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DISPOSAL OF THE CIS NUCLEAR WEAPONS

Reductions in nuclear weapon arsenals have been agreed under the START Treaty, and will be taken much further following unilateral decisions by both the USA and the Commonwealth of Independent States (CIS). The task of dismantling weapons will stretch resources in Russia, and gives rise to concern over the safety and security of nuclear weapons and their fissile materials.

This briefing discusses the safe dismantling of nuclear weapons, what may be done with the materials resulting and related policy issues.

REDUCTIONS IN NUCLEAR WEAPONS

Since the late 1980's the momentum towards the withdrawal, reduction and ultimate elimination of many categories of nuclear weapons has been gathering pace. The Intermediate Nuclear Forces Treaty of 1987 (covering launchers only) was followed in 1991 by the signing of the Strategic Arms Reduction Treaty (START) which would commit the USA and the (then) USSR to reduce their strategic warheads to 6,000 'accountable' weapons[1] over seven years.

Even though neither side has yet ratified START[2], further measures to reduce nuclear arsenals have followed. In September 1991, President Bush announced *inter alia*, that the US would accelerate the implementation of START measures (after ratification). The US would also withdraw and destroy all nuclear artillery shells and warheads for the Lance missile, and remove all tactical weapons from surface ships, attack submarines and land-based naval aircraft. President Gorbachev's response included a reduction to 5,000 accountable strategic warheads, elimination of all nuclear artillery shells, tactical missile warheads and nuclear mines, and the withdrawal of tactical nuclear warheads from several other delivery systems.

NATO has also announced an 80% reduction in its European tactical stockpile; so far as the UK is concerned, Royal Navy ships no longer carry tactical nuclear weapons, the number of WE177 nuclear bombs will be cut by around half, and the nuclear-role tornado squadrons wiil be reduced from 11 to 8.

1. The 'accounting' formula undercounts the actual number of warheads, so that at the end of this process, strategic arsenals of the Soviet Union and USA would still contain ~ 8000 and 10,000 warheads respectively.

Table 1 NUCLEAR WEAPONS REDUCTION PLANS

	Strategic 1991 levels[1]	*Planned*	*Tactical* 1991 levels	*Planned*[4]
Russia	7,449	5,000[2] 2-2,500[3]	8,550[5]	few '000?
Ukraine	1,408		2,605	0
Kazakhstan	1,360		650	0
Belarus	54		1,120	0
Other Republics	0	0	1,280	0
Total CIS	10,271	2-2,500	15,000	few '000?
USA	10,563	4,700[4]	~8,000	few '000?

1 START Treaty Evidence
2 Bush-Gorbachev proposals (1991)
3 Yeltsin proposal (1992)
4 Bush proposals (1992)
5 This estimate (Norris and Arkin, 1991) of the distribution within the Republics is believed to be an under-estimate; the real figure may be nearer 15,000.

In January, President Bush announced that the US would reduce the number of its strategic warheads to half that agreed under START. Following the dissolution of the USSR and the formation of the CIS, President Yeltsin responded and called for cuts to go further to around 2 -2,500 strategic warheads each. The effect of these various agreements is summarised in Table 1. The former Soviet Union is committed to withdrawal and destruction of up to 8,000 strategic warheads and the majority of its 15,000 or so tactical warheads (in addition some believe there may be up to several thousand redundant older warheads already in store). President Yeltsin has stated that Russia will assume all responsibility - initially for accepting all warheads withdrawn from the former Soviet Republics, and ultimately for warhead dismantling and storage or disposal of resulting materials.

NUCLEAR WEAPONS AND DISMANTLING

All nuclear weapons depend on fissile material, which is either weapons grade (highly enriched) uranium (usually ~90% U235) or plutonium 239. Nuclear bombs exploit the fact that both elements break up into smaller fragments when struck by neutrons (one of nature's elementary particles), releasing large amounts of energy in the process. As each atom of uranium or plutonium splits, more neutrons are released which can trigger a runaway chain reaction - the nuclear explosion. There is a minimum amount of fissile material needed to sustain the chain reaction - the critical mass.

The main components of nuclear weapons are shown in Figure 1, based on information published in open scientific publications. The uranium or plutonium core does not explode so long as it remains in its initial form

2. Procedures for ratification of START by Russia, Belarus, Ukraine and Kazakhstan have just been agreed with the USA.

of a hollow sphere, which is non-critical. As soon as it is compressed by chemical explosives however, the mass achieves 'criticality' and the chain reaction takes off, resulting in the atomic blast. The efficiency of the explosion is enhanced by putting a 'reflector' around the fission core - normally the metal beryllium (Fig 1a), and the power can be increased by including tritium (an isotope of hydrogen). In thermo-nuclear warheads (fusion or H-bombs - Fig 1b), the fission explosion is used to trigger the fusion of tritium and deuterium to give helium, releasing energy which greatly increases the power of the original explosion. Fusion weapons can also include an outer casing of natural or depleted uranium which, under the extreme conditions of the exploding Hydrogen Bomb, undergoes fission, increasing the power of the explosion as well as the amount of radioactive contamination.

Unlike conventional weapons, nuclear warheads cannot simply be destroyed by burning or explosion - they must be taken apart with great care in properly equipped secure plants. The most appropriate sites would be at plants responsible for the original design and assembly; for the CIS, these are all believed to be in Russia (at Arzamas, Chelyabinsk, Nizhnyaya Tura and Yuryuzan).

Once taken apart, the conventional explosive, the electrical circuits, packaging, detonators etc. can be destroyed, re-used or disposed of. Special materials such as beryllium and other non-radioactive materials may be worth recovering or recycling. This leaves the key components of the nuclear bomb - the special nuclear materials tritium, uranium or plutonium.

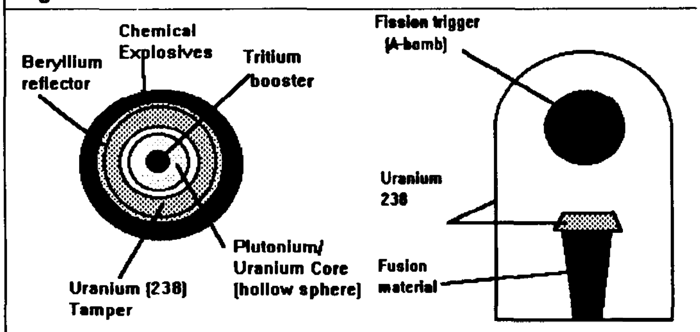
TECHNICAL OPTIONS FOR DISPOSAL OR RE-USE OF NUCLEAR MATERIALS

Tritium. Tritium decays into helium quite swiftly (half is lost every 12.3 years) and thus the tritium in nuclear warheads requires periodic replenishment. Gas from retired warheads can be used to replenish that lost by decay in the remaining warheads, and could meet demands over the next decade or so. The US has ceased production because of difficulties with the plants involved, but Russia is believed still to produce tritium; the UK also makes tritium (at Chapelcross).

Highly Enriched Uranium (HEU) and Plutonium. Although the exact amounts in particular types of weapons are secret, a typical weapon will contain 15-20 kg of HEU or 3-4 kg of plutonium. The CIS States may have around 800 tons of HEU and 100-150 tons of plutonium in stock and in weapons.

Once separated from the weapon, fissile material needs to be placed in safe storage pending decisions on its ultimate fate. While still in their relatively pure state, both HEU and plutonium could be re-used for weapons. Confidence in the nuclear arms reduction process

Figure 1 MAJOR COMPONENTS OF NUCLEAR WEAPONS



a) Atom Bomb **b) Hydrogen Bomb**

will depend on the extent of physical security in storage or on irreversibly converting fissile material into forms which render them useless for nuclear weapons.

HEU is required in most nuclear submarine reactors, but this would require only a small fraction of the amounts released from weapon dismantling. The most likely use for substantial amounts of HEU would be as fuel in civil nuclear power stations. For this purpose, the HEU would be diluted from its original 90% U235 content, using naturally-occurring or depleted uranium (U238), and converted from metal to oxide form to give slightly-enriched (3-4% U235) fuel. This would make its re-use in weapons very difficult, since the uranium would have to be re-enriched before use and returned to the metal form. The incentive for this method of disposal is, however, reduced by the current over-supply of uranium in the civil market, and there are already commercial pressures to keep the HEU off the market to prevent a collapse in the price of uranium. There is thus a potential conflict between economic and security considerations.

Plutonium (Pu) has been recovered from spent reactor fuel at Sellafield and in France for a number of years with the intention that it ultimately be used as fuel. This could either be as a replacement for the U235 to give mixed oxide (MOX) fuel for commercial light water reactors (such as the Sizewell PWR) or in fuel for Fast Breeder Reactors (FBR). In theory, plutonium released from nuclear weapons could be similarly used. This is viewed as problematic for the following reasons:

- It is currently cheaper to use uranium than plutonium recovered from spent fuel, and the main interest in plutonium-run reactors is in countries such as Japan, which are without indigenous uranium reserves and heavily dependent on nuclear electricity. This could change in the future, and research on MOX fuels continues in the UK and elsewhere.
- FBR programmes have run into development difficulties world wide and the nuclear industry sees little prospect for commercial fast breeder programmes anywhere in the world for 30 years or so.
- There are already 125 tonnes of unused plutonium which have been separated by reprocessing spent uranium fuel in the UK, France and Russia.

If Pu is not re-used, it might be disposed of as radioactive waste along with high-level waste from re-processing (this would be expensive and technically difficult). A contentious suggestion from Russian weapons scientists is that plutonium be destroyed in an underground nuclear explosion, where it would, in theory, be fused into the glass (solidified molten rock) caused by the blast. This would raise serious environmental and other questions which have not yet been addressed.

SECURITY CONCERNS

Concerns have been expressed about the security of handling nuclear weapons given the major changes in the former Soviet Union. Studies by the Center for Science and International Affairs at Harvard University and others identify a number of potential dangers to Western security:

- seizure from the hundreds of storage sites around the country for tactical nuclear weapons;
- seizure of or accidents involving weapons in transit;
- sale or 'leakage'[3] of essential bomb components (fissile material, electronics, explosives etc.) to 'proliferating' countries or groups;
- transfer of expertise to 'proliferating' countries or groups (some 100,000 people are involved in the nuclear programme of whom 2-3,000 have access to sensitive information on weapons production).

Strategic warheads are currently deployed in Russia, the Ukraine, Kazakhstan and Belarus (Table 1). Tactical weapons may have been held in up to 11 of the former Soviet Union's 15 Republics, but Russia has recently announced that all have now been withdrawn to Russia well before the target of July 1 under last year's Alma-Ata Declaration.

The process of dismantling may well take ten or more years. There is concern at the small amounts of fissile material (a few kg of plutonium) which would be needed to make a crude atomic device, and it is widely accepted that a substantial and well-funded group could construct a nuclear bomb if it got hold of fissile material. Such a bomb would not have to deliver the full power of a more sophisticated construction (18 kilotons of TNT) to be devastating or to cause serious contamination by plutonium or other radioactive contaminants; the prospect of damage would be such that mere possession of fissile material would provide huge bargaining power. There is thus a major incentive to establish secure and long-lasting systems to account for, transport, handle, store and dispose of nuclear weapons and materials.

CURRENT ISSUES

Technical Assistance Needs

The US Congress has appropriated $400M towards the dismantling of the former Soviet Union's weapons of mass destruction (nuclear, chemical and biological weapons) which are covered by international arms control agreements. After discussion with Russia, the US is proposing to provide containers for fissile material, bullet-resistant (kevlar) blankets, and help to increase the security of Russian railcars used for weapons transport. The largest component of this aid could be the construction of a secure storage facility (50,000m^2) in Siberia for the fissile materials released by the dismantling programme under Russian control.

The UK has also discussed forms of technical assistance with Russia, and the Secretary of State for Defence has announced a £30M programme which includes the provision of 250 special containers and 20 special vehicles for the safe transport of nuclear weapons. Advice has been offered on accident response and fissile material storage/transport design; and technical assistance in using weapons grade fissile material in the fuel cycle, and on environmental restoration. The US, Russia, EC and Japan are also financing an International Science and Technology Centre near Moscow. This will fund projects in civil science by some of Russia's top 2,000 nuclear scientists and engineers. The US contribution of $25M will be matched by the EC, and Japan has also promised $20M. A second centre is proposed for Kiev.

While the above actions have been generally welcomed, some non-governmental groups such as the Federation of American Scientists and the UK's Scientists for Global Responsibility, suggest further steps be taken.

Firstly, some see it as urgent to build on the new intelligence cooperation between the US and Russia. One suggestion is that inventories of all weapons might be drawn up under START or the Bush-Gorbachev proposals. Some go further and advocate creating an international structure (either based on existing institutions like the UN or establishing a new one) within which all Nuclear Weapon States (NWS) could cooperate on drawing up inventories of weapons and materials, ensure verification and cooperate in tracking any missing materials. Currently, NWS are each responsible for their own inventory and tracking systems.

Even though aid on transport has already been offered, it may be several years before all weapons can be moved safely from local weapon stores to secure central storage near the dismantling sites in Russia. The question has thus been raised of security at intermediate storage sites, and whether some form of joint or international custody could be arranged. Possibilities would range from bilateral (US/Russia), or multilateral (e.g. Nuclear Weapon States) custody, to placing specific sites under international custody by the United Nations, IAEA, or CSCE.

3. Such leakage could arise from carelessness, lack of export controls, individual enterprise, corruption or government policy.

There are ways in which weapons can be made safe in storage or transit. Temporary disabling mechanisms include removal of tritium, changing the configuration of explosives, removal of batteries, arming circuits etc. According to the Russians, all weapons are disabled in some way before transport. Special coded switches could be installed, but this would be difficult and time-consuming and is not recommended by many experts.

The Russians estimate that they have the capacity to dismantle up to 2,000 warheads each year, and say that their most pressing need is for safe and secure storage for the fissile material produced while routes for the ultimate disposal or use of uranium and plutonium are developed. This is being pursued by the USA. A particular problem surrounds the dismantling of old weapons already in store, since the warheads' construction may present greater difficulties in dismantling than their modern counterparts. Although this is a sensitive area in which to offer technical assistance, some observers believe the West should address this issue.

On personnel, the Royal Society has started a short-term fellowship scheme to allow Russian scientists to visit the UK to develop collaborative links, and the Society has recommended to the Prime Minister further measures which might be taken to prevent the collapse of science in the CIS. These would be aimed at preserving the best of Russian science in its own country and strengthening cooperation. The US National Academy of Sciences and others also see an urgent need to support diversification of work at the main nuclear centres and wish to encourage bilateral collaborative research with the USA. They suggest that up to $200M be available for joint projects and some collaborative grants have already been awarded.

In view of the widespread contamination reported around Russian weapons plants, environmental clean-up is an area where existing personnel might be redeployed. Here, the USA has valuable experience in handling its own contamination problems. The UK has offered technical assistance, drawing on the experience of companies such as BNFL, but the scale of the problem is beyond the resources of any single country. The EC has some funds which could be used for assistance in this area, whose allocation will need to be decided during the UK presidency.

Ultimate Disposal of Nuclear Material

The technical options described earlier depend to a large extent on using uranium or plutonium in civil nuclear power stations. For economic and technical reasons, uranium will be much easier to use than plutonium and half the Russian stock of uranium 235 could be worth as much as $6Bn at current prices. However, as the uranium market is depressed at present, a key question is whether this could be realised on the free market. Some US scientists suggest that the US Government should buy Russian HEU instead of continuing its enrichment plant operations.

On plutonium, the Russians have a MOX production plant under construction as part of their fast reactor programme, though the economic justification is widely questioned. In view of the safety record of CIS power stations, some question whether it is wise to switch to a new fuel requiring different operating conditions on which there is very limited experience worldwide, and almost none in Russia (only one reactor in the world (Switzerland) is running on MOX fuel and most relevant experience is with the Belgian and German nuclear industries). The debate over what to do with military plutonium also brings into focus the question of the ultimate fate of the UK and other countries' civil stocks from reprocessed spent fuels which have not yet found an economic use, and which continue to be produced.

A proposal has been made in Japan to build a special 800MW fast-reactor to generate electricity from weapons-grade plutonium. Without breeding capacity, such a reactor could remove 2 tonnes per year of plutonium for 40 years. This proposal may be made at the coming July summit of the G7 Group, but UK energy scientists see this as a much more expensive option than increasing usage of mixed oxide fuel.

The Nuclear Non-Proliferation Treaty(NPT)

Assuming that all Soviet tactical nuclear weapons are now in Russia, the only nuclear weapon resources in other former Soviet Republics are strategic weapons in Ukraine, Belarus and Kazakhstan. Providing the weapons on their territories remain under joint command with Russia, UK legal experts do not see these residual elements as fundamentally incompatible with non-nuclear weapon status under the NPT. Recently, Ukraine, Belarus and Kazakhstan have declared their intention to accede to the NPT as non-nuclear weapon states, in which case the nuclear infrastructure outside Russia will be brought under IAEA Safeguards.

FURTHER READING

Additional details and background information are available from POST, 2 Little Smith St., London SW1P 3DL, tel: (071)-222-2688.