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Alternative Method for Calculating Embrittlement for Steel Reactor Vessels

Comment On: NRC-2019-0180-0003
Alternative Method for Calculating Embrittlement for Steel Reactor Vessels; Request for Comment on Petition for Rulemaking

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General Comment

NuScale reactor pressure vessels are more at risk than regular nuclear reactors for neutron induced embrittlement deeper within the wall of the reactor pressure vessel, which can result in sudden catastrophic pressure vessel failure, and thus catastrophic nuclear disaster. These mechanisms have been known since the 1950s. The RPV is of low alloy steel, albeit lined.

Thus, the petitioner NuScale falsely states that "small modular reactor design is unnecessarily burdened with an excessively conservative methodology". NuScale proposes use of ASTM 900-15, which specifically states that it does NOT take into consideration variation in neutron fluence. Additionally, ASTM 900-15 is based upon the assumption of 31 years of operating experience for PWR, whereas NuScale proposes to operate for 60 years-meaning much more damage would occur.

Thus, ASTM 900-15 is NOT appropriate for use by NuScale. Based on the facts, the current standards may not conservative enough for NuScale. The standard used should be based upon basic science, conservative measures, and may require additional experimentation.

A DOE funded study of NuScale stated: "The smaller diameter and lower operating pressures used by LWSMR designs allow for significantly thinner vessel shells, but with higher EOL neutron fluence. As a consequence, significant radiation damage occurs through a greater fraction of the wall thickness..." This means that NuScale will suffer from more embrittlement and be more subject to sudden through wall cracking and pressure vessel failure than traditional nuclear reactors. See: "Assessment of Materials Issues for Light-Water Small Modular Reactors " by Dave Sandusky et al., 2013.

Thus, it is entirely inappropriate to base the embrittlement upon data from traditional nuclear power stations, used in ASTM E900-15.

It has been pointed out: "SMR and advanced reactor designs require or may benefit from use of materials that do not presently have sufficient irradiation test data". https://www.osti.gov/servlets/purl/1494317

ASTM states that "Differences in fluence rate and neutron energy spectra experienced in power reactors and test reactors have not been accounted for in these procedures.... Future versions of this guide may incorporate the effect of neutron fluence rate or irradiation time, or both, on TTS , as such effects are described in (1).4" See: ASTM E900-15e1, "Standard Guide for Predicting Radiation-Induced Transition Temperature Shift in Reactor Vessel Materials", ASTM International, West Conshohocken, PA, 2015 And, see p. 15 of the NRC document re concerns raised: https://www.nrc.gov/docs/ML1530/ML15309A007.pdf

This is apart from the problem posed by using the mean (arithmetic average) of data from reactor pressure vessels for historic nuclear power stations, which have been generally unique in design, construction, materials, and operating experience. Use of the mean doesn't take into consideration large scatter in the data and is, by its nature, dangerously unconservative.

NuScale RPV are made of lined low alloy carbon steel: "Neutron irradiation can promote significant changes in the microstructure and associated mechanical properties of low alloy steels. In particular, irradiation can induce the formation of non-equilibrium phases and segregation, which may lead to a degradation in toughness". See "Microstructural Aspects of Irradiation Damage in A508 Gr 4N Forging Steel by MG Burke, 2002.

"The degrading effects of neutron irradiation on carbon and low-alloy pressure vessel steels have been recognized and investigated since the early 1950s..." https://info.ornl.gov/sites/publications/files/Pub2592.pdf

Shippingport was a PWR (Pressurized light water reactor) with around the same output as NuScale and had a reactor pressure vessel thickness of over 8 inches -- roughly twice as thick as the figure found for NuScale. It ran for 25 years, meaning that less embrittlement would occur.

It is worth noting that: "No ASME code cases have been accepted for AM processes or parts." https://www.osti.gov/servlets/purl/1494317

Furthermore, the Lucens reactor, which was 1/10th of the size of NuScale, and situated underground in what looks like the same design literally blew up and half a century later still pollutes the groundwater. Lucens was deep underground in a bunker-like facility, which NuScale likely will not be.

One month is entirely inadequate to solicit comment on a topic of such great importance. The lack of comments shows that people have not been alerted. We urge you to extend the comment period.