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New Developments in NPP

Nuclear Power Plants: Safe During War?

By Alvin Chew

SYNOPSIS

Nuclear deterrence strategy has so far prevented the world superpowers from engaging in a nuclear armed conflict. But could a nuclear dystopia be averted when a civilian nuclear power plant is accidentally attacked during a war?

COMMENTARY

RUSSIA HAS at some point escalated its invasion of Ukraine by putting its nuclear forces on high alert, thereby raising the possible use of nuclear weapons in the theatre of operations. With more sophisticated and lethal nuclear weapons being developed over time, one shudders to imagine the destructive aftermath since the detonation of the atomic bombs over Hiroshima and Nagasaki in August 1945.

The prospect of a nuclear war remains unlikely – as superpowers having 'second-strike' capabilities reinforce the principle of 'Mutually Assured Destruction' (MAD) in nuclear deterrence strategy. However, there is another possibility of the world experiencing a nuclear dystopia – a military attack on a civilian Nuclear Power Plant (NPP) that could cause a catastrophic meltdown. The International Atomic Energy Agency (IAEA) has been alerted to monitor the radiation levels surrounding the Zaporizhzhia NPP in Ukraine, Europe's largest operating nuclear plant, since the onset of the military invasion. Russian troops and tanks passing through dormant Chernobyl region had raised concerns of elevated radiation levels.

Longer-term Impact of NPP Disaster

Nuclear weapons are designed to detonate via a short nuclear fission process to release a large amount of energy in the form of immense blast waves and intense heat. For Hiroshima, the radiation fallout from 'Little Boy' was less significant and the city took approximately two years to rebuild.

The Daiichi NPP in Fukushima had much larger source term of radioactive release because it housed more fuel than a nuclear bomb and it had also undergone several years of fission during its operational life span. More than 10 years after the disaster, Fukushima has yet to return to full normalcy as widespread radiation contamination resulted in extensive clean-up of the region.

Instruments to Protect NPP Facilities

In the past, pre-emptive strikes had been executed to destroy nuclear facilities, most notably during armed conflicts in the Middle East. However, these surgical strikes targeted near-completed NPPs, research reactors or other nuclear facilities, and thus the radiological fallout were not significant.

It is by no means that the collateral damage arising from attacking a full-fledged NPP in operation could stoke more fear than an outright nuclear warfare, but are there any international norms or treaties that grant immunity on the destruction of civilian NPP infrastructure during an armed conflict?

Under *Protocols I & II* of the *Geneva Convention*, there are provisions made to prevent any attacks on nuclear infrastructure. Similar to hospitals, it is deemed as a 'war crime' if any State actor launches attacks on civilian NPP facilities. However, such overarching international conventions, although ratified by several Member States, often suffer from the subjective interpretations of their specific articles or clauses.

It remains contentious whether the nuclear facility being attacked has indeed been a resource support to the defending military forces. In the case of the latter, an attack to cripple military supporting facilities is legitimate.

There are also no clear penalties if a State is convicted of attacking civilian nuclear facilities. Under the various civil liability conventions for a civilian nuclear disaster, plant operators are exempted to provide any compensation under force majeure circumstances.

Safe from Missile Attacks?

Even if States' military doctrines preclude an attack on civilian NPPs, any margin of error during warfare could still make NPPs as vulnerable targets. Hence, NPPs must be designed to withstand extreme events, including military attacks.

The safety design of an NPP adopts a 'defence-in-depth' approach, whereby the most outer layer of the protection is the containment building. In 1988, Sandia National Laboratories crash-tested an F-4 Phantom jet into a thick reinforced concrete wall. NPPs designed nowadays are known to withstand an aircraft crashing into its concrete containment building.

However, protecting an NPP against a direct military missile hit takes on a different design philosophy altogether. The conical-shaped charge of the weapon, coupled with its supersonic speed, will have far more penetrative power to breach the thick concrete containment building.

Furthermore, in times of war, the structural integrity of the containment would have been compromised with the heavy artillery bombings. It is highly probable that any direct missile hit (and usually not just a single missile) on an operating NPP will result in a catastrophic radioactive release into the surrounding environment.

New Design Philosophy: Go Small, Go Under

With so many military strikes that had damaged nuclear facilities and their auxiliary infrastructure in the past, it is timely for the IAEA to review and incorporate military threats into their safety standards.

Indeed, the IAEA *Specific Safety Guide SSG-64 'Protection Against Internal Hazards in the Design of NPP'* mentioned about industrial missiles, e.g. fast-flying industrial shrapnel from uprooted equipment caused by natural hazards, which is a different taxonomy from military missiles used in war.

The dual functionality of the containment is to: i) physically protect the reactor vessel; and ii) prevent any leakage of radioactive materials into the environment. Therefore, strengthening the containment feature should be a priority in the safety design.

Underground NPPs, with the cooling systems designed adequately, can offer extra layer of protection against missile attacks. In addition to the above ground containment building, the risk of an accidental radioactive release into the atmosphere will be significantly reduced if the reactor is sited underground, thus leading to a smaller footprint for emergency planning.

Small Modular Reactors (SMRs)

There is already increasing global interests in Small Modular Reactors (SMR). In addition to advanced safety features, a unique characteristic of an SMR is the smaller fuel content in its reactor core, which contributes to smaller source term emission in the event of a nuclear emergency.

In this regard, SMRs are safer compared to large conventional reactors. Therefore, future nuclear reactors should be designed with smaller capacities.

In considering all these additional safety parameters, the IAEA can review its design guidelines so that newcomer states will have the assurance to embrace the new generation of NPPs coming online. Technically, NPPs are not more vulnerable than any type of power generating plants in times of war.

However, the public is fearful of the 'what ifs' that could result in a nuclear accident – and the nuclear industry has the responsibility to eliminate those 'what ifs' in order to make NPPs safer.

Alvin Chew is a Senior Fellow at the S. Rajaratnam School of International Studies (RSIS), Nanyang Technological University (NTU), Singapore. He also currently holds an Adjunct appointment at the Energy Studies Institute (ESI), National University of Singapore (NUS). This is part of a series.

S. Rajaratnam School of International Studies, NTU Singapore
Block S4, Level B3, 50 Nanyang Avenue, Singapore 639798
T: +65 6790 6982 | E: rsispublications@ntu.edu.sg | W: www.rsis.edu.sg