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Congress of the United States
House of Representatives
Washington, DC 20515–2107

March 7, 2011

The Honorable Greg Jaczko
Chairman
Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

Dear Chairman Jaczko:

I write to urge the Commission not to finalize its pending approval of the AP1000 reactor design until serious safety concerns about its shield building have been addressed. These concerns include those raised by one of the Commission's most long-serving staff that there is a risk that an earthquake at, or aircraft impact on, the AP 1000 could result in a catastrophic core meltdown. The danger of terrorist attacks on nuclear power plants, and the importance of their structural resilience, was made very clear on February 24, 2011. A man was arrested in Texas for allegedly planning to blow up nuclear plants using explosive chemicals he purchased online.

The Commission has recently voted to approve the design of the AP 1000. As a result, the NRC's proposed rule for the AP1000 Design Certification Amendment was published in the Federal Register on February 24, 2011. The proposed rule is set to be finalized in the next few months, following a public comment period that ends May 10, 2011 and a 30 day review of public comments. However, the Commission has taken this step toward final approval despite serious safety concerns about the Westinghouse design for the reactor shield building that have been raised by Dr. John Ma. Dr. Ma has been with the NRC since it was created by Congress in 1974. He was the Commission's lead structural reviewer charged with evaluating the design of the reactor shield to determine whether it met NRC safety standards. Dr. Ma has identified potential loopholes, which, if left open, allow designs for unsafe reactors to go forward despite the risk that an earthquake or aircraft impact could result in a catastrophic core meltdown.

While I appreciate the substantive assistance and time spent by your staff in addressing my staff's questions related to the AP 1000 review process, I remain concerned about the safety of the reactor design. I therefore request that the Commission definitively resolve these potential loopholes prior to the finalization of the NRC licensing process.

As you know, the shield building for the AP1000 serves the critical safety function of preventing catastrophic damage to the reactor that could cause fuel melting and radiation releases. The shield building physically protects the highly radioactive core of the nuclear reactor (as well as critical operating equipment) against earthquakes, storms, and airplane strikes. The shield building is intended to ensure safe shutdown following such impacts. As it is designed, the

AP1000 shield building supports a water storage unit on top of it. This water is part of the vital cooling system for the reactor, which is necessary to prevent the sort of overheating that led to core melt at the Three Mile Island reactor in Pennsylvania in 1979.

NRC regulations are intended to ensure that any new reactor design will be able to withstand the dangers of earthquakes, storms, or commercial airplane strikes. The consequences of failure could be severe: According to the report of the 9/11 Commission, Al-Qaeda considered attacking a nuclear power plant as part of its September 11th plot. The Energy Policy Act of 2005 thus included my language that required the NRC to consider the "events of September 11, 2001" and the potential for "suicide attacks" and "air-based threats" in making rules for how reactors will be able to withstand a variety of scenarios related to terrorist attacks. I have long agreed with your 2006 statement that "We should be requiring they design these plants to withstand such attacks.[1]"

On June 12, 2009, NRC issued a rule, 10 CFR 50.150, requiring applicants for new reactors to include an assessment of the ability of the reactor design to withstand the impact of a large, commercial aircraft. The NRC issued its aircraft impact rule after having already issued a final rule certifying the design of the AP1000 on January 27, 2006.[2] In anticipation of the rule change on aircraft impact, Westinghouse amended its design to address aircraft impact, by submitting Revision 16 of its AP1000 design to NRC on May 26, 2007. The NRC is currently considering Revision 18 of the AP1000 design, submitted December 1, 2010[3].

When reviewing the design for the shield building, Dr. John Ma grew concerned that the structure was too brittle and could fail if struck by a natural or manmade catastrophe. He was so concerned by this and other issues that he filed a "Non-Concurrence" statement of dissent[4] on November 4, 2010. Despite the Non-Concurrence, NRC staff issued a positive Advanced Final Safety Evaluation Report (AFSER) on December 28, 2010. The Non-Concurrence accompanied the AFSER throughout a series of approval stages, allowing you and other reviewers to know that these concerns have been raised.

If the NRC approves the AP1000, then it may have widespread use throughout the United States, making questions about its safety of crucial national importance. Among the applications for the construction of 28 new reactors being considered by NRC, the AP1000 would be the design for 7 Combined License applications covering 14 reactors, to be built in Alabama, Florida, North Carolina, South Carolina, and Georgia.[5] The Department of Energy has approved

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[1] http://www.nytimes.com/2006/11/09/us/09nuke.html

[2] http://www.nrc.gov/reactors/new-reactors/design-cert/ap1000.html

[3] The current revision is a Design Certification Amendment application that would revise the AP1000 Design Control Document, which is the overall design that NRC certified in 2006.

[4] The Non-Concurrence (NRC Form 757), the response to it by other Division of Engineering staff, and Dr. Ma's rebuttal to this response are all internal NRC documents, Accession Number ML103370648 within the Agencywide Documents Access and Management System (http://www.nrc.gov/reading-rm/adams/web-based.html). The Non-Concurrence Package was published on December 3, 2010.

[5] http://www.nrc.gov/reactors/new-reactors/col.html. The proposed sites include Jackson County, Alabama (Tennessee Valley Authority's Bellefonte site); Levy County, Florida (Progress Energy Florida, Inc.'s site); Homestead, Florida (Florida Power and Light Co.'s Turkey Point site); Wake County, North Carolina (Progress Energy Carolinas, Inc.'s Harris site); Cherokee County, South Carolina (Duke Energy's William States Lee III site);

an application for a loan guarantee of $8.3 billion to Georgia Southern for two proposed AP1000 reactors, conditional on NRC approving the AP1000. Taxpayer dollars should not be spent on unsafe reactors. The Non-Concurrence identifies several potential loopholes. I am asking the Commission to reconsider its approval of the AP1000, in light of these loopholes, the most serious of which I summarize below:

1. The AP 1000 shield building failed tests because it is brittle, and could shatter "like a glass cup"

If a reactor shield is too brittle, it may fail in an earthquake or if struck by an airplane or an automobile or other missile carried by a storm. In fact, Dr. Ma warned that if the AP1000 shield was struck, it could shatter like a "glass cup." The reason for Dr. Ma's statement is that the AP1000 shield building failed, or failed to complete, physical tests designed to evaluate whether the structure has adequate toughness for these sorts of impacts.

In its new design in response to the aircraft impact rule, Westinghouse changed the composition of the shield building from reinforced concrete to a combination of steel and concrete. This "steel-concrete module" is a first-of-its-kind design for nuclear power plants. About 60 percent of the shield building would consist of a module design (module #2) that "failed miserably" in a direct physical test of its toughness. According to the NRC Design Certification Application Review of the AP1000, "test results for out-of-plane shear showed that the modules with **[redacted]** failed in a brittle manner.[6]" A second physical test, of in-plane shear, could not be completed "due to laboratory safety constraints." These shear tests are intended to determine whether the structure will be brittle or "ductile." Ductility enables an object to deform and stretch under force, rather than breaking. Both in-plane and out-of-plane shear would act on the shield building during an earthquake. As you note in comments accompanying your "Yes" vote on the AP1000, the module that would be used for 60 percent of the shield building "was unable to satisfy the experimental protocol developed by Westinghouse and agreed to by the [NRC] staff."

The potential loophole here is that the Commission has apparently accepted Westinghouse's argument that the brittle module design would only be used in regions of the building that are unlikely to encounter high loads. Thus the failing tests were ignored. Instead of relying on the results from the test intended to prove the shield building's design, Westinghouse substituted results from computer simulations that may be a poor approximation of reality.

In his Non-Concurrence, Dr. Ma asks, "How could the [NRC] staff justify using a lower standard, by accepting a brittle structural module for about **[redacted]** of the [steel-concrete] wall for AP1000 shield building, which has more safety functions and greater consequence if the wall collapses, than other types of [reinforced concrete] shield buildings that are required to design to a higher standard of ACI [American Concrete Institute] Code?" Dr. Ma also points to NRC codes stating that the standard to which a design is held must be "commensurate with the

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Fairfield County, South Carolina (South Carolina Electric & Gas' Virgil C. Summer Nuclear Station site); and Burke County, Georgia (Southern Nuclear Operating Co.'s Vogtle site).

[6] Design Certification Application Review – AP1000 Amendment. Chapter 3, page 155. http://www.nrc.gov/reactors/new-reactors/design-cert/amended-ap1000.html

importance of the safety function to be performed".[7] The AP1000 design should not be approved when the material making up 60 percent of the shield building, an essential structural component that is meant to withstand earthquakes, storms, and airplane strikes, has failed a critical physical test showing it to be brittle.

Additionally, the AP1000 shield building design has evidently failed to meet the standards of the American Concrete Institute, despite these being endorsed by NRC[8]. Westinghouse has not complied with the American Concrete Institute (ACI) "Code Requirements for Nuclear Safety-Related Concrete Structures" (ACI-349). . The design fails to meet the Code, because ACI-349 requires the structure to be ductile, would require different spacing between the steel tie-bars, and would not allow substitution of computer models in place of physical tests. Dr. Ma notes that the Safety Evaluation Report "has not provided justifications as to why its acceptance standard, which is lower than that of the ACI Code, is adequate".

To ensure the safety of the AP1000, and any future reactor designs involving steel-concrete composites, I urge you to develop a standard for this novel type of design that would apply both to the AP 1000 and other reactor designs that might seek to use it in the future. The NRC Advisory Committee on Reactor Safeguards notes that "the effort and scope of analysis and assessment required for the shield building in this case suggests that if SC [steel-concrete] composites are to be more widely used in nuclear applications, a consensus code should be developed, as has been done for other types of nuclear construction." You echoed this concern in comments accompanying your "Yes" vote for the AP1000, noting "the lack of a directly acceptable design and construction consensus standard." You write that "it would be advantageous to have such a detailed standard developed independent of any specific design approval. Therefore, I also encourage the [NRC] staff to aid in any effort ... to develop a standard." However, developing such a standard after approving the AP1000 is like planning to comply with building codes to prevent fires after the building has burned down. I ask the Commission to reverse its approval of the AP1000 until such a standard is developed, and then apply this standard to the AP1000 before reconsidering the design.

2. **Weak computer simulations were used to "prove" the reactor shield is "strong enough"**

Westinghouse's assertion that the brittle module is "strong enough" is based on questionable computer simulations in place of the physical tests that it should have done. The computer analysis that Westinghouse did was flawed, because it used off-the-shelf, commercially available codes to evaluate a first-of-its-kind design that could not be expected to be accurately modeled in this manner. The shield building's steel-concrete structure is novel and complex, as is the overall design of the reactor. Given the novelty and complexity of the design, Westinghouse should have developed custom code.

Additionally, Westinghouse relied on a technique known as a static "push-over" simulation. A push-over simulation imagines that an earthquake functions like a finger slowly

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[7] Codes and standards: 10 CFR 50.55a(a)(1). http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0055a.html

[8] Regulatory Guide 1.142 - Safety-Related Concrete Structures for Nuclear Power Plants (Other Than Reactor Vessels and Containments). http://www.nrc.gov/reading-rm/doc-collections/reg-guides/power-reactors/rg/01-142/

pushing a cup until it falls over. Dr. Ma notes that such an analysis is not appropriate, because the shield building would experience several types of forces simultaneously during an earthquake, rather than just one simple "push." In a Technical Evaluation of Westinghouse's modeling work, scientists at Brookhaven National Laboratory agreed, stating that Westinghouse's "models may be inappropriate for static analyses intended to represent cyclic dynamic loading (i.e. earthquake); the effect of load cycling on the effective stress-strain relationship apparently is not considered [**redacted**].[9]" Westinghouse does not appear to have considered the back-and-forth forces ("cyclic dynamic loading") that occur during an actual earthquake. Instead Westinghouse appears to have fantasized that an earthquake acts like a constant force in one direction. Had Westinghouse included dynamic cyclic loading, the effective "stress-strain" curve would have had a "backbone" shape; instead, it appeared to be a monotonic curve which is consistent with Westinghouse leaving out the dynamic cyclic loading that occurs in an earthquake. The "static push-over" analysis that Westinghouse did may therefore have been inappropriate because it failed to accounts for the real back-and-forth forces in an earthquake.

Unfortunately, the Technical Evaluation document that details the software's limitations consists mostly of text redacted by NRC staff on Westinghouse's request, but the text that remains is overwhelmingly negative about Westinghouse's simulations. In addition to concerns about how Westinghouse modeled the effects of an earthquake, Westinghouse's results were presented sloppily: There is "no confidence that an appropriate level of quality assurance was implemented in the conduct of the [redacted] analyses." There were "numerous confusing, misleading, or erroneous statements." The concerns raised in this May 30, 2010 Technical Evaluation do not appear to have been addressed by Westinghouse or NRC.

I urge you to require Westinghouse, and other reactor license applicants, to complete and pass physical tests of all materials used in the design, rather than using computer models to substitute for tests that their materials have failed. There should be clear regulations indicating any exceptions where computer analyses are appropriate – and these regulations should require the use of code that is suitable to the design of the particular reactor under consideration. Where computer models are necessary, the NRC should set standards defining the quality of the models that applicants are required to use, and should conduct independent validations of those models and of the original code. Original code and data should be made available for public review, while accounting for real proprietary and security concerns. As it stands, Westinghouse may be relying on defective models that provide no meaningful assurance of whether the reactor is safe.

3. **Earthquake Forces May Have Been Underestimated by Westinghouse**

Westinghouse exploited an apparent loophole in how NRC defines earthquake forces. Westinghouse underestimated the earthquake forces that the reactor would be subjected to through use of a "seismic wave incoherency model to effectively reduce... ground motion"

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[9] R. Morante, M. Miranda, J. Nie. Technical Evaluation: AP1000 Shield Building Design Report, Revision 2. Dated 5/30/2010. Submitted as part of Dr. Ma's rebuttal to the staff response to the Non-Concurrence statement. Accession Number ML103370648 within the Agencywide Documents Access and Management System (http://www.nrc.gov/reading-rm/adams/web-based.html).

during an earthquake.[10] It is a "manifestation of mathematical concept that has not been verified and validated by experiments," according to a letter sent by Dr. Ma to your office and mine on November 8, 2010. Indeed, the "interim staff guidance" on incoherency appears to be based on a solitary report of the Electric Power Research Institute, rather than consensus in the peer-reviewed scientific literature. In his letter to my office and to you, Dr. Ma wrote that even assuming these reduced earthquake forces are correct, "the design margin in the shield wall is practically non-existent; the design will be grossly inadequate if the 'correct' and actual earthquake analyses were used." I ask that the Commission require that estimates of seismic forces be drawn from consensus, peer-reviewed scientific literature. Please ensure that Westinghouse re-does its analyses to demonstrate that the AP1000 can withstand real earthquake forces, without minimizing these forces using ill-founded assumptions.

I would note that, generally speaking, the NRC staff responses to the Non-Concurrence statements do not dispute the concerns raised by Dr. Ma. Instead, they appear to have acknowledged the flaws associated with Westinghouse's analysis, agreed that addressing the non-concurring staff member's concerns would improve the design, and then shrugged their collective shoulders and chose to abdicate responsibility to further investigate these matters prior to providing a positive Safety Evaluation Report on the shield building of the AP1000 reactor.

In fact, in your January 31 vote to approve the AP 1000 design, you acknowledge that "While it is clear that the use of a ductile material in all areas of the shield building would provide an additional enhancement to safety, I am not convinced that such a design requirement exists..." This is a far cry from a ringing endorsement: you could have said that you are convinced that the design is safe, but you do not go this far. All you say is that there is nothing requiring you to disapprove the design.

There appear to be many unresolved concerns about the AP1000 shield building design, concerns that may justify reversing your vote of approval. Consequently, I ask for your prompt assistance in responding to the following questions.

1. Why did you not require improvements to the AP1000 design to enable it to pass direct physical tests of ductility? Have past reactor shield designs approved by the NRC succeeded in meeting ductility tests that the AP1000 has failed (out-of-plane shear) or has not even completed (in-plane shear)? If so, why is a weaker standard being allowed for the AP1000, which is supposed to be even tougher than past reactor shield designs to meet the aircraft impact rule?

2. There are uncertainties associated with the modeling codes used by the applicant to analyze the accident responses of the highly complex shield building design. Given these uncertainties, are you able to provide me a guarantee that use of brittle modules for about 60 percent of the AP1000 shield building design will not significantly degrade the capability of the wall to resist being hit by a missile propelled by a storm or by an airplane, relative to a design that does not use a brittle module? If so, on what basis, and if not, then why did the Commission vote to approve the design?

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[10] Design Certification Application Review - AP1000 Amendment. Chapter 3, page 58. http://www.nrc.gov/reactors/new-reactors/design-cert/amended-ap1000.html

3. There are uncertainties associated with Westinghouse's use of generic computer modeling codes and sloppily presented analyses, the "seismic wave incoherency model," and the static "push-over" analyses of the accident responses of the highly complex shield building design. Given these uncertainties, are you able to provide to me a guarantee that use of brittle modules for the majority of the AP1000 shield building design will not significantly degrade the capability of the shield building to resist an earthquake, relative to a design that does not rely on a brittle module? If so, please explain the basis for such a conclusion. If not, then why did the Commission vote to approve the design?

4. Are you certain that the brittle module is strong enough to withstand the combined stress (in-plane shear, out-of-plane shear, axial force) during a "safe shutdown earthquake"? If so, on what basis did you reach this conclusion? If not, then why did the Commission vote to approve the design?

5. What is the magnitude of earthquake for which the AP1000 would be able to maintain its ability to safely shut down the reactor? Will the NRC require that the AP1000 be able to withstand earthquakes of the magnitudes experienced in all regions of the US, or otherwise limit their deployment to areas in which earthquakes beyond the threshold, "design-basis" magnitude have never been experienced? Why or why not?

6. The shield building design includes two types of steel-concrete modules. Module #2, which failed, has wider spacing of the steel ties that go through the concrete. Module #1 has narrower spacing, which makes it tougher and enabled it to pass the out-of-plane shear test. Instead of accepting Westinghouse's flawed simulations, will the Commission reverse its approval of the AP1000 and instruct Westinghouse to simply replace the brittle module # 2 with a tougher module, such as module #1? If not, why not?

7. Given that there are applications for 14 new reactors using the AP1000 design, will NRC develop a consensus design code for this type of reactor, as has been done for other types of nuclear construction? If yes, will you reverse your approval of the AP1000 design until this code is developed and applied to the AP1000? If not, why not?

8. There are many pages in the Non-Concurrence that have been entirely redacted. For each substantive redaction, please provide me with the legal basis used to justify the redaction in question. If no appropriate basis exists, please ensure that an un-redacted version of the page in question appears in the docket for the AP1000 rule. I also ask that the Non-Concurrence package itself be placed in the docket, since it does not appear to be included among the documents that support the AP1000 rule.[11] The public should be made aware of the existence of the Non-Concurrence when commenting on the proposed design approval.

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[11] The AP1000 documents are available through the Federal e-Rulemaking website at http://www.regulations.gov by searching under Docket ID NRC-2010-0131.

Thank you for your attention to this important matter. Please provide your response no later than March 28. If you have any questions, please have your staff contact Dr. Ilya Fischhoff or Dr. Michal Freedhoff of my staff at 202-225-2836.

Sincerely,

Edward J. Markey

Edward J. Markey