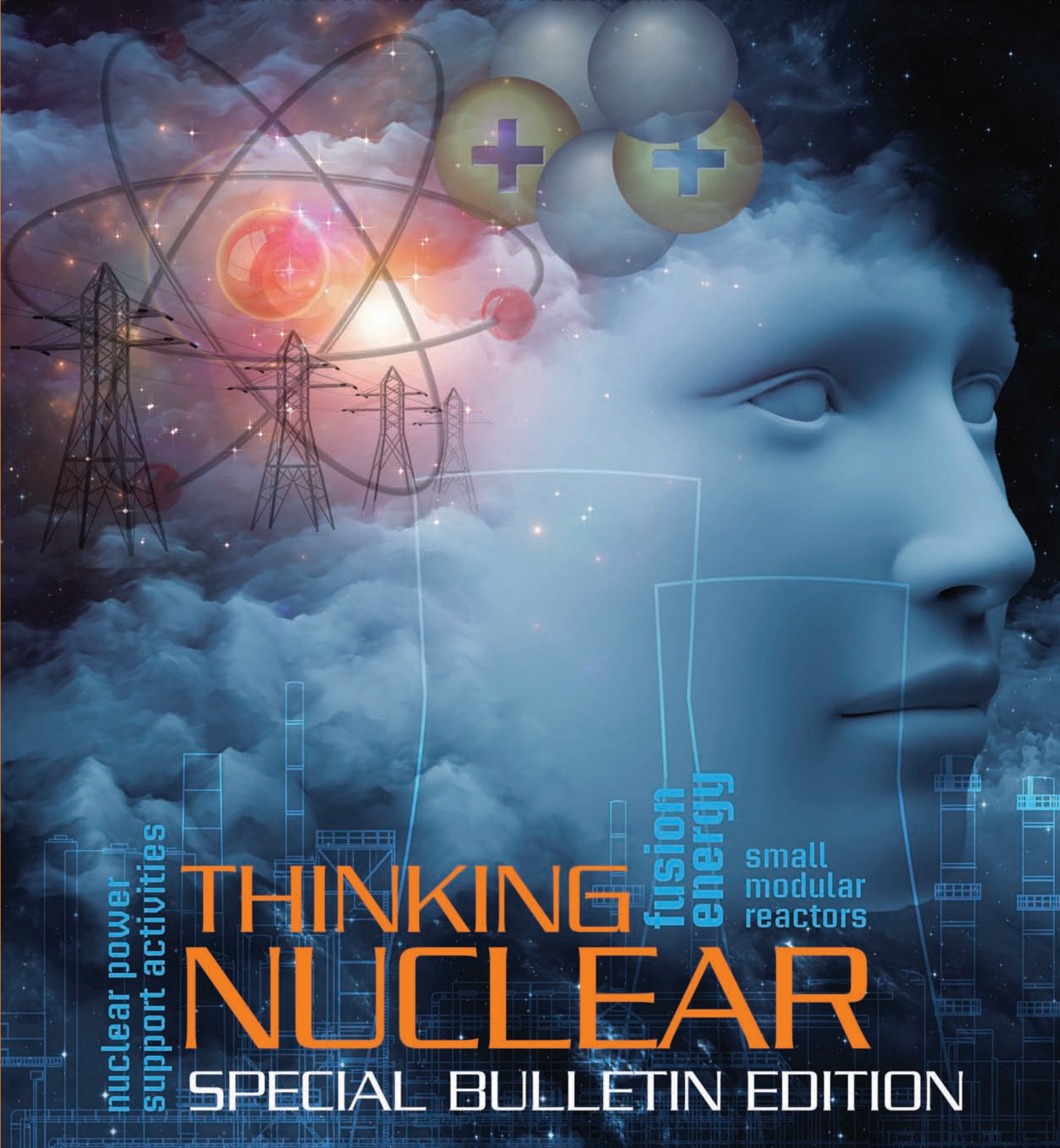
WINTER 2015

BULLETIN

TECHNICAL JOURNAL OF THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS



THINKING NUCLEAR

SPECIAL BULLETIN EDITION

nuclear power support activities

fusion energy

small modular reactors

BULLETIN
TECHNICAL JOURNAL OF THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS

The National Board of Boiler and Pressure Vessel Inspectors was organized for the purpose of promoting greater safety by securing concerted action and maintaining uniformity in the construction, installation, inspection, and repair of boilers and other pressure vessels and their appurtenances, thereby ensuring acceptance and interchangeability among jurisdictional authorities empowered to ensure adherence to code construction and repair of boilers and pressure vessels.

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CONTENTS

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FEATURES

Thinking Nuclear: An update on the current fleet of US nuclear reactors, and informative overviews of innovative nuclear energy technologies that could change the way our world is powered in the future.

DEPARTMENTS

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Opinions expressed in this special nuclear-themed issue of the BULLETIN *are solely those of the individual authors and do not necessarily reflect the policy or position of the National Board. The contributors and publications editor have made every effort to ensure that the information was accurate at press time.*

Thinking Nuclear – A *BULLETIN* Special Issue

BY DAVID A. DOUIN, EXECUTIVE DIRECTOR

Innovation in nuclear power is vital to ensure the world's future energy needs will be met. According to the World Nuclear Association, electricity demand is increasing twice as fast as overall energy use and is likely to rise by more than two-thirds by 2035.

There is plenty of discussion regarding the 99 nuclear power plants currently operating in the United States. In his comprehensive article beginning on page 4, Kenneth Balkey explains that more than one-third of these reactors are now operating in an extended licensing period, having surpassed their 40-year operating license. Ken details the major questions that industry, government, and regulatory experts must address in managing aging plants, as well as other key factors that will help secure a safe future for nuclear power, such as inspection and standards education.

Different from "traditional" nuclear reactors, small modular reactors (SMRs) are advanced-technology reactor designs that are being hotly pursued in the power marketplace. SMRs are characterized as having passive safety features, the ability to be manufactured in a shop and easily transported to an installation site, and as being cost-effective. Furthermore, SMRs could be deployed within 20 years. The advancement of SMRs is something to keep an eye on, as new reactor designs will mean new inspection techniques. Two insightful articles on SMRs begin on page 12.

Now think beyond the year 2035 to the energy needs of future generations. According to ITER (an international energy project), global energy consumption could triple by the end of the century. Imagine a power source that could release nearly four times more energy than a fission reaction. This potential lies in harnessing the same source that powers the sun and stars – fusion energy. At a glance, the story of ITER and fusion energy seems the plotline of a science fiction novel, but fusion energy is real and the technology is advancing. Two articles on fusion begin on page 20.

A number of industry experts contributed articles for this special nuclear-themed issue. Not surprisingly, the *BULLETIN* received such great response from contributors that additional articles will appear in the summer 2015 issue. So stay tuned.

Speaking of industry experts, in less than three months professionals from the boiler and pressure vessel industry will gather at The Broadmoor resort in Colorado Springs, Colorado, for the 84th National Board / American Society of Mechanical Engineers (ASME) General Meeting, April 27 – May 1. *Safety: A Commitment for Life* is designated as this year's theme.

A diverse panel of speakers and topics has been selected for the General Session portion of the program. Some of this year's presentations include: "The 150th Anniversary of the *Sultana* Explosion," by Patrick Jennings (The Hartford Steam Boiler Inspection and Insurance Company); "Carbon Monoxide: The High Cost and Effects of Complacency," by Carey M. Bilyeu (Zurich North America Insurance); "Hoover Dam – Maintaining a Giant," by Nathaniel Gee (US Bureau of Reclamation); and "Making ASME Codes and Standards Smaller: Small Modular Reactors and Their Needs for Future ASME Codes," by A. Thomas Roberts (MPR Associates Inc.), who also wrote a primer on SMRs in this issue. A full line-up of guest tours is also scheduled, and Colorado's breathtaking natural beauty will be at the center of each experience. Full General Meeting coverage begins on page 36 and can also be found on our website.

Final thoughts . . . In this issue we glimpse at how new codes, standards, and inspection techniques are being developed to support advanced nuclear energy technologies, reminding me of an old epigram: *The more things change, the more they stay the same*. The history of steam shows us that technology rapidly changes to meet the energy demands of each generation, but decade after decade, safety has been the common-sense, unyielding anchor that has endeavored to secure the public's well-being.

Our industry's shared commitment to safety *is* a commitment for life, and a priority that will always stay the same, no matter.

National Board *Synopsis* Update

The National Board *Synopsis* (NB-370), is a compilation of jurisdiction laws, rules, and regulations as reported to the National Board by jurisdictional authorities. The table below notes changes by category for 2014. Jurisdictions not listed either had no changes or did not submit changes at time of print. For more information, go to www.nationalboard.org under "Resources" to view the complete *Synopsis*. Data is subject to change; consult the appropriate jurisdiction for final verification.

JURISDICTION	DEPARTMENT	DATE OF LAW PASSAGE	RULES FOR CONSTRUCTION AND STAMPING	OBJECTS SUBJECT TO RULES FOR CONSTRUCTION AND STAMPING	OBJECTS SUBJECT TO RULES FOR FIELD INSPECTION	INSPECTIONS REQUIRED	CERTIFICATE OF INSPECTION	FEES	MISC
US STATES									
Alabama	X	X							
Connecticut	X								
Delaware	X	X	X			X			
Georgia									
Hawaii		X	X	X	X	X		X	X
Illinois			X						
Indiana	X								
Kansas	X			X	X				
Massachusetts	X								
Mississippi									
Missouri	X								
Montana	X								
Nebraska			X						
Nevada	X	X	X	X	X	X	X	X	X
New Hampshire	X	X		X	X				
New Jersey	X								
New Mexico									
North Carolina	X			X	X				X
Ohio		X	X						
Oklahoma	X							X	
Oregon		X	X						
Pennsylvania	X								
South Dakota	X								
Washington		X	X						
CANADIAN PROVINCES/TERRITORIES									
Alberta	X	X	X				X	X	X
Manitoba	X		X						X
Newfoundland	X								
NW Territories	X							X	
Nova Scotia	X								
Ontario			X			X			
Prince Edward Is.	X	X						X	X
Saskatchewan							X	X	
US CITIES/TERRITORIES									
Detroit	X								
Milwaukee	X								
Puerto Rico						X			
Seattle			X						

May 2014 aerial photo of the construction site at V.C. Summer, where South Carolina Electric & Gas Company (SCE&G) is building two new Westinghouse AP1000® reactors. Photo Courtesy of SCE&G.

The Role of Inspection and Standards Education on the Future of Nuclear Power

BY KENNETH R. BALKEY, P.E.

Nuclear power is the most reliable source of electrical generation, with stable generation costs, no carbon emissions, and a small land "footprint" when compared to other carbon-free energy sources. It gives good voltage support for electric power grid stability compared to intermittent sources such as wind and solar. Yet, the outlook for this important major electrical generation source continues to face challenges in the United States and throughout the world. Work associated with The National Board of Boiler and Pressure Vessel Inspectors, along with standards education, will continue to play a vital role in the future of this industry, particularly given the growing need to address greenhouse gas emissions and the resulting potential impact of detrimental climate change.

The containment vessel bottom head (CVBH) is placed on the basemat of V.C. Summer Unit 3 in May 2014. The approximately 900-ton CVBH was lifted into place with the Heavy Lift Derrick, which is one of the world's largest cranes. Photo courtesy of SCE&G.

The Current Status of Nuclear Power in the US and the World

The United States has a fleet of 99 nuclear power plants that produce nearly 100,000 megawatts of nameplate capacity, comprising nearly 20 percent of the net generation. Most of those plants were built in the 1970s and 1980s and each was given a 40-year operating license from the US Nuclear Regulatory Commission (NRC). Thanks to proactive efforts more than 20 years ago, a License Renewal Rule was enacted in 1991 to allow the majority of today's operating reactors to extend their operating licenses from 40 years to 60 years. More than one-third of US reactors are now operating in this extended license period.

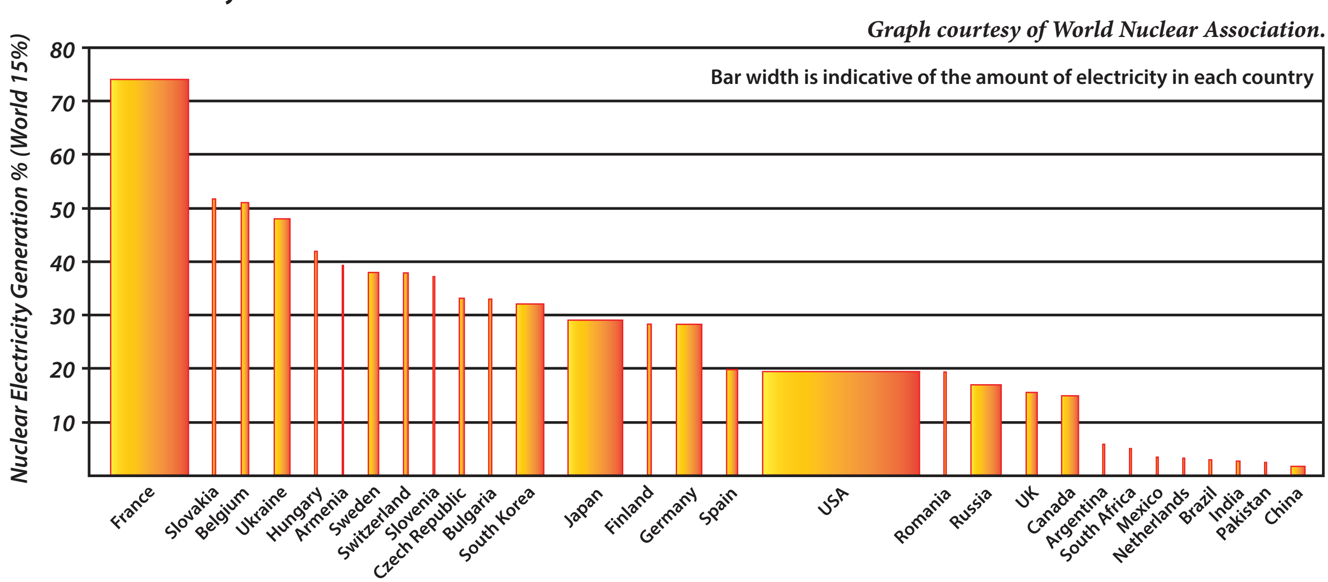
Up until 2013, there had been no ground-breaking on new nuclear reactors at existing power plants in the US since 1977. Then, the US NRC approved construction of four new Westinghouse **AP1000**® (*see Note*) reactors at existing nuclear plants. Construction of the Virgil C. Summer Nuclear Generating Station Units 2 and 3 in South Carolina and Vogtle Electric Generating Plant Units 3 and 4 in Georgia began in March 2013. In addition, Tennessee Valley Authority's new reactor at Watts Bar Unit 2 near Spring City is at an advanced stage, since construction was resumed after being halted in 1988.

While this new construction is good news, it does not come close to meeting the need to eventually replace existing nuclear generation. Without extending the current fleet beyond 60 years of operation, reactors will begin coming off-line in the year 2030. The US would need to bring on-line four to five reactors each year over the next 25 years to maintain equivalent levels of emission-free electrical generation from nuclear power. Adding to this dilemma is the closure (or planned closure) of five reactors due to major component or containment concrete issues or economic issues, such as the low price of natural gas as an alternative to nuclear operations. This situation is driving industry and regulatory efforts to take steps to operate nuclear power plants beyond 60 years.

According to the World Nuclear Association, there are over 430 commercial nuclear power reactors operational in 31 countries, with over 370,000 MWe of total capacity. About 70 more reactors are under construction. Plants currently operating provide over 11% of the world's electricity as continuous, reliable base-load power, without carbon dioxide emissions (down from 15% in 2010 before the events at Fukushima). Fifteen countries depend on nuclear power for at least a quarter of their electricity. France gets around three-quarters of its power from nuclear energy; while Belgium, the Czech Republic, Hungary, Slovakia, Sweden, Switzerland, Slovenia, and Ukraine get one-third or more. South Korea, Bulgaria, and Finland normally get more than 30% of their power from nuclear energy; while in the US, the United Kingdom (UK), Spain, and Russia almost one-fifth is from nuclear. Japan is accustomed to relying on nuclear power for more than one quarter of its electricity and is slowly beginning to return to use of this energy source following the accident at the Fukushima Daiichi Station as a result of the seismic shocks and tsunami waves from the historic Great East Japan Earthquake on March 11, 2011.

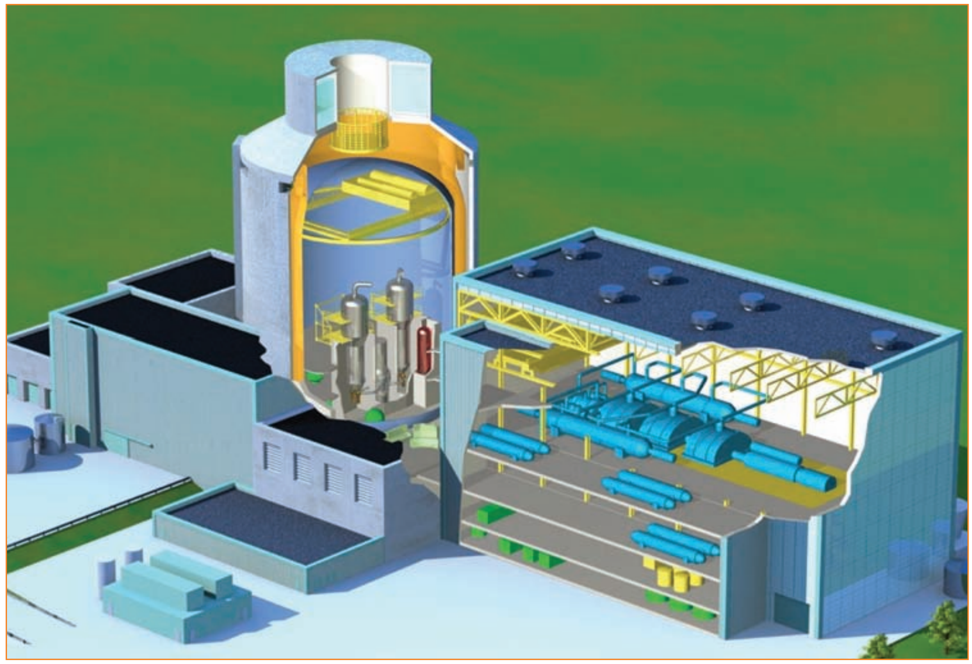
The international reaction to the Japan event is diverse and widespread. The major consequences of such a severe accident have been socio-political and economic disruptions,

Nuclear Electricity Generation 2010



which have inflicted enormous cost to society, according to an American Society of Mechanical Engineers (ASME) Presidential Task Force Report, "Forging a New Nuclear Safety Construct," from June 2012. Germany closed off its old nuclear power plants and decided to phase out the rest by 2022. Italy, Switzerland, and Belgium have held referendums in which their citizens have voted against government plans to build new nuclear power plants. In France, there is a move to reduce reliance on nuclear power.

New nuclear projects covering a range of reactor designs, however, continue to proceed in some countries. For example, China has 27 reactors under construction. The UK and Russia are still planning nuclear expansions along with the United Arab Emirates and other Middle Eastern countries, such as Saudi Arabia. Despite protests, India is also pressing ahead with a large nuclear program, as is South Korea.



Cutaway illustration of a Westinghouse AP1000® reactor. Image courtesy of Westinghouse Electric Company.

Following the 2011 nuclear accident in Japan, additional safety reviews have been performed on reactors around the globe. While there is variation in preventive measures being taken by each country, design and operational safety enhancements are being made globally with particular emphasis on addressing rare, yet credible, events such as what happened in Japan.

Even with this setting, many countries plan to continue operating their reactors into extended lifetimes while exploring the use of advanced reactor designs and concepts to obtain benefits of emission-free electrical generation. Inspection will play a vital role in meeting this challenge.

Role of Inspection to Support Extended Life of Nuclear Power Plants

Industry, government, and regulatory experts in the US, along with their counterparts from many other countries, have identified major questions that need to be addressed to confront and manage aging nuclear power plants. Four areas need to be addressed – primary components, concrete structures, underground cables, and buried pipe – as reported by B.R. Snyder and co-authors in a May 2014 *Mechanical Engineering* article titled "Nuclear's Next 40 Years."

We can think of these four areas in terms of the following questions the industry must be prepared to answer.

- ***What new technologies are required for the inspection, repair, or replacement of primary components?*** The integrity of the reactor vessel, reactor internals, and primary side piping are important technical areas for long-term operation. These nuclear components are part of the plant's defense-in-depth and are exposed to both high temperatures and radiation. These components are inspected and managed under existing plant programs. Further investigation can help reduce uncertainty for long-term operation. The areas for further investigation include the development of advanced inspection methods, repair techniques, and new materials. Ultimately, it will have to be determined whether continued inspection and potential repair of these components will be sufficient.
- ***How do we demonstrate the robustness of concrete for long-term operation?*** The concrete containment building has had exposure to environments that could cause chemical interactions and induce strain. The internal support structures have had prolonged exposure to high temperatures and radiation that could impact strength. Lessons learned from recent operating experience involving concrete structures have also demonstrated the inability of a plant to continue to operate if the containment structure is damaged. Further investigation is needed for long-term operation to demonstrate the strength of concrete over time and the ability to

Close-up of the CVBH being placed on the basemat of V.C. Summer Unit 3. Photo courtesy of SCE&G.

inspect through concrete and rebar structures. As part of the defense-in-depth of a plant, determining the merit of inspection and repair versus replacement of concrete structures is imperative for long-term operation.

- ***How do we confirm that the requirements for electrical equipment are being met for long-term operation?*** Nuclear plants have near-term license renewal commitments to develop and implement Cable Aging Management Programs in order to continue to operate beyond the initial license of 40 years. They also have to address submerged cables, which are typically part of electrical power cable systems that are buried underground and may be partially exposed to water or moisture. Some of these cables can be difficult to access for inspection. For long-term operation, the ability for all cables to perform their function may need to be considered. Certainly, plant operators need to confirm that the requirements for electrical equipment are being met during the extended period of operation.
- ***What are the best ways to inspect and repair or replace buried equipment?*** It is imperative that underground piping systems, which typically transport cooling water, can be inspected. It is now known that damage in the corrosion-resistant piping coatings can cause small leaks. While such leaks may not have created safety hazards because there is still sufficient cooling for the plant, those small leaks can introduce exposure to radiation even though the levels are so slight as to be below regulatory limits. The discovery of these leaks has led to a reexamination of the buried-equipment issue to determine changes to the design, maintenance, and inspection of buried piping. In addition, companies are developing technologies for monitoring corrosion on the soil side of the piping and installation of cathodic protection to prevent corrosion of piping and structures. Efforts are also underway to replace buried systems with high-density polyethylene (HDPE) pipe as a viable alternative technology (*See article on p. 28*). The issue likely will rise to greater importance over the course of long-term operation.

While confronting the above challenges, operational efficiency and job performance will remain important in prioritizing and implementing upgrades and advanced

Photo courtesy of Kenneth Balkey.

Kenneth Balkey speaking at the Nuclear Research Institute near Prague, 2006.

technologies. Compounding this situation, however, is a changing workforce. It is well known that the US nuclear industry, along with that of other countries, is encountering an aging workforce.

The International Atomic Energy Agency (IAEA) issued a report in June 2004 titled "The Nuclear Power Industry's Ageing Workforce: Transfer of Knowledge to the Next Generation," in IAEA-TECDOC-1399. While there are several actions needed to address this matter, the IAEA report recommended that "partnerships with educational institutions and universities that provide qualified professionals for the nuclear industry should be assessed based upon medium and long-term needs, and strengthened where needed." Once again, while several educational topics are critical for knowledge transfer, a key qualification that ASME and other standards development organizations (SDOs) are addressing is the incorporation of standards education into engineering school curricula.

Standards in Engineering Curricula with Focus on Nuclear Power Needs

Discussions have been held with mechanical and nuclear engineering education leaders in some professional engineering societies about ways to broadly disseminate codes and standards in undergraduate and graduate curricula. The chart on the next page shows a range of potential ways to deliver codes and standards material in existing engineering curricula depending on faculty knowledge of codes and standards along with the level of detail and complexity of the material being presented.

Some SDOs are building content to be used in engineering curricula. For example, ASME has developed a brochure titled "Example of Use of Codes and Standards for Students in Mechanical Engineering and Other Fields" and online Assessment Based Courses (ABCs) that can be assigned by professors outside of class lectures to begin to expose students to the role and impact of standards on engineering applications. This ASME material includes information on the ASME *Boiler and Pressure Vessel (BPV) Code* and ASME standards for nuclear quality assurance, risk management and cranes, along with US government use of standards. A specific example is provided on US NRC endorsement of the ASME BPV Code, Section XI, *Rules for Inservice Inspection of Nuclear Power Plant Components*. In addition, a number of ASME staff and volunteers have been giving guest lectures on nuclear industry standards topics individually or in concert with ASME Board on Nuclear Codes and Standards (BNCS) meetings being held at universities. The ASME BNCS has been holding meetings at universities since 2006, including the University of Pittsburgh, the University of Colorado at Boulder, Georgia Institute of Technology, the University of Kentucky, Kansas State University, and Oregon State University, and will visit the US Naval Academy in February 2015.

The highest level of transfer of standards knowledge and experience has been demonstrated via a 15-week, full-semester graduate course at the University of Pittsburgh titled "Case Studies in Nuclear Codes and Standards," as outlined by Balkey and co-authors in ICONE20-POWER2012-54894 (ASME 2012). This course is delivered by a team of standards experts addressing 17 critical standards used in nuclear power plant design and operations. Related homework and exam problems are assigned for students to learn how to use the standards in real-life engineering applications. This course, which has been delivered since 2010, recently incorporated use of the book *Blowback – An Anecdotal Look at Pressure Equipment and Other Harmless Devices That Can Kill You!* as a reading assignment for the students, thanks to National Board author Paul Brennan, to complement the nuclear pressure vessel design lectures.

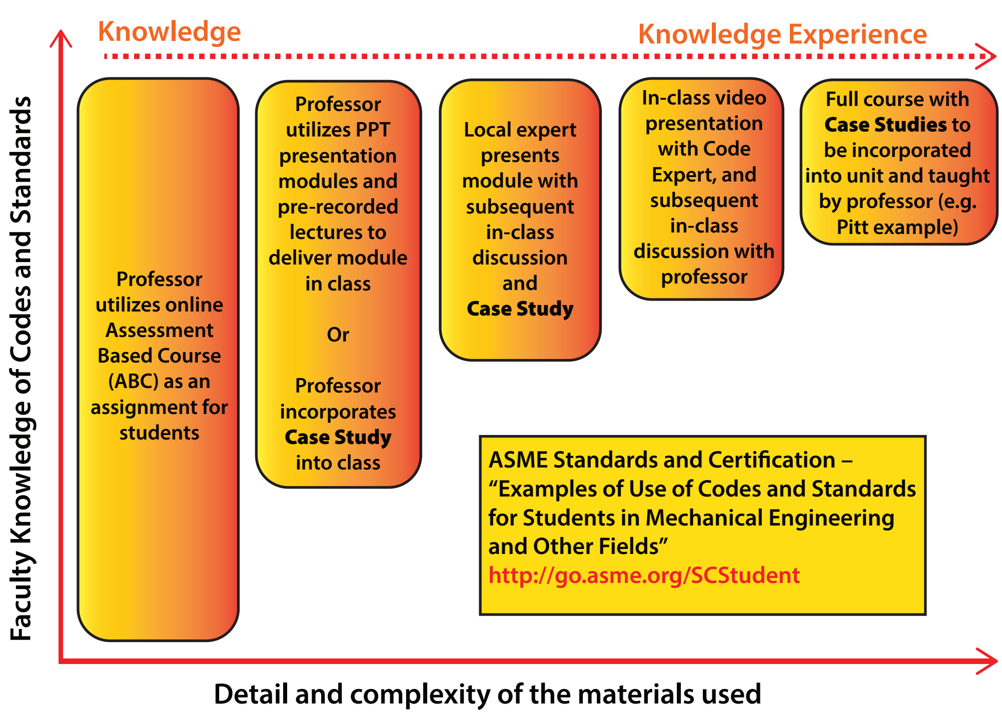
The response from students and faculty to all these efforts has been positive, and discussions continue with engineering education leaders on how to more broadly incorporate standards in undergraduate programs, e.g., in senior capstone design programs in mechanical engineering.

A solid example of the partnership advocated by the IAEA to address nuclear knowledge transfer needs is the ASME Nondestructive Examination (NDE) Personnel Certification program that is administered by ASME in collaboration with Chattanooga State Community College in Tennessee. This collaborative program, sponsored by the US Department of Labor and US NRC with key industry oversight, has been accredited to prepare students in becoming high-quality NDE technicians to fulfill the needs of nuclear power and other industries. This mission is accomplished through classroom instruction and extensive hands-on training using state-of-the-art equipment in modern labs. The graduates of this program are NDE technicians capable of critical thinking, committed to a strong work ethic, prepared for life-long learning, and are sought after by employers in the impacted industries. They also have the ability to pursue careers in eddy current inspection, liquid penetrant inspection, magnetic particle inspection, radiographic inspection, ultrasonic inspection, visual inspection, quality engineering, or quality control. For industry, this program provides independent and consistent exams and yields transportable credentials for certified personnel and helps increase the NDE and quality control workforce. It also improves the probability of detection of flaws and effectiveness of inspection activities promoting safety for the general public.

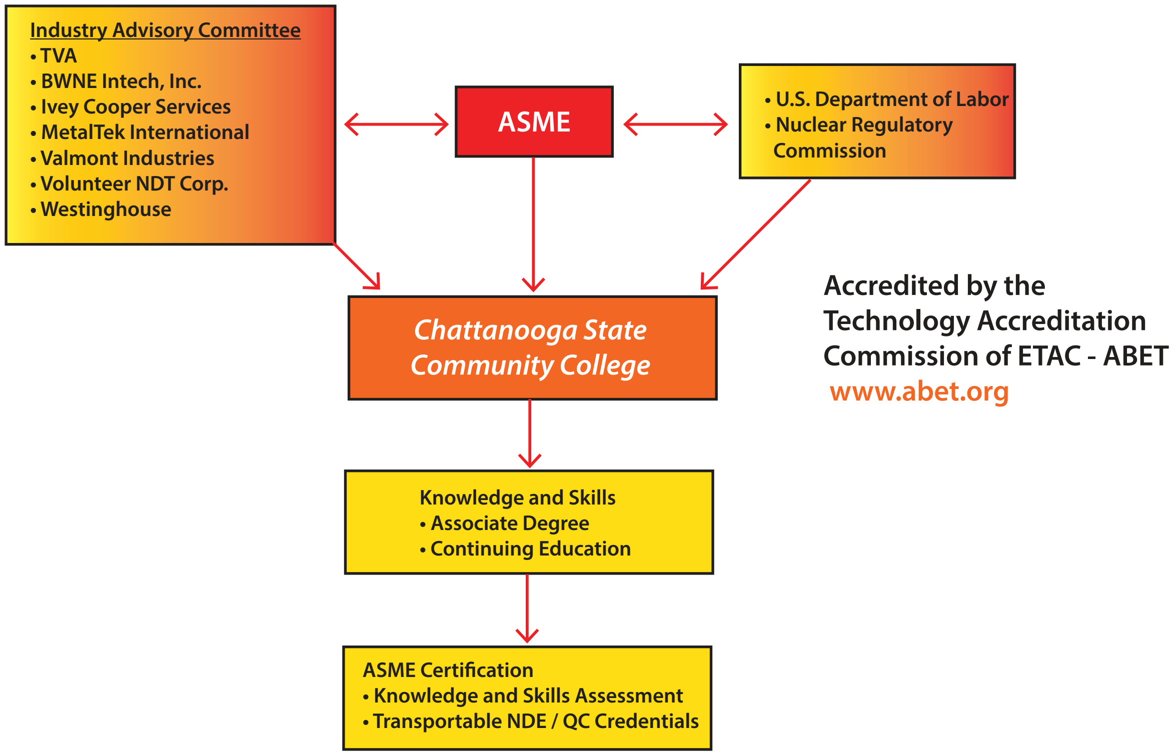
SUMMARY

Nuclear power needs to remain a major source of safe, economical, emission-free electrical generation in the US and throughout the world to address growing concerns about greenhouse gas emissions and the resulting potential impact of detrimental climate change. Despite challenges related to the Fukushima Daiichi accident of March 2011, many countries plan to continue operating their reactors into extended lifetimes while exploring the use of advanced reactor designs and concepts to obtain benefits of carbon-free nuclear power. Inspection will play a vital role in confronting and managing aging nuclear power plant structures and components. Knowledge transfer from the current aging nuclear industry workforce to the next generation on critical topics such as standards education will also be needed to

Standards in Engineering Curricula



ASME NDE Personnel Certification – A Collaborative Program



support the future of safe nuclear power plant design and operations worldwide.

Kenneth R. Balkey, P.E., is Adjunct Faculty Lecturer in the University of Pittsburgh Nuclear Engineering Program, and recently retired from Westinghouse Electric Company after 42 years of service in the nuclear power industry. He is the immediate past senior vice president, ASME Standards and Certification (June 2011 – June 2014).

SOURCES AND REFERENCES:

Wikipedia website: www.wikipedia.com (on topic of "nuclear power in the United States" and "nuclear power"); World Nuclear Association website: www.world-nuclear.org ("Nuclear Power in the World Today); The ASME Presidential Task Force on Response to Japan Nuclear Power Plant Events, *Forging a New Nuclear Safety Construct*, June 2012; Snyder, B.R., Meyer, T.A., and Balkey, K.R., "Nuclear's Next 40 Years," *Mechanical Engineering*, May 2014, pp. 30-35; International Atomic Energy Agency report, "The Nuclear Power Industry's Ageing Workforce: Transfer of Knowledge to the Next Generation," IAEA-TECDOC-1399, June 2004; Balkey, K.R., Elder, G.G., Foulke, L.R., and Metzger, J.D., "Case Studies in Nuclear Codes and Standards – A Successful Incorporation of Codes and Standards into Engineering School Curriculum," ICONE20-POWER2012-54894, ASME 2012; Brennan, P, *Blowback – An Anecdotal Look at Pressure Equipment and Other Harmless Devices That Can Kill You*, The National Board of Boiler and Pressure Vessel Inspectors, 2013; Chattanooga State Community College website: www.chattanoogastate.edu (on topic of "non-destructive testing technology"); ASME website: www.asme.org (on topic of "benefits of ASME NDE and the nuclear industry").

An Overview of Small Modular Reactors (SMRs):
Diverse Technology for Tomorrow's Energy

BY A. THOMAS ROBERTS, MPR ASSOCIATES INC.

In the last few years, the nuclear power industry has been promoting the design development of small modular reactors (SMRs), but the question often asked by those not intimately involved with this growing business sector is, "Exactly what is an SMR?" The simple reply is that SMRs consist of a *wide variety of advanced technology reactor designs*.

In basic terms, SMRs are characterized by three main attributes: SMRs produce 300 megawatts (MWe) or less, are physically small enough to be manufactured in a shop environment, and they incorporate advanced passive safety features. To further elaborate, SMRs all generally produce MWe outputs in the range of 50 MWe to 300 MWe depending on the particular design, as compared to larger existing plants that often have electric outputs in excess of 1,000 MWe, hence the abbreviation "SMR." In general, each of the present designs are physically small enough to be readily transported to the site for installation using conventional truck, rail, or barge capabilities. Most of the designs incorporate varying degrees of passive safety features that increase their overall safety reliability in comparison to the current operating fleet.

Beyond this over-simplified explanation, SMR designs currently in development are individually unique unto themselves. Some present SMR designs employ light water reactor (LWR) technology (functionally the same as existing pressurized water reactors [PWRs] and boiling water reactors [BWRs] but may differ from traditional plants by having a single integrated reactor module that consists of a single pressure vessel that serves the function of the reactor, steam generator, as well as the pressurizer [see Figure 1]).

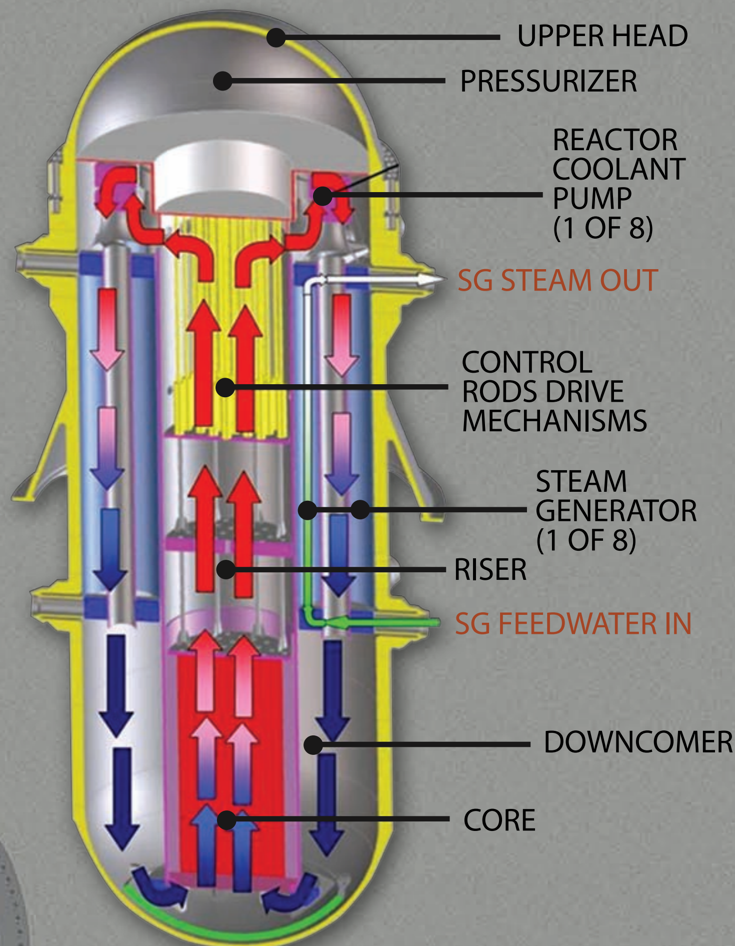
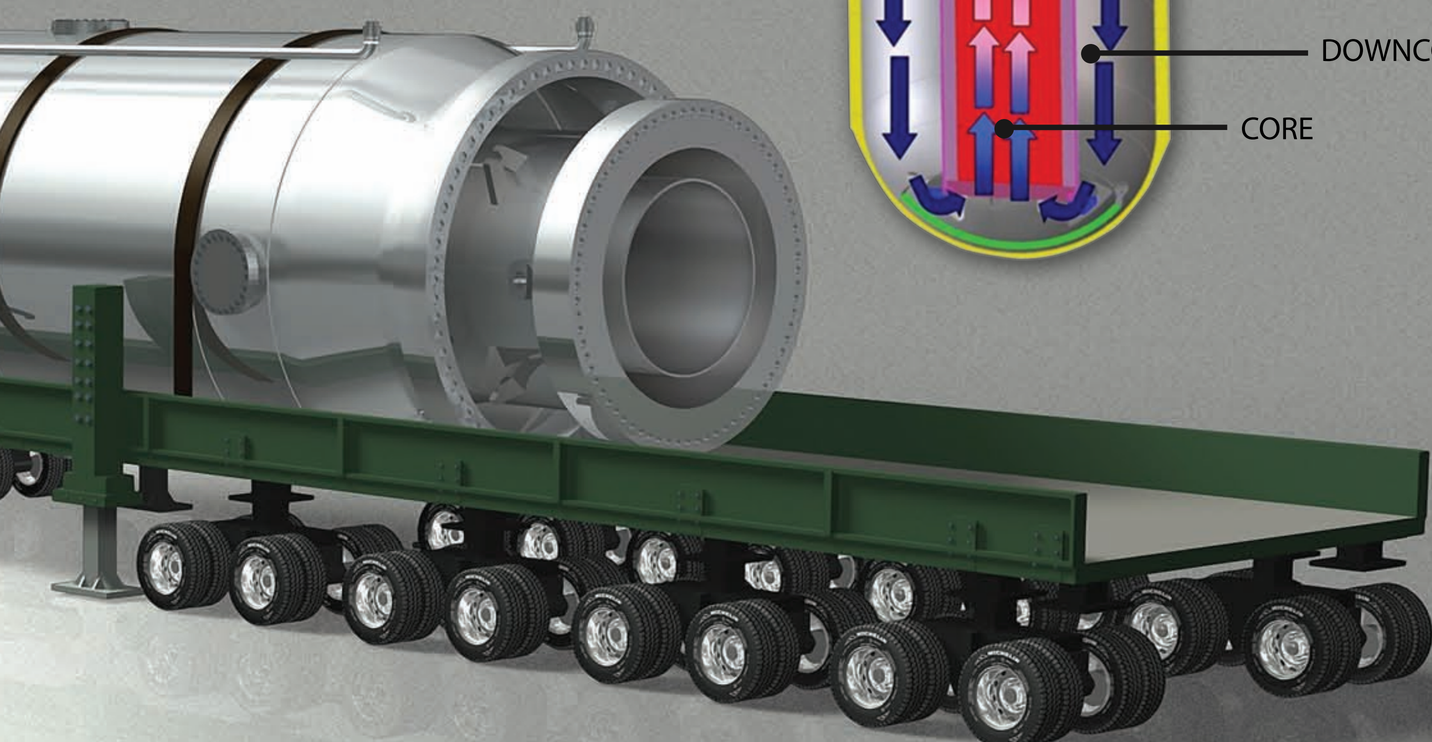


FIGURE 1
Early SMR concept, the IRIS, demonstrates a single reactor with multiple functions. Image courtesy of Dr. Bojan Petrovic, Professor, Nuclear & Radiological Engineering, Georgia Institute of Technology.



"SMR on Wheels." Image courtesy of NuScale Power, LLC.

A. Thomas Roberts has over 39 years' experience in the nuclear power industry, including nuclear plant construction, business operations, and a wide span of engineering management responsibilities. Currently, he is an engineering consultant and project manager with MPR Associates in Alexandria, Virginia. He is the current secretary of ASME Section XI Special Working Group RIM—ASME XI, Division 2, and has participated in numerous other industry committees throughout his career. Mr. Roberts can be contacted at troberts@mpr.com.

This sub-category of SMR (i.e., where a single pressure vessel serves multiple functions) is sometimes referred to as an integrated pressurized water reactor (iPWR). Even in this type of SMR there are many differences in the designs, such as the associated containment vessels employed, the total number of iPWR modules anticipated to be installed at a given plant facility, variations in the fuel cycle lengths (e.g., 18 to 48 months), and other unique, distinguishing design features.

Other categories of SMRs currently in development also employ non-light water-cooled reactor designs such as high-temperature (gas-cooled) reactors (HTRs), liquid metal (liquid metal-cooled) reactors (LMRs), and molten salt (salt-cooled) reactors (MSRs). Nations currently supporting SMR design/development are the US, Russia, South Korea, and China. SMR designs are also being developed in Argentina and Japan.

An all-inclusive list of current SMR designs would be lengthy, but the business market suggests there are a dozen or so potential contenders for deployment within the next one to two decades. Below is a partial listing of various types of SMRs currently under development.

Advantages and Risks of SMRs

As with any technology advancement there are pro and con attributes that must be addressed. These involve business, regulatory, and commercialization considerations.

Advantages

While SMRs have various divergent designs from a technical perspective, as noted above, the growing general interest associated with SMRs is that they all share a number of attributes that make them attractive from business and operational safety points of view.

In general, SMRs are expected to have much shorter construction periods than a traditional nuclear power plant facility. They are expected to be constructed in fabrication shops and erected at field sites employing modular erection techniques. This "shop build and modular erection" approach reduces overall construction time and provides for direct cost reduction. It also allows the prospective owner to realize earlier returns on his or her investment by minimizing the time from project initiation to actual power generation.

Although there is no current data to evaluate the actual duration of construction time from start to finish for any SMR, the industry's projection estimates one to three years, as compared to the current generation of nuclear plants that range from six to 10 years duration from start to finish. Additionally, almost all current designs of SMRs allow for over-the-road or rail transport using conventional trucks and trains, which make delivery to the final site very affordable and efficient.

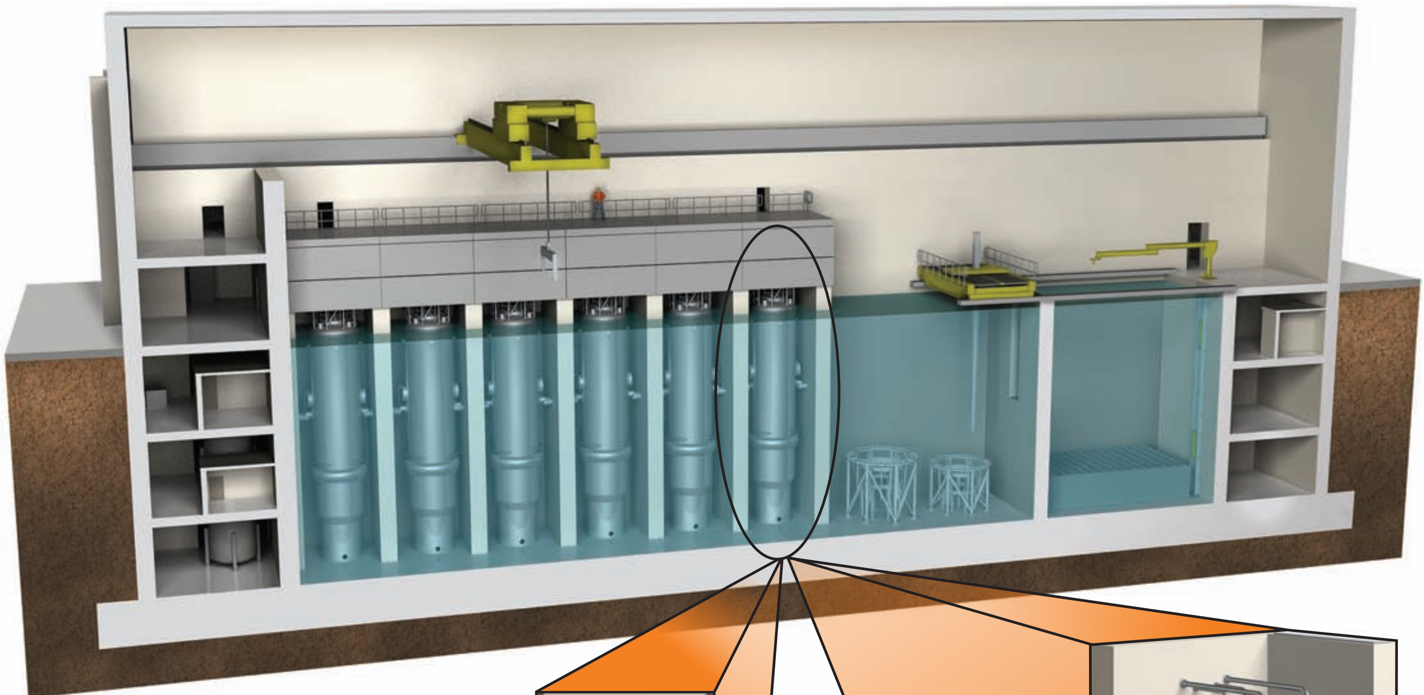
Similarly, most SMR designs are expected to require much smaller site profiles, allowing them to be placed in locations that would otherwise preclude the placement of a conventional nuclear plant. Because SMRs generally provide smaller electrical outputs, the benefit of having a smaller site profile allows the placement of an SMR facility in more remote regions that do not have a large initial power demand to serve customers, and should power demand needs expand, additional SMRs can be added in a "plug and play" type of expansion (see Figure 2).

Another SMR design actively being developed in the US and receiving early US Nuclear Regulatory Commission

Design	Company	Country	Type	Single module output (MWe)
mPower	Babcock & Wilcox	US	LWR	180
NuScale	NuScale Power Inc.	US	LWR	45
W-SMR	Westinghouse	US	LWR	225+
SMR-160	Holtec	US	LWR	160
SMART	KAERI	S. Korea	LWR	100
CAREM	CNEA	Argentina	LWR	25
KLT-40S	OKBM Afrikantov	Russia	LWR	35
VBER-300	OKBM Afrikantov	Russia	LWR	325
ACP-100	CNNC	China	LWR	100
HTR-PM	Tsinghua & Huaneng	China	HTR	211
SVBR-100	AKME-Engineering	Russia	LMR	102
4S	Toshiba	Japan	LMR	10
HPM	Gen4	US	LMR	25
PRISM	GE-Hitachi	US	LMR	311

Note: As of the printing of this article, mPower and W-SMR have currently suspended further development of their SMR designs.

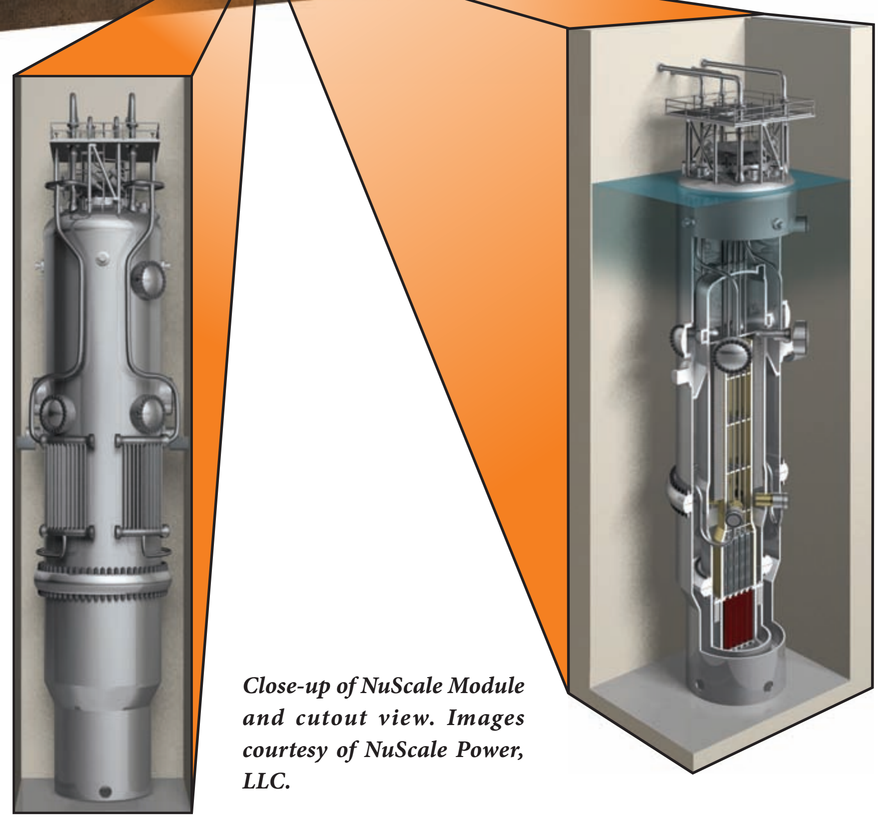
FIGURE 2
Cutaway of the NuScale reactor building. Each individual module is isolated in its own operating bay. This illustration shows six SMRs, but up to 12 could be added to the facility as power demand increases.



(USNRC) review is illustrated in Figure 3 on page 16.

SMRs are also generally capable of providing electrical output as base load[1] supply or can provide load-following[2] output to the electrical grid. In today's energy market, load-following capability is becoming a major consideration for existing power plants in many geographic regions that are seeing increased use of renewable energy sources, such as wind and solar.

In general, the present renewable energy sources are not very efficient for base load operation. When these renewable source plants come on-line, they often create a condition where the larger base load units (e.g., coal and nuclear) need to reduce output in order to maintain stability on the local energy grid. While many existing coal and nuclear plants are functionally capable of reducing energy output to accommodate renewable power contributions to the grid at any moment, many of these plants are inefficient at "moving power,"[3] and in some instances would require plant modifications to allow them to become more efficient for this cyclic mode of operation.



Close-up of NuScale Module and cutout view. Images courtesy of NuScale Power, LLC.

Another advantage for SMRs is that they all employ simplified designs and enhanced safety systems with varied passive emergency systems, unlike conventional nuclear plants in the current domestic fleet that require active components, such as pumps for emergency core cooling and backup or offsite power to provide power to run emergency cooling system pumps. Many SMR designs do not need emergency diesel generators or offsite power to run their emergency core cooling functions. This is because their design features employ natural circulation or their reactor coolant media (e.g., molten salt) intrinsically provide for safe shutdown and cooling of a reactor. These integrated safety features make SMRs less vulnerable to accident conditions, whether by natural disasters or terrorist threat, and increase the overall safety performance.

Risks

While there are many positive aspects to bringing SMRs into the power marketplace, there are also associated risks for this advanced technology. The most apparent is that almost every SMR design represents a "first-of-a-kind" design. As with any first-of-a-kind initiative that is subject to regulatory approvals, the regulatory framework of the countries where SMR licensing will occur will need to be adjusted to accommodate these advanced-feature plants.

For example, within the US, the USNRC has already started evaluation of several SMR designs well in advance of any actual licensing ("pre-application engagements"). This is essential since the current USNRC regulations were developed and intended for the existing PWR and BWR (pressurized and boiling water reactor) technologies.

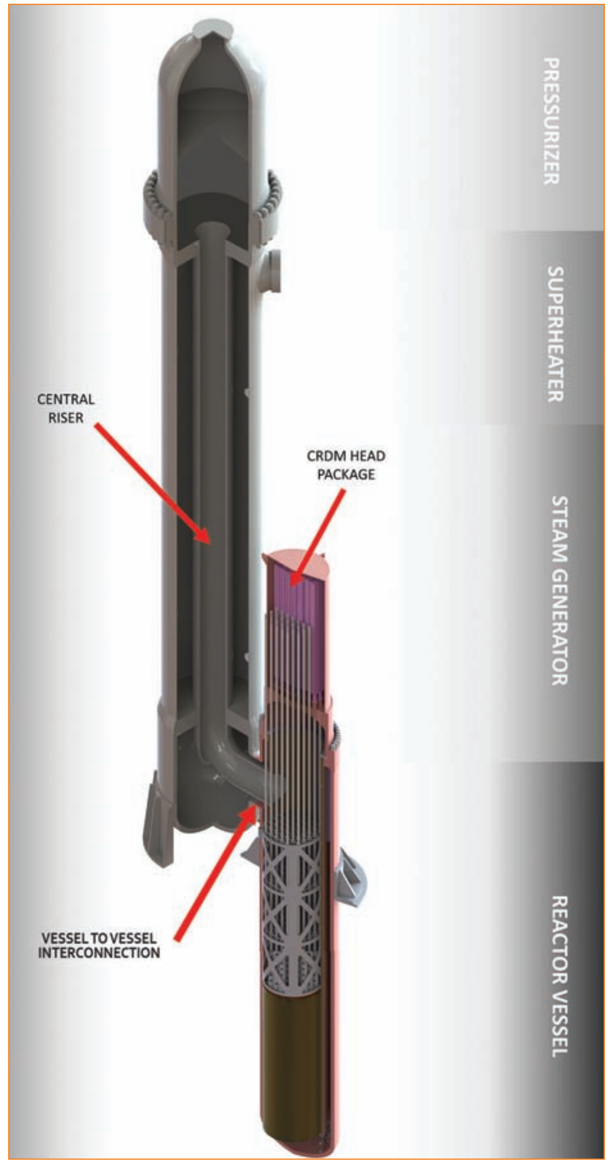
With the normally long lead time to update or create new regulations, the time to market and the costs for a commercial SMR are uncertain. This is a business risk to potential investors since most regulatory bodies are not obliged to meet any specific time frames or deadlines in bringing about needed regulations that would accommodate the SMR market. As an added challenge to SMRs, there are no models on which to base economic estimations relating to initial start-up or operating costs once a specific SMR does become licensed.

From this vantage point, in order to minimize financial investment risks, investors will be appropriately cautious unless there are clear indicators that regional power demands (both immediate and long-term) justify introducing the various SMR designs, compared to other competing energy sources, such as known markets for renewable energy sources, with more favorable political and regulatory environments.

In order to curb some of these business and regulatory challenges, some SMR design organizations are seeking avenues to build prototypical, non-commercial pilot plant facilities which would be government-controlled (such as those that exist at a Department of Energy [DOE] location within the US), but that are not intended for commercial energy production applications.

If successful, these prototype pilot plants would then be used to benchmark actual construction times, cost of construction, licensing, maintenance, and operation. This information in turn can be used as a model for the commercial power market to remove some of the investment community's uncertainties.

Figure 3



Cutaway of the Holtec SMR-160 Reactor Coolant System. Image courtesy of Holtec.

The American Society of Mechanical Engineers (ASME) and SMRs

To help with some of the regulatory conditions that need to be addressed for SMRs, the American Society of Mechanical Engineers' *Boiler and Pressure Vessel Code* (ASME B&PVC) Section XI Standards Committee has been developing a new inservice inspection code to accommodate various SMR designs. This document is currently under development, and when published, will become ASME Section XI, Division 2, *Reliability and Integrity Management* (RIM). It is intended to be a "technology neutral" inservice code that may be applied to advanced reactor designs, including SMRs.

Most readers will recognize that ASME Section III and Section XI are mandated for use by the USNRC in the US, both for the construction of new nuclear power plant safety-related components using ASME Section III; and ASME Section XI, Division 1, for conducting inservice inspections at nuclear facilities.

Since most SMR designs are essentially pressure vessels by nature, the use of ASME Section III already lends itself to accommodating SMR new construction. While some SMR designs may need to utilize ASME Section III, Subsection NH, *Class 1 Components in Elevated Temperature Service* rules (because a particular SMR design operates in a higher-temperature regime than what would otherwise be permitted by ASME Section III, Subsection NB, *Class 1 Components - Rules for Construction of Nuclear Facility Components)*, the existing ASME Section III construction rules are well-postured to accommodate any new construction.

In contrast, ASME Section XI, Division 1, was developed and has evolved over 30-plus years but focuses on existing PWR and BWR technology. Consequently, the use of ASME Section XI, Division 1, does not lend itself as well to being used as an inservice code for many SMR designs, as does ASME Section III for new construction. This was the impetus for the development of ASME Section XI, Division 2.

With several domestic and international SMR designs on the horizon, the ASME community has committed to the development and issuance of Division 2 (Reliability and Integrity Management, RIM) in order to create an inservice code that could suitably apply to various advanced reactor designs other than the present US PWR and BWR fleet of light water reactors.

The format being planned for Division 2 (RIM) is to create a generic set of requirements that would apply to all reactor types, and individual appendices that would be technology-specific (e.g., integrated light water reactors, molten salt reactors, etc.). Then, specific appendices would address examination methods, examination scope, periodicity, etc., for each individual SMR type.

SMRs and the National Board

For the National Board commissioned inspector who holds an Authorized Nuclear Inspector (ANI) endorsement, the future construction of any SMR is not likely to represent a substantive departure from activities that normally are performed by the ANI in a shop, since the use of ASME Section III, Division 1, Subsections NB or NH, is likely to be employed.

However, since the use of ASME XI, Division 2 (RIM), is likely to become the standard for inservice inspection activities, individuals holding National Board Authorized Nuclear Inservice Inspector (ANII) or Authorized Nuclear Inservice Inspector Supervisor (ANIIS) endorsements (and who will be performing ANII nuclear inservice activities) are likely to experience a significant change in the nature or methods of examinations; the nature of tests; the frequency of examinations or tests for a RIM-based inservice inspection program; as well as the third-party oversight that they may be accustomed to when working under ASME XI, Division 1.

RIM-based inservice inspection will undoubtedly require indoctrination and training for ANII and ANIIS inspectors who will provide third-party AIA services to a nuclear facility that utilizes the new ASME Section XI, Division 2, standard. This is analogous to other areas, such as regulatory changes, that will need to adapt to the innovations likely to be seen with the introduction of SMRs into the commercial operating power industry.

Conclusion

The future of energy generation lies in innovation like that found in the advanced, compact, and mobile SMR. The SMR approach to supplying power opens up unrivaled possibilities for speedy manufacture, easy transport, enhanced safety, and greater availability to geographically remote areas. While this article is merely an overview of the various issues surrounding SMRs, it's becoming clear that every facet of the power industry – the business and financial communities, regulators, ASME, and the National Board – will need to adapt to support this emerging approach to power.

NOTES:

1. Base load plants are the production facilities used to meet some or all of a given region's continuous energy demand, and produce energy at a constant rate, usually at a low cost relative to other production facilities available to the system.
2. A load-following power plant, also known as mid-merit, is a power plant that adjusts its power output as demand for electricity fluctuates throughout the day.
3. Moving power is defined as adjusting the electrical output of a power plant, either upward or downward, in order to accommodate the fluctuating power demands which regularly occur on all electrical distribution networks, and which is done in order to maintain the required stability of a given electrical distribution network.

SMR Applications, Safety Features, and Potential ANI Inspection Considerations

BY WILLIAM J. BEES

The first commercial electricity from nuclear energy was supplied by a 45-kilowatt (kW) reactor plant at the Idaho Falls Nuclear Energy Laboratory (INEL) on December 20, 1951, to a small city located in the high desert of southeastern Idaho (Arco, the Atomic City). While the original output was able to illuminate four 200-watt bulbs, it opened the door for commercialization. In the ensuing years, reactors have grown to produce electrical outputs of over 1,400 megawatts (MWe). Recently, applications for reactors with low electrical outputs, compact size for ease of transportation, and enhanced safety features are being designed.

This "new" concept known as small modular reactors (SMRs) has the objective to provide a safe, transportable, and cost-effective power plant having a smaller "footprint" than traditional power plants. They are scalable and can even be bundled to provide larger power output. SMRs require smaller forgings that can be produced domestically rather than abroad. SMRs also have enhanced safety and security through their compact size and operating characteristics.

The Department of Energy's Office of Nuclear Energy (DOE-NE) has placed a high priority on the acceleration of the timeline to commercialize and deploy SMR technologies through the SMR Licensing Technical Support program.

SMR power plants can replace aging coal plants with multiple units bundled to provide the required capacity. The reclaimed sites may reduce the capital expenditure for property acquisition and electric grid infrastructure. They can also provide power to remote US military installations and other remote sites, provide steam/process heat and electricity to petrochemical facilities, and provide district heating in cities. The possibilities are endless, depending on the local acceptance of the system.

Photo courtesy of Idaho National Laboratory

The Experimental Breeder Reactor-I (EBR-I) at Idaho National Laboratory was the world's first nuclear power plant. Today it is a National Historic Landmark.

One of the factors affecting the success of SMRs will be the economic benefits, especially the overnight capital costs ($/kW – i.e., the costs of short-term borrowing). If the overnight costs are not in the right range, all the other benefits will not be realized, such as the use of existing infrastructure/grid, low operating costs, low fuel costs, zero greenhouse gas emissions, etc. All players in the cost structure need to redouble efforts to minimize costs while maintaining safety and quality standards, and the challenge will be to develop efficient processes and inspection techniques to achieve that goal while providing the assurances needed by vendors, regulators, utilities, and the public.

SMRs and Safety

Since the advent of the peaceful use of the atom more than 60 years ago, there has only been one serious incident in the US with commercial reactors – Three Mile Island in 1979. There have been two incidents abroad: Chernobyl in 1986, and Fukushima in 2011 (which was the result of a natural disaster and subsequent loss of support facilities).

Each of these incidents, although regrettable, has served to increase safety by helping industry to better understand deficiencies in design, construction, and installation; and then implement changes to address those deficiencies, while at the same time incorporate new technology.

The nuclear industry has always focused on safety. Passive safety features within its designs of small modular reactors are no exception. An example includes one SMR design that utilizes a vacuum for thermal insulation (similar to a coffee thermos), instead of insulation material. This will alleviate concerns of sump-screen plugging during an accident condition. Most of the systems are designed to be cooled passively by natural circulation during an accident condition, eliminating the need for active emergency cooling systems. More importantly, these systems will be regulated by the Nuclear Regulatory Commission (NRC) throughout the design, construction, and operational phases (and code verification will be performed by third party AIAs), to ensure their safety and security for workers and the general public.

There are several different concepts for SMR designs and therefore many different safety features are involved. Coolant systems can use natural circulation – convection – so there are no pumps or moving parts that could break down, and they keep removing decay heat after the reactor shuts down, preventing core overheating and meltdown.

Photo courtesy of Idaho National Laboratory

On December 20, 1951, four light bulbs were strung from the generator (right bottom corner) and they were lit. It was the first time in the world a reactor made that much electricity.

Inspection

Construction of SMRs would involve authorized inspection agencies (AIA) very much as they are now. The big change is in field installation, which will not be as long-term as it is presently. Because the reactor/steam generator is contained in one preassembled unit, the installation is not as complex as building a system in the field. There will still be a large amount of concrete containment work, assembly of appurtenances, penetrations, and pressure part intersections that would require a cadre of inspectors to be in the field during construction.

Presently, the authorized nuclear inspector (ANI) reviews the manufacturer's quality assurance program and designates in-process hold points or inspection points where he can witness a specific action or operation for verification of code requirements. With the modular reactor, the potential for having parts or assemblies rendered not inspectable, by reason of following assembly operations, is greater and may require more oversight to ensure proper inspection during construction.

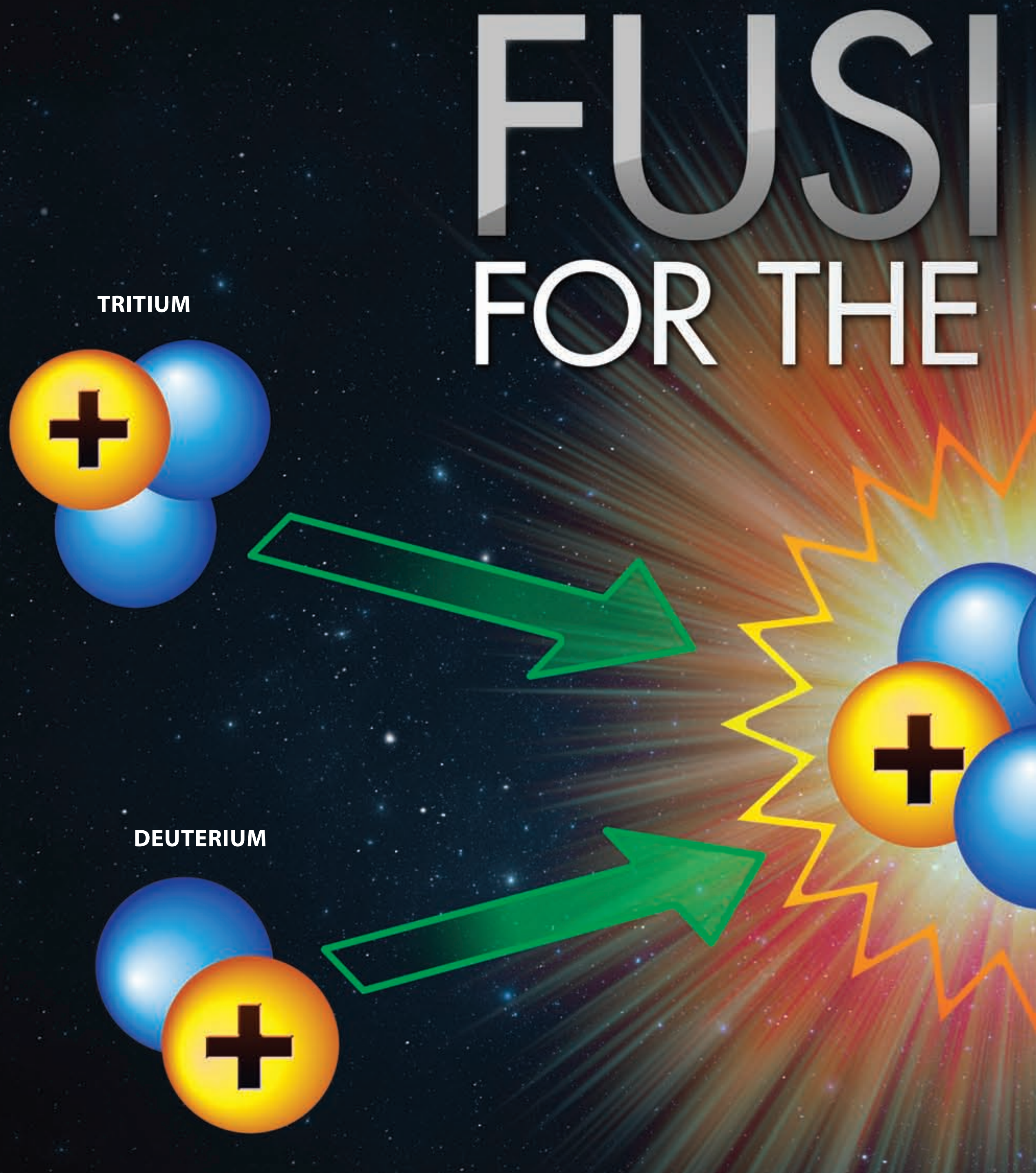
It may become necessary for National Board commissioned nuclear inspectors and supervisors to adopt additional training to broaden their understanding of new SMR technology in order to support SMR inspection. Inspectors will still be needed to provide third-party inspections to meet the requirements of the *American Society of Mechanical Engineers* (ASME) *Boiler and Pressure Vessel Code*.

Moreover, the need for inspectors and AIAs may increase rather than decrease as a result of multiple units being constructed and installed in various shops and field sites rather than one large unit installation. For example, one big change for SMR manufacturing and construction is that SMR designs will utilize smaller forgings, which will allow more US shops to participate in manufacturing nuclear components. Presently, all large forgings for reactor vessels, steam generators, and pressurizers are produced internationally.

This change could also affect AIAs in that they would have to monitor the activities at many shops that otherwise would not be involved in manufacturing nuclear components. Additionally, more inspectors would need to be trained in the construction and fabrication techniques, and the installation techniques at field sites.

New construction and inservice inspection will still be a high-priority issue. With more construction sites and more installation sites, there will be a need for more monitoring and verification of code requirements. The ASME Conformity Assessment program is a strong, well-established system and will be used to ensure safe construction and operation of SMRs. The National Board nuclear inspector training programs will also play a vital role in preparing new authorized nuclear inspectors for their job of ensuring code compliance with the guiding viewpoint of public safety being in the forefront.

William J. Bees is a registered Professional Engineer in Ohio. He received his bachelor of engineering from Youngstown State University and his master of science from University of Akron. He is a Fellow in the American Society of Mechanical Engineers and the American Society of Civil Engineers. He received the ASME S.Y. Zamrik Pressure Vessels & Piping Division Medal in 2013. He was also recognized by ASME with the Dedicated Service Award. Mr. Bees is retired from The Babcock & Wilcox Company after 43 years of service and has consulted for several companies.



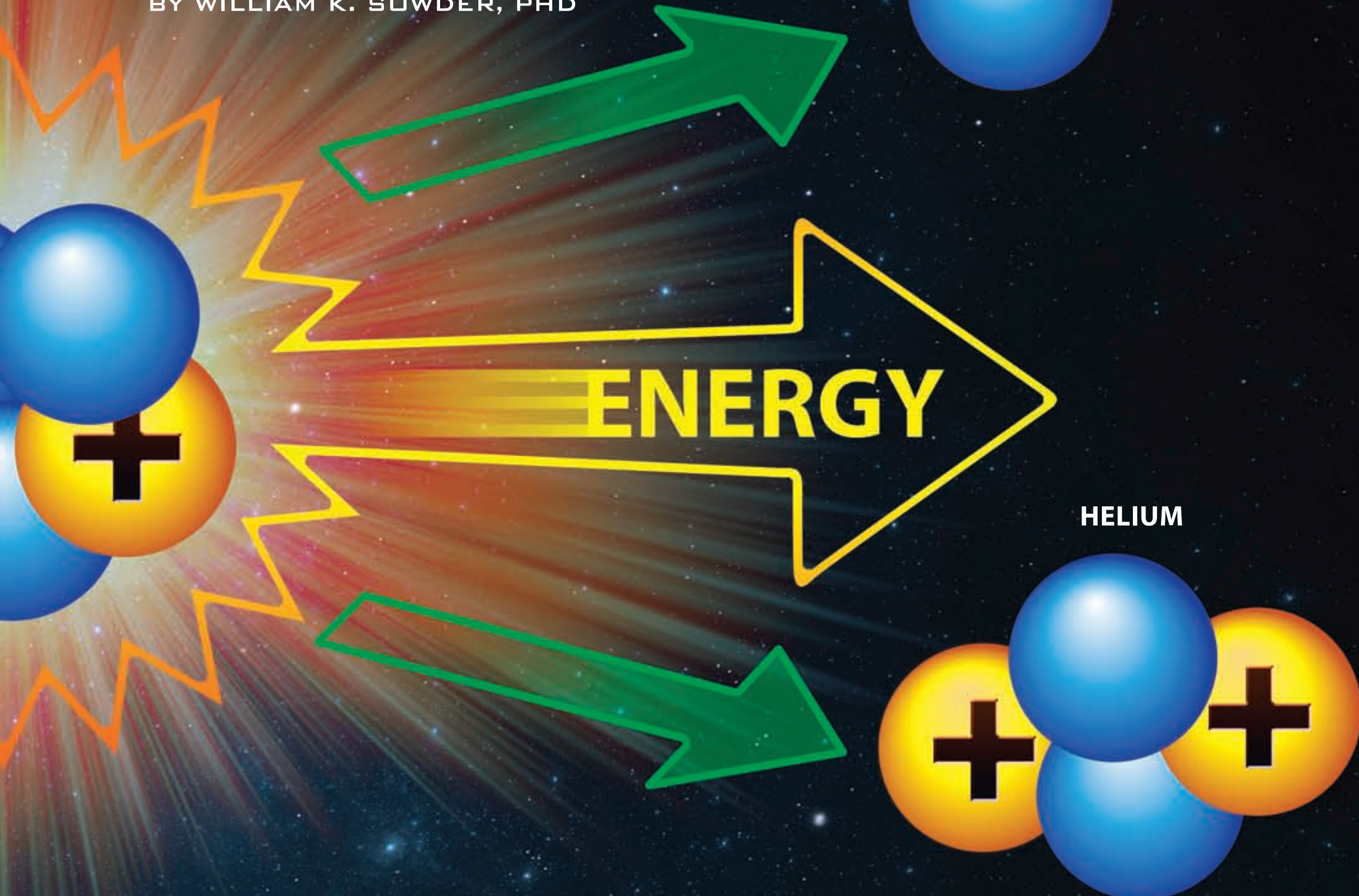
The foundation of nuclear energy is harnessing the power of atoms. Nuclear fusion and nuclear fission are two different types of energy-releasing reactions in which energy is released from bonds between neutrons and protons in the nucleus. The main difference between these two processes is that fission is the *splitting* of a large atom into two or more smaller ones (which yields fission products), while fusion is the *fusing* of two or more small atoms into a larger one.

The specific application of fusion for the future is power generation, since fusion is a clean alternative to using nuclear fission, which has waste issues, potential for release of high radioactivity, and long-term fuel and maintenance costs.

With fusion there is low fuel cost, since nuclear fusion is a process where light nuclei, usually deuterium and tritium, are fused. Deuterium is abundant in water, and tritium can be bred as needed in the fusion power plant. There is no environmental risk of fusion product leakage in an accident. But if an accident were to occur, either the fusion reaction self-extinguishes or fuel feed is stopped. In addition,

ON FUTURE

BY WILLIAM K. SOWDER, PHD



fusion-decommissioning waste typically qualifies for near-surface burial rather than deep, geologic disposal as is the case for fission waste.

There are two leading methods of fusion energy devices being developed to accomplish controlled nuclear fusion. One method is magnetic confinement, where nuclei are in a vacuum chamber, guided at high velocity by magnetic fields and heated by microwave energy and / or other means so that the nuclei's high velocity overcomes electrostatic repulsion and fusion reactions occur. The confined deuterium and tritium ions are referred to as a plasma, and fusion reactions release heat and high-energy particles whose heat is captured in blanket modules.

The other method is inertial confinement and uses tiny frozen pellets of deuterium and tritium in a vacuum chamber. The pellet is rapidly compressed with great force by laser beams, x-ray beams, or ion beams. The beams create a compression force in the pellet, thus overcoming electrostatic repulsion, and the atoms fuse. The heat from fusion reactions is captured at the walls of the vacuum chamber.

Current Status of Fusion Energy Devices

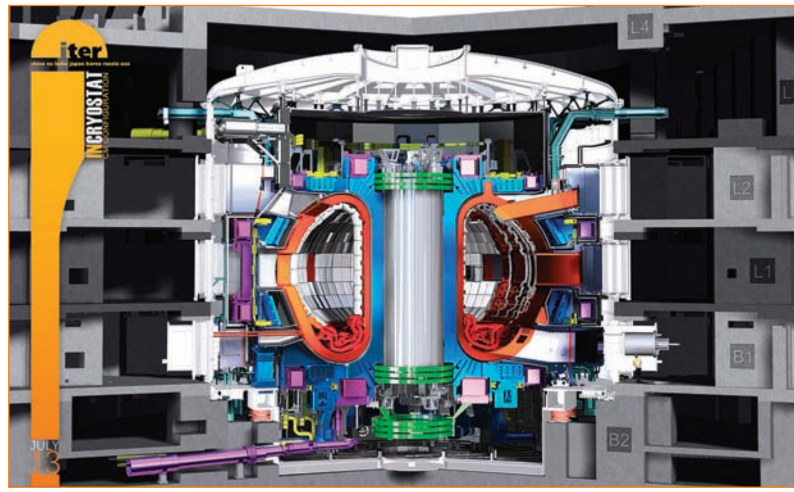
There are at least 200 fusion energy devices or machines called tokamaks (the Russian acronym for "Toroidal Chamber, Magnetic Coils") that have been built and operated since the T-1 was constructed in the USSR in 1958, which was considered the world's first tokamak. Fusion devices exist in various sizes and shapes and are used to perform experiments and research for the use of fusion in the future. There are several very large fusion devices operating today, but they are limited in their operational parameters and scientific focus. Examples of these large devices are JET in the United Kingdom; JT-60SA in Japan; EAST in China; KSTAR in Korea; and SST-1 in India; and the European Union (EU) based ITER Project. The purpose of the current ITER Project is to build a device that incorporates the best and latest technologies into one massive device that will be the final step before a fusion device will be built to demonstrate its ability to produce electricity. That future device is called DEMO by the major partners in the ITER Project.

The construction requirements for ITER, as was the case for the other five large machines mentioned, were a mixture of various requirements from existing codes, industrial standards, or were in some cases developed as the project progressed. In the case of ITER, there was a mixture of existing codes such as the American Society of Mechanical Engineers (ASME) Section III and VIII, and RCC-M, which the ITER scientists and engineers could use or modify to fit their needs. In the case of ITER partner countries, existing country standards are being used to supplement or enhance what is needed to do their work activities; but there is no uniform fusion code and standard recognized by all the ITER parties for use, as the use of Section III is recognized for fission-based construction.

There is an ongoing effort within the ASME Boiler & Pressure Vessel Committee on Construction of Nuclear Facility Components (III) Codes and Standards Committee, approved by the ASME Board of Nuclear Codes and Standards (BNCS), to develop rules for the construction of fusion energy devices. These devices consist of fusion-energy-related components, such as vacuum vessel, cryostat, and superconductor structures and their interaction with each other. These rules will be found in the new Division 4 of Section III Standards Committee entitled, "Fusion Energy Devices (BPV III)".

Other related support structures, including metallic and non-metallic materials, containment or confinement structures, fusion-system piping, vessels, valves, pumps, and supports will also be covered. The rules shall contain requirements for materials, design, fabrication, testing, examination, inspection, certification, and stamping.

Within the ASME Section III organizational structure there is a Sub-Group, "Fusion Energy Devices," which has five newly approved working groups reporting to it and reports directly to the Section III Standards Committee. The Fusion Energy Devices Sub-Group's charter is to develop the code rules for construction of fusion components and is continuing to add to its membership and that of the working groups. The current working groups are: Magnets, Vacuum Vessel, Materials, In-Vessel Components, and Support Structures and Balance of Plant Equipment.



The Configuration Management Model of the ITER Tokamak. Image courtesy of the ITER Organization.

The new Division 4 of Section III Standards Committee has developed an organizational structure for these new code rules, assigned responsibilities to approved working groups and their chairmen, and produced a beginning section of these new code rules that is proceeding through the ASME balloting process.

The membership of this new Division 4 is global in its participation, with members from China, the United Kingdom, the ITER Project, South Korea, India, Japan, the US, and several nuclear regulators. The current membership stands at 21.

Existing ASME Section III code rules do not address the construction rules for fusion energy devices that are currently being considered for future global construction; or provide support to the ongoing projects, such as ITER (tokamak design), and other fusion concepts such as Inertial Confinement Fusion (primarily laser fusion; an example is the National Ignition Facility), or any of the DEMO facilities that are currently in the planning stages in China, Korea, Japan, and in the EU.

The current Section III rules need to be modified to meet some of these future needs. However, it has been recommended that a complete new set of code rules be developed specifically for new fusion energy devices to cover their design, construction, and inspection / testing. In addition, it is anticipated that operation and maintenance requirements for fusion energy devices may also require a new set of rules or major modifications to the existing ASME Operation and Maintenance (OM) Code *(see* *article on pg. 32)*. It is necessary that these new rules contain the best available methods and technology in each area.

In order to efficiently develop new fusion code rules, a Division 4 Fusion Energy Device Roadmap was established to guide in the development of Fusion Energy Device Code Rules. This roadmap will help focus committee resources on all areas of the proposed new rules for development, as well as provide project management to this development effort.

BULLETIN Interview with Dr. Sowder

***BULLETIN*: Why was the Division 4 committee created and how did you come to be involved?**

Dr. Sowder: The Division 4 effort was started during the 2003-2004 time frame when the ITER Japanese team presented the ASME Board of Nuclear Codes and Standards (BNCS) with the need for a fusion-specific code and standard. The Japanese, as part of the ITER Project, were competing with Spain, France, and Canada for the ITER fusion device to be built in their country. The Japanese team's bid was to have the device built in the northern part of Japan. The Japanese presentation was given and the BNCS approved this new fusion division (called Division 4) to proceed in its development. There was some development started but due to political pressures within the global fusion community and competing ITER members, the ASME action was placed on hold until it was restarted in February 2007. The restarted effort was supported by the then-director general of the ITER Project, who saw the need for this fusion-based code and standard for future fusion plants beyond the ITER Project. He then asked me (I was returning to the US from the ITER Project) to support its development. After consultations with the then-chairman of the ASME Section III Standards Committee, we both felt that it was time to develop this code and standard and restart the Division 4 effort.

***BULLETIN:* Which related support structures (vessels, piping, valves) will inspectors be examining on fusion energy devices, and how might inspection of these devices differ from inspections on current nuclear support structures?**

Dr. Sowder: That type of definition is being developed, but similar types of inspections are anticipated. The RAMI principle (reliability, availability, maintainability, and inspectability) is in its developmental phase; but what is known about the state-of-the-art equipment being developed and built is that it will require different levels of inspections. The inspectors doing that type of activity will require a higher level of knowledge and training.

***BULLETIN*: Do you anticipate a new type of specialized inspector will emerge for fusion devices in the future?**

Dr. Sowder: That type of definition is also being developed. Similar types of inspectors to those in fission construction are anticipated; but will by necessity require different levels of inspections and thus the inspectors doing that type of activity also will require a higher level of knowledge and training.

***BULLETIN:* You mentioned in your article that it has been recommended that a complete new set of code rules and OM codes be developed or at least modified, and that any new rules must contain the best available methods and technology. Does ITER provide your committee insight for best methods?**

Dr. Sowder: No, not really, but ITER represents the latest technologies and ideas from a global pool of people who can provide their best ideas without the constraints of politically focused agendas, although that still exists. We maintain as close a relationship as possible without totally forgetting the global audience and the user base for which we are providing a code and standard.

***BULLETIN:* Are there any Division 4 members who are involved in ITER, or are there any working relationships between ASME and ITER?**

Dr. Sowder: Some of the members of Division 4 have been suppliers of services to ITER or, in some cases, are directly involved with the ITER Project management. There are others who work for companies that are making parts and components for the ITER Project, including governmental agencies. We currently have six members who are ITER employees or were recently employees, and several from ITER partner countries who were at senior-level management positions supporting the ITER Project.

***BULLETIN:* How does the Division 4 Fusion Energy Roadmap assist in code development?**

Dr. Sowder: The Division 4 Roadmap provides an organized approach to the development of these new rules and/or what is needed for research and development (R&D) activity. The results of the R&D then provide a basis for the inclusion or exclusion of rules governing construction of fusion parts and components.

BULLETIN: What is the potential of fusion energy?

Dr. Sowder: I believe there is great potential for the future of fusion, and if correctly and prudently pursued, it will be our future power source. The ITER Project will be the vanguard to the future of fusion power.

***BULLETIN*: Thank you, Dr. Sowder.**

William K. (Ken) Sowder, PhD, is a senior consultant to the nuclear industry. He works with manufacturers and suppliers to develop management systems meeting requirements of codes and standards. He worked for the ITER Project first from 2004 to 2006 outside of Munich, and then on-site in France 2006-2008 as responsible officer and division head for ITER quality assurance, and 2008-2009 as an expert contractor. He also helped develop ITER interfaces with international organizations. He is a member of ASME Section III Committees, NQA-1 Committees, International Organization for Standardization (ISO) 9001 TC 176 US TAG, and is a member of the ASME Board on Nuclear Codes and Standards.

ITER Fusion Project:
The Way to New Energy

BY KRISTA DULON, ASSISTANT EDITOR, ITER ORGANIZATION

There is one form of energy that may completely change the way we fuel our future.

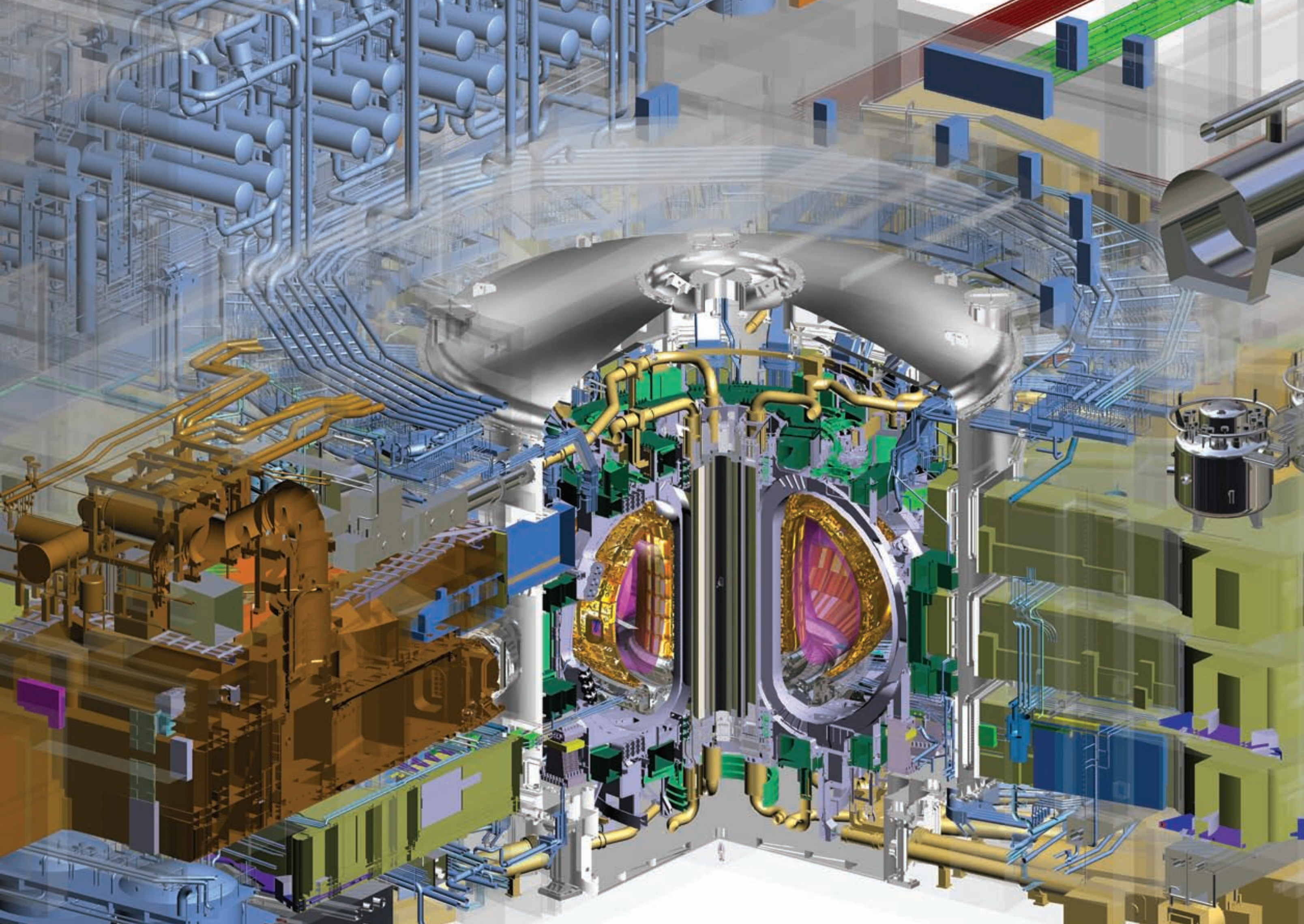
Fusion, the energy that powers the Sun and stars, has the potential to become a new source of base-load energy – more powerful than nuclear fission, free from the carbon emissions of fossil resources, and run on fuel that will be available for thousands, if not millions, of years.

This has been the Holy Grail of fusion science since the 1930s, when physicists attempted for the first time to reproduce the energy source of the Universe in the laboratory. In three generations, great empirical strides have been made in the fields of plasma science and fusion technology. But the ultimate goal – harnessing the power of fusion for commercial applications – has remained out of reach.

In a rural area of southern France, some of the world's most energy-hungry nations are collaborating on an experiment that aims to advance fusion from the realm of "potential" energy source to that of "promising" energy source.

China, the European Union (EU), India, Japan, Korea, Russia, and the United States (the Members) have joined together to build ITER (Latin for "the way") – the world's largest fusion device and the one that has been designed as the final experimental step before the conception of electricity-producing fusion power plants.

ITER will be the first fusion device in the world to produce net energy and the first to maintain fusion for long pulses. The experiment won't produce electricity, but by generating 500 MW of power from an input of 50 MW – a "gain factor" of 10 – ITER will prove the scientific and technological feasibility of fusion, and test along the way the necessary integrated technologies, materials, and physics regimes at reactor scale.



Cutaway of ITER tokamak core.
Image courtesy of the ITER Organization.

Joining Forces for a New Form of Energy

The ITER Project was set in motion at the Geneva Superpower Summit in November 1985, when the idea of a collaborative international project to develop a new form of energy for peaceful purposes was proposed by General Secretary Mikhail Gorbachev of the Soviet Union to US President Ronald Reagan.

Two years later, an agreement was reached: the European Union (Euratom, the European Atomic Energy Community), Japan, the Soviet Union, and the US would jointly pursue the design for a large international fusion facility, ITER. Conceptual design work began in 1988, followed by increasingly detailed engineering design phases until the final design for ITER was approved by the Members in 2001.

The People's Republic of China and the Republic of Korea joined the project in 2003, followed by India in 2005. Selecting a location for ITER was a lengthy procedure that was concluded in 2005 when the Members agreed on the site proposed by the EU in southern France. The ITER Organization was established in 2007, followed by the creation of seven Domestic Agencies to manage procurement for each Member.

The ITER machine will be a tokamak (the Russian acronym for "Toroidal Chamber, Magnetic Coils") and is a donut-shaped configuration designed to create the conditions of temperature, density, and confinement that cause light atoms to fuse, form heavier atoms, and liberate huge amounts of energy in the process.

The Advantages of Fusion

In terms of sheer scale, the energy potential of the fusion reaction is superior to all other energy sources that we know on Earth: fusing atoms together in a controlled setting releases nearly four million times more energy than

Tokamak Complex aerial view.

a chemical reaction such as the burning of coal, oil, or gas; and four times more energy than a fission reaction.

For the kind of fusion reactor envisaged for the second half of this century, energy consumption is estimated at 765 grams of deuterium-tritium (D-T) fuel per day, or 280 kg / year. (Comparable coal-fired or oil-fired power stations consume 550-740 tons and 360-520 tons / day, respectively.)

And the energetic potential of the fusion reaction is not its only advantage – fusion doesn't emit harmful toxins like carbon dioxide or other greenhouse gases into the atmosphere; fusion reactors produce no high-activity, long-lived nuclear waste; and run-away reactions are impossible. What's more, deuterium fuel can be distilled from all forms of water, while tritium can be produced during the fusion reaction as fusion neutrons interact with lithium (ITER will test key tritium breeding technologies).

Decades of fusion research and generations of fusion devices have contributed to the design of ITER. And ITER, in its turn, will contribute to the design of the next-generation machine.

The knowledge and know-how gathered during the exploration of ITER's hot plasmas will be used to conceive the machine that will test the large-scale production of electrical power and tritium fuel self-sufficiency.

All Eyes on ITER

Today, on a vast construction site in southern France, the ground support structure and the seismic foundations of the ITER tokamak are in place and work has begun on the Tokamak Complex – a 440,000-ton edifice that will

Aerial view of the ITER construction site in southern France. Images courtesy of the ITER Organization.

Tokamak Complex under construction.

The final pour of the Tokamak Complex floor.

house the fusion experiments as well as diagnostics and tritium management systems.

In parallel, in factories all over the world, manufacturing has started for the components and systems of the ITER scientific facility.

Once the buildings are finalized and the elements of the facility have reached the site, scientists and engineers will progressively integrate, assemble, and test the ITER plant and fusion device. Twenty years of experiments are planned on ITER: first experiments in hydrogen and helium, followed by 15 years of deuterium-tritium fusion experiments between 2027 and 2042 (the term of the international treaty that establishes ITER).

The seven ITER Members represent three continents, over 40 languages, half of the world's population, and 80 percent of its gross domestic product. By sharing the manufacturing of the ITER machine and plant – and by participating in the scientific adventure of ITER – the ITER Members are gaining experience in key fusion technologies and preparing their scientific, technological, and industrial infrastructures for the advent of the fusion era.

In the offices of the ITER Organization and the Domestic Agencies; in laboratories and in industries around the world; literally thousands of people are working toward the success of ITER and, ultimately, the success of fusion.

Krista Dulon is an American who writes and edits for the ITER Organization in France. To learn more visit www.iter.org

HIGH-DENSITY POLYE

A KEY INNOVATION FOR SURVI

BY CLAYTON SMITH, P.E.; MICHAEL MARTIN, P.E.; AND PRAMOD KUMAR, P.E.

Facing an abundant supply of historically low-cost carbon-based fuels, nuclear power plant owners and operators are being challenged to evaluate potential cost-saving initiatives to ensure the continued longevity and competitiveness of their operating fleet. These evaluations also are playing a major role in licensees' decisions for new plant construction. As existing plants continue to age and reach the end of their operating licenses (40 years), owners must decide whether they will pursue license extensions, with the hope to gain an additional 10 to 20 years of useful plant life and power generation. Expensive repair and replacement of major systems and components is a primary concern and plant operators are increasingly looking for innovative, value-added engineering solutions to drive down operational costs. On the new construction side, with the

THYLENE PIPE (HDPE):


HDPE buried pipe installation at a nuclear power plant installed on elevation. All images courtesy of Clayton Smith.

VAL OF THE NUCLEAR INDUSTRY

average cost of building a typical two-unit nuclear site exceeding $8 billion, it is imperative to identify ways to reduce construction costs while ensuring future maintenance and upkeep is safe and affordable.

A significant financial burden to operating plants has been the repair and replacement of buried piping systems. This issue has caused enough concern over the last several years that regulators and industry have jointly reexamined the issue of buried piping in terms of design, maintenance, and inspection. Multiple buried piping initiatives have been established to provide a unified and robust approach to maintaining the integrity of these systems.

As the industry continues to benefit from material advances, improved construction techniques, and enhanced tools for fitness assessments, existing and new plant owners are demanding longer operating lifetimes, with life extensions and new builds aiming for a 60-year design life. HDPE offers plant owners many tangible benefits ranging from design and engineering to construction, operations, and maintenance.

HDPE piping has been historically used in place of steels in petrochemical, power, and mining industries to mitigate corrosion and erosion issues. Additionally, as HDPE pipe is resistant to galvanic corrosion, Microbiologically Influenced Corrosion (MIC), and fouling, it appears to be a perfect fit for nuclear safety-related cooling water applications. Polyethylene's exceptional resistance to corrosion from both soil-side and media-side interaction is perhaps its greatest benefit.

FIGURE 1:
The Impact of raw water systems on steel pipe vs. HDPE.

HDPE was first used in an American Society of Mechanical Engineers (ASME) Nuclear Class 3 emergency service water system in 2005 at Sizewell B, a plant operated by British Energy in the United Kingdom. The long, successful history of non-nuclear HDPE pipe operating along with the successful operation at Sizewell B and other non-safety-related nuclear applications has resulted in Duke Catawba (South Carolina) and Ameren Callaway (Missouri) plants installing polyethylene piping in safety-related, Class 3 service water systems. After receiving regulatory approval from the NRC, both plants made use of the rules established by ASME in Code Case N-755. Additionally, the Baraka Nuclear Power Plant Units 1-4, in the United Arab Emirates, are currently installing HDPE in their essential service water systems, utilizing the provisions of ASME Code Case N-755-1. This is on pace to be the first installation utilizing the ASME Certification Mark and data report to certify the design, fabrication, and installation of HDPE piping. This certificate includes third-party inspections by an authorized nuclear inspector. Other nuclear facilities continue to employ HDPE in non-safety water systems, and nuclear new builds are strongly considering HDPE for additional buried service and cooling water applications.

Design and installation of HDPE piping systems are short-lived activities when considering the plant's entire life cycle. Over the next 60 years, this pipe will be subjected to fluctuating pressure and thermal cycles, potential seismic and other impact loads, and must withstand the crushing weight of the soil and other structures above it. It is critical that the pipe withstand these stresses and continue safe operations. Any failure would carry with it enormous costs – not only financially, but also a shaken public confidence in the safety of our operating nuclear plants.

While HDPE presents peculiar design considerations due to creep and stress relaxation tendencies of the material under long-term static loads, these challenges can be overcome and actually demonstrate one of the advantages in design with the use of thermoplastic material. This viscoelastic behavior enables HDPE to withstand tremendous short-term, high-impact loads, such as water hammer and seismic events. In the wake of the Fukushima-Daiichi disaster, operating plants are revisiting seismic risk, expending much effort in re-analyzing plant structures, systems, and components (SSCs) to assure themselves and the public that there is little risk of similar events transpiring at other nuclear plants. HDPE's marked advantage of being classified as a "flexible" piping system is a clear benefit of the material.

Another unique advantage of HDPE is its relatively low modulus of elasticity (approximately 1,000 times less than that of steel). With only the friction of surrounding soil acting as a restraint, movement of buried piping systems due to thermal expansion and contraction can often result in high loads being transmitted to interfacing structures, and

HDPE fusion machine.

often requires expensive and large thrust restraint systems. Because of HDPE's low modulus of elasticity, loads imparted by this type of piping system on interfacing structures are a fraction of that compared with systems constructed of steel or concrete, and the need for thrust blocks or restraint systems can often be avoided.

The absence of thrust blocks is not the only advantage of HDPE for constructability. The material's relatively light weight (as compared with other piping materials) makes it easier to move around on the job site without the same heavy lift equipment requirements. A largely automated fusion process also reduces risk of unacceptable joints and reduces labor hours when compared to the time it takes for welding steel pipe. All of these features result in a smaller workforce and fewer labor hours involved per joint – which translates to cost savings and improved safety on-site.

The lower total installed cost (materials, labor, etc.) makes HDPE a viable alternative to traditional buried piping systems. The greatest benefit to nuclear power plant owners is in the reduced costs of ongoing maintenance due to a reduction in needed future repair / replacement activities when compared with piping systems constructed with traditional materials, such as steel or concrete. As evidenced in Figure 1 on page 30, the question is not *if* an open cooling water system will foul, but *when* it will occur. HDPE's corrosion-resistant properties, along with the inherent lack of MIC sensitivity, ensure a substantial reduction in future maintenance costs.

HDPE prefabricated elbow.

HDPE pipe installation through sleeve into heat exchanger building.

These savings have been found to be two or three times the cost of the initial installation.

To realize the promise of a nuclear renaissance, it is imperative that the industry evolve with the technology surrounding it and make use of innovative and cost-effective solutions to historical issues that have troubled the current operating fleet. For its material advantages and potential cost savings in construction and operations, HDPE may prove to be one such innovation for which the industry has been searching. To this end, it is a rare occurrence when perhaps the best technical solution is also the most cost-competitive.

Clayton Smith has over 30 years of experience in nuclear design, construction, and procurement. He is vice chair of the ASME Board of Nuclear Codes and Standards, member of the ASME Section III Standards Committee and Committee for Nuclear Certification, and is active in many other ACI, ASME, and AWS standards development organization committees.

Michael Martin is a licensed engineer, specializing in piping engineering. He currently works for Fluor Corporation and has supported projects in the chemical, pharmaceutical, mining, and nuclear power industries. He is an active participant in ASME code committee work.

Pramod Kumar has more than 30 years of mechanical and civil engineering experience in the fields of biotechnology, chemical, petrochemical, refinery, and power plants. He has extensive experience analyzing the piping systems in accordance with ASME B31.1, B31.3, and ASME Section III codes using AUTOPIPE, CAESAR II, PE 30, and various other computer design programs. ✤

How ASME Operation and Maintenance Standards for Nuclear Power Plants Affect Maintenance and Inspection Processes

BY JOHN J. ZUDANS, CHAIR, ASME OM STANDARDS COMMITTEE

The American Society of Mechanical Engineers (ASME) Standards Committee on Operation and Maintenance of Nuclear Power Plants, commonly known as the OM Committee, is chartered to develop, review, maintain, and coordinate codes, standards, and guides applicable to the safe and reliable operation and maintenance of nuclear power plants. The OM Committee prepares a code (Division 1) for testing safety-related pumps, valves, and dynamic restraints (snubbers).

The Nuclear Regulatory Commission (NRC) currently endorses the OM code through the Code of Federal Regulations 10 CFR 50.55a. The standards and guides (Divisions 2 and 3) provide valuable information on methods of testing and inspection of various other components (heat exchangers, diesel generators, vibration monitoring of components, reactor coolant pump condition monitoring, etc.). These are not typically endorsed by the NRC, but can be used as necessary to supplement program implementation or enhancement of inservice testing (IST) programs, as well as maintenance and inspection activities.

The OM code allows risk-informed approaches to the testing of components so that high-risk and low-risk components are differentiated and appropriate test methodologies can be applied to each component. The OM code has been enhanced to include requirements that are specifically tailored to new reactor designs, so that new designs can implement the OM code and the NRC can endorse its implementation. The current edition of the OM code is the 2012 Edition. The new 2014 Edition will be published in early 2015.

Current Use of OM Code

Commercial nuclear power plants in the United States utilize the OM code to develop and implement IST programs at each facility to detect degradation and to ensure that their safety-related pumps, valves, and snubbers will function when required in an accident, or that they will perform as postulated in their design bases. There are typically 500 to 700 valves, 30 to 40 pumps, and 100 to 1,000 snubbers required to be inspected and tested within these IST programs. IST programs and their implementation are routinely inspected for completeness and compliance by both the NRC and other interested parties. The primary systems covered by these programs are safety-related systems whose function is to shut down the plant and mitigate the consequences of accidents. The primary types of components included are centrifugal and positive displacement pumps; gates, globes, check, butterfly, and relief valves; and mechanical and hydraulic snubbers.

Foreign countries such as Spain, Japan, Korea, and others have adopted some or all aspects of this code. Other nations, including China and the Czech Republic, have expressed interest in using the OM code and have scheduled conferences with ASME to explore its adoption. Increased interest is expected in the future as most new construction is currently occurring outside the US.

Preventive Maintenance and Inspection, and Their Interactions with Inservice Testing

Typically, nuclear facilities have a number of preventive maintenance processes, which include:

- Condition Maintenance
- Overhaul Maintenance
- Predictive Maintenance
- Scheduled Maintenance
- Inservice Testing
- Inservice Inspection

Inservice testing is viewed as an integral part of the preventive maintenance and inspection process at commercial nuclear facilities to ensure that these safety-related components function as required after completion of one of the preventive maintenance processes, inspection activities, or in conjunction with the maintenance activity. As an example: if a safety-related pump is overhauled, the activities associated with the overhaul culminate in a post-maintenance test, which is expected to demonstrate that the component will function as required.

Although National Board Commissioned Authorized Nuclear Inservice Inspectors (ANII) are not typically involved in operation and maintenance testing activities, the ANII (acting as a

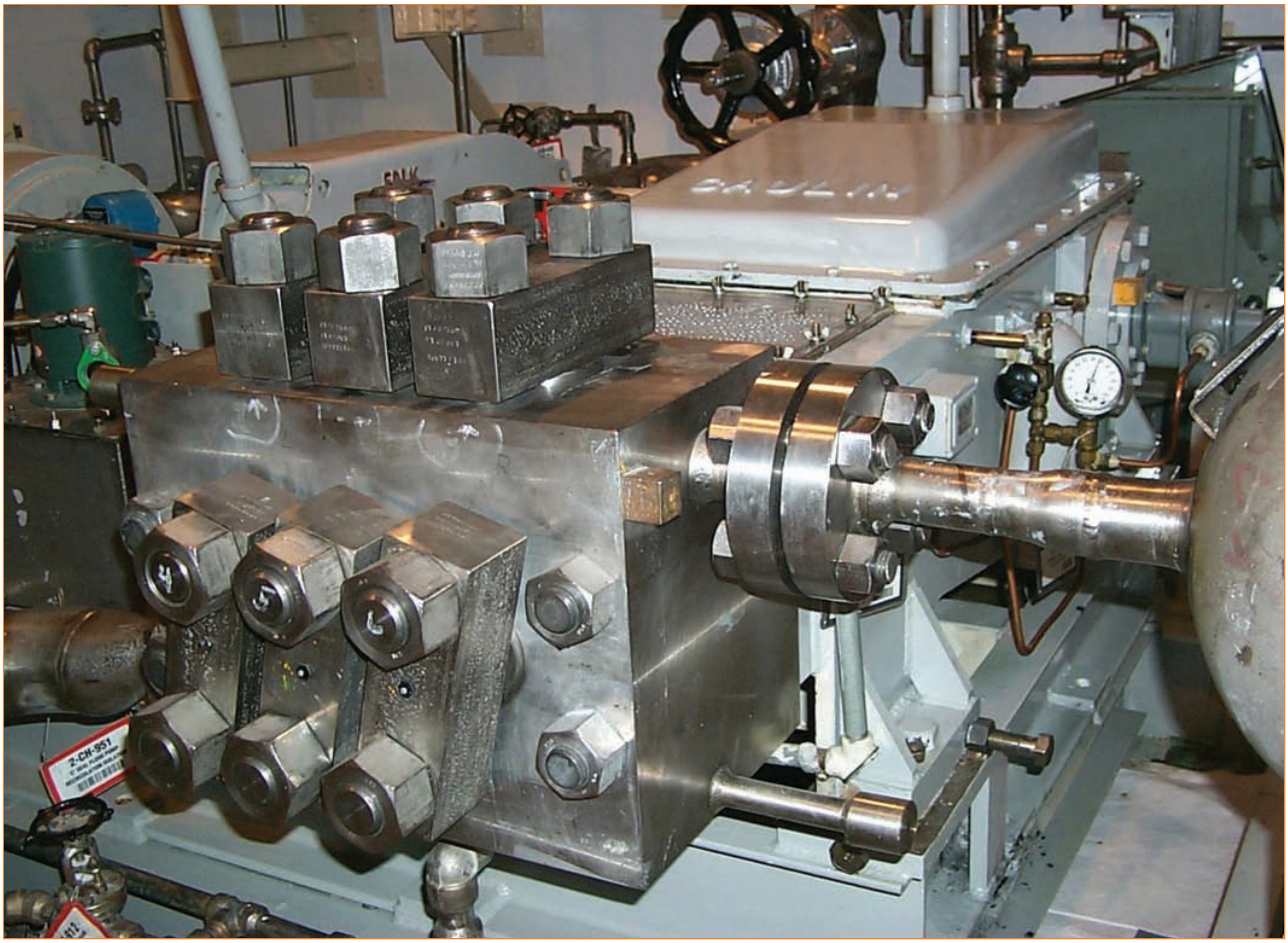


Photo courtesy of Energy Steel & Supply Co.

Positive displacement pump, one type of component represented in the OM code and IST Programs.

third-party inspector) may be involved in inspection activities of pumps and valves designated to be inspected within a plant's inservice inspection program. They will also be involved in any repair/replacement activities for those pumps and valves if corrective action is needed.

Inspection activities often result in findings that may call into question the qualification or operational readiness of a component. In such a case, the component can be shown to be acceptable after the successful implementation of its inservice test.

The undetected failure of active or passive components can lead to failure of the system to successfully complete its safety-related function. Inservice inspection findings can lead to questions about the functionality of a vital component or system (e.g. diesel generator air-start system tank inspections), necessitating further corrective action which may include additional examinations, testing, and repair/replacement activities.

Conclusion

Preventive maintenance, tests, inspections, and repair/replacement activities are essential, and collectively ensure the safe and reliable operation of our nuclear fleet. Understanding the full scope of the safety effort and the interaction among its elements provides the ability to identify, correct, and prevent undesirable consequences. ANII activities that include the inspection of boilers, pressure vessels, or pressure relief devices are an integral part of the preventive maintenance, inspection, and test programs in commercial nuclear power plants' vital systems.

John Zudans is an independent consultant. He has worked as a mechanical engineer in the US nuclear industry in design, supervision, and management of engineering organizations since 1972. Zudans has been an active participant since 1977 as a member of ASME Nuclear Codes and Standards, specifically pump, valve, and snubber testing. He is currently chairman of the ASME Standards Committee on Operation and Maintenance and an ex-officio member of the ASME Board on Nuclear Codes and Standards.

The Redesign of National Board Nuclear Training

BY KIMBERLY MILLER, MANAGER OF TRAINING

Gone are the days when students sat in their chairs each and every day listening to the instructor lecture on course material. Here are the days of student interaction and participation via instructor-led workshops, student work groups, video segments, inspection room demonstrations, hands-on training, scheduled question-and-answer/knowledge-check sessions, and even online training pre-work.

Make no mistake, there is still a lecture component to courses. However, blended among lectures now are greater interactive methods of teaching in order to allow for the highest level of comprehension possible for our adult learners.

This approach began to take shape a few years ago when we built our 25,000-square-foot Inspection Training Center. Since then we have redesigned all National Board training to provide more effective, participatory methods of instruction in our classrooms. The last part of this training renovation has been our nuclear program. With four nuclear classroom courses (**N**, **I**, **C**, and **NS** endorsement training) each being only one week in length, we need to use our instructional time wisely.

We teach in a way that provides students the foundation for being good inspectors.

We began with the Authorized Nuclear Inspector (**N**) Course, as it is the first in the nuclear program. After taking a very hard look at the course content, we rearranged a few sessions to provide a better flow of knowledge; then determined what would be the most effective way to teach each session and if the allotted time was adequate.

The first decision made was to pull the *navigating nuclear codes and code reading* session from the first day and create a new online course given to students as pre-work. This new primer provides students with a foundation and familiarity with the nuclear codes covered throughout the **N** course. New support materials were developed to be used by all instructors throughout the course to provide a common thread for students to follow. Then all lectures were reviewed for relevance, cohesiveness, and instructional methods. The result: a total of seven workshops, one group exercise, and one Lessons Learned video segment were integrated into the course. Also, additional quiz and homework review time has been extended at the start of days two through five to allow instructors to provide as much feedback as possible to students, and to allow for open discussion and question-and-answer time.

This exact approach has been used in the redesign of the **I**, **C**, and **NS** endorsement courses. Where possible, we took support materials created for the **N** course and continued to build upon them where applicable. The **I** course now offers multiple video segments, two workshops, and several case studies. The **C** course opens with sessions taught by an instructor from the American Concrete Institute (ACI) and ends with an afternoon in our inspection room of actually mixing and working with concrete to perform tests to determine slump, temperature, air content by volumetric and pressure methods, and to produce test specimens. And the **NS** course takes the student through the responsibilities and duties of a nuclear supervisor via two new workshops and case studies. Again, review time has been expanded each morning in all courses so feedback can be provided to students and comprehension may be assessed.

All students attending National Board training – not just those coming up through our nuclear program – should understand we do not teach to simply "pass an exam." We teach in a way that provides students the foundation for being good inspectors. And by introducing new instructional methods and encouraging students to interact, participate, and ask questions, our hope is to connect with students on many levels, not just by "telling."

Because in the end, a better-trained inspector benefits us all.

2015 Classroom Training Courses and Seminars

All training is held at the National Board Training Centers in Columbus, Ohio, unless otherwise noted. Class size is limited and availability subject to change. Check the National Board website for up-to-date availability.

COMMISSION/ENDORSEMENT COURSES

(B/O) Authorized Inspector Supervisor Course
TUITION: $1,495
2.5 CEUs Issued
March 16-20, 2015
October 12-16, 2015

(N) Authorized Nuclear Inspector Course
TUITION: $1,495
3.1 CEUs Issued
August 24-28, 2015

(I) Authorized Nuclear Inservice Inspector Course
TUITION: $1,495
2.5 CEUs Issued
September 14-18, 2015

(IC) Inservice Commission Course
TUITION: $2,995
9.6 CEUs Issued
April 13-24, 2015
June 1-12, 2015
August 10-21, 2015
November 9-20, 2015

(A) New Construction Commission and Authorized Inspector Course
TUITION: $2,995
7.0 CEUs Issued
May 4-15, 2015
June 15-26, 2015
July 20-31, 2015
September 14-25, 2015
October 19-30, 2015
November 30 - December 11, 2015

REPAIR SEMINARS

(VR) Pressure Relief Valve Repair Seminar
TUITION: $1,495
OFF-SITE TUITION: $1,595
2.6 CEUs Issued
March 23-27, 2015
June date/location TBA
September 28 - October 2, 2015

(RO) Boiler and Pressure Vessel Repair Seminar
TUITION: $795
OFF-SITE TUITION: $895
April 7-9, 2015
August 4-6, 2015
October date/location TBA

2015 GENERAL MEETING
COLORADO SPRINGS
SAFETY A COMMITMENT FOR LIFE

THE 84TH GENERAL MEETING

COLORADO SPRINGS, COLORADO

April 27 - May 1, 2015

The Broadmoor

The distinct spirit of the West can be seen and felt among The Broadmoor's historic halls and surrounding property. Built in 1918, The Broadmoor is a modern-day gem that preserves its historic roots and inspires guests with notions of Old West adventure, romance, and intrigue. The Broadmoor was established near the southern edge of the Rockies and is surrounded by breathtaking views of open skies and mountain landscapes. Notable amenities include a Forbes Travel Guide five-star day spa; several restaurants, including the only five-star, five-diamond restaurant in Colorado, The Penrose Room; 54 holes of championship golf; six tennis courts; indoor and outdoor pools; and 26 specialty retail shops. The Broadmoor is conveniently located only 8.3 miles (15-minute drive) from the Colorado Springs Airport.

COMING SOON on InfoLink!
An announcement on the Opening Session Speaker & Wednesday Banquet Entertainment.

84th GENERAL MEETING
PRELIMINARY PROGRAM
The National Board of Boiler and Pressure Vessel Inspectors
&
ASME Boiler and Pressure Vessel Committee

Monday, April 27

Opening Session

10:15 a.m. REMARKS
TBA

General Session

1:00 p.m. TBA

1:30 p.m. 150TH ANNIVERSARY OF THE *SULTANA* EXPLOSION
Patrick Jennings, Principal Engineer - Boilers
THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY

2:00 p.m. CARBON MONOXIDE: THE HIGH COST AND EFFECTS OF COMPLACENCY
Carey M. Bilyeu NB-A, Senior Risk Engineering Specialist & Portfolio Engineer, Machinery Breakdown Division
ZURICH NORTH AMERICA INSURANCE

2:30 p.m. BREAK

2:45 p.m. HOOVER DAM - MAINTAINING A GIANT
Nathaniel Gee, P.E., Project Manager, Dam Safety and Examination of Existing Structures
U.S. BUREAU OF RECLAMATION

3:15 p.m. TBA

3:45 p.m. MAKING ASME CODES AND STANDARDS SMALLER: SMALL MODULAR REACTORS AND THEIR NEEDS FOR FUTURE ASME CODES
A. Thomas Roberts, Engineering Consultant/Project Manager
MPR ASSOCIATES, INC.

General Meeting Notices

- Participants and guests are encouraged to dress in a business-casual style for all hotel events except the Wednesday banquet (where ties and jackets will be the evening attire).
- Distribution of any and all literature other than informational materials published by the National Board and ASME is strictly prohibited at the General Meeting.
- To obtain a preregistration discount of $50, all forms and fees must be received by April 13.
- On-Site Registration Desk Hours:

  Sunday, April 26 . . . . 9:00 a.m. - 2:00 p.m.
  Monday, April 27 . . . .8:00 a.m. - 10:00 a.m.
  Tuesday, April 28. . . . 8:00 a.m. - 10:00 a.m.

- General Meeting Registration is required in order to receive the special $199 room rate at The Broadmoor.

Reminder

General Meeting details can also be found on *InfoLink!* located on the National Board website at *nationalboard.org*.

ASME Boiler and Pressure Vessel Code Meetings

- Meetings are scheduled all week.
- Check hotel information board for locations and times.
- Meetings are open to the public.

ASME
SETTING THE STANDARD

GENERAL MEETING GUEST TOURS

NOTE: Registrants are not permitted to attend the Monday or Tuesday tours intended for designated guests. This policy is strictly enforced.

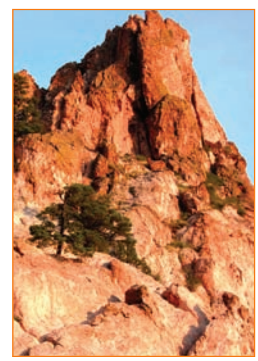
Monday, April 27
Olympic Training Center Tour, 1:00 p.m. – 5:00 p.m.

Have you ever wanted to go to the Olympics? Colorado Springs may be the closest you get. That's because the city is home to the U.S. Olympic Committee (USOC) and the Olympic Training Center. Guests will be transported to the Center (just one of three in the country) where they will observe firsthand what it takes to become an Olympic athlete.

The Colorado Springs facilities provide training for events in swimming, water polo, shooting, boxing, cycling, volleyball, tennis, wrestling, and more. It also provides housing, dining, and recreational resources for over 500 athletes and coaches. United States athletes preparing for the Olympic Games, Paralympics, and Pan-Am Games often live at one of the U.S. Training Centers to train over a period of months or years. Other athletes visit the facilities occasionally for training camps, coaching, and physical testing. While guests need not participate in training exercises, they may experience fatigue watching the athletes work.

NOTE: This tour requires a modest amount of walking. Light jackets are suggested should weather conditions warrant. Running shoes optional.

Tuesday, April 28
Cameras Are Mandatory Tour, 9:00 a.m. – 2:45 p.m.

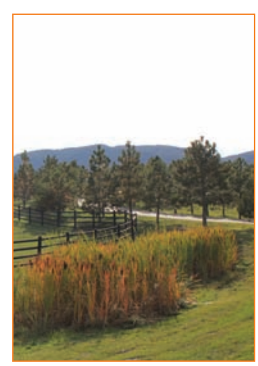


The first leg of this tour will take guests on a deluxe motor coach through some of the most dynamic scenery in Colorado. The Garden of the Gods Park is a registered National Landmark featuring 300-foot towering sandstone rock formations against a backdrop of snow-capped Pikes Peak and brilliant blue skies. Following the Garden of the Gods, it's off to the Royal Gorge Route Railway where guests become passengers on one of the most scenic railroad rides in North America.

This excursion is one of the most popular in Colorado and includes the famous hanging bridge, where the railroad track is suspended directly above the river. Passengers on this specially chartered General Meeting train will be treated to both the scenery and history of one of America's most famous gorges as well as a delicious lunch served as the train traverses the gorge alongside the Arkansas River.

NOTE: This tour requires a modest amount of walking including ascending and descending railcar stairs. Light jackets are suggested should weather conditions warrant.

Wednesday, April 29
A Day at the Ranch - Part Deux, 9:30 a.m. – 3:00 p.m.



All General Meeting guests and participants are invited to spend the day at the prestigious Spruce Mountain Ranch (a working cattle ranch) pursuing their desired entertainment from among a wide variety of event options, including: fly fishing, a mechanical bull, line dancing, horseshoes, horseback riding, a golf green on the lake, corn hole, and more surprise activities too numerous to mention.

Everyone will be transported by deluxe motor coach to the ranch, where the morning will kick off with a refreshing pick-me-up. A large barn house will serve as the day's focal point, featuring saloon beverages and a barbeque lunch that would satisfy the cravings of the hungriest cowpoke.

Participants are invited to sport their best western attire from ten-gallon hats to chip-kickin' boots to enjoy the entire 400-acre ranch. At 2:30 we'll begin the roundup for a trip back to The Broadmoor to prepare for the Wednesday evening banquet.

Please see *InfoLink!* on the National Board website for tour guidelines and restrictions.

GENERAL MEETING REGISTRATION

REGISTRATION FEES

Online Registration
Select the General Meeting Link on the top of the nationalboard.org home page.

Phone Registration
To preregister by telephone using your VISA, MasterCard, or American Express, contact the National Board at 614.431.3203

	Preregistration Pricing On or Before April 13 Save $50 off Participant Registration	Registration Pricing After April 13
Participant Registration	$425.00	$475.00
Additional Guest	$225.00	$225.00
Additional Banquet Ticket	$85.00	$85.00

ATTENDEE GUEST/ADDITIONAL GUEST must be a spouse/domestic partner or family member only (no professional or staff associates).

WHAT'S INCLUDED

Participant Conference Registration

- One Guest Registration
- Opening Session Admission
- General Session Admission
- Wednesday Outing
- One Wednesday Banquet Ticket
- Conference Gift

Participant Guest

- Opening Session Admission
- Monday & Tuesday Tour
- Wednesday Outing

NOTE: Wednesday Banquet Ticket not included

Additional Guest (16 years or older)

- Opening Session Admission
- Monday & Tuesday Tour
- Wednesday Outing
- One Wednesday Banquet Ticket

Those requiring special or handicapped facilities are asked to contact the Public Affairs Department at 614.431.3204

HOTEL RESERVATIONS

Reservations are the responsibility of attendees. The Broadmoor prefers attendees make their reservations by calling 800.634.7711. To receive the $199 nightly group room rate,* reference Group Name: National Board. Group rate reservations must be received by March 23. Room refunds available only with 72-hour prior notification. * *Group rate for General Meeting registrants only.*

While the National Board and the host hotel will do everything possible to accommodate all General Meeting visitors, **registered participants will be given first priority for all discounted sleeping rooms**. In the event of a sold-out hotel, the National Board reserves the right to cancel the reservations of anyone in its room block not preregistered for the General Meeting. It is, therefore, strongly recommended participants register for the General Meeting before securing room reservations. Additionally, it is suggested participants make their hotel arrangements early to ensure availability. Those seeking special room rates but failing to register for the National Board General Meeting are not guaranteed the discounted nightly rate.

Member Retirements

Chief Inspector Dan Willis of the Indiana Department of Fire and Building Services retired on August 29, 2014. Mr. Willis served the state of Indiana for over 20 years. He served as field inspector, authorized inspector supervisor, and conformity assessment coordinator before becoming chief inspector. Prior to joining the state, he worked for 10 years as a boiler and machinery inspector for American States/Safeco Insurance Company. He also served in the US Navy from 1975 to 1979.


Dan Willis

Chief Inspector Robert Reetz of North Dakota retired February 2, 2015. Mr. Reetz was the longest-serving National Board member (with over 31 years of service). He served on the Board of Trustees; Task Group on National Board Bylaws; the Task Group on Definitions of a Jurisdiction; and the Task Group on Budget. Since 1992, he served as chairman of the Standing Committee on Constitution and Bylaws. He also served on no fewer than 11 National Board committees. Mr. Reetz began working for the state of North Dakota in 1979. He was named acting chief in 1982, and finally chief inspector in 1987.


Robert Reetz

Chief Inspector Michael Klosterman of Iowa retired December 19, 2014. Mr. Klosterman served in the US Navy from 1977 to 1981, aboard the *USS Tripoli*. His civilian career began as a power plant engineer with the state of Iowa at the Iowa Veterans Home, where he served for 17 years. Next, he was hired as a state inspector and earned his National Board Commission in 2001. In late 2004, he became temporary chief boiler inspector and was named permanently to the position in 2005. Mr. Klosterman served the state for over 30 years.


Michael Klosterman

Doran and Mankel Remembered

Retired National Board staff member and Florida Chief Boiler Inspector Leroy J. Doran passed away on November 12, 2014. He was 80 years old. Mr. Doran was a 22-year veteran of the US Navy, retiring as a Lieutenant Commander. He was first elected to National Board membership in August of 1991 as chief boiler inspector for the Florida Bureau of Fire Protection. In 1992, Mr. Doran joined the Bureau of Indian Affairs and helped organize a boiler school program at the Southwestern Indian Polytechnic Institute (SIPI) in Albuquerque. In 1993, he was credited with creating the country's first boiler operator course for Native Americans.

In 1995, Mr. Doran became a field staff representative for the National Board. In 1998, he was promoted to government affairs/international representative and retired in 2002.


Leroy J. Doran

Gerard Mankel, retired National Board member and chief inspector for the states of Alaska and Nevada, passed away on December 6, 2014. He was 77 years old. Mr. Mankel joined Hartford Steam Boiler Insurance Company in 1967 as a boiler inspector. He passed the National Board Commission Examination in 1967, and for the next 10 years worked for CNA, Maryland Casualty in Detroit, the State of Michigan in the Upper Peninsula, and Commercial Union in Minneapolis. He moved to Anchorage in 1978 after being hired as a state boiler inspector.

He was named Alaska chief boiler inspector and voted a member of the National Board in 1991, and held that post until he retired in 1997. He moved to Nevada and became state senior supervisor in charge of new installations. Less than six months later, he was named the state's chief elevator/boiler inspector. He retired from Nevada in 2007.


Gerard Mankel

New Members

Gary L. Schultz represents Nevada. Mr. Schultz served in the US Air Force from 1974 through 1996. He began as a high-temperature hot water plant operator and served in many capacities; his last title was civil engineer squadron chief. While in the military, Mr. Schultz earned and was awarded multiple medals, including the Armed Forces Service Medal, National Defense Service Medal, Meritorious Service Medal, Department of Defense Joint Service Commendation Medal, Air Force Commendation Medal, Humanitarian Service Medal, and Korea Defense Service Medal. His civilian career includes positions as heating plant specialist at the University of Nevada, Reno, and loss control specialist for Travelers Insurance Company. He then returned to work for the State of Nevada as a safety specialist III – boiler/elevator inspector. He was promoted to safety supervisor – boiler/elevator inspection, before assuming the role of safety manager in September 2014.

Gary L. Schultz

Derrick Slater represents Manitoba. Mr. Slater served in the Army Reserves from 1975 through 1998. During that time, he served with the Royal/Winnipeg Rifles (1975-1982) and the 17th Service Battalion as a weapons technician (1982-1998). He worked at Consolidated Bathurst (1979-1980) as a 4th class shift engineer; Transport Canada (1980-1981) as a 3rd class assistant shift engineer; and Red River Community College as a 3rd class assistant shift engineer (1982-1986) and 2nd class shift engineer (1986-2002). He is currently employed with Inspection and Technical Services Manitoba, Office of the Fire Commissioner, as a boiler and pressure vessel inspector, an NBIC inservice inspector, and CSA B51 shop inspector. He recently attained the New Construction **A** Endorsement.

Derrick Slater

Charles J. Wilson III represents Kansas. Mr. Wilson was vice president of DM Wilson & Son, a family business founded in 1969 and sold in 2006. For 10 years he was a speaker for the Kansas Safety Health Conference, and he also provided several instructional courses in boiler maintenance and safety. Mr. Wilson was an ASME Section IX qualified welder at the age of 18, was a certified burner technician for Webster and Gordon/Piatte, and was a certified backflow prevention tech for 10 years.

Charles J. Wilson III

Terrence C. Hellman represents Oklahoma. Mr. Hellman attended the University of Tulsa where he studied petroleum engineering. His professional career began in 1997 with Morgan Well Services and Helmerich & Payne, working as a roustabout. In 1999, he worked for Oak Resources as a production technician. He then became a compliance officer for the Oklahoma Department of Labor (ODOL) in 2002, and a boiler/pressure vessel inspector for ODOL in 2006. He was promoted to senior boiler/pressure vessel inspector (manager) in 2012, and advanced to safety and health director in 2014. He remained in that position until assuming the role of chief inspector in July 2014.

Terrence C. Hellman

The 2014 National Board Incident Report

Based on 2009 OSHA Data

In early 2013, the National Board launched a new reporting system to better quantify data published on pressure equipment accidents. While previous efforts tallied incident numbers from a variety of sources, the new process was designed to distribute more credible statistics as well as provide specific accident information in support of those statistics.

The new approach requires compiling actual incident statistics and accident reports only from OSHA. Because of the amount of time required for OSHA to collect facts, thoroughly investigate, revise, and screen relevant information for each accident, comprehensive reports are not available until approximately five years later.

By using key words, the National Board has been able to filter annual results from the OSHA database (*Fatality and Catastrophic Investigation Summaries*) to include only those incidents involving pressure equipment accidents.

This year's report covers 2009. During this period, there were 596 investigated accidents (all categories) of which only 15 were classified boiler and pressure vessel-related. Those accidents resulted in 14 fatalities and 22 injuries.

The chart below details the number of pressure equipment accidents, deaths, and injuries occurring over an eight-year period that began in 2002.

While it is easy to dismiss statistics as mere numbers, it is the particulars that reveal the true impact of each death or injury. The following page provides examples of accidents from which the 2009 statistics were derived. (Some narratives have been modified for clarification purposes.) To view all customized summary reports and to learn more about how the Incident Report is compiled, visit nationalboard.org and click "Incident Report" in the Resources box.

YEAR	Total Incidents Reviewed (Filtered by key words)	Total B&PV-Related Incidents	Total Fatalities	Total Injuries
2002	861	13	8	17
2003	775	14	4	12
2004	838	14	11	14
2005	851	15	5	17
2006	895	15	9	10
2007	800	29	26	16
2008	505	21	12	51
2009	596	15	14	22
TOTAL	6,121	136	89	159

The above statistics are derived from data files available for download from OSHA, for incidents occurring between 12/31/2001 and 12/31/2009

Stories behind the Numbers

ITEM: Employee Is Injured When Struck by Flying Object
Incident Description: At approximately 2:45 p.m. on October 2, 2009, Employee #1, a machine operator, was working with a boiler technician to replace a gas valve actuator on the boiler, a Hurst Boiler and Welding Co. Inc. Mfg., serial number S2500 15037, and model number B66549. The repair was completed and the boiler technician was on the control end while Employee #1 was on the other end of the boiler, looking through the sight glass. There was an internal boiler gas explosion and Employee #1 was hit by a manhole. He was hospitalized for treatment.
Incident Category: N/A
Incident Cause: Failure of Controls
OSHA Open Date: 10/02/2009 **OSHA Close Date:** 04/15/2010
Where did the incident occur? Appleton Medical Center

ITEM: Compressed Gas Cylinder Ruptures, Amputates Worker's Legs
Incident Description: On August 20, 2009, a worker was filling a 60-cylinder manifold system of compressed oxygen. It was operating at 2,350 lbs of pressure. During filling, a gas cylinder ruptured. At the time of the cylinder rupture, the worker was turning off the cylinder valves. EMS responded to the scene, and the worker was transported to Wayne Memorial Hospital and then airlifted to Pitt Memorial Hospital, where he was hospitalized. As a result of the severity of the worker's injury, medical personnel amputated both legs at the mid-thigh level.
Incident Category: N/A
Incident Cause: N/A
OSHA Open Date: 09/30/2009 **OSHA Close Date:** 02/25/2010
Where did the incident occur? Airgas National Welders Inc.

ITEM: Employee Is Injured When Autoclave Door Blows Off
Incident Description: At 1:30 p.m. on June 19, 2009, Employee #1 was walking through a room where medical testing equipment was manufactured. An autoclave door (5 ft square) blew off, striking a wall approximately 12 ft away. Employee #1 was struck by glass and burned by steam. He was hospitalized at UC Davis Medical Center for lacerations and first-degree chest and face burns. Employee #1 was taking a short-cut through this area at the time of the incident. The autoclave had been under 30 psi pressure, resulting in the equivalency of approximately 72 tons of pressure on the door. After the incident, the employer implemented new maintenance procedures and installed different door hardware.
Incident Category: N/A
Incident Cause: N/A
OSHA Open Date: 07/22/2009 **OSHA Close Date:** 01/21/2010
Where did the incident occur? Siemens Healthcare Diagnostics

ITEM: Three Employees Killed and Fifteen Injured in Explosion
Incident Description: At approximately 11:22 a.m. on June 9, 2009, an explosion occurred as contractors were trying to light the pilot light of the newly installed direct contact water heater within vacuum pump in Room Number 2. The water heater was powered by natural gas. The explosion resulted in the collapse of the packaging department building structure. Three employees were killed along with 15 employees injured. The injured employees were hospitalized for burns, amputation, fractures and smoke inhalation.
Incident Category: Pressure Vessel-Related
Incident Cause: Operator Error; Failure of Controls; Violation of Safety Procedures
OSHA Open Date: 06/10/2009 **OSHA Close Date:** 02/08/2010
Where did the incident occur? Conagra Foods Inc.

ITEM: Two Employees Are Killed When Hot Water Tank Explodes
Incident Description: At 11:30 p.m. on March 19, 2009, employees from the third shift had just come in to work. Their employer is a manufacturer of plastic conveyor parts. One employee pointed out to the on-shift supervisor (Employee #1) that there was a pool of water near an 80-gallon water heater (Whirlpool model number EE3Z80HD055V, serial number 0745105567) that was being used to supply heating water to the production process. Minutes after this exchange, the water heater tank exploded. Both Employee #1 and Employee #2, the second-shift supervisor, suffered blunt force injuries in the explosion and were instantly killed. The hot water tank broke through the roof, about 30 feet above the floor, and returned through the roof and fell into the workplace about 25 feet from its original location. A third employee was injured by flying shrapnel and was treated and released at a local hospital.
Incident Category: N/A
Incident Cause: N/A
OSHA Open Date: 03/20/2009 **OSHA Close Date:** 03/20/2009
Where did the incident occur? Solus Industrial Innovations LLC

Code Interpretations

The *National Board Inspection Code* (NBIC) and the American Society of Mechanical Engineers' *Boiler and Pressure Vessel Code* (ASME B&PVC) each issue responses to technical questions submitted by their respective user communities. Interpretations clarify the meaning or intent of existing rules. Section 10 of the NBIC contains an index of all interpretations approved at the time of publishing. A comprehensive index of NBIC interpretations is available at nationalboard.org under the NBIC tab.

The ASME B&PVC contains an index of all interpretations approved at the time of publishing, along with the written interpretations for a given date range, at the end of each Section. All written interpretations are also published online at: http://cstools.asme.org/interpretations.cfm.

Following is a selection of interpretation questions currently posted on the respective websites. ASME Section XI is highlighted in this listing to accentuate the nuclear theme of this issue. To review the complete collection of current interpretations, refer to the websites listed above.

ASME B&PVC Interpretations posted January 2015

Section XI – Rules for Inservice Inspection of Nuclear Power Plant Components

- **Interpretation: XI-1-13-24,** Subject: IWA-2210 (2013 Edition) and Case N-823, Date Issued: January 23, 2014

  Question (1): Is it the intent of IWA-2210 or Case N-823 that there are no illumination, distance, angle-of-view, and resolution demonstration requirements for VT-2 visual examinations?

  Reply (1): Yes

  Question (2): Is it the intent of IWA-2210 or Case N-823 that there are no angle-of-view requirements for VT-3 visual examinations?

  Reply (2): Yes

- **Interpretation: XI-1-13-25,** Subject: IWE-1230 (1992 Edition with the 1992 Addenda through the 2013 Edition), Date Issued: March 7, 2014

  Question (1): Is it a requirement of IWE-1230 that the containment surface covered by thermal insulation be considered accessible for general visual examination in accordance with Table IWE-2500-1, Examination Category E-A?

  Reply (1): No

  Question (2): Is it a requirement of IWE-1230 that the containment surface covered by thermal insulation be considered accessible for augmented examination in accordance with Table IWE-2500-1, Examination Category E-C, if these surfaces are subject to accelerated degradation and aging?

  Reply (2): Yes

- **Interpretation: XI-1-13-26,** Subject: Case N-661-1, Para. 5(b), Date Issued: March 7, 2014

  Question: Does Case N-661-1, para. 5(b), prohibit repairing through-wall leaks by installing a metal plug into the through-wall opening and seal welding?

  Reply: No

- **Interpretation: XI-1-13-27,** Subject: Cases N-770-1 through N-770-3, Paras. -1100 and -1210, Date Issued: March 10, 2014

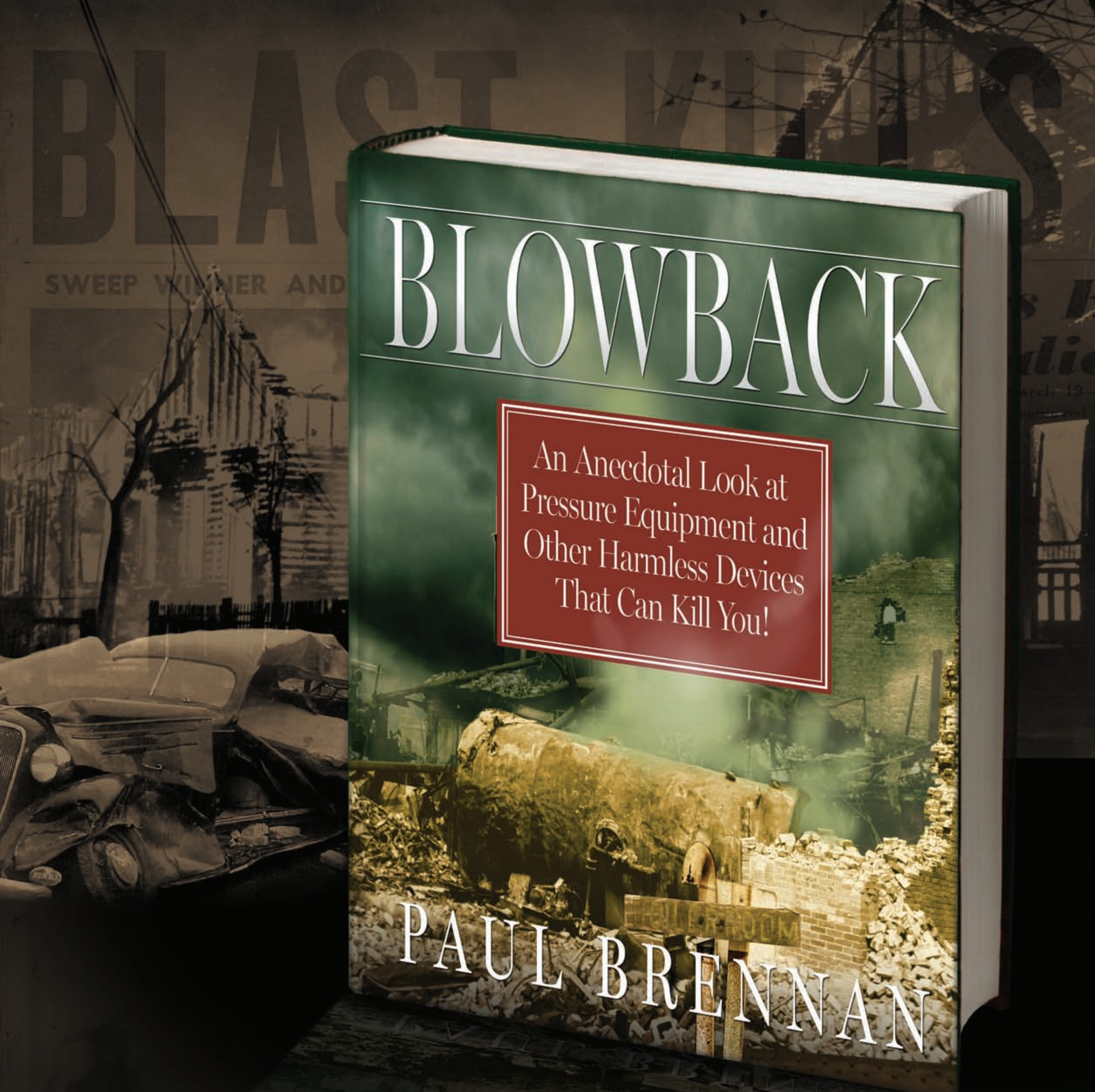
  Question: Is it a requirement of paras. -1100 and -1210 of Cases N-770-1 through N-770-3 that the Case applies to Examination Category B-J branch connection welds in piping?

  Reply: No. Cases N-770-1 through N-770-3 only applies to circumferential butt welds, as shown in Fig. 1 of the Case.

- **Interpretation: XI-1-13-28,** Subject: Table IWB-2500-1, Examination Category B-K, Item B10.10 (1995 Edition with the 1996 Addenda, through the 2013 Edition), Date Issued: April 1, 2014

  Question: Is it a requirement of Table IWB-2500-1, Examination Category B-K, Item B10.10, to perform a surface examination of the weld buildup on a nozzle associated with the vessel support if the weld buildup does not weld any attachment to the nozzle?

  Reply: No


BLOWBACK
An Anecdotal Look at Pressure Equipment and Other Harmless Devices That Can Kill You!
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