

Nuclear Power in Canada and Beyond

Table of Contents

Foreword, by Elgin Horton

Introduction

Acknowledgements

1. Nuclear Fission Explained

2. Reactor Control

3. Reactor Protection

4. Emergency Core Cooling and Containment Systems

5. World's Major Reactor Types

 Magnox Reactors

 Advanced Gas Cooled Reactors – AGRs

 Pressurized Water Reactors – PWRs

 Boiling Water Reactors – BWRs

 Pressurized Heavy Water Reactors - CANDUs – PHWRs

 Graphite Moderated Boiling Water Reactors – RBMKs

 Miscellaneous Reactor Types

 High Temperature Gas-Cooled Reactors – HTGRs

 Fast Breeder Reactors – FBRs

6. Nuclear Reactor Fuel – the CANDU Fuel Bundle

 Canadian Fuel Manufacturing

 Uranium Mining, Concentrating and Refining

 Reactor On-power Fuelling

7. Detailed Views of Canadian Nuclear Power Stations

 Pickering Nuclear Generating Station

 Control Room

 Reactor Building Cutaway

 Heat Transport in the Boiler Room

 Primary System Boilers and Pumps

 Heat Transport Pump

 Reactor Building Elevation

 Reactor Assembly

 Fuel Channel Cutaway

 Feeder Tube Arrangement

 Vacuum Building and Relief Duct

 Vacuum Building Spray System

 Reactivity Control Devices

 Zone Control and Flux Detector Rods

 Hybrid Encapsulated Straight Individually

 Replaceable (HESIR) flux detector assemblies

 Adjuster and Shut-off Rods

 Shutdown Systems

 CANDU 6 Reactor and Reactivity Mechanisms

 Reactor Assembly

- Reactor General assembly – Section
- Reactor General assembly – Plan
- Reactor Layout – Elevation
- Flux Detector Unit
- Typical Ion Chamber Arrangement
- Uncompensated Tri-axial Ionisation Chamber
- Adjuster Unit, Zone Control Unit,
and Shut-off and Control Absorber Units
- Horizontal Flux Detector Units
- Fuel Handling System
 - Pickering GS Fuel Transfer Flow Diagram
 - New Fuel Loader
 - New Fuel Loading Area (East)
 - Fuel Transfer Room
 - New Fuel Magazine
 - Fuel Transfer Mechanism
 - Fuel Transfer Mechanism Telescopic Ram
 - Fuel Transfer Port
 - Spent Fuel Elevator – Complete
 - Spent Fuel Elevator – Details of Top and Bottom Housings
 - Pickering GS General Layout of Fuelling Machine Facilities
 - Fuelling Machine Bridge
 - Fuelling Machine Carriage
 - Fuelling Machine Head
 - Snout and Magazine Assembly, Fuelling Machine Head
 - Fuelling Machine Magazine Drive
 - Fuelling Machine Separators
 - Operation of Side Stops, Sensor and Pusher – 1
 - Operation of Side Stops, Sensor and Pusher – 2
 - Fuelling Machine Ram – Front of Ram Assembly
 - Fuelling Machine Head – Rear of Ram Assembly
 - Fuelling Machine Tape Drive
 - Fuelling Machine Snout Plug
 - Operation of Snout Plug
 - Coolant Channel Closure
 - Fuelling Machine Guide Sleeve
 - Coolant Channel Shield Plug
 - Ram Adapter
 - Fuel Handling Console
 - Fuel Handling – On-Power Fuelling
- 8. Standby and Emergency Power Supply Generators
- 9. Keeping Your Fuel Cool
- 10. Nuclear Power and Nuclear Weapons
 - Safeguards
 - Safeguards, Non-Proliferation and the Peaceful Uses of Nuclear Energy

Treaty on the Non-Proliferation of Nuclear Weapons (1968)
Situation on 31 December, 1999 with Respect to the Conclusion of Safeguards Agreements
between the Agency and Non-Nuclear Weapons States in Connection with NPT
Situation on 31 December, 1999 with Respect to the Conclusion of Safeguards Agreements
between the Agency and States party to the Treaty of Tlatelolco
Non-Proliferation Issues, by Dr Jeremy Whitlock, PhD

11. Heavy Water Management
12. Radioactive Emissions to the Environment
13. Radioactive Waste from Nuclear Power
 - Canadian Wet Spent Fuel Storage Facilities
 - Canadian Dry Spent Fuel Storage Facilities
14. Radiation Protection
15. The Conventional Side of a Nuclear Power Station
16. Things that can Go Wrong
17. The Economy of CANDU Reactors
18. The Life Span of Nuclear Plants
19. Plant Decommissioning
20. Photographs and Drawings of various Canadian Nuclear Facilities
 - Chalk River Nuclear Laboratories
 - Bruce Nuclear GS
 - Reactor Building (Cutaway View)
 - Darlington Nuclear GS
 - Darlington cutaway drawings
 - Darlington Turbine Hall
 - Darlington Unit 4 Turbine
 - Darlington Reactivity Mechanism Deck
 - Darlington East Spent Fuel Bay
 - Gentilly Nuclear Power Station
 - Point Lepreau Nuclear Generating Station
 - Main Control Room Panels
 - Equipment Airlock
 - Personnel Airlock
 - 600 MW Reactor Building Cutaway
21. Drawings and Descriptions of Reactors Other than CANDUs
 - Magnox Reactors
 - Calder Hall and Chapel Cross
 - Hunterston "A"
 - Wylfa
 - Advanced Gas-Cooled Reactors
 - Dungeness "B"
 - Hartlepool
 - Heysham
 - Pressurized Water Reactors
 - Sequoyah Nuclear Power Station
 - Boiling Water Reactors

- Vermont Yankee Nuclear Power Station
- Advanced Boiling Water Reactor
- Fast Breeder Reactors
 - Enrico Fermi, Unit 1
- RBMK Light-Water Graphite Reactor
 - Positive Void Coefficient
 - A table listing the World's RBMK reactors
 - Post Accident Changes to the RBMK, including
 - Immediate safety changes
 - Control rod redesign, and
 - Backfitting
- 22. Reactor Accidents
 - Fuel Meltdown Incidents, by Kursat Burak Bekar
 - The NRX Incident (12 December, 1952), by Peter Jedicke
 - Windscale (10 October, 1957)
 - Three Mile Island
 - The Three Mile Island 2 (TMI-2) Reactor Accident, compiled by Dr. Tony Baratta
 - The Accident at Three Mile Island
 - What Happened at TMI-2 on 28th March 1979
 - The Accident
 - The Accident at Chernobyl Unit 4 (26 April 1986)
 - Chernobyl – A Canadian Perspective, by Dr. V.G. Snell and J.Q. Howieson
 - Cross-section drawing of destroyed Chernobyl Unit 4 reactor
 - Chernobyl - Assessment of Radiological and Health Impacts - 2002
 - Update of *Chernobyl: Ten Years On*. Reference to this 157 page paper on the Internet

Conclusions

Appendices

- A Canadian Power Reactors
- B Off-Shore CANDU Power Reactors
- C Canada's Nearest Nuclear Neighbours - Power Reactors in the United States
- D Canadian Uranium Mines
- E Uranium in Saskatchewan Uranium Reserves and Resources
- F Uranium Milling, Refining and Conversion
- G Canadian Heavy Water Production Plants
- H Know Your Reactors
- I Load Factors to end December, 2005, courtesy of Nuclear Engineering International
- J Nuclear Power Plants and Their Fuel as Terrorist Targets

Glossary

Bibliography

Index