

## PROFESSIONAL RESUME

DR. KRISHNA P. SINGH  
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### CURRENT AFFILIATIONS:

President and Chief Executive Officer  
Holtec International

Professor, Institute for Advanced Discovery &  
Innovation University of South Florida

### EDUCATION:

University of Pennsylvania  
Ph.D. in Mechanical Engineering (1972)

University of Pennsylvania  
M.S. in Engineering Mechanics (1969)

B.I.T. Sindri, Ranchi University (India)  
B.S. in Mechanical Engineering (1967)



### PROFESSIONAL EXPERIENCE:

Dr. Singh has been active in the nuclear power industry since 1971 and has served as President and CEO of Holtec International since 1986. In his early career, Dr. Singh participated in the development of design of systems, structures, and components, with special focus on critical service heat exchangers and pressure vessels for PWRs and BWRs for scores of nuclear units around the world. In this period, he helped develop several national consensus codes and standards for the heat exchanger and pressure vessel industry that are still being used decades after their publication. After the TMI accident, his professional focus shifted to the introduction and regulatory acceptance of safe and robust technologies to deal with the growing stockpile of used nuclear fuel and high-level waste. Under Dr. Singh's leadership, Holtec International has risen into a complex global organization with an active business presence in 18 countries on five continents, thirteen operation centers and four world class manufacturing plants that produce a whole range of equipment and systems for the nuclear power industry. In recent years, Dr. Singh has been focusing on developing innovative solutions for *prompt decommissioning* of aging nuclear power plants which have enabled Holtec to build a fleet of seven retired nuclear units which is the largest such fleet in North America. Holtec's ongoing efforts to establish world's first *subterranean* consolidated interim fuel storage facility is another area of Dr. Singh's professional concentration.

He has been leading the development of a uniquely safe small modular reactor named SMR-160 since 2010 which is Holtec's entrant in the global race to produce a supremely safe and economical nuclear plant.

PROFESSIONAL ENGINEERING CERTIFICATIONS:

Registered Professional Engineer - Pennsylvania (1974-present)

Registered Professional Engineer - Michigan (1980-present)

AWARDS AND HONORS:

- Robert Yarnall Award, University of Pennsylvania, Engineering Alumni Society (2007)
- Elected Member of the National Academy of Engineering (2013)
- George Washington Metal, Engineers' Club of Philadelphia (2014)
- Thomas Alva Edison Patent Award, Public Health and Safety Category, Edison Foundation (2015)
- Elected South Jerseyean of the Year, Rutgers University (2017)
- Inducted to University City Science Center's Innovators Walk of Fame (2017)
- Elected to the National Academy of Inventors (2017)
- Distinguished Alumni Award, B.I.T. Sindri (2018)
- Elected to the Academy of Science, Engineering and Medicine of Florida (2019)
- Member, PAN American Academy of Engineering (2020)

PROFESSIONAL SOCIETY AFFILIATIONS:

- Fellow of the ASME (1987); Member since 1973.
- Member ANS (1979-present)
- Chairman, TEMA Flow Induced Vibration Committee (1979-86)
- Chairman, PVP Committee of the ASME, Nuclear Engineering Division (1988-92)
- Member, ASME O&M Committee (1991-97)
- Member ASCE (1977-83)
- Member, Heat Exchange Institute (1976-86)
- General Chair, American Nuclear Society, Annual Meeting (2018)

BOARD MEMBERSHIPS:

- Chairman, Board of Directors, Holtec International (1986-present)
- Member of the Board, Nuclear Energy Institute (1998-present)
- Member, Board of Overseers, School of Engineering and Applied Science, University of Pennsylvania (2003-present)
- Member, Advisory Board, Nuclear Engineering Department, University of California, Berkeley (2015-present)
- Trustee Emeritus, University of Pennsylvania (2017-present); Trustee (2009-2017)
- Member, Board of Trustees, Cooper Health System (2011-present)
- Director, The Atlantic Council, Washington, DC (2016-present)
- Member, National Investment Council, Ukraine (2017-present)

GRANTED PATENTS IN THE UNITED STATES (PATENTS IN FOREIGN COUNTRIES NOT LISTED):

1. "Radioactive Fuel Cell Storage Rack" (with M. Holtz), U.S. Patent No. 4,382,060 (May 1983).
2. "Heat Exchanger for Withstanding Cycle Changes in Temperature" (with M. Holtz and A. Soler), U.S. Patent No. 4,207,944 (1980).
3. "Apparatus Suitable for Transporting and Storing Nuclear Fuel Rods and Methods for Using the Apparatus," U.S. Patent No. 5,898,747 (April 1999).
4. "Apparatus Suitable for Transporting and Storing Nuclear Fuel Rods and Methods for Using the Apparatus," U.S. Patent No. 6,064,710 (May 16, 2000).
5. "Cask Mating Device" (with Stephen J. Agace) U.S. Patent No. 6,625,246 (September 23, 2003).
6. "HI-TRAC Operation" (with Stephen J. Agace) U.S. Patent No. 6,587,536 (July 1, 2003).
7. "Duct Photon Attenuator" (with Everett L. Redmond, John C. Wagner, and Stephen J. Agace) U.S. Patent No. 6,519,307 (February 11, 2003).
8. "Improved Ventilator Overpack" (with Stephen J. Agace) U.S. Patent No. 6,718,000 B2 (April 6, 2004).
9. "Below Grade Canister Transfer Facility" (with Stephen Agace) U.S. Patent No. 6,793,450 B2 (September 21, 2004).
10. "Seismic Cask Stabilization Device" (with A.I. Soler) U.S. Patent No. 6,848,223 B2 (February 1, 2005).
11. "Hermetically Sealable Transfer Cask" (with Stephen J. Agace) U.S. Patent No. 6,853,697 (February 8, 2005).
12. "Underground System and Apparatus for Storing Spent Nuclear Fuel," U.S. Patent No. US 7,068,748 B2 (June 27, 2006).
13. "Forced Gas Flow Canister Dehydration," U.S. Patent No. US 7,096,600 (August 29, 2006).
14. "Below Grade Cask Transfer Facility" (with Stephen J. Agace), U.S. Patent No. 7,139,358 B2 (November 21, 2006).
15. "Closed Loop Forced Gas Fuel Dehydration," U.S. Patent No. 7,210,247 B2 (May 1, 2007).
16. "System and Method of Storing High Level Waste," U.S. Patent No. 7,330,526 B2 (February 12, 2008).
17. "Method and Apparatus for Maximizing Radiation Shielding During Cask Transfer Procedures" (with Stephen J. Agace), U.S. Patent No. 7,330,525 B2 (February 12, 2008).
18. "Systems and Methods for Storing Spent Nuclear Fuel Having Protection Design," U.S. Patent No. 7,590,213 B1 (September 15, 2009).
19. "Manifold Systems for the Ventilated Storage of High-Level Waste and a Method of Using the Same to Store High Level Waste in a Below-Grade Environment," U.S. Patent No. 7,676,016 B2 (March 9, 2010).
20. "Method and Apparatus for Dehydrating High Level Waste Based on Dew Point Temperature Measurements," U.S. Patent No. 7,707,741 B2 (May 4, 2010).
21. "Apparatus and Method for Supporting Fuel Assemblies in An Underwater Environment Having Lateral Access Loading" (with Evan Rosenbaum) U.S. Patent No. 7,715,517 B2 (May 11, 2010).
22. "Apparatus for Providing Additional Radiation Shielding to a Container Holding Radioactive Materials, and Method of Using the Same to Handle and/or Process Radioactive Materials," U.S. Patent No. 7,786,456 B2 (August 31, 2010).
23. "Apparatus, System and Method for Facilitating Transfer of High-Level Radioactive Waste to and/or From a Pool," U.S. Patent No. 7,820,870 B2 (October 26, 2010).

24. "System and Method of Storing and/or Transferring High Level Radioactive Waste," U.S. Patent No. 7,933,374 B2 (April 26, 2011).
25. "Apparatus for Transporting and/or Storing Radioactive Materials Having Jacket Adapted to Facilitate Thermosiphon Fluid Flow," (with Stephen J. Agace) U.S. Patent No. 7,994,380 B2 (August 9, 2011).
26. "Method of Removing Radioactive Materials from Submerged State and/or Preparing Spent Nuclear Fuel for Dry Storage" (with Stephen J. Agace) U.S. Patent No. 8,067,659 B2 (November 29, 2011).
27. "Systems and Methods for Storing Spent Nuclear Fuel," U.S. Patent No. 8,098,790 B1 (January 17, 2012).
28. "Canister Apparatus and Basket for Transporting, Storing, and/or Supporting Spent Nuclear Fuel" (with Stephen J. Agace) U.S. Patent 8,135,107 B2 (March 13, 2012).
29. "Apparatus and Method for Supporting Fuel Assemblies in an Underwater Environment Having Lateral Access Loading" (with Evan Rosenbaum) U.S. Patent 8,139,706 B2 (March 20, 2012).
30. "Single-Plate Neutron Absorbing Apparatus and Method of Manufacturing the Same" (with Evan Rosenbaum and Thomas G. Haynes III). U.S. Patent 8,158,962 B1 (April 17, 2012).
31. "Method and Apparatus for Dehydrating High Level Waste Based on Dew Point Temperature Measurements". U.S. Patent 8,266,823 B2 (September 18, 2012).
32. "Apparatus, System and Method for Facilitating Transfer of High-Level Radioactive Waste to and/or From a Pool" (with Stephen J. Agace), U.S. Patent 8,277,746 B2 (October 2, 2012).
33. "Atomized Pico-scale Composite Aluminum Alloy and Method Thereof," (with Thomas G. Haynes, III), U.S. Patent 8,323,373 B2 (December 4, 2012).
34. "Apparatus, System and Method for Low Profile Translation of High-Level Radioactive Waste Containment Structure," U.S. Patent 8,345,813 B2 (January 1, 2013).
35. "Method of Storing High Level Waste," U.S. Patent 8,351,562 B2 (January 8, 2013).
36. "Apparatus for Providing Additional Radiation Shielding to a Container Holding Radioactive Materials, and Method of Using the Same to Handle and/or Process Radioactive Materials" (with Stephen J. Agace), U.S. Patent 8,415,521 B2 (April 9, 2013).
37. "Spent Fuel Basket, Apparatus and Method Using the Same for Storing High Level Radioactive Waste" (with Stephen J. Agace), U.S. Patent 8,548,112 B2 (October 1, 2013).
38. "System and Method for Preparing a Container Loaded with Wet Radioactive Elements for Dry Storage" (with John D. Griffiths), U.S. Patent 8,561,318 B2 (October 22, 2013).
39. "Apparatus for Supporting Radioactive Fuel Assemblies and Methods of Manufacturing the Same" (with Stephen J. Agace), U.S. Patent 8,576,976 B2 (November 5, 2013).
40. "Heat Exchanger Apparatus for Accommodating Thermal and/or Pressure Transients," U.S. Patent 8,602,089 B2 (December 10, 2013).
41. "Systems and Methods for Storing Spent Nuclear Fuel," U.S. Patent 8,625,732 (January 7, 2014).
42. "System and Method for the Ventilated Storage of High-Level Radioactive Waste in a Clustered Arrangement" (with Stephen J. Agace) U.S. Patent 8,660,230 B2 (February 25, 2014).
43. "Single Plate Neutron Absorbing Apparatus and Method of Manufacturing the Same" (with Evan Rosenbaum and Thomas J. Haynes III), U.S. Patent 8,681,924 B2 (March 25, 2014).

44. "Fuel Basket Spacer, Apparatus and Method Using the Same for Storing High Level Radioactive Waste" (with Stephen Agace), U.S. Patent 8,712,001 B2 (April 29, 2014).
45. "Manifold System for the Ventilated Storage of High-Level Waste and a Method of Using the Same to Store High Level Waste in a Below Grade Environment," U.S. Patent 8,718,220 B2 (May 6, 2014).
46. "Method of Transferring High Level Radioactive Materials and System for the Same" (with John D. Griffiths), U.S. Patent 8,718,221 B2 (May 6, 2014).
47. "Method and Apparatus for Preparing Spent Nuclear Fuel for Dry Storage," U.S. Patent 8,737,559 B2 (May 27, 2014).
48. "Apparatus for Storing and/or Transporting High Level Radioactive Waste and Method for Manufacturing the Same," U.S. Patent 8,798,224 B2 (August 5, 2014).
49. "Heat Exchanger Apparatus for Converting a Shell-Side Liquid into a Vapor", U.S. Patent 8,833,437 B2 (September 16, 2014).
50. "Ventilated System for Storing High Level Radioactive Waste" (with John Griffiths), U.S. Patent 8,905,259 B2 (December 9, 2014).
51. "Canister Apparatus and Basket for Transporting, Storing and/or Supporting Spent Nuclear Fuel" (with Stephen J. Agace), U.S. Patent 8,929,504 B2 (January 6, 2015).
52. "System, Method and Apparatus for Providing Additional Radiation Shielding to High Level Radioactive Materials" (with Stephen J. Agace and Paul Stefan Anton), U.S. Patent 8,995,604 B2 (March 31, 2015).
53. "System and Method for Reclaiming Energy from Heat Emanating from Spent Nuclear Fuel" (with John D. Griffiths and Debabrata Mitra-Majumdar), U.S. Patent 9,001,958 B2 (April 7, 2015).
54. "Method for Controlling Temperature of a Portion of a Radioactive Waste Storage System and for Implementing the Same" (with Richard M. Springman), U.S. Patent 9,105,365 B2 (August 11, 2015).
55. "System and Method for Preparing a Container Loaded with Wet Radioactive Elements for Dry Storage" (with John D. Griffiths), U.S. Patent 9,165,690 B2 (October 20, 2015).
56. "System, Method and Apparatus for Providing Additional Radiation Shielding to High Level Radioactive Materials" (with Stephen J. Agace and Paul Stefan Anton), U.S. Patent 9,208,914 B2 (December 8, 2015).
57. "Neutron Shielding Ring, Apparatus and Method Using the Same for Storing High Level Radioactive Waste" (with Stephen J. Agace), U.S. Patent 9,269,464 B2 (February 23, 2016).
58. "Ventilated System for Storing High Level Radioactive Waste" (with John D. Griffiths), U.S. Patent 9,293,229 B2 (March 22, 2016).
59. "Ventilated Transfer Cask with Lifting Feature" (with John D. Griffiths), U.S. Patent 9,466,400 B2 (October 11, 2016).
60. "Method of Storing High Level Radioactive Waste," U.S. Patent 9,443,625 B2 (September 13, 2016).
61. "System and Method for the Ventilated Storage of High-Level Radioactive Waste in a Clustered Arrangement" (with Stephen J. Agace), U.S. Patent 9,460,821 B2 (October 4, 2016).
62. "Fail-safe Control Rod Drive System for Nuclear Reactor" (with Leyland Vann), U.S. Patent 9,496,057 B2 (November 15, 2016).
63. "System for Storing High Level Radioactive Waste" (with John D. Griffiths), U.S. Patent 9,514,853 B2 (December 6, 2016).

64. "Passive Reactor Cooling System" (with Joseph Rajkumar), U.S. Patent 9,589,685 B2 (March 7, 2017).
65. "Heat Exchanger Apparatus for Converting a Shell-Side Liquid into a Vapor," U.S. Patent 9,612,058 B2 (April 4, 2017).
66. "Storage System for Nuclear Fuel" (with Richard Springman and Stephen Agace), U.S. Patent 9,640,289 B2 (May 2, 2017).
67. "Cask Apparatus, System and Method for Transporting and/or Storing High Level Waste," U.S. Patent 9,672,948 B2 (June 6, 2017).
68. "Apparatus for Supporting Radioactive Fuel Assemblies and Methods of Manufacturing the Same" (with Stephen Agace), U.S. Patent 9,728,284 B2 (August 8, 2017).
69. "System for Low Profile Translation of High-Level Radioactive Waste," U.S. Patent 9,728,286 B2 (August 8, 2017).
70. "Container and System for Handling Damaged Nuclear Fuel, and Method of Making the Same," U.S. Patent 9,748,009 B2 (August 29, 2017).
71. "Method and Apparatus for Preparing Spent Nuclear Fuel for Dry Storage," U.S. Patent 9,761,338 B2 (September 12, 2017).
72. "Manifold System for the Ventilated Storage of High-Level Waste and a Method of Using the Same to Store High Level Waste in a Below-Grade Environment," U.S. Patent 9,761,339 B2 (September 12, 2017).
73. Vertical Bundle Air Cooled Heat Exchanger, Method of Manufacturing the Same, and Power Generation Plant Implementing the Same" (with Indresh Rampall and Joseph Rajkumar), U.S. Patent 9,770,794 B2 (September 26, 2017).
74. "Nuclear Reactor Shroud" (with Indresh Rampall and Joseph Rajkumar), U.S. Patent 9,773,576 B2 (September 26, 2017).
75. "Radioactive Material Storage Canister" (with John Griffiths and Joseph Meckley), U.S. Patent 9,779,843 B2 (October 3, 2017).
76. "Passive Reactor Containment Protection System," U.S. Patent 9,786,393 B2 (October 10, 2017).
77. "Component Cooling Water System for Nuclear Power Plant" (with Joseph Rajkumar), U.S. Patent 9,786,394 B2 (October 10, 2017).
78. "Air-Cooled Heat Exchanger and System and Method of Using the Same to Remove Waste Thermal Energy from Radioactive Materials" (with Joseph Rajkumar), U.S. Patent 9,786,395 B2 (October 10, 2017).
79. "Autonomous Self-Powered System for Removing Thermal Energy from Pools of Liquid Heated by Radioactive Materials, and the Method of the Same" (with Indresh Rampall and Joseph Rajkumar), U.S. Patent 9,803,510 B2 (October 31, 2017).
80. "System and Method of Storing and/or Transferring High Level Radioactive Waste," U.S. Patent 9,831,005 B2 (November 28, 2017).
81. "Nuclear Steam Supply System," (with Joseph Rajkumar), U.S. Patent 9,852,820 (December 26, 2017).
82. "High-Density Subterranean Storage System for Nuclear Fuel and Radioactive Waste," U.S. Patent 9,852,822 (December 26, 2017).
83. "Nuclear Fuel Core, Nuclear Fuel Cartridge, and Methods of Fueling and/or Defueling a Nuclear Reactor," (with P. Stefan Anton and Peter Stefanovic), U.S. Patent 9,865,363 B2 (January 9, 2018).

84. "Reactivity Control Device for Storing Nuclear Fuel," (with Stephen Agace), U.S. Patent 9,875,819 B2 (January 23, 2018).
85. "Space Saver Flanged Joint for a Nuclear Reactor Vessel," (with Joseph Rajkumar), U.S. Patent 9,892,806 B2 (February 13, 2018).
86. "Passively-Cooled Spent Nuclear Fuel Pool System and Method Therefor," (with Joseph Rajkumar), U.S. Patent 9,916,910 B2 (March 13, 2018).
87. "Systems and Methods for Storing Spent Nuclear Fuel," U.S. Patent 9,916,911 B2 (March 12, 2018).
88. "Nuclear Power Generation System," (with Joseph Rajkumar), U.S. Patent 9,922,740 B2 (March 20, 2018).
89. "System and Method for Minimizing Movement of Nuclear Fuel Racks During a Seismic Event," (with Charles Bullard), U.S. Patent 9,991,010 B2 (June 5, 2018).
90. "Passively Cooled Spent Nuclear Fuel Pool System," (with Joseph Rajkumar), U.S. Patent 10,008,296 B2 (June 26, 2018).
91. "Canister Apparatus and Basket for Transporting, Storing and/or Supporting Spent Nuclear fuel," (with Stephen Agace), U.S. Patent 10,026,514 (July 17, 2018).
92. "Apparatus for Supporting Spent Nuclear Fuel," (with P. Stefan Anton), U.S. Patent 10,037,826 B2 (July 31, 2018).
93. "Method for Storing Radioactive Waste, and System for Implementing the Same," U.S. Patent 10,049,777 B2 (August 14, 2018).
94. "Loss-of-Coolant Accident Reactor Cooling System," (with Joseph Rajkumar), U.S. Patent 10,096,389 B2 (October 9, 2018).
95. "Nuclear Steam Supply System," (with Joseph Rajkumar), U.S. Patent 10,102,936 B2 (October 16, 2018).
96. "Shutdown System for a Nuclear Steam Supply System," (with Joseph Rajkumar), U.S. Patent 10,115,487 B2 (October 30, 2018).
97. "Dry Cooling System for Power Plants," (with Vytas Maciunas and Indresh Rampall), U.S. Patent 10,132,568 B2 (November 20, 2018).
98. "Dry Cooling Systems for Powerplants," (with Vytas Maciunas and Indresh Rampall), U.S. Patent 10,161,683 B2 (December 25, 2018).
99. "Ventilated System for Storing High Level Radioactive Waste," U.S. Patent 10,147,509B2 (December 4, 2018).
100. "Atomized Picoscale Composition Aluminum Alloy Method Thereof," (with Thomas Haynes, Martin Walcher and Martin Balog), U.S. Patent 10,202,674B2 (February 12, 2019).
101. "Container for Radioactive Waste," (with Stephen Agace), U.S. Patent 10,217,537B2 (February 26, 2019).
102. "System and Method for Preparing a Container Loaded with Wet Radioactive Elements for Dry Storage," (with John Griffiths), U.S. Patent 10,229,764 B2 (March 12, 2019).
103. "Tubular Heat Exchanger Having Multiple Shell-Side and Tube-Side Fluid Passes," (with Vytautas Maciunas), U.S. Patent 10,295,266B2 (May 21, 2019).
104. "Storage System for Nuclear Fuel," (with Richard Springman and Stephen Agace), U.S. Patent 10,297,356B2 (May 21, 2019).
105. "Wet Storage Facility for Nuclear Fuel," (with Joseph Rajkumar), U.S. Patent 10,311,987B2 (June 4, 2019).
106. "Apparatus for Storing and/or Transporting High Level Radioactive Waste, and Method for Manufacturing the Same," U.S. Patent 10,332,642B2 (June 25, 2019).

107. "Vertical Bundle Air-Cooled Heat Exchanger, Method of Manufacturing the Same, and Power Generation Plant Implementing the Same," (with Indresh Rampall, Joseph Rajkumar and Frank David Sanderlin), U.S. Patent 10,343,240B2 (July 9, 2019).
108. "Nuclear Fuel Storage Facility with Vented Container Lids," U.S. Patent 10,373,722B2 (August 6, 2019).
109. "Steam Generator for Nuclear Steam Supply System," (with Joseph Rajkumar), U.S. Patent 10,395,783B2 (August 27, 2019).
110. "Container for Storing and/or Transporting Spent Nuclear Fuel," U.S. Patent 10,410,756B2 (September 10, 2019).
111. "System and Method for Reclaiming Energy from Heat Emanating from Spent Nuclear Fuel," (with John Griffiths and Debabrata Mitra-Majumdar), U.S. Patent 10,418,136B2 (September 17, 2019).
112. "Self-Aligning Neutron Absorbing Apparatus for Reactivity Mitigation in Nuclear Fuel Storage Systems," (with Stephen Agace), U.S. Patent 10,418,137B2 (September 17, 2019).
113. "System for Low Profile Translation of High-Level Radioactive Waste," U.S. Patent 10,446,285 (October 15, 2019).
114. "High-Density Subterranean Storage System for Nuclear Fuel and Radioactive Waste," U.S. Patent 10,446,287 (October 15, 2019).
115. "Environmentally Sequestered Spent Fuel Pool," U.S. Patent 10,468,145B2 (November 5, 2019).
116. "Autonomous Self-Powered System for Removing Thermal Energy from Pools of Liquid Heated by Radioactive Materials, and Methods of the Same," (with Indresh Rampall and Joseph Rajkumar), U.S. Patent 10,472,996B2 (November 12, 2019).
117. "Steam Generator for Nuclear Steam Supply System," (with Joseph Rajkumar), U.S. Patent 10,510,452B2 (December 17, 2019).
118. "Brazing Compositions and Uses Thereof," (with William Scholfield, Dmitriy Kats, Joseph Mosher, Robert Sloan, and Thomas Haynes), U.S. Patent 10,512,990B2 (December 24, 2019).
119. "Apparatus for Storing and/or Transporting Radioactive Materials," (with Paul Stefan Anton and Robert Mahorter), U.S. Patent 10,515,730B2 (December 24, 2019).
120. "Method for Preparing Spent Nuclear Fuel for Dry Storage," U.S. Patent 10,535,439B2 (January 14, 2020).
121. "Snap-In Insert for Reactivity Control in Spent Nuclear Fuel Pools and Casks," (with Stephen Agace, Stephen Thompson, John Griffiths, and Richard Springman), US Patent 10,535,440B2 (January 14, 2020).
122. "Fail-Safe Control Rod Drive System for Nuclear Reactor," (with Patrick Ingravallo and Leyland Vann), U.S. Patent 10,573,418B2 (February 25, 2020).
123. "Fail-Safe Control Rod Drive System for Nuclear Reactor," (with Patrick Ingravallo and Leyland Vann), U.S. Patent 10,573,419B2 (February 25, 2020).
124. "Nuclear Reactor Shroud," (with Indresh Rampall and Joseph Rajkumar), U.S. Patent 10,580,539B2 (March 3, 2020).
125. "Manifold System for the Ventilated Storage of High-Level Waste and a Method of using the Same to Store High Level Waste in a Below-Grade Development," U.S. Patent 10,614,924B2 (April 7, 2020).
126. "Rack for Underwater Storage of Spent Nuclear Fuel," U.S. Patent 10,650,933B2 (May 12, 2020).



127. "Loss-of-Coolant Accident Reactor Cooling System," (with Joseph Rajkumar), U.S. Patent 10,665,354B2 (May 26, 2020).
128. "Nuclear Steam Supply System," (with Joseph Rajkumar), U.S. Patent 10,665,357 (May 26, 2020).
129. "Component Cooling Water System for Nuclear Power Plant," (with Joseph Rajkumar), U.S. Patent 10,672,523B2 (June 2, 2020).
130. "Atomized Picoscale Composition Aluminum Alloy and Method Thereof," (with Thomas Haynes, Martin Walcher and Martin Balog), U.S. Patent 10,676,805B2 (June 9, 2020).
131. "Container and System for Handling Damaged Nuclear Fuel, and Method of Making the Same," U.S. Patent 10,692,617B2 (June 23, 2020).
132. "Method of Storing High-Level Radioactive Waste," U.S. Patent 10,714,223B2 (July 14, 2020).
133. "Passive Reactor Cooling System," (with Joseph Rajkumar), U.S. Patent 10,720,249B2 (July 21, 2020).
134. "Nuclear Reactor System Having Natural Circulation of Primary Coolant," (with Stephan Anton, Ranga Nadig and Indresh Rampall), U.S. Patent 10,726,962B2 (July 28, 2020).
135. "Container for Radioactive Waste," (with John Griffiths, Joseph Meckley and Stephen Agace), U.S. Patent 10,811,154 (October 20, 2020).
136. "System and Method for Preparing a Container Loaded with Wet Radioactive Elements for Dry Storage," (with John Griffiths), U.S. Patent 10,839,969B2 (November 17, 2020).
137. "Earthquake-Resistant Fuel Storage Rack System for Fuel Pools in Nuclear Plants," U.S. Patent 10,847,274B2 (November 24, 2020).
138. "Macro-Chip Enforced Alloy," (with Thomas Haynes and Luke Sibus), U.S. Patent 10,843,272B2 (November 24, 2020).
139. "Fuel Basket for Spent Nuclear Fuel and Container Implementing the Same," (with Stefan Anton and Richard Springman), U.S. Patent 10,854,346B2 (December 1, 2020).
140. "Air-Cooled Heat Exchanger and System and Method of Using the Same to Remove Waste Thermal Energy from Radioactive Materials," (with Joseph Rajkumar), U.S. Patent 10,854,344B2 (December 1, 2020).
141. "Apparatus for Storing and/or Transporting Radioactive Materials," (with Stefan Anton and Robert Mahorter), U.S. Patent 10,861,612B2 (December 8, 2020).
142. "Storage System for Nuclear Fuel," (with Stephen Agace and Richard Springman), U.S. Patent 10,867,714B2 (December 15, 2020).
143. "Nuclear Waste Storage Canisters," U.S. Patent 10,872,707B2 (December 22, 2020).
144. "Flood and Wind-Resistant Ventilated Module for Spent Nuclear Fuel Storage," (with Stefan Anton), U.S. Patent 10,878,973B2 (December 29, 2020).
145. "System and Method for Storing and/or Transferring High Level Radioactive Waste," U.S. Patent 10,892,063B2 (January 12, 2021).
146. "Self-Alignment Method of Neutron Absorbing Apparatus for Reactivity Mitigation in Nuclear Fuel Storage Systems," (with Stephen Agace), U.S. Patent 10,910,119B2 (February 2, 2021).
147. "Moving an Entire Nuclear Reactor Core as a Unitary Structure" (with Stefan Anton and Peter Stefanovic), U.S. Patent 10,923,239B2 (February 16, 2021).
148. "System for Low Profile Translation of High-Level Radioactive Waste," U.S. Patent 10,939,787B2 (March 9, 2021).

149. "High-Density Subterranean Storage System for Nuclear Fuel and Radioactive Waste," U.S. Patent 10,950,361B2 (March 16, 2021).
150. "Single-Plate Neutron Absorbing Apparatus and Method of Manufacturing the Same," (with Evan Rosenbaum and Thomas Haynes), U.S. Patent 10,991,472B2 (April 27, 2021).
151. "System and Method for Minimizing Movement of Nuclear Fuel Racks During a Seismic Event" (with Charles Bullard), U.S. Patent 11,017,908B2 (May 25, 2021).
152. "Method for Heating a Primary Coolant in a Nuclear Steam Supply System" (with Joseph Rajkumar), U.S. Patent 11,031,146B2 (June 8, 2021).
153. "Multi-Component Cask for Storage and Transport of Spent Nuclear Fuel," U.S. Patent 11,043,312B2 (June 22, 2021).
154. "Container for Storing and/or Transporting Spent Nuclear Fuel, U.S. Patent 11,081,248B2 (August 3, 2021).
155. "Nuclear Waste Cask with Impact Protection," (with Charles Bullard and Xuejun Zhai), U.S. Patent 11,081,249B2 (August 3, 2021).
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158. "Heat Exchange for Severe Service Conditions," U.S. Patent 11,187,471 (November 30, 2021).
159. "Air-Cooled Condenser System," U.S. Patent 11,204,201 (December 21, 2021).
160. "Optimized Nuclear Fuel Core Design for a Small Modular Reactor," (with Thomas Marcille and Joseph Rajkumar), U.S. Patent 11,205,521 (December 21, 2021).
161. "Method of Preparing Spent Nuclear Fuel for Dry Storage," U.S. Patent 11,217,353 (January 4, 2022).
162. "Manufacturing Methods to Fortify Nuclear Waste Canisters from Stress Corrosion Cracking," U.S. Patent 11,250,962B1 (February 15, 2022).
163. "Nuclear Fuel Storage Facility," U.S. Patent 11,250,963B2 (February 15, 2022).
164. "Manifold System for the Ventilated Storage of High-Level Waste and a Method of Using the Same to Store High Level Waste in a Below-Grade Environment," U.S. Patent 11,264,142 (March 1, 2022).
165. "Spent Nuclear Fuel Cask with Dose Attenuation Devices," US Patent 11,282,615 (March 22, 2022).
166. "Nuclear Reactor Shroud," (with Indresh Rampall and Joseph Rajkumar), US Patent 11,289,219 (March 29, 2022).
167. "Spent Nuclear Fuel Canister," US Patent 11,289,227 (March 29, 2022).
168. "Nuclear Fuel Storage System With Integral Shimming," US Patent 11,289,229 (March 29, 2022).

***BOOKS AND ARCHIVAL VOLUMES (AUTHORED OR EDITED):***

1. "Mechanical Design of Heat Exchangers and Pressure Vessel Components" (authored with A. I. Soler), Arcturus Publishers, Cherry Hill, New Jersey, 1100 pages, hardbound (1984).
2. "Theory and Practice of Heat Exchanger Design" (sole author) (In preparation)
3. "Feedwater Heater Workshop Proceedings" (edited with Tom Libs), EPRI 78-123 (1979).
4. "Feedwater Heater Technology: State-of-the-Art" (sole author), EPRI - cs - 4155 (1985).

5. "Analytical Correlations of Fluid Drag of Fuel Assemblies in Fuel Rack Storage Locations" (sole author), EPRI Project RP-2124.
6. "Thermal/Mechanical Heat Exchanger Design" (edited), ASME, PVP - Vol. 118 (1986).
7. "Time Dependent and Steady State Characterization of the CAES Recuperator" (principal author), EPRI TR-104224 (July 1994).
8. "Pressure Vessels, Heat Exchangers and Piping" (editor), Proc. ASME, IEEE Joint Power Generation Conference, NE-14 (1994).

**EXPERT WITNESS AND TECHNOLOGY APPRAISAL SERVICES FOR ALSB AND LEGAL PROCEEDINGS:**

1. Pacific Gas & Electric Company vs. National Sierra Club (1986-87) - ASLB Hearings on High Density Fuel Racks for Diablo Canyon, Avila Beach, California (1987).
2. Florida Power & Light Company vs. Stuart Intervenor Group (1990).
3. Pacific Northwest Laboratories, Rockwell International, and U.S. DOE vs. RSI (1994).
4. PFS, LLC vs. State of Utah (2002) – ASLB Hearings on the Skull Valley Away-From-Reactor Facility (Salt Lake City, Utah).

**ACADEMIC AFFILIATIONS AND ACTIVITIES:**

- Chair, Advisory Committee on Mechanical Engineering and Mechanics, University of Pennsylvania (1993-1999)
- Professor (Adjunct) in Mechanical Engineering and Mechanics, University of Pennsylvania (1986-92), Offered Graduate and Undergraduate Courses in Heat Transfer Equipment and Pressure Vessel Technology.
- Senior Fellow, Department of Mechanical Engineering, University of Pennsylvania (2014-present)

**GRADUATE LEVEL CONTINUING EDUCATION COURSES OFFERED TO PRACTICING ENGINEERS (1979-1992):**

- I.I.T. Bombay, One Week Course on Heat Exchanger Design (1979).
- Duke Power Company, Charlotte, NC (1982, 1983, 1986, 1990) - In-house Training Course on Heat Exchanger Design and Testing.
- National Italian Reactor Authority, Genoa, Italy - On Condensers, Steam Generators, and Moisture Separator Re-heaters (1985).
- Mississippi Power & Light Company, Courses on Moisture Separator Re-heaters, and Surface Condensers (1987).
- Center for Professional Advancement (1988, New Brunswick, NJ; 1990, Caracas, Venezuela; 1991, Houston, Texas; 1992, Amsterdam, Holland).

**PRINCIPAL DEVELOPER OF TECHNOLOGIES WITH HIGH INDUSTRIAL IMPACT:**

- Industry's first *free-standing detuned honeycomb high-density fuel rack* design which expanded the aggregate wet storage capacity worldwide at nuclear power plants by a factor of three averting the premature closure of nuclear units. Over 120 nuclear units use this technology since mid-1980s.
- Industry's first thermo-siphon enabled *multi-purpose canister* (patented) for storage and transport of used nuclear fuel (1994), Double Wall Canister (2010); worldwide over 100 nuclear plants utilize Holtec's MPC technology.
- Forced Helium Dehydration system to minimize radiation dose and environmental safety, adopted by over 30 nuclear units since 2002.
- Subterranean used fuel storage system for security of stored fuel; in use at several plants; adopted for Consolidated Interim Storage system at the planned site in New Mexico.
- SMR-160, walk away safe nuclear reactor; in development since 2010.
- Essential elements of *Proto-prompt decommissioning* to enable complete deconstruction of a shuttered nuclear unit in less than 7 years (less than half the duration of the current normal).

#### TECHNICAL CONSULTING (1980-1995):

Technical consulting services rendered to over fifty national and international organizations since 1975, including: Electric Power Research Institute (EPRI); Pressure Vessel Research Council (PVRC); Tubular Exchanger Manufacturers Association (TEMA); Department of Energy (DOE) (Idaho Operations); Department of Energy (DOE) (Chicago Operations); American Electric Power Corporation; Baltimore Gas and Electric; Carolina Power & Light; Commonwealth Edison Company; Detroit Edison Company; Duke Power Company; Entergy Operations; GPU Nuclear; Iowa Electric Light and Power; New York Power Authority; Niagara Mohawk Power Corporation; North Atlantic Energy Services; Northeast Utilities; Northeast Nuclear Energy; Pacific Gas and Electric Company; PECO Energy; Southern Nuclear Operating Company; and Tennessee Valley Authority.

#### AUTHOR OR PRINCIPAL CO-AUTHOR OF PUBLICATIONS IN THE OPEN LITERATURE:

1. "A Method for Solving Ill-Posed Integral Equations of the First Kind" (with B. Paul), Computer Methods in Applied Mechanics and Engineering 2 (1973) 339-348.
2. "Numerical Solutions of Non-Hertzian Elastic Contact Problems" (with B. Paul), Journal of Applied Mechanics, Vol. 41, No. 2, 484-490, June 1974.
3. "On the Inadequacy of Hertzian Solution of Two-Dimensional Line Contact Problems," Journal of the Franklin Institute, Vol, 298, No. 2, 139-141 (1974).
4. "How to Locate Impingement Plates in Tubular Heat Exchangers," Hydrocarbon Processing, 147-149 (1974).
5. "Stress Concentration in Crowned Rollers" (with B. Paul), Journal of Engineering for Industry, Trans. ASME, Vol. 97, Series B, No. 3, 990-994 (1975).
6. "Application of Spiral Wound Gaskets for Leak Tight Joints," Journal of Pressure Vessel Technology, Trans. ASME, Vol. 97, Series J, No. 1, 91-93 (1975).
7. "Contact Stresses for Multiply-Connected Regions - The Case of Pitted Spheres" (with B. Paul and W. S. Woodward), Proceedings of the IUTAM Symposium on Contact Stresses, August 1974, Holland, Delft University Press, 264-281 (1976).

8. "Design of Skirt-Mounted Supports: Hydrocarbon Processing, Vol. 4," 199-203, April 1976.
9. "Predicting Flow Induced Vibration in U-Bend Regions of Heat Exchangers - An Engineering Solution," Journal of the Franklin Institute, Vol. 302, No. 2, 195-205, August 1976.
10. "A Method to Design Shell-side Pressure Drop Constrained Tubular Heat Exchangers" (with Mr. Holtz), Journal of Engineering for Power, Trans. of the ASME, Vol. 99, No. 3 July 1977, pp 441-448.
11. "An Efficient Design Method for Obround Pressure Vessels and Their End Closures," International Journal of Pressure Vessel and Piping, Vol. 5, 1977, pp 309-320.
12. "Analysis of Vertically mounted Through-Tube Heat Exchangers," Journal of Engineering for Power, Trans. ASME, Vol. 100, No. 2, April 1978, pp 380-390.
13. "Study of Bolted Joint Integrity and Inter-Tube-Pass Leakage in U-Tube Heat Exchangers: Part I - Analysis," Journal of Engineering for Power, Trans. ASME, Vol. 101, No. 1, pp 9-15 (1979).
14. "Study of Bolted Joint Integrity and Inter-Tube-Pass Leakage in U-Tube Heat Exchangers: Part II - Application," Journal of Engineering for Power, Trans. ASME, pp. 1-7 (1979).
15. "On Thermal Expansion Induced Stresses in U-Bends of Shell-and-Tube Heat Exchangers" (with Maurice Holtz), Trans. ASME, Journal of Engineering for Power, Vol. 101, No. 4, October 1979, pp. 634-639.
16. "Heat Transfer Characteristics of a Generalized Divided Flow Heat Exchanger," Proceedings of the Conference on Industrial Energy Conservation Technology, Houston, Texas, pp. 88-97 (1979).
17. "An Approximate Analysis of Foundation Stresses in Horizontal Pressure Vessels" (with Vincent Luk), Paper No. 79-NE-1, Trans. ASME, Journal of Engineering for Power, Vol. 102, No. 3, pp. 555-557, July 1980.
18. "Generalization of the Split Flow Heat Exchanger Geometry for Enhanced Heat Transfer" (with Michael Holtz), AIChE. Symposium Series 189, Vol. 75, pp 219-226 (1979).
19. "Analysis of Temperature Induced Stresses in the Body Bolts of Single Pass Heat Exchangers," ASME Winter Annual Meeting, Paper No. 79 QA/NE-7, New York, NY, 1979.
20. "Optimization of Two-Stage Evaporators for Minimizing Rad-Waste Entrainment" (with Maurice Holtz), Journal of Mechanical Design, Trans. of the ASME, Vol. 102, No. 4, pp. 804-806 (1980).
21. "A Comparison of Thermal Performance of Two and Four Tube Pass Designs for Split Flow Shells" (with M. J. Holtz), Journal of Heat Transfer, Trans. of the ASME, Vol. 103, No. 1, pp 169-172, February 1981.
22. "A Method for Maximizing Support Leg Stress in a Pressure Vessel Mounted on Four Legs Subject to Moment and Lateral Loadings," International Journal of Pressure Vessels and Piping, Vol. 9, No. 1, pp. 11-25 (1981).
23. "Design, Stress Analysis and Operating Experience in Feedwater Heaters," (with Tom Libs), Proceedings of the Conference on Industrial Energy Conservation Technology, Houston, pp. 113-118 (1980).
24. "On the Necessary Criteria for Stream Symmetric Tubular Heat Exchanger Geometries," Heat Transfer Engineering, Vol. 3, No. 1 (1981).
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28. "Feasibility Study of a Multi-Purpose Computer Program for Optimizing Heat Rates in Power Cycles" (with Y. Menuchin and N. Hirota), Proceedings of the Conference on Industrial Energy Conservation Technology, Houston, (1981).
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60. "A Structural Assessment of Candidate Fuel Basket Designs for Storage and Transport of Spent Nuclear Fuel" (with Max Delong), INMM Conference, Washington, DC (1998).
61. "Seismic Response Characteristics of HI-STAR 100 Cask System on Storage Pads" (with Mark G. Smith and A.I. Soler), INMM Conference, Washington, DC (1998).
62. "Analysis of Mechanical Impact Events in Spent Fuel Storage Equipment" (with Charles Bullard) (1997).
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65. "Validation of an Impact Limiter Crush Prediction Model with Test Data: The Case of the HI-STAR 100 Package" (with A.I. Soler, and C. Bullard), PATRAM 2004, Berlin, Germany (2004).
66. "Predicting the Response of the Impact Limiter in the HI-STAR Family of Transport Packages Using a Benchmarked LS-DYNA Dynamic Model" (with John Zhai and A. I.

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