ISSN: 2414-1895 DOI: 10.6919/ICJE.202201_8(1).0091

Research of American Nuclear Weapon Accident and Response Procedures

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Abstract

The definition of nuclear weapons accidents in the United States, the meaning of code names and the situation of nuclear weapons accidents that have occurred were introduced in this paper. And the emergency response strategy of U.S. nuclear accident was briefly analyzed. Based on the current situation of the development of nuclear weapons equipment in China, the deficiencies of the construction of emergency forces for nuclear weapons accidents in China were compared and analyzed. Ultimately, three suggestions from three aspects were put forward to provide reference for China's nuclear weapon accident emergency capacity construction.

Keywords

The United States, Nuclear Accidents, Nuclear Emergency Response.

1. Introduction

The Dongfeng-41 intercontinental strategic nuclear missile came on October 1, 2019 [1-2], which surprised everyone. While we lament the impressive success of national defense modernization, moreover, we cannot forget the tough lesson of the Fukushima nuclear accident in Japan on March 11, 2011 [3, 4]. In addition to the design faults of the nuclear power plant itself, the wrong emergency measures after the reactor went wrong, domestic departments at all levels irresponsibly shirked their responsibilities and were slack, it has a particularly difficult far-reaching impact on later generation while causing major disasters [5, 6]. As the strategic cornerstone of the country [7], nuclear weapons are the core force of China's strategic deterrence [8], and their safety problem in production, transport, and storage is about national lifeline and national well-being, although safety measures are done well in the links of design, production, operation and management of nuclear weapons as much as possible to reduce the risk of nuclear accidents, it has become the consensus of the national nuclear safety idea to build a strong nuclear emergency team with fast and efficient nuclear accident emergency handling capacity [9-11].

How to improve China's nuclear accident emergency response capacity is one of the important tasks of our nuclear force building [12, 13]. In this respect, we started later and lacked experience. The United States is the country with largest nuclear industry scale, most complete category, and most advanced technology in the world, nearly a thousand nuclear weapon accidents occurred cumulatively, it has some practical experience in the making of laws, response handling in nuclear weapon accidents, which is worth our research and learning. This paper aims to briefly introduce the concepts related to nuclear weapon accidents in the United States and the response process of nuclear weapon accidents, it proposes the construction suggestions of nuclear accident emergency force suitable for China's national conditions through summary and induction, and provides lessons and references for the emergency response capacity construction of nuclear weapon accidents in China.

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2. Relevant Definitions of Nuclear Weapon Accidents in the United States

2.1 Nuclear Weapon Accidents (Accident)

The definition of nuclear weapon accidents are important incidents that lead to adverse consequences of nuclear weapons or weapon components due to unexpected reasons. They mainly includes 7 categories [14]:

(1) Unexpected errors happen during equipment assembly, testing, loading and transport, due to equipment or material failure, it may lead to accidental operation of all or part of weapon equipment and launch sequence, or cause significant changes in production or even increase in failure probability;

(2) Accidental and unauthorized launch, ignition and use of the nuclear weapon system appear in the United States Military or its Allies, thus causing the probability increase of nuclear war;

(3) Lost incidents of nuclear weapons or weapon components, unauthorized destruction, and disposal incidents;

(4) Incidents that induce chemical explosion of nuclear weapons and increase the possibility of radioactive contamination caused by nuclear explosion;

(5) Incidents that are not nuclear explosions but lead to the burning of nuclear weapons or components;

(6) Hidden or actual public hazard events caused by nuclear weapons;

(7) Damage incidents of nuclear weapons, nuclear facilities or nuclear components caused by natural disasters, adverse environment, and adverse conditions.

According to the above definition, we can see that nuclear weapon accidents usually lead to incidents with big consequences, involving nuclear weapon damage, loss, unauthorized launch, etc., which may increase the risk of nuclear war and public hazards. The above seven categories almost cover the accidents that may occur in the whole process from assembly, transportation to use, which has a certain reference for China's definition of nuclear weapon accidents.

2.2 Nuclear Weapon Incidents (Incident)

The definition of nuclear weapon incidents are nuclear weapon accidents or deliberate hostile incidents involving nuclear weapons, nuclear facilities, and nuclear components. The meaning of nuclear weapon incidents is broader, on the one hand, nuclear weapon accidents all belong to nuclear weapon incidents, on the other hand, all incidents related to nuclear weapons can be included in nuclear weapon incidents [15]. The difference between the two is: the nuclear weapon accident caused significant consequences that can lead to the damage of the nuclear weapon itself, and the incidents include all things related to nuclear weapons, such as transportation, reprint, use under normal circumstances, etc. The concept use of nuclear weapon accident is more meaningful related to nuclear accident emergency, according to the severity or scene of the accident, the United States labeled special accident codes.

2.3 Nuclear Accident Codes

(1) Nuclear flash (Nucflash): Nucflash is accidental, unauthorized, or unexplainable incident that may cause war risks [16]. For example, accidental, unauthorized launch of a missile with nuclear weapon or nuclear capacity of American forces or American allies, such incidents can be listed as hostilities by the American forces.

(2) Broken Arrow: broken arrow is accidental, unauthorized, or unexplained incidents involving nuclear weapons without causing war risk [17]. For example, the accidental and unauthorized use of nuclear weapon systems and nuclear missile launch of by the American forces or allies, but do not cause security threat to other countries.

(3) Empty Quiver: empty quiver is the incidents where nuclear weapons are lost, stolen, or seized [18]. In 1996, the famous director John Woo made the action film broken arrow with the material of nuclear weapon hijacking. However, according to the classification standard of American Los Alamos National Laboratory, the story of the film should be attributed to the empty quiver [14].

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(4) Bent Spear: Bent Spear includes incidents where burning, theft, detention, etc. lead to abnormal leakage of the internal filling of nuclear weapons or limited radioactive components are destroyed and cause radioactive contamination, and they are mainly the incidents where nuclear weapons themselves have been damaged [19].

If the meaningless start causes obvious damage to limited-life components, nuclear weapons, or nuclear components, such cases require the Department of Energy to carry out major rework, replacement, inspection, or recertification for nuclear weapons.

(5) Dull Sword: dull sword is mainly used to report incidents that may lead to nuclear safety or nuclear insurance defects [19]. For example, nuclear power system or electromagnetic energy cause damage to nuclear weapons, nuclear components, or nuclear weapon systems are exposed to abnormal environments such as floods, earthquakes, etc., affected by the natural environment, hardware, and software failures, resulting in weapon system failures, etc.

(6) Pinnacle Faded Giant: Pinnacle Faded Giant is mainly used to report dangerous radiological accidents [14]. For example, due to the release of radioactive materials, a person who is in a radiation-contaminated area for 24 hours may have to receive the dose with 0.25 sievert (Sv) (the internal radiation dose is calculated according to after ingesting radioactive material 50 years); individual single cumulative dose reaches 0.25 Sv or more radiation, and the eyes are radiated by 0.75 Sv or more radiation, or the extreme incident where external radiation dose reaches 2.5 Sv due to exposure; the incidents where public hazards caused by radioactive contamination accidents are widely reported by the news media. The term Pinnacle is events that can arouse the attention of the national command organization and the Ministry of National Defense, they trigger higher-level military operations, cause the national response, affect international relations, cause widespread media coverage, even harms national interests, and affects current national policies, etc.

(7) Beeline Faded Giant: Beeline Faded Giant is radioactive incidents or accidents that do not require submitting the report of beeline faded giant, and the corresponding situation does not reach the severity of the beeline faded giant. For example, due to the release of radioactive materials, individual may have to receive the dose with 0.05 Sv within 24 hours; individual single cumulative dose is 0.05~0.25 Sv, eyes are 0.15~0.75 Sv and other incidents.

Nuclear accident code is a type of proper nouns used to refer to the classification and level of accident condition when the American forces, the Department of Defense, and the Department of Energy and other relevant departments to report nuclear weapon accidents, different codes need to be reported to different levels of national departments, which also decide on the responsible unit and the handling process for the follow-up nuclear accident emergency response. For example, when an incident is defined as the broken arrow, the National Military Command Center (NMCC) will activate the Joint Staff's Joint Nuclear Accident/Incident Response Team (JNAIRT), this team is led by the Joint Staff Operations Board (J-3 for short), and it is composed of all the staff officers of the Department of Defense (DOD) related to nuclear accident response. After the notice is made, the National Military Command Center should establish linkages between the nuclear accident situation report and all relevant units, including the service operation center, the Defense Threat Reduction Agency (DTRA) Operations Center (CSEO), and the Department of Energy (DOE) Emergency Operations Center (EOC), Homeland Security Operations Center, Operational Command Center, etc. When the Department of Defense as the leading federal agency, the National Military Command Center can dispatch emergency resources of the Department of Defense/National Nuclear Safety Commission (DOE/NNSA) by requesting the Emergency Operations Center of Department of Energy (DOE) when necessary.

3. Brief Introduction to Nuclear Weapon Accidents Occurred in the United States

According to the top-secret report of the American Department of Defense, "Brief Reports on American Nuclear Weapon Incidents from 1950 to 1980," 32 "broken arrow" nuclear accidents

ISSN: 2414-1895 DOI: 10.6919/ICJE.202201_8(1).0091

occurred in the United States between 1950 and 1980, including 28 accidents of American Air Force, 3 accidents of American Navy, 1 accident of American Department of Energy. [20]. The area where the accident occurred and the weapons carried are shown in Table 1.

Table 1. public nuclear weapon accidents in the United States

year	number	carried weapon	place
1950	5	bomber	Pacific Ocean, Manzano (Italy), Lebanon, Fairfield-Suizon, Overwater O'Coast
1956	2	bomber	Mediterranean, O'Seas
1957	2	bomber	Homestead, Conant
	1	carrier	Atlantic
1958	5	bomber	Pacific Ocean, Manzano (Italy), Lebanon, Fairfield-Suizon, Overwater O'Coast
1959	1	attacker	Whidbey Island
	1	bomber	Hardinsburg
	1	fighter	Pacific Base
	1	carrier	Barksdale (Britain)
1960	1	missile	McGrail (Britain)
1961	2	bomber	Goldsboro, Yuba City
1963	1	storage device	Medina(Saudi Arabia)
1964	2	bomber	Cumberland(Britain), Bunker Hill
	1	missile	Ellsworth
1965	1	attacker	Pacific Ocean
	1	carrier	Wright-Patterson Air Force Base
1966	1	bomber	Palomares(Spain)
1968	1	bomber	Thule(Sweden)
	1	torpedo	on the sea
1979	1	missile	Damascus(Syrian)

According to the analysis of public data, we can see that most nuclear weapon incidents originate in transportation accidents of nuclear weapons, among which the number of accidents occurred during the air force transport is the most, this is an aspect worthy of our attention, in the emergency scenario setting and sand table deduction of nuclear weapons accidents in our country, nuclear weapon accidents caused by air transport of nuclear weapons should be regarded as one of the most important scenarios.

The main reason why we can see the public data is probably because the accident happened mainly overseas, and it is difficult for Americans to hide them. In fact, just decades from the end of World War II to the 1960s, there were 60 nuclear accidents in the United States, and native nuclear accidents

ISSN: 2414-1895 DOI: 10.6919/ICJE.202201_8(1).0091

were concealed or covered up in the name of "state secrets." The most serious accident of native nuclear weapons was mistaken fire of two guided aircraft missiles with nuclear warheads. From 1965 to 1977, there were 383 nuclear accidents in the US Navy alone; the top-secret report of the Government Accountability Office in 1985 stated that there were 233 major nuclear accidents in the American from 1965 to 1983. One secret report from Sandia National Laboratory in the United States stated that there were 1250 nuclear weapons accident and 272 major nuclear weapon accidents from 1950 to 1968, which even includes the close nuclear weapon accident soon[21], [21], including 107 nuclear warheads suddenly fell during assembly or transport, and the bomb bodies were damaged; 26 accidents happened in the container during storage or loading of nuclear bombs, 48 accidents were that nuclear warheads that fell suddenly in launchers or missile sites; 41 accidents were that the plane carrying the bomb crashed; 24 accidents were mistaken firing of nuclear weapons of carrier aircraft or ships; 22 accidents were that traffic accident occurred during ground transportation; and 4 accidents were that nuclear weapons were hit and damaged. In American film and television works, there is no lack of terrorist attacks or major incidents which take related subjects as the background. Since 1988, there have been at least 96 nuclear weapon accidents, and dangerous levels are from being hit of the outside of the projectile to chemical explosion.

4. Nuclear Weapon Accident Response and Disposal Process in the United State

For the response to nuclear weapon accidents, the United States provided 5 links or steps in the 2005 version of the Nuclear Weapon Accident Response Procedure (NARP, No. DOD3150.8-M) [22] document: (1) announcement and scheduling; (2)initial response; (3)field reinforcement; (4)weapon repair operation; (5)field restoration. Fig.1 shows the time relationship among the above five steps.

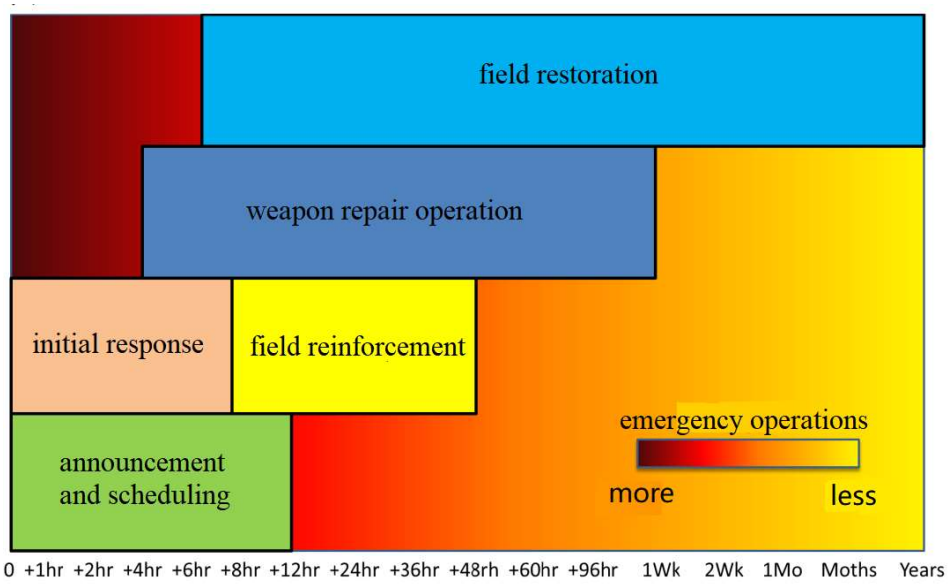

Fig.1. timeline of response steps

(1) Announcement and scheduling: the first time the nuclear weapon accident happened, personnel who are on the first field and have nuclear weapon emergency knowledge should immediately report to the National Military Command Center or the Emergency Operation Center of Department of Energy, and give notice to the relevant authorities. then implement the logistics plan and equip the local emergency assets of the accident. This step gradually unfolds as the emergency force increases.

(2) Initial response: the process of initial response process spans the process of announcement and scheduling process, it is included in the time range of the first link, and it will start immediately when the response force of the high echelon reaches. It usually includes the blockade of contaminated areas, surviving search and rescue, firefighting, public management, and emergency protection

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measurements for the safe environment required for necessary operations. With the gradual development of this step, the response state gradually changes from field rescue, fire extinguishing, and public protection to pollution suppression and hazard elimination.

(3) Field reinforcement: field reinforcement starts from the initial response link, there is no clear starting time point for this process, and it is developed with the arrival of powerful emergency equipment and the field blockade as signs. It usually includes the establishment of the contact point among the Ministry of National Defense and Joint Command Center of Nuclear Emergency Security Agency of the Ministry of Energy (NASS), the office and the emergency operation execution team, pollution containment control, continuous actions to reduce the safety risks of the public and emergency forces, hazard elimination, and consolidation of safety measurement, start the initial assistance safety procedures, make the subject of public affairs clear, and start to plan field recovery actions, etc.

(4) Weapon repair operations: weapon repair operations usually start after survivors' search and rescue, firefighting and fire extinguishing, and other operations are completed, and short-term public and emergency force protection monitoring has been implemented. It usually includes developing a series of weapons search, monitoring, evaluation, safety description, sealing, removal of nuclear weapons, nuclear components and other related dangerous goods caused by accidents on field. This step ends with the safe removal of nuclear weapons, nuclear components, and related dangerous objects on field.

(5) Field restoration: during the real-time process of field reinforcement, the field restoration link is started with the making of the field restoration plan, and gradually developed as the emergency operation eliminates field hazard. It includes the establishment of field restoration operation team, quantification of radiation hazard, establishment of sampling plan and control procedure, radioactive monitoring, assessment of public risk, operation and clearing standard, making of restoration plan, command and develop research, and finally implement the restoration plan. Since continuous monitoring is necessary, moreover, it takes a lot of work and effort to realize the fundamental treatment of the polluted environment, therefore, this link may last for many years to reach the level which the public can accept.

During the implementation of the above five links, the steps and time overlap each other, and there is no time dead angle, whether within the military, the country, state, and local governments, their division of responsibilities are very clear, even in order to break the cooperation barrier between the military and the local governments, the establishment of field contact point and the reporting mechanism of both parties are clear. As can be seen that in dealing with nuclear weapons accidents, the United States has the determination to deal with it with national power, and this attitude is also worth our learning. Comparing the Chernobyl accident with the Fukushima nuclear accident in Japan, the former is that the former Soviet Union did its best to prevent the situation from further expanding, while the Japanese government and the power company prevaricated, did not actively act, even pour waste water into the open sea, make people all over the world will pay for their mistakes, this action is extremely wrong both scientifically and politically [23].

5. Enlightenment and Suggestions of China's Nuclear Emergency Force Construction

This paper introduces the emergency response situation of the American nuclear weapons accident from three aspects: the definition of American nuclear weapons, the condition of accidents occurred, and the emergency response mechanism. According to the above discussion, we can see that the America has rich experience in nuclear accident emergency response, has established a sound response mechanism, laws and regulations, and the powers and responsibilities of all levels of power from top to bottom are clear. The author believes that our country still needs to make the following efforts in the definition of nuclear weapon accidents, emergency response procedures, and supervision systems:

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5.1 Strengthen the Basic Theoretical System Construction of Nuclear Accident Emergency Response

With the proposal of the national nuclear security concept, the construction of nuclear emergency forces at the national level is gradually accelerating. Taking China's nuclear emergency response force as an example, the talent shortage has become a core issue restricting the construction of effective nuclear forces. Under this background, some domestic colleges and universities have added relevant courses, hoping to at the forefront in the construction and training of nuclear professionals. However, the concrete goals of talent training are still unclear, it is not clear from which aspects to train, the core problem is the weak basic theoretical system of nuclear emergency. The basic theoretical system is formed from the perspectives of management, law, economics, and education, make what students should learn clear, in this way, we can effectively guide the subsequent curriculum and research direction setting, and thus serving talent training.

5.2 Improving Nuclear Accident Emergency Response Mechanism, Laws and Regulations from the Basic Theoretical System

Although the nuclear accident emergency response points to the nuclear accident field, the top-down management mechanism, operation mode, and division of authority and responsibility conform to the operation laws of management, law, and environmental protection. China's national conditions differ greatly from those of the United States, and it is not scientific to copy the mechanisms and laws of the United States, therefore, the strength of experts in various fields such as environmental protection, law and finance should be absorbed to form the professional committee, after the basic theory is perfected, through the fusion of big data, artificial intelligence and other high-tech, coupled with mathematical modeling, military chess deduction and other simulation methods, the long-term mechanism is formed in the classification of nuclear weapon accidents, the improvement of response mechanisms, the classification of personnel involved, the management of financial operations, etc., then the basic theory research is fed back through combat exercise and other ways, after practical application and theoretical iterations, the rich and perfect national mechanism and laws and regulations of nuclear emergency response are finally formed.

5.3 Training Nuclear Emergency Response Forces with Actual Combat Requirements

According to the number and location of nuclear weapon accidents in the United States, we can see that the United States itself is not afraid of nuclear weapon accidents, and it is obvious that military needs have a higher priority than safety management, it may also be the reason for frequent nuclear weapon accidents in the United States, multiple emergency combat experiences have guided the United States to form more scientific and efficient emergency response mechanisms, and laws and regulations. At present, the nuclear accident emergency training in China is mainly imaginary accidents, and emergency training is mainly personnel running, process development and equipment training, lack real nuclear accident environment and scenarios. At the national level, the real accident scenario simulation mechanism should be established, make the national nuclear emergency response force, especially the nuclear weapon accident response force, carry out emergency response training in a real environment, train the team in the process of actual combat, and ensure that China's nuclear emergency response force can carry out emergency response calmly when the real nuclear accidents occur.

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