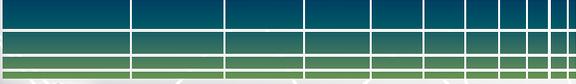


ANATECH CORP.



A  **Structural Integrity Associates, Inc.**® COMPANY

**NUCLEAR FUEL
AND REACTOR TECHNOLOGY**

LINKING THEORY AND PRACTICE



ANATECH CORP.

In 2013 we expanded our engineering expertise by joining Structural Integrity Associates, Incorporated. ANATECH Corp., that you've known for 35 years, is now ANATECH Corp., a wholly owned subsidiary of Structural Integrity Associates, Inc.® This brought our engineering leadership together to provide more innovative and integrated client solutions while maintaining our core expertise in Nuclear Fuel and Reactor Technology and in Structural Engineering.

We also expanded our technical base by bringing in key nuclear fuel analysis talent that became available due to the unexpected permanent shutdown of the San Onofre Nuclear Generating Station. This nuclear fuel analysis expertise complements our existing nuclear fuel performance expertise and broadens our portfolio of engineering services to our clients.

WHO ARE WE?

ANATECH Corp., a Structural Integrity Associates, Inc. Company, is a consulting engineering firm based in San Diego, California. We provide services in the expert application of state-of-the-art analytical methods to both nuclear and non-nuclear engineering systems.

NUCLEAR FUEL AND REACTOR TECHNOLOGY

Our ANATECH Fuels division is highly experienced in performance evaluations, material modeling, and engineering analysis of nuclear fuel behavior under normal operating conditions, off-normal transients, and postulated accidents. We have unique experience in all aspects of fuel reload design including core neutronics, thermal-hydraulics, transients and radiological dose analyses. Recognizing the importance of component quality on fuel performance and reliability, we have developed advanced capabilities in the technical assessment and fabrication surveillance of fuel rods and assembly components.

STRUCTURAL ENGINEERING

In the area of structural analysis, our ANATECH Structures division provides detailed local and global two- and three-dimensional, nonlinear analysis of concrete and steel structures subjected to normal operating loads as well as, thermal, seismic and impact loadings. These applications span a wide range of civil structures, including long-span bridges, buildings, dams, navigational hydraulic structures, nuclear containments and related structures, heavy-lift cranes, and spent fuel handling and storage systems.

OUR NUCLEAR FUEL AND REACTOR TECHNOLOGY SERVICES

The mission of the Nuclear Fuel and Reactor Technology is to provide practical and innovative engineering services to assess and improve the performance, reliability and safety of nuclear fuel and associated core components and to provide nuclear fuel related licensing support for nuclear utilities. Because of our direct experience in the performance assessment and safety analysis of nuclear fuel, we are peer-recognized for our competence and experience for providing fuel vendor-independent engineering analysis services to the nuclear industry. This includes evaluating critical fuel performance related issues, such as root cause failure analysis, operational and lifetime performance, and accident evaluations.

We are a leader in the engineering analysis of cladding mechanical performance (stress, strain and failure) under steady state and power ramp conditions, including evaluation methods to assess the impact of missing pellet surface defects and tubing reduction flaws on the cladding failure mode. Our experience in the modeling and analysis of degradation behavior in failed zirconium-clad fuel is unique to the industry and has provided us with significant experience in the design and operational alternatives developed to mitigate the release of radioactive isotopes to the reactor coolant system. With the addition of our nuclear fuel analysis capability, we are able to provide reload design and analytical support as well as startup and operations support for nuclear plant maneuvers.

In addition to traditional nuclear fuel performance services, we provide structural analysis of fuel assembly and component performance under a variety of in-reactor and accident conditions. Such analyses include fuel assembly and component distortion due to irradiation growth, assembly vibration in seismic events, and fuel assembly deformation during handling and storage cask drop accidents.

We also provide a wide range of services to assist clients in achieving their quality and fuel performance objectives. We have a staff of highly experienced personnel who have been involved in all phases of the nuclear fuel cycle from design, fabrication, and inspection, through operation, storage, and disposal. This first-hand technical expertise, gained through many years of involvement with nuclear fuel issues, results in our unique ability to provide practical and innovative engineering services to meet our clients' needs.



DESIGN ANALYSES OF NUCLEAR FUEL AND COMPONENTS

The independent review of proposed fuel and component design changes is critical to ensure that the components will meet the supplier's performance goals and the utility's expectations without introducing new performance issues. Our fuel design reviews ensure that the fuel supplier has considered the full range of performance characteristics that may be impacted by the design change. These review activities include an independent review of the supplier's design calculations, test reports, and performance database along with direct discussions with the supplier's engineering staff.

Our experience is among the best in the industry and consists of design reviews of BWR, PWR, VVER and test reactor fuel for utilities in the US, Europe and Asia. Selected design review projects have included:

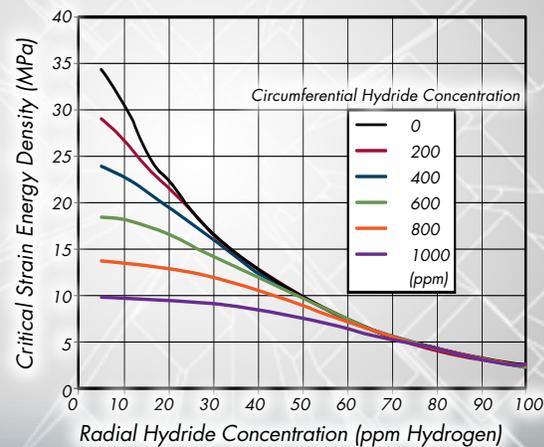
- Advanced BWR, PWR and VVER Designs
- Structural Design of Advanced Components
- Material Evaluations of Advanced Cladding Alloys and Structural Components
- Design and Analysis of Fuel Assembly and Core Components in Support of an Advanced Reactor Concept

ROOT CAUSE ANALYSES

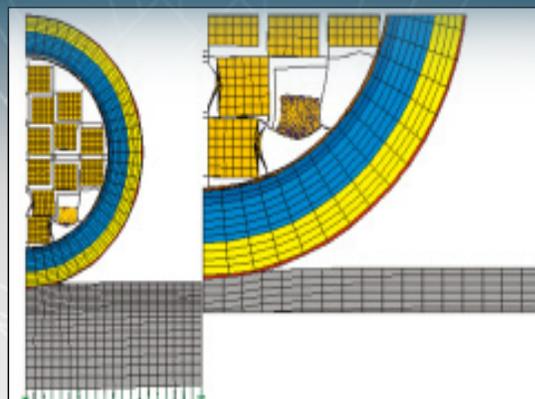
With the occurrence of a fuel or incore component failure, it is imperative that the cause of failure be determined to ensure that appropriate design or operational remedies are implemented in a timely fashion to minimize future failures. We have supported US, European and Asian utility root cause analyses in response to in-reactor failures, fuel fabrication issues, and core component failures. Areas of review can include:

- Visual and non-destructive examination records
- Supplier root cause evaluation reports
- Fuel supplier and sub-supplier fabrication and inspection records
- Analytical evaluations of operational conditions and potential material defects

We also directly assist utility personnel as part of their on-site failed fuel inspections at their nuclear plants and their fuel and component suppliers.



Failure Criteria for Cladding with Mixed Hydride Structure



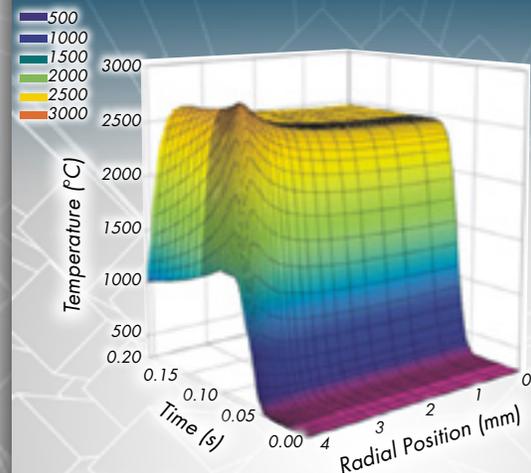
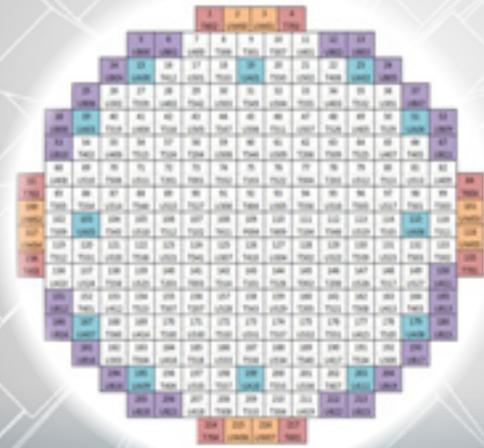
Hypothetical Transportation Accident View of Assembly Deformations at Maximum Response

CORE DESIGN OPTIMIZATION

Core design has been the exclusive area of expertise of fuel vendors. To manage fuel costs utilities have recognized the value of independent core design and multi-cycle optimization. We have performed licensing analysis, reload core optimization and fuel vendor transitions resulting in significant fuel cost savings and operational flexibility to support such projects as reduced power operation, cycle length extension and reduction, and emergency cycle re-designs caused by fuel failures. We are currently uniquely positioned to offer this independent capability to enhance long-term performance, plan reload cycles, validate vendor core designs, and support flexible power operations including cycle length changes and reduced power operation.

FUEL LICENSING AND SAFETY ANALYSES

The continued evolution of fuel designs, fuel vendor transitions, plant operating strategies, and performance goals in the power generation market demands that licensing and safety analysis of nuclear reactors be flexible and responsive. We have the operation and licensing expertise to perform all aspects of reload engineering including core design, thermal hydraulics, fuel performance, transient analysis and accident dose analysis to perform, support and independently validate all aspects of nuclear fuel design and operation. Our personnel have orchestrated fuel vendor transitions including mixed core analysis, cycle length changes and reduced power operation. Our safety analysis and radiological dose personnel have also performed Alternate Source Term analyses and licensing submittals to provide additional plant safety analysis margins. Through these activities, our staff interacts closely on behalf of our utility clients with regulatory agencies and international research organizations in the design, conduct and interpretation of experiments and hot-cell examination results. We are also uniquely poised to support fuel related licensing submittals for power uprates, life extension and Fukushima-related activities.



RIA Analysis Temperature Distributions

DEVELOPMENT OF INDUSTRY FUEL RELIABILITY GUIDELINES

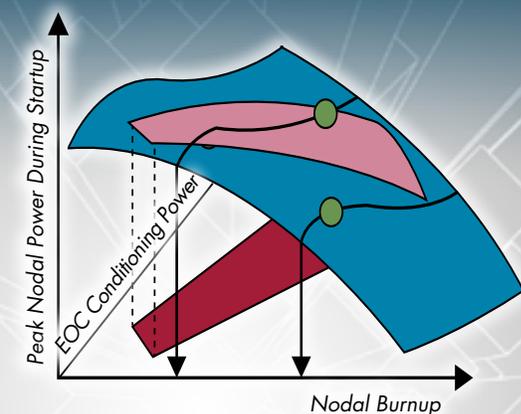
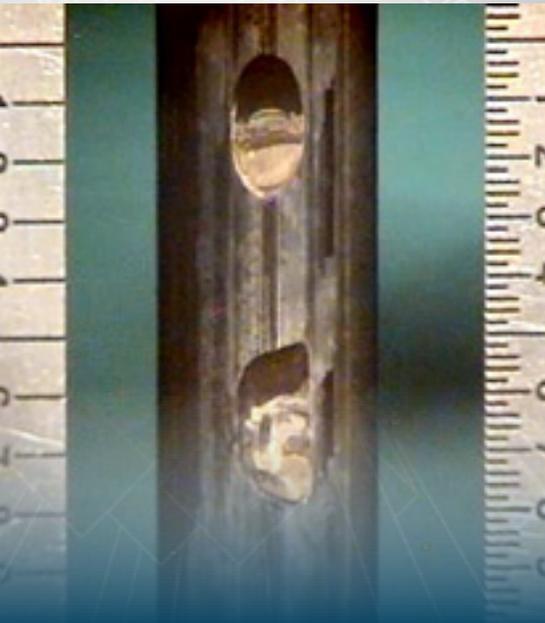
In support of the nuclear industry's initiative to eliminate fuel failures, we worked with the Electric Power Research Institute (EPRI), to develop the following important fuel reliability guidelines for use by utility personnel and industry oversight organizations:

- 1) Fuel surveillance and inspection programs to identify and assess trends in key fuel performance characteristics for currently operating reactors, following changes in fuel design, manufacture and operation, or after anomalous plant operational conditions.
- 2) Pellet-cladding interaction (PCI) failure mitigation in BWR and PWR fuel designs through the development of improved power maneuvering procedures.
- 3) Grid-to-rod fretting fuel failure recommendations to eliminate failures through improvements in debris mitigation features in fuel designs, core design modifications and fuel spacer grid design improvements

This guidance will utilize experience gained from evaluating both power-related fuel failures and successful fuel performance combined with expected trends in fuel operating conditions.

FUEL BEHAVIOR MODELING AND ANALYSIS

We have unique experience in developing material constitutive models and integral behavior codes for nuclear fuel and irradiated materials. Under EPRI sponsorship, ANATECH developed the Falcon code for the analysis of fuel rod behavior during normal operation, maneuvers, transients and postulated accidents. As a finite-element-based code, Falcon has versatile 2-D geometric representation capabilities that can be used to model a full-length fuel rod or a local region of the fuel and cladding material and considers all aspects of nuclear fuel performance, including thermal, mechanical, chemical, and irradiation effects. We have performed fuel rod behavior analyses using Falcon for a wide range of LWR applications, including fuel rod failure assessments during power maneuvers, postulated accidents (Reactivity Insertion Accidents and LOCA) and fuel design verification. ANATECH also has expertise in the use and application of other fuel performance codes including FREY, ESCORE, DEFECT, FRAPCON, FRAPTRAN, and FATES. We are active participants in the DOE-sponsored Nuclear Energy Advanced Modeling and Simulation (NEAMS) and Consortium for Advanced Simulation of Light Water Reactors (CASL) programs by contributing to the development and application of BISON and BISON-CASL (PEREGRINE) 3D fuel performance codes.



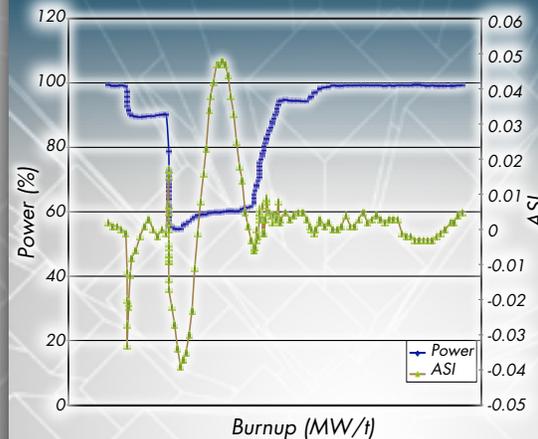
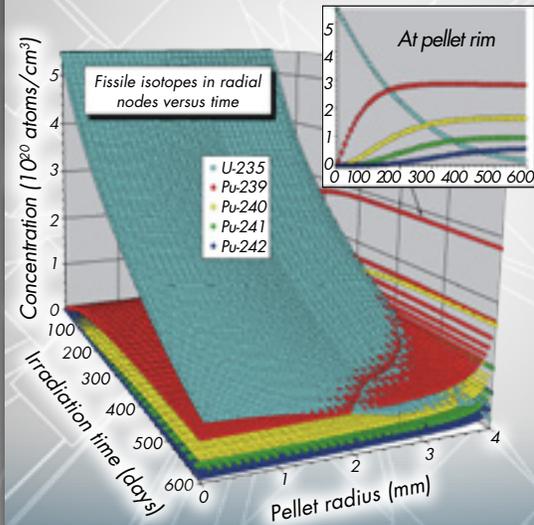
SPENT FUEL STORAGE AND TRANSPORTATION AND DECOMMISSIONING

The behavior of high-burnup spent fuel during long-term dry storage and subsequent transportation has been the subject of research and evaluation at EPRI for many years, in which ANATECH has played a significant role as an EPRI contractor. At issue is the evolution of damage mechanisms, such as hydrides re-orientation during dry storage and their threat to cladding integrity during drop accidents. Our involvement in this program has produced a large volume of original work, and is still continuing. The EPRI-ANATECH products include reports and position papers submitted to NRC for review, which include the characterization of failure mechanisms and associated failure criteria, and the response analysis of spent fuel systems subjected to normal and hypothetical accident conditions of transport prescribed in Part 71 of Title 10 of the Code of Federal Regulations, (10 CFR 71). Similarly, we have participated in the DOE's repository program.

With the advent of nuclear plant shutdowns, decommissioning of power plant sites is becoming a new focus area in the industry. Decommissioning and emergency response reduction licensing submittals, spent fuel pool islanding and dry cask canister design verifications are becoming familiar terms at nuclear plant sites. Our personnel have the knowledge and expertise to perform and review all fuel related analysis in this area including dry cask storage loading patterns, heat load analyses, safety analyses and dose calculations to support these functions.

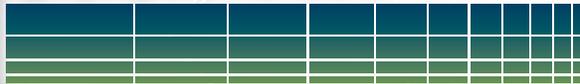
PLANT OPERATIONAL SUPPORT

Due to changing power needs, aging of nuclear plants, and as a result of accidents like Fukushima, the need for plant operational flexibility is now more significant than when plants were run base load outage to outage. Reduced power operation, reload cycle length changes, load following and accurate online core monitoring are becoming prevalent topics of technical discussion. Due to our wide ranging expertise in fuel analysis engineering, we are well positioned to support EPRI and industry initiatives and utilities in all of these emerging plant areas.



Axial Shape Index (ASI) Variation During Power Changes

ANATECH CORP.



A  **Structural Integrity Associates, Inc.**® COMPANY

www.ANATECH.com

877-474-7693

877-4SI-POWER

Parsippany, NJ
973-334-0812

Akron, OH
330-899-9753

Denver, CO
303-792-0077

Austin, TX
512-533-9191

San Diego, CA
858-455-6350

Charlotte, NC
704-597-5554

San Jose, CA
408-978-8200

Chicago, IL
877-474-7693

State College, PA
814-954-7776

Toronto, Canada
905-829-9817