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Arms Control TODAY

THE SOURCE ON NONPROLIFERATION AND GLOBAL SECURITY

Volume 51 | Number 9
NOVEMBER 2021

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Not Necessarily a Sure Or a Good Thing

By Trevor Findlay

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U.S. $7.00 Canada $8.00

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A Publication of the Arms Control Association
www.armscontrol.org

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The Australia-UK-U.S. Submarine Deal

Mitigating Proliferation Concerns

On September 15, U.S. President Joe Biden joined UK Prime Minister Boris Johnson and Australian Prime Minister Scott Morrison to announce an Australian-UK-U.S. security pact (AUKUS) under which the United States and the United Kingdom will assist Australia in building at least eight nuclear-powered attack submarines. The purpose is to strengthen the alliance trying to contain a growing Chinese navy. The first submarine is not expected to be operational before 2040.

The AUKUS countries said that it would take 18 months to work out the specifics of the deal, but obvious candidates for the submarine designs to be provided to Australia are the U.S. Virginia-class attack submarine and the UK Astute-class submarine, in production since 1999 and 2001, respectively.

Both submarine classes are fueled with U.S. weapons-grade uranium enriched to more than 90 percent uranium-235 that was declared excess to weapons needs following the drastic downsizing of the U.S. Cold War nuclear warhead stockpile. Both submarine types have life-of-ship cores, which means they should not have to be refueled during their design lives of approximately three decades.

The deal replaces one that Australia reached with France in 2016 under which Australia would have received 12 French Suffren-class submarines equipped with conventional propulsion rather than the nuclear propulsion used by France. In 2016, Australia did not wish to develop the infrastructure required to supply fuel for a nuclear-powered ship.[1] France refuels its nuclear submarines every 10 years.

Life-of-ship cores could enable Australia to avoid having to produce its own nuclear fuel, refuel its submarine reactors, and dispose of the spent fuel. The United States or UK could simply sell Australia the reactor cores and then take them back for disposal when the submarines are decommissioned.

A Troublesome Precedent

The proposed AUKUS submarine plan, however, would set an important precedent of a nuclear-weapon state selling nuclear submarines to a non-weapon state. The use of highly enriched uranium (HEU) fuel makes the AUKUS precedent especially troublesome from a nonproliferation perspective.

HEU can be used directly by nations to make nuclear weapons. It also could be used by terrorists to make a simple gun-type nuclear weapon like the Hiroshima bomb.

Because HEU is so easily weaponized, the United States has spent $2 billion

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Brazil, a non-nuclear-weapon state with a program to develop nuclear-powered attack submarines, plans to power its first submarine with LEU fuel but has not forgone the right to use HEU. Photo from 2019 shows ceremony in Rio de Janeiro celebrating Brazil's French-designed, Brazilian-built Humaita submarine, which runs on diesel-electric propulsion. (Photo by Mauro Pimentel/AFP via Getty Images)

since the September 11 terrorist attacks to eliminate it as a research reactor fuel and replace it with low-enriched uranium (LEU) fuel, containing less than 20 percent U-235, which cannot be used to make a nuclear explosive.[2] As part of this effort, the United States has converted most of its own research reactors to LEU use and has cleared HEU from 33 of 55 countries down to a level of less than one kilogram, a small fraction of the amount required to make a nuclear weapon.[3]

At the same time, U.S. and UK naval reactors are the world's largest consumers of HEU. Annually, about three tons of weapons-grade uranium, enough for more than 100 nuclear weapons, are being fed into their naval reactors. In contrast, Chinese and French submarines are fueled with LEU, while India and Russia are believed to use HEU enriched to 21–45 percent U-235.[4] HEU in this enrichment range is considered weapons usable, but has a critical mass much larger than weapons-grade uranium.

The United States and UK should be designing their future naval reactors to use LEU fuel. They certainly should not be setting the precedent of spreading HEU-fueled naval reactors to non-nuclear-weapon states such as Australia, especially when Iran and a few other non-nuclear-weapon countries are considering fielding their own nuclear-fueled submarines. Whether to fuel research reactors or naval reactors, expanding the use of HEU increases the risk of this material being diverted to nuclear weapons use.

Nuclear Submarines and Non-Nuclear-Weapon States

Nuclear-powered attack submarines have been of interest to non-nuclear-weapon states for some time. In the late 1980s, Canada explored buying some from France or the UK to reinforce its sovereignty in its northern waters, but with the end of the Cold War, abandoned the project as too costly.[5]

Brazil has a program to develop nuclear-powered attack submarines that dates to the 1970s.[6] It is learning from France how to build conventional submarines and is assembling a land-based prototype reactor inside a mockup of a hull section of a future nuclear submarine. The Brazilian navy developed and controls Brazil's uranium-enrichment plants. This was a major proliferation concern for the United States when Brazil was ruled by a military dictatorship in 1964–1985 and before it entered a nuclear transparency agreement with Argentina in 1991 and joined the nuclear Nonproliferation Treaty (NPT) in 1998. Brazil plans to fuel its first submarine with LEU, but has not forgone the right to use HEU fuel if that proves advantageous.

In South Korea, President Moon Jae-in and his administration have expressed a sustained interest in developing nuclear-powered submarines.[7] The United States has refused to change the two countries' nuclear cooperation agreement to allow South Korea to enrich uranium. Therefore, South Korea may look to Russia, which has offered Seoul an icebreaker propulsion reactor design that can be fueled with 19.75 percent-enriched LEU.[8] Russia's existing nuclear agreement with South

Korea covers only "peaceful uses of atomic energy."[9] If the United States can change its agreement with Australia,[10] however, Russia can change its agreement with South Korea.

In the past, Japan has not expressed an interest in nuclear submarines. After the AUKUS deal was announced, however, two of the four candidates for prime minister declared their interest,[11] although not Fumio Kishida, who won the Liberal Democratic Party's support and was sworn in as prime minister in October.

There is also the case of Iran. In 2013, during the hard-line administration of President Mahmoud Ahmadinejad, the head of the Atomic Energy Organization of Iran suggested Tehran might require uranium enriched to 45–56 percent U-235 for a nuclear submarine program.[12] In April, as U.S.-Iranian negotiations stalled on reviving the Joint Comprehensive Plan of Action, Iran began producing 60 percent-enriched HEU.[13]

After the AUKUS deal was announced, two journalists from *The New York Times* interviewed aides accompanying Iran's new hard-line foreign minister to the United Nations and reported that the aides noted that HEU "could be used in naval reactors, suggesting they might want to use it for that purpose. And they cited Mr. Biden's new deal with Australia, which calls for [the United States and the UK] to supply Australia with the technology for nuclear-propelled submarines," which use HEU.[14]

Other countries are likely to see the deal as creating a more permissive environment to acquire their own HEU-fueled nuclear submarines…

HEU and Naval Fuel

The United States and UK are creating a dangerous precedent by proposing to export HEU naval fuel to a non-nuclear-weapon state. Other countries are likely to see the deal as creating a more permissive environment to acquire their own HEU-fueled nuclear submarines and, in the absence of a willing supplier, make HEU fuel themselves as Iran threatens to do. The world does not need HEU in more places and more being produced in more countries.

Ironically, the nuclear version of France's Suffren-class attack submarine, which Australian leadership insisted in 2016 should be converted to diesel-electric power, is fueled with LEU containing an average of only 6 percent U-235.[15]

To make LEU weapons usable, a country would have to run it through an enrichment plant to produce HEU. In a non-nuclear-weapon state, especially one that has an additional protocol to its safeguard agreement, the International Atomic Energy Agency would have a good chance of detecting such an activity. Therefore, if non-nuclear-weapon states feel they need nuclear submarines and to have their own enrichment plants to fuel them, the fuel should be LEU.

Congressional Interest in LEU Fuel

Since 1994, reducing the risk of proliferation of naval HEU fuel has been the primary driver behind efforts by some members of Congress to require the National Nuclear Security Administration (NNSA) Office of Naval Reactors to develop LEU fuel for future U.S. submarine and aircraft carrier propulsion reactors.

As the office has made clear, however, its priority has been to achieve life-of-ship cores. In fact, it believes it has done so for the Virginia-class attack submarine, which began production in 1999, and for the Columbia-class ballistic missile submarine, the first of which began construction in 2020. The design lives of these submarines are 33 and 42 years, respectively. This means that, after the older classes of U.S. submarines have had their midlife refueling, there will be no need for routine refueling of submarines. Refueling equipment and capabilities will be retained only on a standby basis for core repair or replacement following potential fuel-element failure.

The Office of Naval Reactors' first report in response to Congressional interest in LEU fuel was in 1995.[16] It stated that because the U-235 chain reaction provides almost all of the fission energy from the fuel, if the U-235 were

The Virginia-class attack submarine Minnesota (SSN-783), shown under construction in 2012, is among the class of submarine that could be sold to Australia. (U.S. Navy Photo)

Four torpedo tubes in the bow of a Suffren-class nuclear attack submarine, under construction in north-western France in 2017, during a visit by French Defence Minister Florence Parly and Australian Prime Minister Malcolm Turnbull. Australia would have bought 12 Suffrens equipped with conventional propulsion from France under a deal Australia abrogated in favor of buying nuclear submarines from the United Kingdom and the United States. (Photo by Charly Triballeau/AFP via Getty Images)

diluted to just below 20 percent U-235, which is the top of the LEU enrichment range, it would be necessary to increase the volume of the core threefold to achieve the same core life. This would require a larger, heavier pressure vessel and a bigger hull.

For Virginia-class submarines, the Office of Naval Reactors found that a life-of-ship core would require the diameter of the submarine to be increased from 10 to 11 meters. The office did not expect a significant impact on the sizes of the larger ballistic missile submarine and aircraft carrier. If, as reported,[17] the SSN(X) next-generation U.S. attack submarines are to have hull diameters significantly larger than the Virginia-class, they too could accommodate larger LEU cores.

In 2012, Congress asked for an update and this time, the response was more encouraging. The Office of Naval Reactors reported it was developing a new higher uranium-density fuel that might not require as large a core volume increase for an LEU life-of-ship core.[18] Yet, it was testing the new fuel design with weapons-grade uranium to pack more U-235 into the core and to increase U.S. submarines' lifetime energy budgets for higher-speed transits across the Pacific Ocean and other uses. The energy requirement for potential LEU cores was therefore a moving target.

Congress asked for a research and development plan for developing and testing the new fuel design with LEU.

The Office of Naval Reactors delivered the outline of a plan in July 2016. The report emphasized that the R&D would cost about $1 billion and take "at least 15 years" and that "success is not assured." It also said that providing LEU cores for aircraft carriers would cost an additional "several billion dollars," including the cost of a land-based prototype aircraft carrier propulsion reactor.[19] This would be comparable to the cost of an additional nuclear-powered submarine.

The Office of Naval Reactors also asked JASON, an elite technical group of mostly academic consultants for the Department of Defense, the NNSA, and other agencies, to review its proposed program for developing LEU fuel. The JASON report, which was partially declassified three years later was supportive. It emphasized, however, that there is only a limited opportunity to make sure that the follow-on to the Virginia-class submarine, the not-yet-named SSN(X) that is scheduled to be procured starting in the early 2030s,[20] will be able to accommodate an LEU core. "If the reactor compartment is not designed to accommodate a life-of-ship LEU core, and if later re-design to accommodate such an LEU core is impractical, then HEU cores will be required for all [SSN(X)s], the last of which will launch in the 2060s. On the other hand, if design parameters and fuel development allow an LEU reactor…then it is possible that the Navy's final HEU core will be built in the 2040s."[21]

Unfortunately, the Navy came to oppose even conducting that R&D. The simplest explanation is that the Navy does not view minimizing HEU use as its responsibility. Members of Congress sympathetic to this perspective inserted into the 2016 National Defense Authorization Act (NDAA) the requirement that "the Secretary of Energy and the Secretary of the Navy shall jointly submit to the congressional defense committees the determination of the Secretaries as to whether the United States should continue to pursue research and development of an advanced naval nuclear fuel system based on low-enriched uranium."

At the beginning of 2018, the Trump administration responded that it saw no benefits to the Navy incurring the cost of shifting to LEU fuel use.[22]

Despite this opposition, Congress has appropriated funding for Navy LEU fuel development every year since fiscal year 2016, starting at $5 million and rising to $20 million in fiscal year 2021.[23] Given the Office of Naval Reactors' resistance, congressional advocates of LEU fuel for

naval reactors shifted the funding for LEU fuel development to the NNSA Office of Defense Nuclear Nonproliferation.

The executive branch, however, has never requested funding for this program. For fiscal year 2022, the House of Representatives voted to appropriate another $20 million, but the Senate Armed Services Committee recommended in the 2022 NDAA a provision that would "prohibit the obligation or expenditure of any fiscal year 2022 funds [by the NNSA] to conduct research and development of an advanced naval nuclear fuel system based on low-enriched uranium unless the Secretary of Defense, the Secretary of Energy, and the Secretary of the Navy communicate certain determinations to the congressional defense committees."[24]

What Is Next

Recently, a group of nonproliferation experts, including the author, wrote to the Biden administration stressing the importance of designing future U.S. naval reactors to use LEU fuel.[25] The AUKUS deal highlights the fact that the United States and UK are undermining the nuclear nonproliferation and anti-terrorism regimes by fueling their naval reactors with weapons-grade uranium. Now they propose to export these reactors to a non-nuclear-weapon state.

If the United States does not switch to using LEU naval fuel by about 2060, when its excess stock of weapons-grade uranium is projected to run out, it will have to restart production of weapons-grade uranium for the first time since the end of the Cold War.

The United States and UK should instead exploit the opportunity created by the furor over the AUKUS deal to commit to design their future naval propulsion reactors to use LEU fuel. They also should use the planned 18-month period of study and evaluation of the technical and policy details of the proposed AUKUS submarine deal to do their utmost to design any submarines built by or leased to Australia to use LEU-fueled propulsion reactors rather than the more problematic HEU-fueled option. Otherwise, the three AUKUS countries, long-time leaders in efforts to limit the spread of nuclear weapons, may well find themselves on a path that would undermine global nonproliferation norms and long-standing nonproliferation objectives.

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