Sandia National Laboratories

Energy, Climate & Infrastructure Security

SAND2012-1846P

Training

Sandia experts customize training and instruction in a variety of tools and capabilities to uniquely fit each group's specific set of needs and available resources.

Sandia Provides Training

Sandia provides training to enhance the use and application of many of its tools and capabilities within the area of nuclear energy. Sandia recognizes that while some groups require intensive instruction detailing every step of every process and the associated underlying principles driving them, others have more expertise or experience in the area. Given the varied nature of groups and organizations, Sandia experts customize training and instruction to uniquely fit each group's specific set of needs and available resources. They bring decades of experience designing, developing and delivering a variety of training courses to effectively introduce concepts and prepare trainees for real world situations.

Severe Accident Modeling Instruction

Sandia offers a comprehensive training suite of material for courses on nuclear reactor safety and Sandia-developed computational codes MELCOR and MACCS, used to model and simulate severe accidents. Training generally includes modules regarding

- Development of safety concepts
- Severe accident perspectives
- Accident progression in the reactor vessel
- Containment characteristics and design basis
- Source terms and offsite consequences

The training can be tailored to meet specific needs and requirements.

Training in Transportation Risk Assessments

Leveraging 35 years of experience in this area, Sandia's training courses address key elements of transportation risk assessments. With past trainees including individuals and groups from the Nuclear Regulatory Commission, Department of Energy, American Nuclear Society, other national laboratories and other countries. Whether a group needs training to better-understand transportation regulations and who they affect, or hands-on instruction for using Sandia's RADTRAN code to best generate, interpret and use simulated transportation data, trainers can customize a course to help.

Courses in Probabilistic Risk Assessment

The courses Sandia offers for probabilistic risk assessments (PRAs) help trainees understand the purpose of PRAs and how they can be managed to increase levels of safety and security. Like other trainings, Sandia experts design courses to be as broad or in-depth as needed, with content ranging from Level 1 - 3 PRA and Fire PRA, to human reliability analysis, human factors and reactor system overviews.

Training in Action: Gulf Nuclear Energy Infrastructure Institute

In 2011, Sandia teamed with the Nuclear Security Science and Policy Institute and regional Middle East partners to jointly develop and operate the Gulf Nuclear Energy Infrastructure Institute (GNEII). Located in Abu Dhabi, UAE, GNEII is a regional education program which offers both classroom instruction and hands-on experience in topics related to nuclear energy safety, security, safeguards, and nonproliferation.

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Regulatory Gap Analysis

Sandia provides regulatory and risk analyses in a comprehensive and efficient manner to close the gap between dated regulations and new technologies being developed in the nuclear energy sector.

Evolving Regulations for Evolving Technology

As technology evolves, old regulations and frameworks for the nuclear power industry are proving to be inadequate to regulate new technology such as the Department of Energy-supported Next Generation Nuclear Plants (NGNP), inlcuding high-tempurature gas cooled reactors (HTGR). The absence of appropriate, applicable regulations for NGNPs and other new nuclear energy technology poses serious challenges to the safe and reliable operation of nuclear power plants. In order for the nuclear energy industry to continue operating in a socially and environmentally responsible manner, regulations must be adjusted or established to effectively meet the regulatory needs of evolving technology.

Refueling floor at Fort St. Vrain Generating Station, one of the first HTGR power reactors in the U.S.

Sandia Rethinks Regulatory Needs

Working with new and untested designs, Sandia National Laboratories provides regulatory and risk analyses in a comprehensive and efficient manner to close the gap between dated regulations and new technologies. Sandia's regulatory gap analysis is based on the principle that as technologies evolve, the risks associated with those technologies evolve, as well. In the case of NGNPs, this means that current regulations originally formulated in the context of systems designed to prevent or mitigate fuel damage in Light Water Reactors (LWR), a high consequence event with serious potential consequences are not applicable because NGNPs uses graphite-based fuel which would not melt and fail in the same manner as LWR fuel.

Sandia's expertise in risk assessment facilitates the Nuclear Regulatory Commission's (NRC) move towards appropriate risk informed regulations for new technologies. This is because a risk-informed regulatory process requires a rethinking of what regulatory priorities should be based on major contributors to risk rather than hypothetical deterministic criteria. With greater adherence to the changing nature of technology, regulations can be refined or developed based on the new technology's significant contributors to risk rather than relying on policies that do not apply or cannot effectively provide regulation.

HTGR reactor at Forschungszentrum Jülich Germany

Uniquely Facilitating Risk-Informed Regulation

Sandia leverages decades-worth of expertise and experience supporting regulatory problems involving risk, safety, and security. Drawing on work extensively developed through its nuclear weapons work, Sandia applies expertise in three major areas to identify and resolve regulatory gaps in order to improve the efficacy of regulations for new power plants.

- Risk and Safety Assessment - Sandia uses risk and safety assessments to systematically evaluate the safety of power plants. With over 35 years of experience supporting the NRC as the lead laboratory in nuclear power severe accident research, these systematic assessments highlight possible points of vulnerability in nuclear power safety designs using combinations of modeling, simulation, and testing. MELCOR, for example, is a Sandia-developed code designed to model accident progression for a broad spectrum of severe accident phenomena, both in boiling water and pressurized water reactors.

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- Emergency Planning - Sandia's experience in emergency planning analysis is used to enhance regulations designed to minimize public health and environmental impacts in the event of an accident. Since new plants are designed to be inherently safer, Sandia's expertise in this area is leveraged not only to put effective mitigation measures in place, but to help rethink and identify new areas where regulations can be revised based on a risk-informed perspective of new and evolved technology.
- Safeguards and Security - Sandia uses its expertise in safeguards and security to ensure the physical protection of nuclear power plants from activities including sabotage and attacks. As with accident risk and safty and emergency planning, the inherently safer plant designs of new reactors will require a rethinking of where and how regulations should be revised based on a risk-informed perspective. Sandia brings nearly six decades of experience providing physical protection to the Department of Energy's important assets.

A nuclear plant security guard in front of the facility entrance gate

NRC resident inspector and trainee conduct inspection at Byron Nuclear Plant in Byron, Illinois

Determining Priorities and Developing Regulations

A significant challenge for regulatory agencies like the NRC is developing effective regulations when there is a lack of detailed design information or operational data about new nuclear reactors. Sandia helps fill these gaps by using its research and analysis capabilities to better-understand new technology and the risks that are associated with it through an efficient, logical, risk-based approach.

Sandia also uses its regulatory gap analyses to assist regulatory agencies in streamlining their license application process. While old license applications processes were deterministic and generally did not systematically address key contributors to risk, Sandia's analyses help regulatory agencies focus resources on the risk-significant aspects of a power plant. Through this approach, license requirements are developed with insights regarding the major contributors to risk for a new technology.

Sandia's Regulatory Gap Analysis in Action: Adjusting SMR Guidelines

In 2010, the Department of Energy (DOE) raised issues surrounding the applicability of licensing processes for a class of new reactor technology called small modular reactors (SMRs). To address these issues, DOE convened a diverse committee of specialists representing more than three dozen organizations to consider SMR-related gaps in regulatory framework and policies. Multiple experts from Sandia joined representatives from government, universities, other national laboratories, reactor designers, industry consultants, technical service providers, law firms, and electric power companies in this effort.

Ultimately, the committee concluded that many U.S. nuclear reactor licensing regulations were focused on the safety and security of large LWRs and recommended a number of approaches to correct these problems for SMRs including seeking exemptions to current rules, revising NRC rulemaking practices and making legislative changes. Heeding this governmental and industry initiative, the NRC requested help from Sandia to revise its fundamental guidelines for reviewing reactor licensing applications. These revisions will result in a licensing process to better-serve the public interest in regulating new SMR designs.

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Sandia National Laboratories

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Quality Assurance

Sandia National Laboratories implements systematic quality assurance (QA) processes in everything from data collection and software, to modeling and analysis.

Trusted Answers for Complex Questions

Sandia National Laboratories abides by high quality assurance (QA) standards, integrating QA practices into virtually every element of its work. Its active enactment of QA is evident both at the group-level when Sandia's Responsive Neutron Generator Product Deployment Center was awarded the prestigious Shingo Prize recognizing its superb manufacturing quality, and on the lab-wide level with the institutional deployment of its International Organization for Standardization (ISO) 9000-registered internal QA system, which is used as the principle framework to manage, plan, execute, and monitor all of Sandia's work.

As a pillar of technical excellence, Sandia integrates QA principles and standards into high consequence problems within the realm of nuclear energy. In order to deliver answers to complex questions with confidence, it implements systematic QA processes in everything from data collection and software, to modeling and analysis. This allows researchers to perform work in a reliable, sound manner, and customers to be confident that they can trust Sandia's results.

Quality Assurance in Experiments

Experiments performed at Sandia consistently and reliably generate quality data because Sandia researchers use QA processes to assure quality testing. Compliant with the highest level of QA, NQA-1, Sandia's test facilities and data collection tools are calibrated and maintained to ensure that accurate, detailed information can be produced for every test. For example, the Mobile Instrumentation Data Analysis System (MIDAS) is a controlled, verified, and well-documented system that provides high-quality measurement data in support of transportation system testing. Constantly checking itself for errors and monitoring its own accuracy, the MIDAS onboard diagnostic system verifies that data acquisition components are functioning correctly. This diagnostic system can verify equipment calibration and characterize individual component performance.

MIDAS trailer on location

Sandia's researchers also contribute to QA in experiments. With over six decades of experience supporting a variety of high QA-required activities ranging from nuclear weapons testing to materials experiments, Sandia's researchers represent a wide breadth of subject matter expertise and experimental know-how. Rather than simply generating data from an experiment, researchers understand the scientific dynamics of what is happening during the test, as well as how and why results are produced. In the case of MIDAS, every piece of data from its nearly 1,000 tests is stored, which enables data comparisons over time. This incredible level of data retrievability can be used to produce a record of equipment parameters and performance both during the test and retroactively, providing a computer-generated audit trail of each piece of gear in the data path. Applying detailed knowledge of experimental dynamics, researchers know what to look for and are able to use audits like this to assure the quality of data produced.

Assuring Quality through Software

In addition to implementing QA processes into experimental design and procedures, Sandia also builds QA measures into the software it produces. Developed at Sandia, MELCOR is a fully integrated, engineering-level computer code designed to analyze severe accidents in nuclear power plants.

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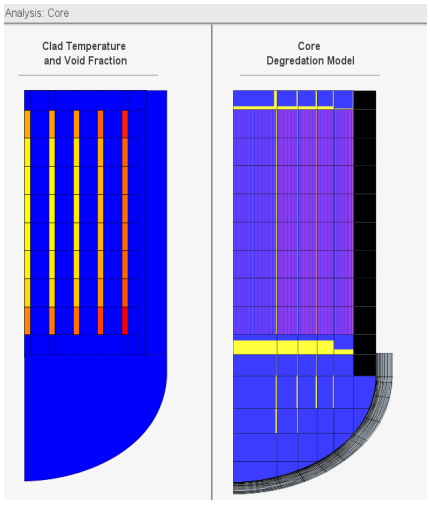
Waste Isolation Pilot Plant

Primarily used to model accident progression, MELCOR undergoes continuous development to address emerging issues, process new experimental information, and create a repository of knowledge on severe accident phenomena.

Despite its constant state of development, Sandia maintains configuration control over MELCOR to uphold high standards of QA. With control over the source code and user modules, Sandia code developers track and store information on all changes. Further, MELCOR's system runs a series of 100 test cases nightly and larger test cases on a weekly basis to ensure that the code is running properly. Validated against experiments, this allows developers to compare the current code to previous versions and actual data generated through experiments. These QA measures help developers quickly catch and resolve inaccuracies and inconsistencies in MELCOR, and help users understand how updates to the code affect the data produced.



MELCOR core depiction

Modeling and Analysis

Sandia researchers use a number of methods to validate computer models and assure the quality of resulting analyses. In the simplest sense, quality input is used to produce quality output. Applying increasingly transparent data sets and computer code algorithms, researchers produce data with a high degree of traceability. This heightened traceability facilitates the ease and speed of periodic system checks allowing for better, more accurate quality assessments.

Further, as a systems engineering laboratory, Sandia leverages its expertise in complex systems to ensure high levels of QA in modeling and analysis. Due to the nature of complex systems, the development of a validated model is an iterative evolutionary process. Requiring a continuous feedback loop, quality assurance checks are performed to generate and enhance confidence in the model's conceptualization and results.

QA in Action: Waste Isolation Pilot Plant

The Waste Isolation Pilot Plant (WIPP) is the first deep geologic repository for radioactive waste disposal in the world to be certified by a regulator. As the science advisor for the WIPP program, Sandia applies rigorous nuclear-industry QA requirements imposed by the U.S. Environmental Protection Agency (EPA) to experimental studies and performance assessments used in the certification and recertification process. Implementing a QA program allows Sandia to provide objective evidence that the program is rigorously implementing sound scientific practices with qualified staff and producing defensible results. As a result, regulators are able to evaluate and certify the WIPP.

QA is integrated into all technical and administrative work conducted by Sandia through continuous quality reviews of documentation and oversight assessments of in-process activities in the performance assessment and repository performance sections of the Carlsbad Field Office's QA Program Document (CBFO QAPD). The overall objective is to effectively satisfy QA requirements imposed by the CBFO QAPD and to maintain, improve, and verify implementation of Sandia's QA program. General deliverables and associated schedules entail maintaining readiness for audits of Sandia's QA program by CBFO and the EPA. Sandia's WIPP-compliant QA program also supports the delivery of technical reports to CBFO in support of periodic recertification and regulatory streamlining.

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Sandia National Laboratories

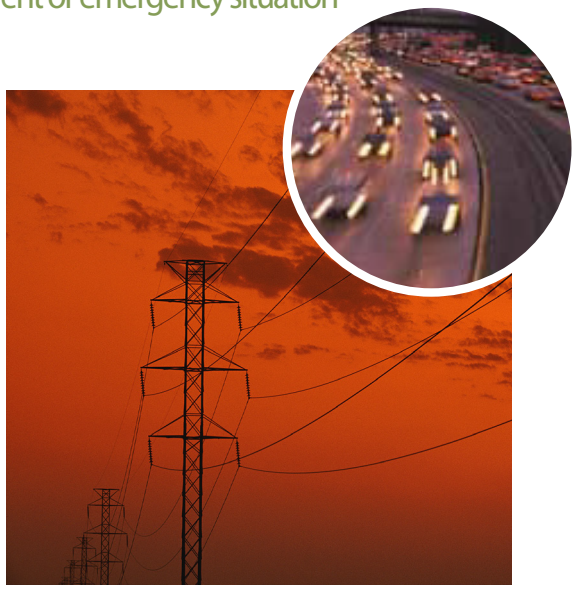
Energy, Climate & Infrastructure Security

Probabilistic Risk Assessments

Used as a systematic process to identify potential accidents and threats at hazardous facilities such as nuclear power plants, PRAs highlight possible points of vulnerability within a complex system before an incident or emergency situation

A New Age of Risk Assessment

Probabilistic Risk Assessment (PRA), sometimes referred to as Probabilistic Safety Assessment (PSA), is a systematic, logical analysis process that is a powerful tool for ensuring the safe design and operation of complex engineered systems that have the potential for significant failure consequences. Sandia is a leader in the development and application of these methods to both civilian nuclear power and defense applications. In the past, PRAs have provided largely qualitative results, but with increasingly accurate modeling and data analysis techniques, PRAs now provide much more quantitative risk assessments. In the future, Sandia researchers will continue to advance the state-of-the-art in PRA techniques and methodologies and apply them to high consequence engineered systems. Many opportunities exist for the application of Sandia PRA research and analysis expertise including national infrastructure, transportation, health care, agriculture and, of course, nuclear power and national defense.



PRA analyses can be used to evaluate a variety of applications including infrastructure and transportation systems

Characterizing Risk

In simple terms, risk represents the product of the likelihood of an adverse event and the consequences of that event. Sandia researchers use an array of analysis techniques including event and fault trees, influence diagrams, decision trees, network diagrams, etc. combined with deep systems knowledge and substantial professional expertise in order to produce realistic risk estimates for complex systems. The resulting analyses explore the often subtle and non-intuitive interactions between initiating events, hardware failures, human errors, and operational and organizational factors that influence the risk profile for a system. Insights obtained from PRA analyses can play valuable roles throughout the system lifecycle from design and licensing, to construction, through operation and regulation.

Application to Civilian Nuclear Energy

Sandia has over 30 years of experience developing and applying PRA methods to civilian nuclear power dating from the Three Mile Island event in 1979. This history coincides with the development of the modern risk informed, performance based regulatory framework employed by the U.S. Nuclear Regulatory commission today. Sandia has played a central role in many of the seminal works which form the basis of the U.S. nuclear regulatory structure and is an active contributor in the development of industry standards which provide

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guidance for the correct application of these techniques in an industrial setting. Not only does Sandia staff include many of the original developers of current PRA methods but also a new generation of researchers capable of continuing the development of this important technology for the next 30 years.

There are many compelling challenges in the area of civilian nuclear power risk analysis which will need to be addressed in the coming decades. Some of these challenges will be associated with new reactor designs including small modular reactor as well as next generation light water reactors and advanced gas and metal cooled reactors. These designs will incorporate new technology including digital instrumentation and control systems and passive safety features, as well as new operating conditions and business models including industrial heat applications and distributed or multi-module siting. It will be necessary to extend current PRA methods and develop new methods to address the needs of new technology but also to conduct the empirical studies that provide the system and component performance data upon which future risk analyses will depend.

The challenges posed by the analysis of the current aging U.S. and international fleet of third generation reactor designs are no less important than those posed by new designs. The impact of aging on the performance of existing reactor systems and components is of particular importance and will require new empirical and analytical studies. New data and methods from the constantly evolving field of PRA will suggest ways to improve current understanding of the risk profile for existing designs and may allow extension of PRA analysis into operational modes that are poorly characterized currently.

Sandia-Originated Methods and Tools

As a leader in PRA methodology development since the 1970s, Sandia has established a best in class reputation in several specific technology areas relevant to PRA analysis of civilian nuclear power. In particular Sandia has been an active force in establishing the state-of-the-art in human reliability analysis and fire risk analysis as well as computational modeling of severe accident progression and off-site health consequences. The methods and empirical data developed at Sandia inform both regulatory guidance and industrial standards used throughout the U.S. civilian nuclear energy industry. The MELCOR and MACCS2 computational analysis tools incorporate physical models for severe accident phenomenology including radionuclide transport and release based on more than 30 years of U.S. and international experimental data. Maintained and under continuous development at Sandia, these tools represent a repository of the best models of the physical processes involved in severe reactor accidents and their off-site health consequences.

Risk-Informed Decision-Making

By identifying potential risks and safety vulnerabilities in complex, high-consequence, engineered systems, PRAs ultimately support risk-informed decision-making. While assumptions and inferences may seem logical in certain circumstances, PRAs provide the scientific rigor and

Human Reliability Analyses are a key component of assessing risk at nuclear power plants

support needed to justify regulations, industry standards and decisions. With more information available, better decisions are made to optimize facility function, avoid incidents and promote public safety.

Publications

Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants, NUREG-1150, 1991

Reexamination of Spent Fuel Shipment Risk Estimates, NUREG/CR-6672, 2000

Fire PRA Methodology for Nuclear Power Facilities, NUREG/CR-6850, 2005

Good Practices for Implementing Human Reliability Analysis, NUREG-1792, 2005

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Sandia National Laboratories

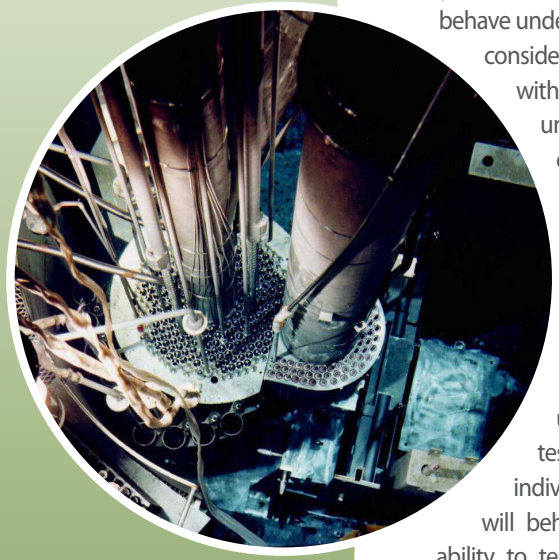
Energy, Climate & Infrastructure Security

Multi-Scale, Multi-Process Testing

Sandia National Laboratories uses multi-scale and multi-process testing to explore and understand how individual components and subsystems will behave in different environments.

Understanding the Parts that Make a Whole

When using a particular package to transport radioactive or hazardous material, designers and regulators must know whether the package will be able to effectively contain the material and prevent material releases into the atmosphere. They must be able to predict how parts of the package--the seal, for example--will behave under a variety of circumstances. Whether considering the seal of a package or wiring within a nuclear reactor, it is important to understand the behavior of individual components and subsystems, and how that behavior will affect the system as a whole.



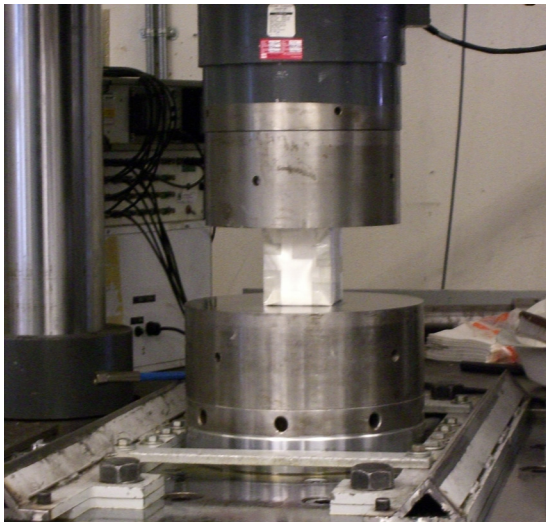
Sandia's Annual Core Research Reactor

As a measure to inform risk and safety assessments and performance certification processes, Sandia National Laboratories uses multi-scale and multi-process testing to explore and understand how individual components and subsystems will behave in different environments. The ability to test these individual elements serves as an important element of total system integrity and performance assurance.

Sandia's Testing Combines Applied and Pure Science

Since the performance of a single component or subsystem within a larger system can mean the difference between proper system function and total system failure, Sandia uses testing to determine how individual parts behave. Often combining principles of both applied and pure science, Sandia's testing is designed to generate detailed, increasingly useful data for both designers and regulators, alike.

Many of Sandia's tests examine behavior and performance from a function-based point of view. Will this package seal survive a high temperature fire? Does a medium velocity impact cause wiring within a unit to short out? Can a particular material be used as an energy absorber during an electrical fire? These questions of performance are answered through testing behavioral responses in one of Sandia's many controlled environments.



Materials Testing at Sandia

Sandia also leverages pure science in its testing to better-understand and more accurately characterize the physics of events. Sandia looks beyond the simple question of whether or not a component or subsystem performed successfully to understand the phenomenology of the environmental conditions. For example, extra instrumentation is sometimes used during package fire tests not to gather data about what's happening to the package, but to gather information about the fire itself. By better-understanding the fire's behavior, researchers can better-understand component and subsystem tests that involve fire. This results in a more complete, thorough examination of subject and phenomena of interest.

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A Legacy of Testing Leadership

Leveraging over six decades of extensive experience in weapons component testing, Sandia serves as a hub of testing expertise. When needed, Sandia applies a multi-physics approach to testing achieved through its vast expertise base including important areas such as fire science, instrumentation, explosives, and mechanics. With a wide variety of fielded expertise, Sandia's testing experts are capable of performing all steps of the experimentation process. Whether custom experiment design, preparation, execution, or a unique combination is needed to achieve particular goals, Sandia's researchers have the experience and procedural know-how to produce the best data possible.

Sandia is also home to a number of notable testing facilities. With high profile facilities like the Thermal Test Complex, used to demonstrate the performance of components and assemblies under a variety of abnormal thermal environments, and the Water Impact Facility which provides a controlled environment for high-velocity water impact and underwater testing, Sandia it is capable of simulating nearly any environment required by a test.

Leveraging Testing to Fill Gaps

In order to understand the function and performance of a system, it is important to understand the components and subsystems that comprise it. This is of particular importance in high consequence situations such as those in the area of nuclear energy involving radioactive and hazardous materials.

Generally, component manufacturers provide limited information about their products. They may provide performance assurances under general use, but when components are used in high consequence systems such as those used in nuclear reactors, general use assurances are not enough. Industry and regulatory agencies must know that the component can withstand a number of environments that may pose risks to the system.

When needed, Sandia serves as an intermediary between component manufacturers, industry, and regulatory agencies, using component and subsystem testing to help fill the gaps. By testing components at varied temperatures, strain rates, and damage states, for example, users will have the behavior and performance information they need to know whether or not a component or subsystem is suitable for use in a high consequence system.

Testing of this nature is also used to inform risk and safety assessments. By better-understanding a component or subsystem's performance in high consequence situations, potential risks and limitations can be identified and mitigated either through adjusted design or regulatory action. This leads to safer, more reliable complete systems.

Component Testing in Action: Liquefied Natural Gas Vessel

When uncertainty arose regarding how the steel of a Liquefied Natural Gas vessel would behave when subjected to very low temperatures, Sandia was called upon to perform testing. To examine the behavior of the steel and the ship structure when exposed to cryogenic temperatures, Sandia designed a series of tests to produce the extreme environment by applying cryogenic liquid to ship steel plates and representative ship wall sections.

These tests provided researchers with mechanical and thermal information that was then used to generate benchmarks for code validation.

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MIDAS: Mobile Instrumentation Data Acquisition System

MIDAS is a controlled, verified, and well-documented system dedicated to providing high-quality measurement data in support of transportation system testing.

Gathering Vital Information

Testing is a significant element of both the design and certification processes for transportation packages that contain radioactive and hazardous materials. This requires collecting data to accurately characterize what happens to a package under a variety of circumstances including events such as impact, puncture, fire, and immersion.

Sandia National Laboratories created the Mobile Instrumentation Data Acquisition System (MIDAS) to provide on-site data acquisition and analysis capabilities for testing of radioactive and hazardous materials packages. MIDAS allows researchers, designers, and regulators to examine and understand how a package behaves in a variety of environments.

MIDAS trailer at a cable site

MIDAS: Mobile Data Acquisition

MIDAS is a controlled, verified, and well-documented system dedicated to providing high-quality measurement data in support of transportation system testing. Data acquisition equipment is contained in a 44-foot trailer and, with an auxiliary power generator, provides a self-contained mobile data acquisition and reduction facility.

MIDAS is equipped with acquisition systems to gather both structural and thermal data. The structural data acquisition system is capable of acquiring 72 channels of time domain data from any combination of piezoresistive or voltage-based measurement devices. Commonly used to measure package response to regulatory impact, puncture, and immersion tests, the overall structural data bandwidth extends to 100 kHz at -0.5 dB, by sampling at 500,000 samples per second or greater. The thermal data acquisition system can acquire up to 80 channels of Type K thermocouple data and 20 channels of Type T thermocouple data.

Inside the MIDAS trailer

Excellence in Quality Assurance

MIDAS performs in compliance with the highest level of quality assurance, NQA-1. Constantly checking itself for errors and monitoring its own accuracy, the MIDAS onboard diagnostic system verifies that data acquisition components are functioning correctly. This diagnostic system can verify equipment calibration and characterize component performance.

MIDAS also features an incredible level of data retrievability through the system's documentation package. This package allows a record of equipment parameters and performance to be produced both during the test and retroactively, providing a computer-generated audit trail of each piece of gear in the data path. Every piece of data from nearly 1,000 tests using MIDAS is stored, which enables data comparisons over time and facilitates self-calibration.

Supporting Package Design and Certification

While MIDAS is used extensively to gather data in performance and component tests of transportation packages, it is also used in modeling and simulation. Because MIDAS is exceptionally consistent and widely trusted throughout the regulatory community, systems, subsystems, and component-level data are used to benchmark results supporting package design or certification activities.

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Large-Scale Validation Experiments

Sandia researchers apply detailed knowledge of nuclear energy regulations and the regulatory environment to experiments, ensuring that experiments generate the best, most accurate data.

Gathering Data for Validation

The nuclear energy industry and its regulators must have confidence that the technology used in all parts of the enterprise will perform accurately and reliably. Whether designing a new transportation package or certifying a nuclear reactor, performance is often tested through large-scale validation experiments. This allows researchers, designers, and regulators to observe and evaluate how a technology responds to an environment. The results of these experiments indicate whether regulatory requirements are satisfied and can also be used to benchmark further analysis.

Surtsey test facility

Sandia National Laboratories leverages nearly six decades of extensive testing experience with a wide variety of high profile testing facilities to serve as an institutional hub for the design, preparation, and execution of large-scale validation experiments. With a long history of support to regulatory agencies such as the Nuclear Regulatory Commission (NRC), Sandia researchers apply detailed knowledge of nuclear energy regulations and the regulatory environment to experiments, ensuring that experiments generate the best, most accurate data.

Performing Large-Scale Experiments in Nuclear Energy

Drawing on its legacy mission work in nuclear weapons testing, Sandia performs classified and unclassified experiments, and high consequence testing involving hazardous and radioactive material. As the only institution in the world to have performed a containment certification test using actual radioactive material, Sandia maintains strong leadership in this area.

Sandia researchers often perform validation experiments on complete assemblies or high fidelity models. Rather than using simplified models, these assemblies are generally full-scale or near-scale prototype units. By testing what will actually be in use, researchers gather accurate, increasingly realistic performance data. This allows them to determine how the technology's performance measures up to regulatory requirements. Through validation experiments, Sandia is able to test and certify package design, for example, for regulatory agencies.

TRUPACT drop test

Available Nowhere Else in the Country

Sandia performs a number of large-scale validation experiments that cannot be done anywhere else in the country. It is the only institution in the U.S. capable of testing air transportation packages. Using either the Rocket Sled Track to accelerate the package into a target or the Aerial Cable Site to pull it downwards to its impact target, air transportation package designs are tested and certified in extreme environments according to regulations and validation standards.

Full-scale fire tests of large packages are also performed at Sandia, but nowhere else in the U.S. These large-scale validation experiments leverage Sandia's extensive collection of high profile, large-scale fire testing facilities including the Laurance Canyon Burn Facility and the Thermal Test Complex, which is the leading Department of Defense fire testing facility in the nation. Using a variety of data acquisition tools including the in-house-developed Mobile Instrumentation Data Acquisition System (MIDAS), researchers efficiently and effectively

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U.S. DEPARTMENT OF ENERGY

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gather performance data needed to satisfy fire-based regulatory and validation requirements.

Customization Opportunities Based on Experiments

Depending on the needs of a specific experiment, Sandia customizes its facilities, adapting them to meet the unique needs of each situation. For example, Sandia maintains a large outdoor lake facility that can be used for Liquefied Natural Gas (LNG) experiments. Researchers are able to adjust the pool's size, blocking off sections when needed, to accommodate the needs and parameters of individual tests. This customizability helps researchers generate increasingly detailed, accurate performance data since the physical characteristics of the test environment closely resemble those of the actual environment of interest.

LNG experiment at Sandia's outdoor lake facility

Sandia also constructs custom facilities, when needed. In support of the NRC and Japan's Nuclear Power Engineering Corporation, Sandia's researchers custom-built a quarter-scale nuclear reactor designed to test the point at which overpressurization would result in structural failure.

Analyzing Validation Data

In general, data generated through large-scale validation experiments is analyzed to determine whether or not a technology meets requirements. Documenting and characterizing how the technology performs in a particular environment, the resulting analysis indicates what industry and regulatory agencies can expect if the situation were to occur when the technology was deployed. This data is particularly valuable when used to inform risk and safety assessments.

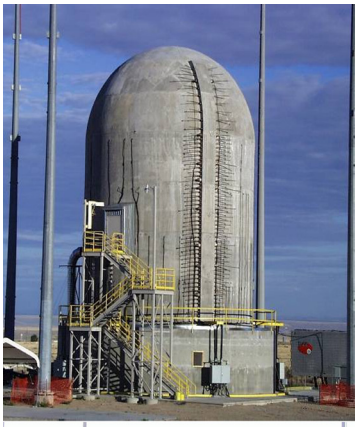
Additionally, data derived from large-scale validation experiments benchmarks modeling and simulation tools. Without physically executing the experiment, these tools generate performance data for technology subjected to a variety of environments and situational scenarios. However, since the experiments are simulated, benchmarks are necessary to permit high confidence in data generated from non-tested scenarios.

Large-Scale Validation Experiments in Action: Quarter-Scale Reactor Experiment

Sponsored by the NRC and Japan's Nuclear Power Engineering Corporation, the quarter-scale reactor experiment was performed to validate NRC computer codes used to predict pre-stressed concrete containment vessel (PCCV) pressure tolerances in severe accidents, and to demonstrate that existing reactors at power plants in Japan and the U.S. could perform safety functions reliably in an accident.

Over the course of three years, Sandia constructed a 70-foot tall, 35-foot diameter PCCV as a small replica of one operating at a nuclear power plant in Japan. During the experiment, the vessel was "tested to failure" as Sandia researchers pumped nitrogen gas into the concrete model, gradually increasing the gas pressure until the structure failed. It is the largest nuclear reactor containment vessel model ever tested to failure.

The PCCV model was built with nearly 1,500 sensors and fiber optic lines embedded into its materials enabling researchers to gather tens of thousands of lines of data about its performance before and during the test. Data from the test was used by an international team of experts to benchmark structural analysis codes and develop new state-of-the-art accident response models.



The largest nuclear reactor containment vessel model ever tested to failure

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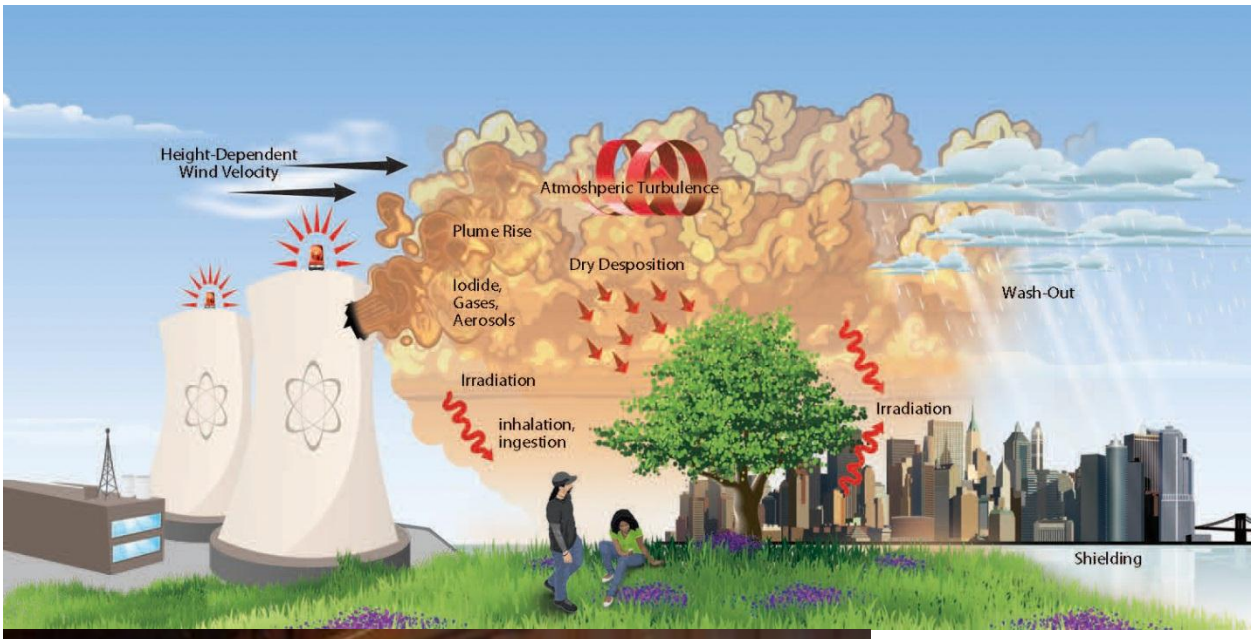
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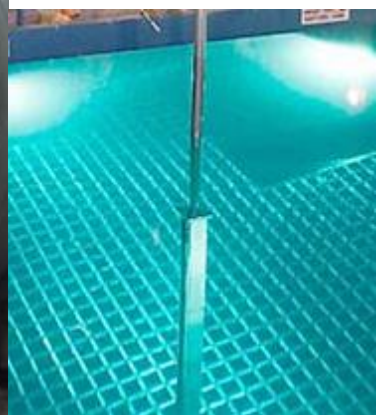

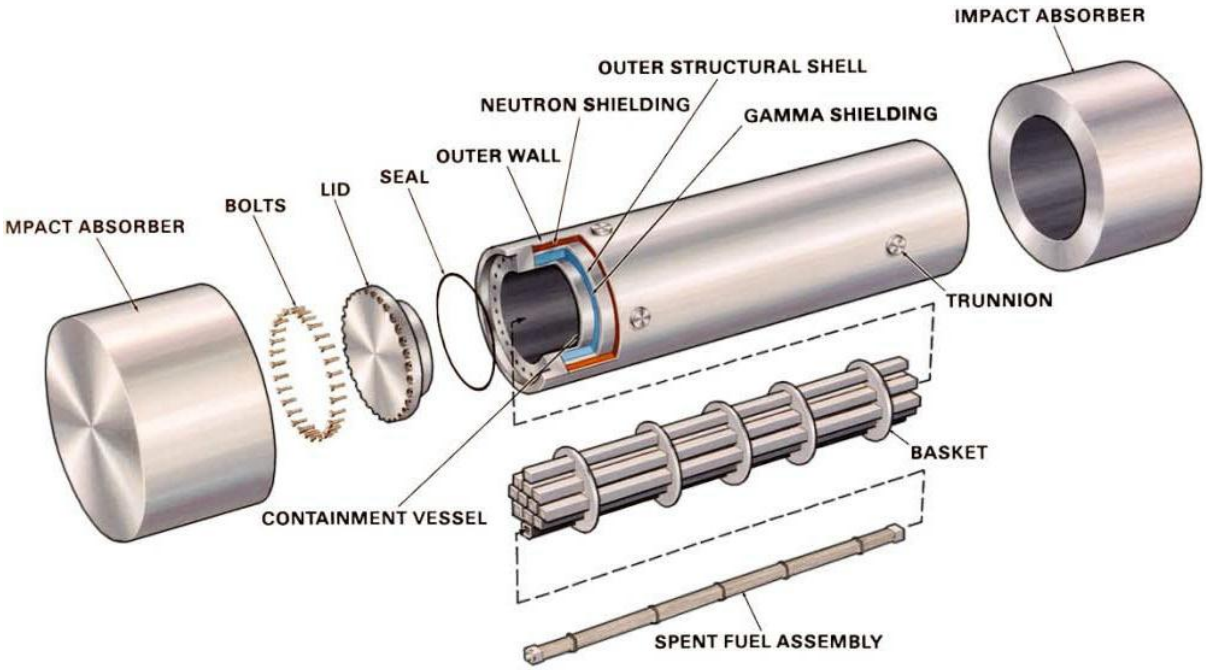
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