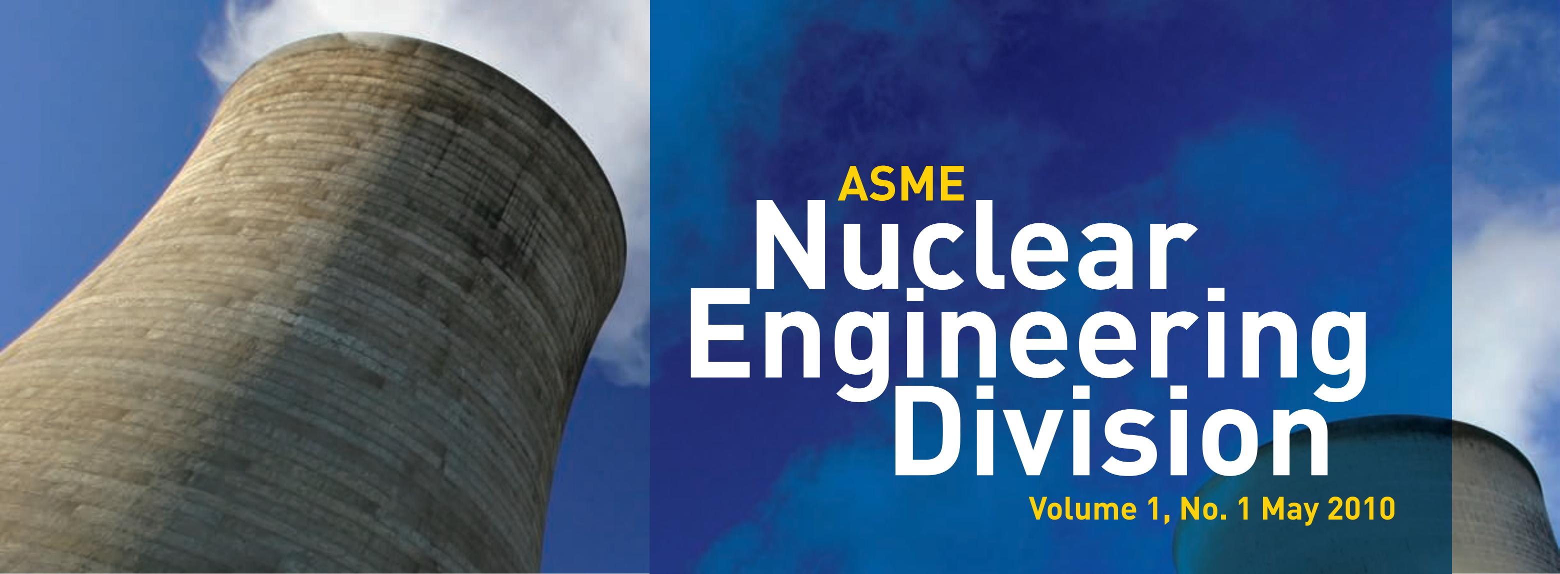

ASME

Nuclear Engineering Division

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Join us for the International Conference on Nuclear Engineering (ICONE-18) in Xi'an, China

Jovica Riznic, Ph.D.
Canadian Nuclear Safety Commission

Nuclear Renaissance Consider the facts:

- Nuclear power generates more electricity today than all sources of power generated 50 years ago.
- Twenty percent of the electricity in the United States is generated using nuclear power.
- Over 25 countries rely on nuclear power for over 25 percent of the electricity needs. In Europe and Japan more than 30 percent of their electricity is generated by nuclear power. So two-thirds of the world's population live in nations where nuclear power is part of their energy programs.
- Over four-hundred (436) nuclear power plants are operating in 29 countries
- Half of the world's population lives in countries where new nuclear power reactors are in planning or are under construction; 53 nuclear power plants are under construction
- Approximately 40 to 50 countries, that presently do not use nuclear power, are considering the nuclear power option.
- Scientists in more than 50 countries use nearly 300 nuclear research reactors to investigate nuclear technologies and to produce radioisotopes for medical diagnosis and cancer therapy.
- Over the years, more than 400 ships have sailed used nuclear power.

Clearly, a "Nuclear Renaissance" is under way. The future will be a very exciting time for the nuclear industry as it offers safe, clean and economical power to meet the global energy need.

The ASME Nuclear Engineering Division invites you to step up and actively participate and contribute to the historic and ongoing Nuclear Renaissance.

International Conference on Nuclear Engineering...

ICONE—the world's premiere nuclear engineering conference—will be held in Xi'an, China in May. The conference will cover a wide range of topics that span the different types of nuclear reactors of current and future generations. In particular, the meeting has placed a specific emphasis on understanding fundamentals of nuclear engineering and nuclear technology to ensure safe operation of the current nuclear generation fleet as well as presenting developments and applications of new innovative technologies in design, operation, maintenance, outage management and inspection. Since the ICONE-1 in 1991, the Nuclear Engineering Division (NED) of the American Society of Mechanical Engineers has partnered with the Japan Society of Mechanical Engineers to organize ICONE meetings held in the U.S.A., France, Belgium, Japan and China. ICONE-18 will be held from May17 to 21, 2010 in Xi'an, China, and is organized in cooperation with the Chinese Nuclear Society. Professor Kenichiro Sugiyama of Hokkaido University and Dr. Aris Candris, President and CEO of the Westinghouse Electric Company are the General Conference Chairs. Professor Guanghui Su of Xi'an Jiaotong University is the Technical Program Chair, and Xi'an Jiaotong University, as the host, along with the Chinese Nuclear Society will provide all the technical support for the conference.

The ICONE-18 keynote theme is "Back to the Future: Nuclear Energy for Global Sustainability." Over 800 papers in 13 Technical Tracks are anticipated, and a Nuclear Industry Forum will be held that includes five invited panels featuring senior leaders and technical experts from government, industry and academia. Finally, a workshop on Computational Fluid Dynamics (CFD) will be held the day before the official start of the conference with international experts to provide in-depth discussions.

Don't miss these ICONE-18 events...

The five Plenary Sessions will explore: (i) Regulation, codes and standards; (ii) Training, education, and the workforce for nuclear power development; (iii) How the best plant's operation and maintenance records were achieved; (iv) Newly designed plants: the issues and challenges during construction, and (v) Generation IV designs and systems.

To aid in the nurturing, education, and encouragement of bright, young, engineers in the nuclear field, a student paper competition will be held. Students from Europe, North America, and Asia will compete and take part in the program. ICONE is designed to maximize interactions between future nuclear engineers and practicing and experienced engineers.

The papers and discussions of the overall technical program will focus on 13 areas including:

- Plant Operations, Maintenance, Engineering, Modifications, Life Cycle, & Balance-of-Plant
- Component Reliability & Materials Issues
- Structural Integrity
- Nuclear Technology Applications & Innovations
- Advanced Reactors
- Safety & Security
- Code, Standards, Licensing & Regulatory Issues
- Fuel Cycle & Decommissioning
- Thermal-Hydraulics
- Reactor Physics and Transport Theory
- Nuclear Education, Public Acceptance & Related Issues
- Instrumentation & Controls
- Fusion Engineering

Exposition & Networking

Exhibits by leading companies such as AECL, AREVA, GE-Hitachi, Mitsubishi, Westinghouse, Toshiba, and many more will be at ICONE. Between the strong nuclear engineering exhibition and a record number of technical presentations, conference participation by a record number of people from the nuclear community will provide an excellent opportunity to promote nuclear power and to network with the world leaders in the field in a nation (China) where more nuclear plants are being built than anywhere else in the world.

More Information...

All registered participants will receive a DVD with the ICONE18 Proceedings—with more than 800 peer-reviewed papers. All can register via the ICONE-18 Web site: http://www.asmeconferences.org/icone18/ which has a more detailed description of not only the program, but also the tourist attractions in Xi'an, China. Or you may send a note to the Technical Program Committee Co-Chair at jovica.riznic@cnsc-ccsn.gc.ca. ■

View from the Chair

Dmitry Paramonov, Ph.D.
Westinghouse Electric Company LLC

Dear colleagues,

This Nuclear Engineering Division (NED) supplement to *Mechanical Engineering* is the first in a series of regular contributions by the NED to the magazine. In this letter I would like to introduce the NED and share my views on nuclear power in today's world and where we might take it in the future.

The ASME NED focuses on the design, analysis, development, testing, operation and maintenance of reactor systems and components, nuclear fusion, heat transport, nuclear fuels technology and radioactive waste as well as promotion of nuclear energy. Approximately 2,000 ASME members list NED as their primary division. Our major activities include:

- Organizing the International Conference on Nuclear Engineering (ICONE), which is the world's premiere nuclear engineering conference. ICONE is co-sponsored by the Japanese Society of Mechanical Engineering and the Chinese Nuclear Society, and is held every year at alternating locations in the U.S., Asia and Europe. ICONE-18, to be held in Xi'an, China on May 17-21, 2010, is promising to become the largest one ever and one of the best.
- Organizing the 13th International Conference on Environmental Remediation and Radioactive Waste Management in Tsukuba, Japan, Oct. 3 to 7, 2010. The ICEM2010 is the world's premier environmental and waste management conference.
- Facilitating international cooperation by nuclear professionals through a number of NED technical committees and ASME committees, and co-sponsoring other international conferences, for example, the 2010 International Heat Transfer Conference (August 2010, Washington, D.C.), the U.S.-European Fluids Engineering Summer Meeting (August 2010, Montreal, Canada), the ASME Power Conference (July 2010 in Chicago), and PHYSOR2010 (May 2010, Pittsburgh), as well as various short courses and workshops.
- Supporting development of a new generation of nuclear engineers through sponsoring attendance of ICONE conferences to participate in student paper competitions, and by establishing a new undergraduate scholarship for mechanical and nuclear engineering students.

Thanks to the dedication of NED volunteers and supporting ASME staff, NED continues to provide a vibrant personal development and professional exchange venue for technical and business leaders and experts from government, industry and academia from around the world. The nuclear renaissance is real and the future, as we nuclear engineering professionals see it, is bright. However, we must remain vigilant and foresee and avoid potential dangers.

I see three key factors necessary to ensure future growth and advancement of nuclear energy: safety, security and stability. While safety, in the sense of assuring reliable, accident-free operation, and security, in the sense of protecting energy infrastructure from sabotage, continually receive high attention from industry, regulators and society, the third aspect—providing stable economic, political and regulatory conditions for the nuclear industry—is often overlooked.

We are now in the third year of a global economic crisis, which will touch every country and only a handful might benefit. Apparently, 70 years past the Great Depression was not enough to learn the lessons and come up with a way to stabilize economies despite availability of supercomputers and armies of economists. How does this relate to the prospects of nuclear power? When explaining how the "invisible hand" of free markets works, Adam Smith wrote "It is not from the benevolence of the butcher, the brewer, or the baker that we can expect our dinner, but from their regard to their own interest." What do we see when comparing a brewery or a bakery with a nuclear power plant? We see orders of magnitude difference in investment, complexity of operation, societal impact and a lifecycle of close to 100 years (from design to decommissioning) for a nuclear power plant. The environment of quick profit-seeking (for example, Enron and California's energy sector deregulation fiasco), blowing and bursting bubbles every few years (dotcom and housing bubbles), and tying investment decisions to fluctuation of prices for commodities subject to market speculations (uranium, oil, gas) is not conducive to 100-years-long projects. The fundamental reasons for nuclear power growth are not market-driven and will persist: population growth; technological progress, which overall increases energy consumption; depletion of hydrocarbons; and disparity in living conditions around the world. Good of mankind, rather than oil price fluctuations and political bargaining, is the fundamental reason for maintaining stability in the nuclear industry. Once the eternal need for growth in energy production is recognized, the worldwide nuclear industry should become a conveyor constantly producing better, more efficient and safer power plants (without a need to disband and then rebuild the workforce every 20 years or so).

How can this be achieved? History teaches us that projects of this magnitude can succeed when a vision becomes accepted by a sufficiently large group of people. This could be either a nation with its government creating a proper investment climate and R&D infrastructure, or at least a large enough corporation that has a planning horizon of dozens of years. I am calling on influential ASME veterans to spread this vision not only among engineering communities, but also among decision makers in government, academia and public organizations.

Do we need to constantly grow energy production? Will it create another bubble resulting from overcapacity of power generation? Human and animal have quite a few differences and one of them is behavior when food and comfort are secured: the animal goes to sleep while the human continues working—inventing, exploring, creating. The need for more energy will always exist as long as technological and human progress continues. This is testified by the fact that growth in living standards was closely followed by the growth in energy consumption, and the correlation between poverty levels around the world and per capita energy use. Finding new ways to harvest energy (nuclear, fusion and whatever will follow) and then applying it present great challenges and self-realization opportunities for young generations of engineers to come. Surely, the need for light and heat will remain, but beyond that, horizons are boundless. Compact and reliable nuclear energy sources will revolutionize transportation multiple times. First, all cars will turn electric or hydrogen, high speed railroads will be fully electrified, sea transport will be carried out by fast nuclear powered ships, most airplanes will be replaced by large nuclear-powered ground effect vehicles. Then, man will return back to space—will go to the moon, Mars and beyond; and to the sea, for underwater tourism, exploration, etc. While the promise of nuclear electricity being "too cheap to meter" has not been fulfilled yet, it will certainly be realized in the future. At first, every human will get access to abundant energy sources for heating, air conditioning and transportation. Further applications include synthesis of materials, for example, hydrocarbons for use in the chemical industry; and complete destruction of all types of waste. Finally, transmutation will emerge as a way to make elements in short supply.

What else can be more exciting for an engineer than making and putting energy to good use?! ■

ASME Nuclear Engineering Division Announces New Undergraduate Scholarships for Study of Nuclear Engineering

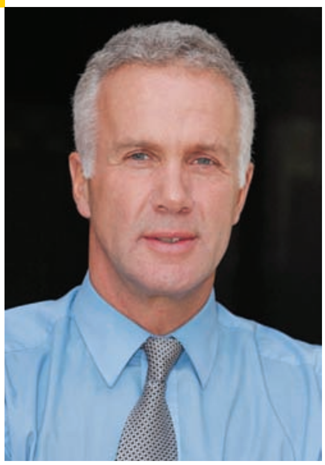
ASME will award annually three scholarships to ASME student members who **demonstrate a particular interest in Nuclear Engineering as defined by the NED** in the design, analysis, development, testing, operation and maintenance of reactor systems and components, nuclear fusion, heat transport, nuclear fuels technology and radioactive waste.

Applicants must be ASME student members in good standing at the time of application, enrolled in an ABET accredited or substantially equivalent nuclear engineering or mechanical engineering baccalaureate program. The award recipient will be selected on the basis of scholastic ability, character, integrity, leadership, financial need, and potential contribution to the nuclear engineering profession.

The NED Scholarships will be granted for study in the junior or senior year. There are no citizenship or geographic requirements for consideration for this scholarship.

Nuclear in the New Decade

Steve Kidd
World Nuclear Association



As we enter another new decade, it is interesting to review the progress that nuclear power has made over the first ten years of the new millennium. Talk of a nuclear renaissance has become increasingly common in popular discussion, but opponents of the industry argue that this is mainly hype and lacking in real substance. So what has changed since the year 2000?

The fireworks going off at midnight on 31st December 1999 were also possibly marking the entry, at last, into a happier period of renewed growth for nuclear after the nadir in its fortunes during the late 1990s. Things were definitely bad in the industry during those years, as participants then will easily recall. There was a mood of pessimism surrounding all industry meetings due to the overwhelming feeling that nuclear was suffering a prolonged, lingering and unpleasant death. Electricity market restructuring and liberalization was widely seen as a final nail in its coffin. The general expectation was that one half of over 100 U.S. operating nuclear reactors would soon shut down and that this trend would subsequently spread to other countries. At the time, there were very few new reactors actively under construction while most of these had been delayed extensively owing to political interference or other awkward issues.

The nuclear fuel sector a decade ago had suffered from low uranium prices for many years, with only the lowest cost mines able to survive, while supply infrastructure in the whole of the fuel cycle was looking clapped out and in urgent need of replacement. Despite occasional voices to the contrary, nuclear was generally regarded as an uneconomical option for generating large quantities of electricity and also suffered from difficult issues over safety, waste management and possible weapons proliferation. Although concerns over greenhouse gas emissions were already rising, nuclear was seldom mentioned in the same breath as a conceivable mitigation technology. The perception was that it was also deeply unpopular with the general public, who would veto the plans of any politician foolish enough to propose it.

It is clear that a lot has changed and in a relatively short period of time. The most obvious sign of this is the increased mentions of nuclear power in the mass media and often with a generally positive slant. The World Nuclear Association (WNA) monitors this very closely, and setting up World Nuclear News (WNN) as a service free of charge to all was an important initiative, satisfying the need from media outlets around the world for sound information and informed comment. WNA also closely monitors the "hits" on its Web site information papers and can measure the increased interest in all aspects of nuclear, extending well beyond power applications to the wider and often less well-known ones in medicine, agriculture and industry.

A very important element has been public statements from respected third-party advocates for nuclear, many of whom were previously either strongly opposed or seen as agnostic. Some of these come from the environmental movement, notably Patrick Moore, one of the founders of Greenpeace, but the support of James Lovelock, the originator of the Gaia Theory of the Earth as a self-regulating organism has been particularly important. He is regarded as a hero by many of the younger generation of scientists who one might otherwise have expected to follow the anti-nuclear bandwagon prevalent in the 1980s and '90s.

To the extent that public opinion can be measured, it is clear that there has been a turnaround in favor of nuclear in key countries, to the extent that public consent is unlikely now to be withheld from new reactor plans in many countries of the world. Public opposition to nuclear remains an important issue in some places, notably in Germany and other European countries, but the new government there and reversal of nuclear phase-out policies in Sweden and Belgium indicate that things are generally improving. The industry has recognized that it has to bring the general public along with its plans via an in-depth dialogue. It accepts that concerns over safety, waste and non-proliferation will continue to impose a strict regulatory regime and that this is necessary, despite its costing a great deal of valuable time and money.

So far as the anti-nuclear movement is concerned, it is looking increasingly marginalized. It varies in strength from country to country but is now coordinated by only a few university departments and non-governmental organizations (NGOs), now more commonly directing their fire at coal and the other fossil fuels than at nuclear. Their arguments against the industry which formerly achieved a good deal of traction are increasingly becoming seen as rather threadbare and sourced from groups opposed to wider developments in the global economy and society as a whole, rather than to nuclear power in isolation.

To put the opposite point of view, is all of this no more than a lot of hype, led by the entrenched, self-interested elements within the nuclear industry? It can, after all, be pointed out that very few new reactors have started up so far in the new millennium, no more than a few per year around the world, and that these have been balanced, numerically if not in generating capacity, by similar numbers closing down. And also that this position is not going to change very quickly over the next period, as there are relatively few new reactors under construction and nearing commissioning. Indeed, many of the 436 reactors in operation are now relatively old, with their peak construction period in the late 1970s and 1980s, and could conceivably close over the next decades. These arguments undoubtedly have a superficial attraction for the ill-informed. It can also be pointed out that some issues, clearly negative for the industry, have arguably increased in significance over the past decade. For example, the possible links between the civil and military sides of nuclear, with the need to ensure a strict world non-proliferation regime, have been reinforced by the North Korean and Iranian cases, to which endless column inches and analyses have been devoted.

It is therefore important to see what has really changed in the industry's favor. The foundations are essentially threefold—the industry's own performance, greenhouse gas emissions and energy security of supply.

The economics of nuclear power are still a question of great debate, particularly with regard to new reactors. Industry opponents never tire of pointing out that the capital investment costs per kW installed of new nuclear reactors have increased sharply over time, in contrast to what one might reasonably expect with a very mature technology. Solving this issue may prove to be the industry's greatest challenge over the next decade, notably by building a high volume of standardized reactors using modular construction techniques. What is unchallengeable, however, is that the current stock of reactors generates electricity very cheaply and earns significant profits for their owners, irrespective of the power market, liberalized or regulated.

The foundation of better economics has been a much improved reactor operating performance indicated by improved capacity factors, together with the higher costs of generating power from fossil fuels, which have experienced fuel cost escalation. The industry readily accepts that previous reactor performance was poor, but capacity factors of 90 percent and above are now the norm. This has not, however, been at the expense of safety. The last decade has thankfully been free of any major incidents involving loss of life. That this contrasts markedly with the performance of the fossil fuel sector, notably in coal mining, is increasingly pointed out. The attention paid to safety and the underlying plant operating performance through establishing INPO, WANO and other initiatives has paid off handsomely, and nuclear plant safety is today arguably of much lower concern to the general public. It is now over 20 years since the Chernobyl accident and 30 years since Three Mile Island, so a whole new generation of young voters has grown up with no direct memory of major nuclear incidents.

It is also unarguable that concerns over climate change and the perceived need to moderate greenhouse gas emissions have worked strongly in the industry's favor and, at the very least, opened an opportunity for the industry as a viable mitigation technology. It certainly underlies the conversion of prominent but previously nuclear-agnostic politicians like the U.K.'s Tony Blair to nuclear. The Copenhagen Summit may have been disappointing for those seeking concrete measures to curtail greenhouse gas emissions but a cold winter in Western Europe is not going suddenly to prompt attention away from this issue. The pressure for the world to bring in emissions trading regimes, to impose carbon taxes or to find other means of encouraging the adoption of clean energy technologies is not going to go away. Ending the use of fossil fuels for energy production by 2050 is now often expressed as an important but achievable objective. It is difficult to see this being achieved without recourse to a large-scale low carbon technology such as nuclear, which is also technically well-proven. Arguments about whether nuclear is sustainable, renewable or whatever are increasingly arcane as the time for intellectual debates over definitions needs to end and action taken. The time lags involved in building lots of nuclear reactors are not in any way a negative, but an argument for proceeding as quickly as possible with new plans and speeding up, wherever reasonable, regulatory and public approvals.

The argument for more nuclear power as a means of securing additional energy security of supply has also become increasingly important, particularly in those countries who perceive themselves as becoming increasingly reliant on supplies from geopolitically unstable or otherwise unattractive countries. It is important to recall that this was the main argument that prompted both France and Japan, now numbers two and three in world nuclear generation, to go down this path in the 1970s in the aftermath of two "oil shocks." There is also clearly an economic dimension to supply security, given the widespread fear of rapidly escalating fossil fuel prices. By contrast, costs of nuclear generation, despite the recent rise in world uranium prices, have always been relatively stable. There is now a realization that countries today should try to ensure some balance in their energy strategies and that reliance on one particular solution is inadvisable. So the decision to build only gas-powered generation in many countries over the final years of the 20th century was flawed, not only environmentally but also economically. Energy balance also at least partly explains why countries in the Middle East with strong oil and gas reserves are looking seriously at nuclear power (in the case of the United Arab Emirates, already ordering reactors).

The final proof of whether the nuclear renaissance is hype or reality will come over the next decade. If it doesn't happen in substance by 2020, it is unlikely ever to occur and we may quickly return to the 2000 situation with all the "doom and gloom" psychology. The signs of success are, however, looking increasingly positive. China now has more than 20 reactors under construction out of a world total of over 50. India seems set to follow and these two huge developing countries, with their seemingly infinite demand for clean electricity, should be the concrete foundations of the new era. What the industry needs now is more and more plant orders in many other countries, precipitating lower unit capital costs and the development of a worldwide supply chain.

The "nuclear winter" may eventually be seen to have lasted for the twenty years from the late 1980s, when the long-term development of an important industry suffered a long and potentially fatal pause. But the bright light has eventually returned. ■

Development of a Standard for Verification and Validation of Software Used to Calculate Nuclear System Thermal Fluids Behavior

Richard Schultz[1], Edwin Harvego[1] & Ryan Crane[2]
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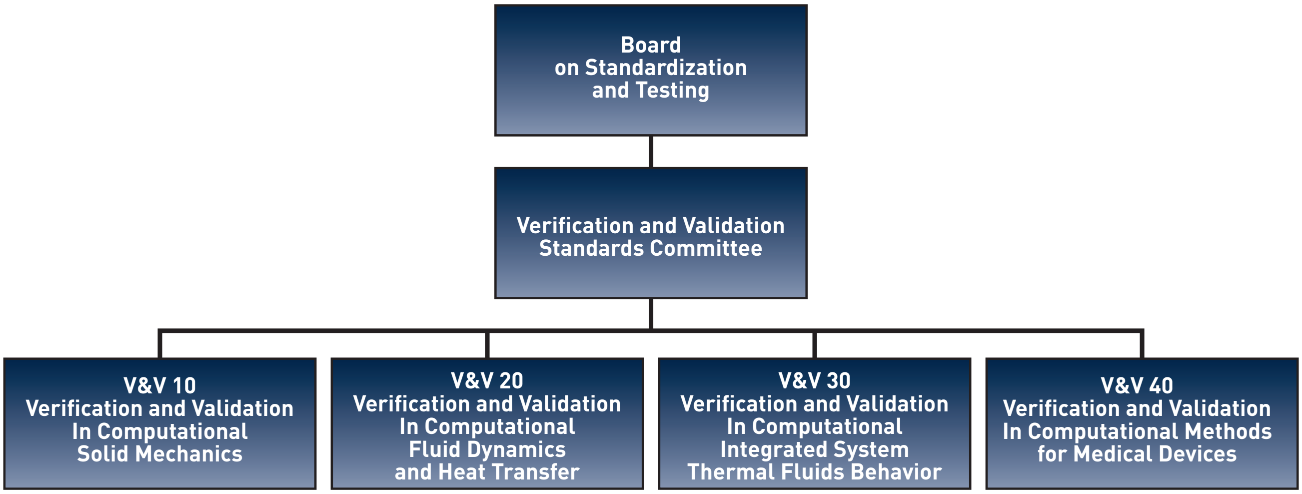
To address the need for internationally recognized standards for verification and validation (V&V) of software used in the thermal-hydraulic analyses of advanced nuclear power plants, the V&V 30 Committee has been established to develop an ASME standard for verification and validation of computational fluid dynamics and system analysis software that will be used in the design and analysis of advanced nuclear reactor systems, with an initial focus on High-Temperature Gas-Cooled Reactors. The committee reports to the Verification and Validations Standards Committee, which falls under the Board on Standardization and Certification as depicted in the organizational structure shown in Figure 1. The title of the committee is "Verification and Validation in Computational Nuclear System Thermal Fluids Behavior." As defined in its charter, the committee … "Provides the practices and procedures for verification and validation of software used to calculate nuclear system thermal fluids behavior. The software includes system analysis and computational fluid dynamics, including the coupling of this software."

The processes and procedures that will be addressed in the new standard will be used in the design and analysis of advanced reactor systems to be licensed in the U.S. As such, the standard should conform to Nuclear Regulatory Commission (NRC) practices, procedures and methods for the licensing of nuclear power plants as embodied in the Code of Federal Regulations and other pertinent documents (such as Regulatory Guide 1.203, "Transient and Accident Analysis Methods"[1] and NUREG-0800, "NRC Standard Review Plan"[2]). In addition, the standard should be consistent with applicable sections of ASME Standard NQA-1[3] ("Quality Assurance Requirements for Nuclear Facility Applications (QA)").

Recently the V&V20 standard was released: *Standard for Verification and Validation (V&V) in Computational Fluid Dynamics and Heat Transfer.*[4] Because of similarities in the standards being developed by the V&V20 and V&V30 Committees, it is important to define the relationship between the work embodied in the V&V20 Standard versus the work that will be forthcoming in the V&V30 Standard. As noted in the V&V20 Standard: "The scope of this Standard is the quantification of the degree of accuracy of simulation of specified validation variables at a specified validation point for cases in which the conditions of the actual experiment are simulated. Consideration of solution accuracy at points within a domain other than the validation points, i.e., a domain of validation,

Figure 1. Relationship of Verification and Validation Standards Committee and Subcommittees to Board on Standards and Testing.



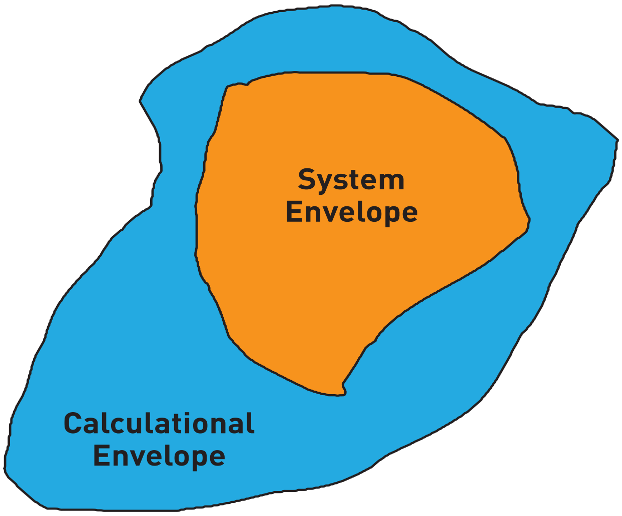


Figure 2. Venn Diagram of System and Calculation Envelope.

is a matter of engineering judgment specific to each family of problems and is beyond the scope of this Standard." This statement clearly limits the applicability of the V&V20 standard to the domain defined by the validation points.

In contrast, the aim of the V&V30 Standard is to expand the domain of validation to encompass points beyond the range defined by the V&V 20 Standard. In other words, the V&V 30 Standard complements the V&V 20 Standard by defining a methodology for experimental validation of an expanded calculation envelope that encompasses the operational and accident domain of the nuclear system. Therefore V&V30 is expected to address: (a) applicable NRC requirements for defining the operational and accident domain of a nuclear system that must be considered if the system is to be licensed, (b) the corresponding calculation domain of the software that should encompass the nuclear operational and accident domain to be used to study the system behavior for licensing purposes, (c) the definition of the scaled experimental data set required to provide the basis for validating the software, (d) the ensemble of experimental data sets required to populate the validation matrix for the software in question, and (e) the practices and procedures to be used when applying a validation standard, such as the V&V20 Standard, to demonstrate that the validated software is capable of performing the needed licensing calculations. Each of the above areas to be addressed by the V&V30 Standard is discussed in an in-depth paper given in the *Proceedings of the International Conference on Nuclear Engineering-18*.

The verification and validation requirements for software intended for the design and analysis of advanced nuclear power systems are determined by the operational and accident envelopes of the reactor plant being considered. Specifically, as depicted in Figure 2, the V&V requirements can only be satisfied if the calculation envelope of the thermal-hydraulic software is demonstrated to either match or encompass the system operation and accident envelopes.

This formation of the new ASME V&V30 Committee, its objectives, and the approach that will be taken are described in greater detail in an ICONE-18 paper with the same title and authors as this short article. The initial focus of the standard will be on advanced High-Temperature Gas Reactors, but it is anticipated that this standard or additional standards will be developed in the future to include other reactor concepts as well as potential non-nuclear applications.

The organizational structure established by ASME for developing this and related V&V standards is described, along with the processes that will be employed to ensure consistency among the related standards and the nuclear regulatory environment. ■

Leadership, Sustainability and Clean Nuclear Technology

Romney Duffey, Ph.D.
AECL

Many issues face nuclear plants today, from financing, cost, licensing, designs and construction in a globally fragmented energy marketplace, to associated international proliferation, security of energy supply, climate change and national pride issues. Despite the hurdles, costs and glacial timeframes, many owners and operators are successfully extending the life of the old and also committing to the process of building new plants. In countries unfettered by endless legal and societal wrangling, and now freeing themselves of energy and economic poverty, demand is expected to grow manyfold, while the "developed economies" largely stagnate or at best hold their own.

One issue should not go unnoticed: all current and under-construction reactors are based on an unsustainable once-through fuel cycle, which is incomplete. Not only is the resource unequally (even inequitably) spread around the world's geology, there is a major mismatch between the resource location versus the world population and energy growth. This once-through use of a valuable resource would not be an issue except it is not in touch either with energy needs or with modern times. Nowadays, the social norm in any civilized town or debate is recycling, selective separations, renewable portfolios, waste to energy, emissions reductions, and waste stream reduction. The touchstone is "renewable," so much so that hugely preferential energy rates and tariffs are gifted to those schemes that can claim sustainable renewability, namely wind and solar power. In the U.S.A., the situation is even more acute, with the failure of Yucca Mountain to attain social acceptance and/or political closure, despite theoretically being already full. What is clearly needed is new leadership in a successful direction.

The sustainability issues are: (a) finite resources ultimately affecting price; (b) finite energy content that is not being replaced; and (c) lack of other resources in the places that need it. With non-proliferation concerns about enrichment,[5] no one trusts anyone to supply, provide or guarantee what may not exist readily or cheaply after the middle of the century anyway. There is no guaranteed 60-year fuel cycle.

Endless debate in the U.S.A. has been whether to pursue a "closed" or "alternate" fuel cycle; a Blue Ribbon Panel will consider the options on what to do with the "waste." This has always hinged on two factors[6]: the technical and the cost comparison of geologic disposal versus alternates, like recycling or other fuel cycles. But this misses the point: the cycle has to be sustainable globally, and not just for the U.S.A. If we are prepared to foot the bill of increased cost for energy from renewable and sustainable resources, why would we not also foot the bill for an endless supply of nuclear fuel, that is used, recycled and bred forever in advanced reactor designs. Hopefully, the new DOE R&D effort on advanced concepts, and Advanced Research Projects Agency-Energy "clean energy technology" will now address this as integral with the Blue Ribbon Panel "waste" issue: it could sustain us forever not only in debate but hopefully also in energy. Everywhere. ■

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