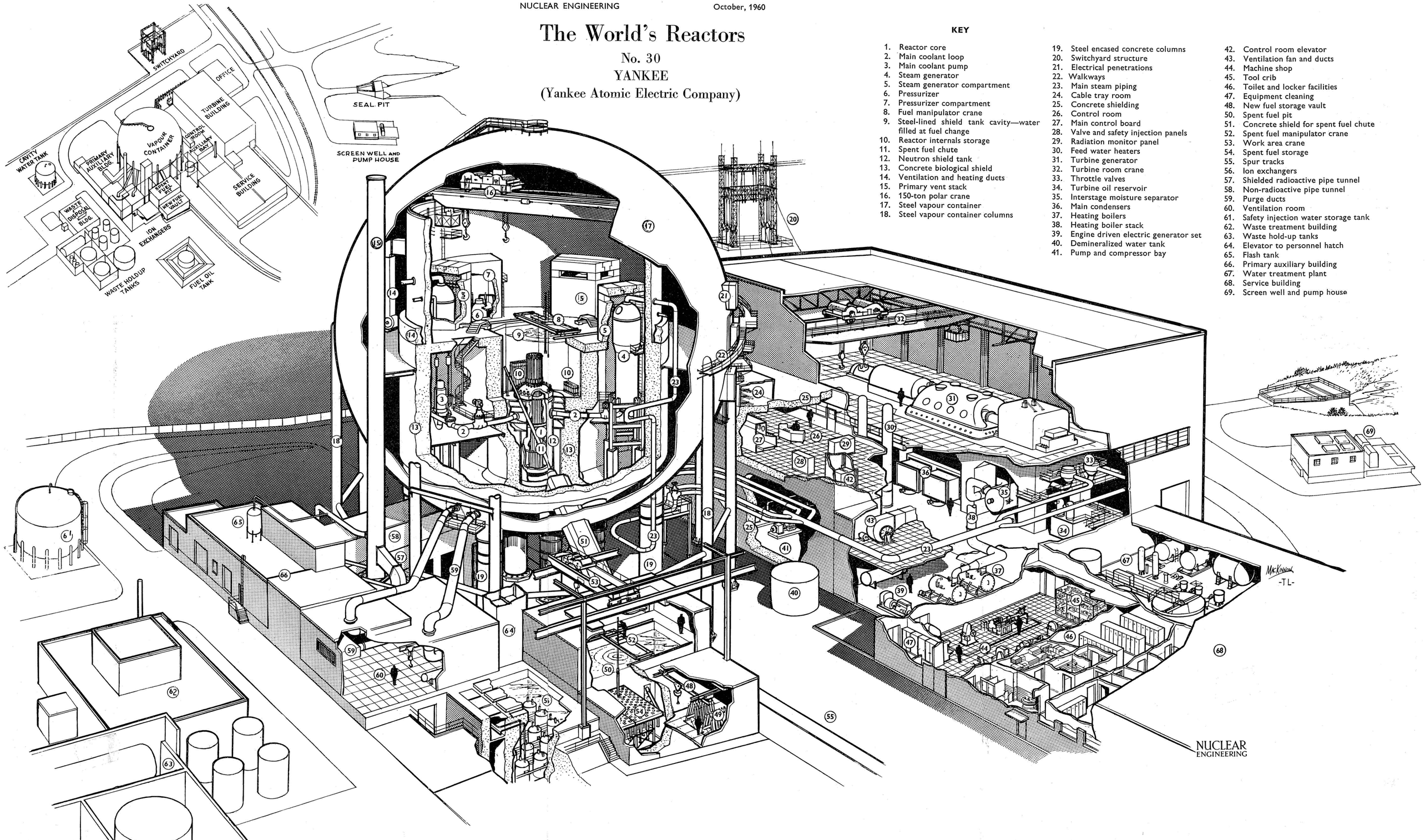
The World's Reactors

No. 30

YANKEE

(Yankee Atomic Electric Company)



KEY

1. Reactor core
2. Main coolant loop
3. Main coolant pump
4. Steam generator
5. Steam generator compartment
6. Pressurizer
7. Pressurizer compartment
8. Fuel manipulator crane
9. Steel-lined shield tank cavity—water filled at fuel change
10. Reactor internals storage
11. Spent fuel chute
12. Neutron shield tank
13. Concrete biological shield
14. Ventilation and heating ducts
15. Primary vent stack
16. 150-ton polar crane
17. Steel vapour container
18. Steel vapour container columns
19. Steel encased concrete columns
20. Switchyard structure
21. Electrical penetrations
22. Walkways
23. Main steam piping
24. Cable tray room
25. Concrete shielding
26. Control room
27. Main control board
28. Valve and safety injection panels
29. Radiation monitor panel
30. Feed water heaters
31. Turbine generator
32. Turbine room crane
33. Throttle valves
34. Turbine oil reservoir
35. Interstage moisture separator
36. Main condensers
37. Heating boilers
38. Heating boiler stack
39. Engine driven electric generator set
40. Demineralized water tank
41. Pump and compressor bay
42. Control room elevator
43. Ventilation fan and ducts
44. Machine shop
45. Tool crib
46. Toilet and locker facilities
47. Equipment cleaning
48. New fuel storage vault
50. Spent fuel pit
51. Concrete shield for spent fuel chute
52. Spent fuel manipulator crane
53. Work area crane
54. Spent fuel storage
55. Spur tracks
56. Ion exchangers
57. Shielded radioactive pipe tunnel
58. Non-radioactive pipe tunnel
59. Purge ducts
60. Ventilation room
61. Safety injection water storage tank
62. Waste treatment building
63. Waste hold-up tanks
64. Elevator to personnel hatch
65. Flash tank
66. Primary auxiliary building
67. Water treatment plant
68. Service building
69. Screen well and pump house

The World's Reactors

No. 30 Yankee

TYPE: Thermal heterogeneous (PWR).

LOCATION: Rowe, Massachusetts.

PURPOSE: Power production.

OWNER: Yankee Atomic Electric Company (combination of 10 New England utility companies).

DESIGNERS: Westinghouse Electric Company and Stone and Webster.

STATUS: Critical: August 19, 1960. Full power scheduled for late autumn.

OUTPUT: First core: 392 MWt; 110 MWe.
Future: 482 MWt; 134 MWe.

FUEL: Enriched uranium oxide (3.4%).
Total loading: 23,738 kg UO_2.

CORE: Cylindrical prism with 76 channels, arranged 4–6–8–10–10–10–10–8–6–4.
Equivalent diameter: 75.68 in. (1.92 m).
Height: 91.86 in. (2.33 m).
Average power density: 58.4 kW/litre.

ε =1.06.
p =0.562.
k_{eff} =1.090.
τ =50.2 cm². } hot
k_{eff}, cold, clean, 1.219.

Excess reactivity for:
Temperature: 9.7%.
Xe and Sm (at rated power): 3.2%.
Burn-up: 9.0%.
Total excess reactivity 21.9% $\Delta k/k$.

Neutron flux:
Thermal, average: 2.0×10^{13} n/cm², sec.
Thermal, max.: 9.6×10^{13} n/cm², sec.
Temperature coefficients at zero power:
Moderator: -3×10^{-2} % $\Delta k/k$°F. } design calculation,
Fuel: -4.6×10^{-3} % $\Delta k/k$°F. } zero power.

FUEL ELEMENTS: Rod bundle type, arranged 18×18 to form an element 7.66 in. (194.5 mm) square, with shortened rows at two corners to leave space for cruciform control rods.
No. of rods per element: 304 or 305, UO_2 pellets clad in stainless steel.
Overall dia. of rod: 0.340 in. (8.64 mm).
Thickness of cladding: 0.021 in. (0.533 mm).
Diameter of pellet: 0.294 in. (7.47 mm).

CONVERSION FACTOR: 0.529.

BURN-UP: Average: 7,800 MWd/te.

CONTROL: Silver-indium-cadmium rods of cruciform section, 7.865 in. (199.8 mm) square, and 0.265 in. (7.24 mm) thick, with Zircaloy-2 followers. Active length: 90 in. (2.286 m).
No. of rods: 32 (24 regulating; 8 fixed shim).
Total worth of rods: 15% $\Delta k/k$.
Scram time: less than 2 sec.
The reactor has no burnable poison, but a boric acid injection system is included in the design.

COOLANT: Pressurized water.
Inlet temperature: 499°F (260°C).
Outlet temperature: 532°F (278°C).
Coolant pressure: 2,000 p.s.i.a. (140.6 kg/cm² abs.).
Mass flow: 37.8×10^6 lb/h (17,140 te/h).
Channel velocity (average): 14 ft/sec (4.27 m/sec).
Heat transfer area: 15,500 ft² (1,440 m²).
Heat flux: Average: 86,300 B.t.u./ft², h (6.50 cal/cm², sec).
Maximum: 446,000 B.t.u./ft², h (33.6 cal/cm², sec).
Maximum fuel element temperatures: Fuel: 4,330°F (2,388°C).
Cladding: 663°F (350°C).

PRESSURE VESSEL: Carbon steel, clad with stainless steel.
Height: 31 ft 6 in. (9.6 m).
Inside diameter: 9 ft 1 in. (2.77 m).
Thickness of side: 7.875 in. (200 mm).
Design pressure: 2,500 p.s.i.a. (175.77 kg/cm²) at 650°F (343.3°C).

HEAT EXCHANGE: Four primary loops each with one heat exchanger of the vertical shell and inverted U tube type.
Heating surface: 4×13,430 ft² (1,247 m²).
Steam generation: 4×500,000 lb/h (228 te/h).
Steam pressure: 500 p.s.i.a. (35.15 kg/cm² abs.).

SHIELDING: Radial shielding (total): 15 in. (0.381 m) of steel; 4 ft (1.524 m) water; 10 ft (3.048 m) concrete.
Top: 7 in. (0.178 m) steel; 12 ft 9 in. (3.886 m) water.

CONTAINMENT: Steel sphere. Diameter 125 ft (38.1 m).
Thickness 0.875 in. (22.2 mm).
Design pressure: 34.5 p.s.i. (2.425 kg/cm²).

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