 ft (580 cm) high and 12.5 ft (382 cm) id., with 0.25 in. (0.635 cm) thick side walls and 3 in. (7.6 cm) thick bottom	54. Working, design & test pressures	Design temperature 800° C
		55. Reactor with shielding	20.5 ft (6.25 m) diameter 32.8 ft (10 m) high

FLUID FLOW

56. Heat exchangers	One Na/Na intermediate U-shape shell & tube, counter flow type. Surface area 1155 ft² (107 m²) One steam generator, once through, U-shaped, double walled SS tubes (with Hg in the annulus), Na on shell side. Rating 60000 lb/hr at 600 psig & 825° F	58. Decomposition & recombination	Negligible amount of Mg-24 formation by neutron capture in sodium
		59. Cooling system safety	Large heat capacity of the system. Double piping and sealed bellows. Isolation valves for each loop
57. Coolant losses and purification	Minor losses of sodium by washing of fuel elements for hot cell examination. There has been no coolant addition to SRE Removal of carbon and oxygen by hot and cold traps	60. Fuel failure detection	Xe^{133} detector system which monitors radioactivity of core cover gas (helium)



FLOW DIAGRAM REACTOR SRE

REFLECTOR AND SHIELDING

61. Reflector	Hexagonal graphite logs, 10 ft long, 10.76 in. across flats. Logs adjacent to core are clad with 0.035 in. Zr and outer logs clad with 0.020 in. SS. Cooled by sodium pool in which core and reflector are immersed. Similar to moderator units but without central channel
62. Radiation levels	30 mr/week at personnel stations
63. Shielding	Sides: 0.25 in. SS liner+2.5 in. Na+1.5 in. SS inner (core) tank+5.5 in. low carbon steel rings +0.25 in. outer tank+0.25 in. cavity liner, biological shield 4 ft of ordinary concrete Bottom: 1.5 in. SS grid plate+18 in. Na+1.5 in. SS inner (core) tank+3 in. outer tank+1 in. carbon steel cavity liner, biological shield 4 ft of ordinary concrete Top: 13 SS plates each 0.032 in.+2 steel plates 1 in. thick+1.25 in. Pb, biological shield 67 in. magnetite concrete+2 in. steel Core cavity liner and top shield cooled with kerosene

CONTAINMENT

64. Type and material	No containment shell, conventional concrete building Reactor and primary system contained in sealed concrete galleries below grade with an inert (nitrogen) atmosphere
65. Surroundings	Reactor located at a 44 acre site in mountainous, rocky area 1850 ft above sea level, 30 miles from Los Angeles and 10 miles from densely populated San Fernando valley

TURBO – GENERATOR

66. Turbine	7.5 MW straight condensing unit, non-reheat, 13 stage, 2 point extraction, 3600 rpm
67. Generator	7.5 MVA, 3600 rpm, 2.4/4.16 kV, power factor 1.0, air cooled

COST ESTIMATE

68. Total capital investment in reactor plant	Reactor 2.43×10^6 Sodium cooling system 1.54×10^6 Auxiliary system 1.18×10^6 Reactor facilities and instr. 1.59×10^6 Steam plant 1.40×10^6 Miscellaneous 0.67×10^6 Total 8.81×10^6 Including first fuel loading but excluding research and development
69. Cost per kw installed	$1470/kW
70. Load factor and production /yr	Not available
71. Plant life and interest rate	Not available
72. Total production costs	Not available

STAFF

REMARKS

SRE is operating with a second core, a change from uranium to thorium-uranium alloy having been made. Future plans indicate an even further switch to uranium carbide as fuel. The reactor nominally produces 20 MW of heat; about 19 MW is handled in the primary system and about 1 MW in the auxiliary system. With the new carbide fuel an increase in output up to 40 MW is expected

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