## The World's Reactors

No. 32 Windscale AGR

OWNER: U.K.AEA. PURPOSE: Experimental; power production. LOCATION: Windscale, Cumberland. DESIGNER: U.K.AEA. TYPE: Thermal, heterogeneous, CO2 cooled graphite moderated, PROGRAMME: Site work commenced: October 1958, Critical: summer 1961. Power operation: end of 1961. CAPACITY: Thermal output: 100 MW. Gross electrical output: 33 MW. Net electrical output: 27-3 MW. FUEL: Enriched uranium oxide pellets. Density: 95% theoretical.

Average fuel rating: 8.6 MW/t(U).

Maximum fuel rating: 19.5 MW/t(U).

Total charge: 13-2t. CLADDING: FUEL Stainless steel clad: ELEMENTS: 4 fuel element assemblies in graphite sleeve, 5 tie rod, per channel.

Sub-assemblies: 2 clusters × 21 fuel elements.

Elements: 0-43 in o.d. × 18 in long.

Pellets: 0-400 in dia. × 0-400 in long.

Enrichment: 2.5% U<sup>235</sup>.

Maximum can surface temp.: 650°C.

Expected burn-up: 10 000 MWd/t.

Beryllium chd. Beryllium clad: tie rod, per channel.

Sub-assemblies: 3 clusters × 36 fuel elements.

Elements: 0-38 in o.d. × 12 in long.

Pellets: 0-300 in dia. × 0-300 in long.

Enrichment: 1.8% U<sup>238</sup>.

Tsm: 600°C. Expected burn-up: 10 000 MWd/t. Moderator and reflector; graphite.
Dimensions: 15 ft dia. (nom.)×14 ft high.
Reflector: 20 in radial; 24 in axial.
Graphite weight: 210 ton.
No. of bricks: 3 000. CORE Lattice: triangular, 10% in pitch.

No. of main channels: 253.

Core contains five independently cooled loops.

Initial charge in main core; stainless steel clad.

Experimental channels: beryllium clad elements.

Core is unflattened. PRESSURE Cylindrical with hemispherical ends. Overall height 53 ft 6 in, 21 ft 3 in o.d. Closure: all welded. COOLANT: Working pressure: 270 psig. Inlet temperature: 250°C to 325°C. Outlet temperature: 500°C to 575°C. Total gas in system: approx. 14 ton. Rate of circulation: 760 lb/s (approx. 20 ton/min). Flow is re-entrant through core, final pass upwards. HEAT
EXCHANGERS: Wall thickness: 17/16 in.
support strake: 2½ in.
Heat exchange surface for evaporator and economizer section:
2 in o.d. ERW tube with extended surface of ½ in helical fins.
pirched 6 in. Superheater 4 240 ft2. Forced circulation evaporation. Steam conditions 650 psi, 850°F (454°C). Four, centrifugal type. Capacity of each: 190 lb/s. Pressure differential 28 psi. Fixed speed: 3 000 rev/min. CIRCULATORS: CONTROL: Reactivity controlled: 1% each. Auto responds to exit gas temperature. Emergency shut-down: 1-4% boron stainless iron balls. Reactivity controlled: approx. 3%. No. of channels involved: 8 provisionally. SHIELDING: Biological side: 7 ft 6 in concrete. Biological top: 6 ft concrete.

TURBINE:

Stainless steel, 0.015 in wall, or beryllium, 0.040 in wall. 4 fuel element assemblies in graphite sleeve, 5 in o.d. on central 4 fuel element assemblies in graphite sleeve, 5 in o.d. on central Overall neight 53 ft 6 in, 21 ft 3 in o.d.

Thickness, barrel portion: plain strakes: 2½ in,

Support strakes: 4½ in and 3½ in,

Ends: 1½ in-3½ in.

Total weight: 250 ton approx.

Material: Al-killed, grain-controlled mild steel, type Conlo 1. pitched 6 in.

Superheater section: plain unfinned 2½% Cr/1% Mo tube.

Heat transfer area for each exchanger

Economizer 11 750 ft².

Evaporator 30 800 ft². Concentric gas ducts between reactor and heat exchangers:

1 ft 11 in and 2 ft 10 in diameter, carbon steel. Flow control: by adjustable inlet vanes.

Drive: 1 570 h.p. squirrel-cage a.c. motor, with pony motor. Coarse control: 12 manually operated boron steel rods. Reactivity controlled: approx. 7-8%. Fine control: 3 manual/auto stainless steel rods. Top and side, thermal: 6 in steel.

Top neutron: 7 ft graphite interleaved with seven & in boron steel NUCLEAR H.E. side: 2 ft concrete. CONTAINMENT: Steel building with hemispherical upper portion, conical lower portion and flat bottom. ENGINEERING Max. dia.: 135 ft. Base dia.: 76 ft 8 in. Height above ground level: 134 ft.
Plate thickness: 115/16 in max., ½ in min.
Total weight (excluding air locks): 850 ton. Capable of withstanding 10 psi internal pressure with leak rate not exceeding 0.1% of net volume in 24 h. 33 MW, 3 000 rev/min, 2-cylinder impulse-reaction type 650 psi. 850°F, 28.6 inHg vacuum. 11. 4 ft gas main 1, Core 21. Inter-shield cooling ducts 31. Economizer 41. Circulator pony motor 51. Hot pressurized test facility 61. Carousel cooling system 71. Cooling towers 81. Electrical control room 42. Circulating pumps 2. Top neutron shield 12. Pressure vessel 22. Inter-shield cooling fans 32. Evaporator 52. Spent element plant room 62. Carousel control room 72. Ventilation chemical plant 82. Turbine hall 3. Thermal shield 13. Inlet gas seal 23. Channel stand-pipes 43. Personnel lock and walkway 33. Superheater 53. Graphite sampling room 63. Stringer break-down cave 73. Stack 14. Hot box 4. Core restraint 24. Control rod motors 34. Steam drum 44. Local H.E. panel 54. Reactor service crane 64. Shield plugs and control rod store 74. Emergency air lock 15. Gas baffles Experimental channels 25. Removable top shield 45. Containment vessel ventilation 35. Steam pipe to T.S.V. 55. Charge/discharge machine 65. Inspection cave 75. Containment shell AGR KEY 6. Diagrid 16. Concentric ducts 26. Control rod storage 36. By-pass ducts 56. Pressurizing / depressurizing C/D 66. Transit flask for s.p.s and c.r.s 76. Sealing membrane 46. BFED equipment 7. Tundish 17. Pressure vessel support members 27. Heat exchangers 37. Hot valve 67. Dismantling cave 77. Cable ducts 47. H.E. rolling supports 57. Spent fuel chute C TEMPLE PRESS LIMITED, 1961. 18. Top dome lagging 8. Bottom dome access 28. Heat exchanger biological shield 38. Cold valve 68. Spent fuel element transit 78. Reactor control room 48. Goods air lock 58. Uncoupling facility 9. Viewing branches 19. Shield cooling ducts 29. Shield pressure relief valves 39, Circulator 69. Gantry hall 79. Emergency reactor control room 49. Test cells 59. Transit tube air locks 10. Bottom cooling membrane 20. Thermal columns Printed in England by Temple Prist Limited. Bowling Green Lane London, E.C.1. 30. By-pass duct diffusers 40. Circulator drive motor 70. New fuel element assembly room 80. Ventilation plant room 50. New fuel facility 60. Spent fuel carousel

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