Leo A. Carrilho, Ph.D.

205 Popes Ln, Lexington, SC 29072 • (803) 931-6471 • lacarrilho@icloud.com

REACTOR CORE MECHANICAL ENGINEER

- ✓ Dr. Leo Carrilho provides value with his ability to apply his technical knowledge, collect and synthesize innovative and creative analyses techniques and methodologies, and leverage his strategic thinking to create a competitive advantage for the company and influence industry technical developments in the areas of mechanical/thermal hydraulic testing, FEA of fuel assembly, fuel assembly sub-component, and reactor core component design and CFD analysis of fuel rod bundles.

CURRENT QUALIFICATIONS & EXPERTISE

• Mechanical Design & Testing	• Seismic & LOCA Analysis	• Vibration Analysis & Testing
• FEM Techniques & Analysis	• Reactor Core Components	• Control Element Assemblies
• CFD Techniques & Analysis	• International Experience	• Fluent in Portuguese/English

Successfully participated in technical programs developing new products, e.g. fuel assembly grids, nozzles, spiders, control rods, and managing multi-functional interfaces for domestic and international customers.
Planned and executed technical activities resolving issues related to fuel and reactor core components performance.

Uses SolidWorks, ANSYS Mechanical APDL, ANSYS LS-DYNA, and ANSYS CFD for Design and Analysis.
Uses ASME B&PV Code Section III/VIII/XI to verify design requirements according to NQA-1 procedures.

PROFESSIONAL EXPERIENCE

Westinghouse Electric Company - WEC, Columbia, SC · October 2010 – Present
PRINCIPAL ENGINEER, FUEL AND CORE COMPONENTS DESIGN

Dr. Leo Carrilho is being nominated for promotion to **Fellow Engineer** based on his recent and potential future contributions to the organization relative to his technical leadership.

- Currently developing an advanced FEA model for lifetime evaluation of Electricité de France control rods during Absorber-to-Clad Mechanical Interaction, which features direct coupled material plasticity, thermal strain, creep, and irradiation-induced swelling.
- Supporting the Accident Tolerant Fuel (ATF) program by using his FEA & CFD models and the Single Heater Element Loop Tester (SHELT) facility expertise to design and conduct testing to determine which type of surface finish gives optimal thermal-hydraulic performance and competitive advantage to the Company.
- Evaluating topical Design Criteria Compliance Summary (DCCS) reports to be submitted to the Korean Nuclear Fuel company in support of new nuclear power plants.
- Continued to develop FEA models, performing stress, fatigue, and modal analyses of fuel and control rod assembly components based on the ASME B&PV Section III code:
    - Fuel assembly spacer grids at SONGS power plant
    - AP-1000 Robust Fuel Assembly enhanced intermediate spacer grid
    - Next Generation control rod assembly spider
    - VVER-1000 fuel assembly intermediate spacer grid
    - 17x17 Fuel assembly removable top nozzle insert and lock tube joint
    - VVER-1000 Robust Westinghouse Fuel Assembly bottom nozzle at South Ukraine
    - Control Element Assembly under Seismic-LOCA event at Shin-Ul Shin in Korea
    - South Ukraine VVER-1000 RWFA top and intermediate spacer grids
    - Plastic (nonlinear) collapse of the 17x17 Next Generation control rod cladding
    - Control rod assemblies during Seismic & LOCA at the Barakah Nuclear Power Plant

  - UO_2 Powder Bulk Container under Vibrator Loads
  - Modal Analysis of the UO_2 Powder Decanter Rotating Bowl
- Structural integrity evaluation of control rod assembly spiders through Fracture Mechanics combined with FEA based on the ASME B&PV code, Section XI:
  - Next Generation control rod assembly machining spider weld
  - Next Generation control rod assembly casting spider
  - 14x14 Enhanced Performance control rod assembly spider vane
  - 14x14 422V+ intermediate spacer grid with indentation
- Patterned with ENUSA in Spain on the development of an FEA model combined with fracture mechanics to evaluate spent fuel under handling, transportation, and dry cask storage loads. This was a first of a kind project for Westinghouse.
- Developed FEA model and performed transient thermal analysis of the Next Generation control rod absorber at faulted LOCA conditions.
- Performed hoop stress analysis of the Next Generation control rod cladding with hollow absorber due to swelling and thermal strain using FEM in ANSYS.
- Developed FEA models and performed thermal expansion analyses of Next Generation control rods after full insertion in the reactor core.
- Developed fuel assembly FEA beam models for reactor core plate motion generation:
  - AREVA 15x15 Fuel Assembly at Robinson Nuclear Plant
  - Electricité de France 900 MWe Fuel Assembly
  - 17x17 Optimized Fuel Assembly simplified beam model for the uprated Byron and Braidwood Plants
  - Simplified Fuel Assembly Beam Model for Surry Units 1 & 2 Upgrade
- Developed the FEA model and analyzed the impact of hydrogen diffusivity on the control rod cladding gap thermal conductivity at post-irradiated conditions.
- Develop the FEA dynamic model and performed impact load analysis of the Combustion Engineering fuel assembly under handling loads in the spent fuel pool rack at Palisades.
- Developed the FEA model and simulated the metal forming process of the fuel assembly spacer grid strap in ANSYS/LS-DYNA to facilitate streamlined designing of the strap production tooling, yielding more consistent strap features that more robustly meet design drawing requirements.
- Updated the Combustion Engineering CEALL code and performed lifetime analysis of Control Element Assemblies for domestic and international power plants:
  - 16x16 CEA B_4C/felt-metal control rod design for APR-1400 plants
  - APS Palo Verde System 80 control rods
  - 16x16 CEA B_4C/felt-metal control rod design for OPR-1000 Reactors with PLUS7 Fuel Assembly Design.
- Performed UFSAR Updates for Vogtle Units 1 & 2
- Prepared several design reports, test reports, and calculation notes

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Westinghouse Electric Company - WEC, Columbia, SC · October 2005 – June 2010
SENIOR ENGINEER, FUEL AND CORE COMPONENTS DESIGN

As a **Senior Engineer**, Dr. Carrilho provided technical expertise in support to the development of multiple fuel assembly components, new product performance assessments, and power plant upgrades and uprates in the US and abroad (Optimized Fuel Assembly, Combustion Engineering Next Generation Fuel, System-80 Fuel, Robust Fuel Assembly designs).

- Developed FEA models and performed stress and fatigue analyses of fuel assembly and control assembly components based on the ASME B&PV code, Section III:
    - Ginna 14x14 fuel assembly intermediate spacer grids
    - Electricité de France Control Rod Assembly Spiders
    - 17x17 Robust Protective Grid under fuel rod loading
- Developed fuel assembly FEA detailed and simplified (beam) models in ANSYS and reactor core dynamic models in WEGAP and performed Seismic & LOCA analyses for several power plants:
    - 16x16 Standard and Next Generation Fuels at the ANGRA-1 power plant after uprate
    - 16x16 Next Generation Combustion Engineering fuel assemblies at Arkansas PP
    - Robust Fuel Assemblies at Beaver Valley and Uljin plant in Korea
- Conducted the impact test of the 17x17 Robust Fuel Assembly intermediate spacer grid
- Converted the WECAN model for nonlinear static and dynamic analysis of Control Rod Drive Mechanism and Control Rod Assemblies to ANSYS.
- Developed the FEA model and analyzed stresses in the Next Generation Control Rod Cladding under irradiation-induced swelling and thermal strain.
- Calculated coupling loads between AP1000 Control Rod Drive Mechanism and Control Rod Assembly by FEM in ANSYS.
- Prepared several design reports, test reports, and calculation notes

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Indústrias Nucleares do Brasil - INB, Rio de Janeiro, Brazil · January 2000 – September 2005
DESIGN ENGINEER, NUCLEAR FUEL

Performed structural analysis based on Siemens methodology. Evaluated nonconformance reports related to fuel assembly component materials and manufacturing. Developed and adapted design and analysis methods for in-house design and verification of acceptance criteria. Performed independent root-cause analysis of failures in components material after irradiation.

- Converted Siemens KWUSTOSS finite element models for nonlinear static and dynamic analyses of fuel assemblies and subcomponents to ANSYS.
- Developed direct formulation models from Siemens codes for stress analysis of fuel assembly components.
- Developed the first tri-dimensional FEA model of the 16x16 fuel assembly in ANSYS for nonlinear static and dynamic analyses.
- Developed CFD model for pressure drop analysis of fuel assembly bottom nozzles
- INB Design Lead for the 16x16 Next Generation Fuel (NGF) development program through innovation based on FEA and CFD Methods, ASME B&PV Code, and Mechanical Testing.
    - Developed the conceptual design of the I-Spring intermediate spacer grid
    - Planed and conducted load-deflection, thermal relaxation, and impact tests of various fuel assembly spacer grid concepts.
    - Developed and benchmarked FEA models of the fuel assembly and subcomponents for structural static and dynamic analyses at beginning and end of life operating conditions based on mechanical tests.
    - Participated and addressed technical concerns from internal and external customers during Concept & Issues, Design & Manufacturability, and Closeout Review Meetings.
    - Prepared 3D CAD models drawings, and performed assembling simulations and interface evaluations of subcomponents.
    - Developed FEA models and performed stress, fatigue, and modal analyses of various fuel assembly spacer grid concepts.

- Developed CFD models and performed pressure drop analyses of fuel rod end plugs and spacer grid flow mixing vanes.
- Performed fuel rod bow analysis to evaluate fuel bundle sub-channel closure and confirm core flow cooling capability.
- Developed FEA models to evaluate and improve spacer grid to fuel rod fretting wear margin
- Developed fuel assembly FEA detailed and simplified (beam) models in ANSYS and reactor core dynamic models in WEGAP and performed Seismic & LOCA analyses for 16x16 designed power plants.
- Prepared several design documents, calculation notes, test reports, and related sections of design review reports such as the Closeout Package Report.

TEACHING EXPERIENCE

University of South Carolina, Columbia, SC · January 2014 – Present
ADJUNCT PROFESSOR

Dr. Carrilho is an **Adjunct Professor** for Graduate Students of the Department of Mechanical Engineering at the University of South Carolina, Columbia. Dr. Carrilho's research and interests include modeling and simulation of processes and phenomena using FEA and CFD methods, nuclear fuel and core components design, analysis, and testing.

Teaching Courses

- *Intermediate Dynamics*
- *Advanced Mechanics of Materials*

EDUCATION

PHD, MECHANICAL ENGINEERING
Dissertation: *Experimental and Computational Study of Roughened Surface for PWR Rod*
University of South Carolina, Columbia

MASTER'S, METALLURGICAL ENGINEERING
Dissertation: *Structural and Modal Analysis of the 16x16 Fuel Assembly using the Finite Element Method*
Universidade Federal Fluminense, Rio de Janeiro

BACHELOR'S, METALLURGICAL ENGINEERING
Dissertation: *Characterization of Stainless Materials for Fuel Assembly Nozzle Components*
Universidade Federal Fluminense, Rio de Janeiro

CONTINUED EDUCATION

- OpenFOAM Foundation and Advanced Training
- ANSYS/LS-DYNA Explicit Finite Element Analysis
- MATLAB Technical Computing Methods
- ASME Flow-Induced Vibration and Failure Analysis
- CE Control Element Assembly Design
- ANSYS Finite Element Analysis Best Practices
- Product Integrated Development Process
- Organizational Operational Model
- Contract and Legal Issues
- Financial Process and Terminology
- Project Management
- Customer Communication Skills
- Customer Service and Accountability
- Human Performance and Tools
- Customer Touchpoint Behavioral Differentiation
- SAP Basics for Project Management I
- STAR-CCM+ Computation Fluid Dynamics
- SOLIDWORKS Solid Modeling
- ANSYS Nonlinear Structural Finite Element Analysis
- ANSYS Dynamic Finite Element Analysis

PATENTS

- Rib-Type Roughness Design for Improved Heat Transfer in PWR Rod Bundles (9,514,851)
- Crush Resistant Nuclear Fuel Assembly Support Grid (disclosure submitted)

SELECTED TECHNICAL PUBLICATIONS

- Conjugated Heat Transfer Model for Ribbed Surface Convection Enhancement and Solid Body Temperature Fluctuations. 9th International Symposium on Turbulence, Heat and Mass Transfer, THMT-18, Rio de Janeiro, 2018.
- Experimental and Computational Study of Ribbed Cladding for PWR Rod Bundles Heat Transfer Enhancement. 16th International Topical Meeting on Nuclear Reactor Thermal Hydraulics, NURETH-16, Chicago, 2015.
- Heat Transfer Characteristics of Three-Dimensional Surface Roughness in Nuclear Fuel Rod Bundles. ASME 2013 International Mechanical Engineering Congress and Exposition, IMECE 2013, San Diego, 2013.
- Finite Element Modeling Applied to Nuclear Fuel Pellet Fabrication. 20th International Conference on Nuclear Engineering – ASME 2012 Power Conference ICONE20-POWER2012, Anaheim, 2012.
- Modeling of the Effect of Parallel Rib-Type Roughness on Local, Single-Phase Heat Transfer in Rod Bundles by CFD. 18th International Conference on Nuclear Engineering, ICONE18, Xi'an, 2010.
- Two and Three-Dimensional Simulations of Enhanced Heat Transfer in Nuclear Fuel Rod Bundles. Proceedings of the ASME Summer Heat Transfer Conference, HT2009, California, USA, 2009.
- A Modal Analysis Procedure for PWR Fuel Assemblies. 16th International Conference on Nuclear Engineering ICONE16, Orlando, 2008.
- Fuel Rod to Support Contact Optimization for the 16x16 Next Generation Fuel. 18th International Conference on Structural Mechanics in Reactor Technology SMiRT18, Beijing, 2005.
- Development of a Numerical Methodology for Determining the Fuel Assembly Natural Frequencies. XII National Meeting for Reactor Physics and Thermal-Hydraulic ENFIR, Rio de Janeiro, 2000.