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Where and how much depleted uranium has been fired?

March 2001 update
of a workshop held at the
CADU conference, Manchester, 4 November, 2000
by: Henk van der Keur
Laka Foundation, Amsterdam

Nuclear fuel chain

Depleted uranium (DU) is the by-product of the enrichment of natural uranium. 'Natural uranium' is the concentrated product after mining and refining uranium ore. One kilogram of 'natural uranium' is obtained from 1000 kg of uranium ore. Only half of this one kilogram is actually released for use. The remaining 999.5 kg is considered as radioactive waste.

DU stockpiles

United States :	700,000 metric tonnes Currently stored in the form of UF ₆ , stored in cylinders at Paducah, Kentucky, and Portsmouth, Ohio. 160,000 metric tonnes, stored in the form of UO ₂ and metal
Urenco (UK, FRG, NL) :	38,000 metric tonnes Currently stored in the form of UF ₆
Cogema (France) :	119,900 metric tonnes (dUF ₆) Stored at Bessines-sur-Gartempe (Haute Vienne) near Limoges

US Proving Grounds with DU Test Firing Ranges

	DU Testing	Amount of DU
Ethan Allen Firing Range (Vermont)	1969 – 1973	4,500 kg
Lake City Ammunition Plant (Missouri)	until 1985	3,500 kg
China Lake Naval Air Warfare Center (California)	10 years	11,300 kg
NM Institute of Mining & Technology (New Mexico)	since 1972	---
Los Alamos National Laboratory (New Mexico)		100,000 kg
Jefferson Proving Ground (Indiana)	1982 - 1988	69,000 kg
Aberdeen Proving Ground (Maryland)		70,000 kg
Eglin Air Force Base (Florida) - Gunnery Ballistic Facility - High Explosive Test Area	1973 - 1978 at present	100,000 kg
Nellis Air Force Base (Nevada)	since 1982	27,800 kg
Total (known) amount DU fired		386,100 kg

Other test-fires with DU ammunition

???? **Panama**

There are strong appointments that the US Army has trained with DU rounds along the sides of the

Panama Channel.
No data available.

1995/1996 Japan

From December '95 – January '96 the US Navy AV-8B Harriers (aircraft) test-fired 1,520 25mm PGU/20 API rounds 100 km west of the main island of Okinawa. Total amount of DU: 251 kg.

1999 Puerto Rico (Vieques)

On 19 February, 1999, two US Marine Corps AV-8B Harriers expended 263 25mm PGU/20 API rounds at Vieques Island, Puerto Rico, North Convoy Site. Between March 10 and 19, 1999, 57 rounds were recovered. 263 Rounds is equal to 34 kg of DU.

The British Army fired/fires DU ammunition at their test sites near Eskmeals and Kirkcudbright. Recently (f.e.: Independent, 12 Jan. 2001) the British MoD acknowledged that about 6,000 120 mm shells have been fired into the Scottish Solway Firth, close to the village Dundrennan, since 1982. Around 60 will be fired until October. About the French tests there are no data available. US and British tank divisions have trained in Central Europe. There are no data available about firing of DU ammunition.

Taiwanese Navy has used some 60,000 DU rounds in maneuvers over the past years (BBC Monitoring, Jan.17, 2001). The type of these munitions is not mentioned.

Greece has decided to take off all DU shells from their inventory. The Greek Navy has in all about 15,000 shells, which are used in the air defense system Phalanx (Close-In Weapons System). During exercises since 1990, 30,000 rounds of 20mm ammunition were fired. It is not clear where they have been fired. In the nineties Greece rejected a US offer of 100,000 DU tank shells after which they were exported to Turkey. (Associated Press, 8 January, 2001)

DU weaponry used in wars

- 1973 Yom Kippur War
Probably the first war with DU ammunition (prototypes)
Probably fired by the M60A1 MBT
No data available

- 1982 Falklands War
Possible use of Phalanx CIWS missile defense gun
No data available

- 1982 Israeli Invasion of South Lebanon
Use of modified / upgraded M60 (series) M60 MBT
No data available

- 1989 US Invasion of Panama
Possible use of DU ammunition
No data available

- 1991 Operation Desert Storm

1994 Bosnia
 In August US A-10s destroyed a Bosnian Serb mobile 'tank buster'.
 No data available.

1999 Kosovo
 On 7 February 2000 NATO confirmed the use of 31,000 30mm PGU/14A API rounds.
 Total amount: 8401 kg of DU.

!! When there is solid evidence about the use of DU in (Tomahawk) cruise missiles, the amounts of DU left behind in Iraq and Yugoslavia will be considerably higher. !!

Approximate Amount of Depleted Uranium Released During Operation Desert Storm

Branch	Weapon System	Ammo Type	Quantity of Rounds	Weight (pounds)
U.S. Army	M1 Tank	105mm	504	4,254
	M1A1 Tank	120mm	9,048	82,243
U.S. Air Force	A-10	30mm	783,514	521,655
U.S. Navy	Phalanx CIWS	20mm	Not Available	Not Available
U.S. Marine Corps	AV-8B Harrier	25mm	67,436	22,003
	M60 Tanks/ M1 Tanks	105mm	Not Available	Not Available
United Kingdom	Challenger Tanks	120mm	88	900
Totals (approximate)			Tanks- 9,640 Aircraft- 850,950	Tanks - 87,397 Aircraft- 543,658 Total - 631,055

Ammunition Type (rounds)	Shipped (rounds)	Left on Ship (rounds)	Left with Reserve Stock (rounds)	Returned after Gulf War (rounds)	Consumed in the Gulf (rounds)	DU used in Gulf (tons)
M900 (105mm)	2,314	0	0	1,810	504	2.14
M829 (120mm)	141,247	5,900	1,800	126,847	6,700	35.85
M829A1 (120mm)	89,473	0	0	87,125	2,348	12.56
Total	233,034	5,900	1,800	215,782	9,552	50.55

Accidents with DU weaponry

1998 Great Britain

On 8 February there was a fire at the Royal Ordnance Special Metal factory at Featherstone in Staffordshire. No data available about the amount of DU which has been released.

1991 Kuwait

Munitions fire US Army base Doha, Kuwait (July 1991). Around 3,500 kg of DU was released.

M60 series MBTs (all supplied by USA, except mentioned otherwise)

Figures from the SIPRI yearbooks 1988 – 1999

L: production under license (Taiwan and Egypt produces under US license)

(..): probable year of figure(s)

Bahrain		25 M-60A3	'91	'93	(25)
		27 M-60A3	'90	'90	27
		43 M-60A3	'90	'91	43
		50 M-60A3	'86	'87-'88	(50)
Bosnia H.		45 M-60A3	'96	'96	45
Brazil		91 M-60A3	'96		
Egypt.		340 M-60A3	'93		
		312 M-60A3	('90)	'90-'93	(312)
Greece	S: FRG	312 M-60A3	('90)	'90-'92	(253)
		359 M-60A3	('90)	'91-'92	(359)
Italy		10 M-60A1	'93	'93	10
Jordan		50 M-60A3	'95	'96	50
Morocco		120 M-60A3	'94	'94	120
		200 M-60A1	'90		
Oman		... M-60A3	'91	'91	27
Portugal		80 M-60A3	'91	'91	80
Saudi Arabia		150 M-60A3	'90	'94-'95	150
		100 M-60A3	'83	'88	100
Spain		260 M-60A3	'91	'92-'92	(260)
		160 M-60A1	'91	'92	(133)
Taiwan	L: USA	160 M-60A3	'91		
		200 M-60A3	'91	'95-'98	(160)
		160 M-60A3	'91	'95-'96	(160)
		470 M-60H	('84)	'85-'89	(470)
		(75) M-60A3	'84		
		(140) M-60A3	('85)		
Thailand		(101) M-60A3	'95	'95-'97	(101)
		300 M-60A1	'90	'91-'92	(300)
		(300) M-6-A1	'90	'93	(53)
Turkey		600 M-60A3	('90)	'92-'93	(600)
		(658) M-60A3	('91)	'93-'94	(658)
		164 M-60A1 MBT	('91)	'92-'93	(109)

M1/M1A1.M1A2 Abrams & Bradleys (all supplied by USA)

Egypt	L: USA L: USA	15 M1 31 M-1A1 499 M-1A1 31 M1A1	'88 '98 '88 '96	'90-'91 '97-'98 '92-'97 '97	15 (499) 31
Saudi Arabia		150 M-1 315 M-1A2 150 M-1 400 M-2 Bradley AIFV	'90 '90 '90 '90	'93-'94 second order '92-'94	315 (400)
Kuwait		218 M-1A2	'92	'95-'97	(218)

US Exports

Excess Defense Articles (EDA)

EDA Grants, EDA Sales, Drawdowns, Leases and Loans, FMS

TTS = with Tank Thermal Sight

FMS = Foreign Military Sales

country	item	year of transfer	quantity	source
Bahrain	M60A3 TTS	'94	1	EDA (internet) EDA (internet) EDA (internet)
	M60A3 TTS	'95	50 (lease)	
	M60A3 TTS	'98	60	
	M60 tank W/blade	'99	6	
Brazil	M60A3 TTS	'95	91 (lease)	
Egypt	M60A1	'90	700	GAO/NSIA-93-164FS Jane's, 17 Jul '93
	M60A3	'93	340	
Morocco	M60A1	'90	300	NSIAD-93-164FS/EDA BBS EDA (internet) EDA (internet) EDA (internet)
	M60A1	'93	60	
	M60A1	'94	120	
	M60A1	'97	7	
Oman	M60A3	'90	40	EDA BBS EDA (internet)
	M60A3 TTS	'98	?	
Taiwan	M60A3	'91	110	CR, 16 Sept '91, pH6600
Thailand	M60A3	'92?	50+	MilBal, 92-93 FMS FMS
	M60A3 TTS	'94	180	
	M60A3 TTS	'97	107	

Inventory of M60 series MBTs in 18 countries

Source: Jane's Armour and Artillery 1999-2000

Country	Model	Quantity	Comments
Austria	M60A3	168	
Bahrain	M60A3	180	includes 20 delivered in 1995
Bosnia	M60A3	45	delivered

Brazil	M60A3	91	deliveries underway
Egypt	M60A3	759	final deliveries 1987 (new)
	M60A1	700	ex-US Army delivery 1990-91
Greece	M60A1	357	from US Army
	M60A3	312	
Iran	M60A1	355	approx. 160 left
Israel	M60/M60A1/ M60A3	1,350	many local modifications
Jordan	M60A1/M60A 3	354	
Morocco	M60A1	60	
	M60A3	240	
Oman	M60A1	6	
	M60A3	73	
Portugal	M60A3	90	
Saudi Arabia	M60A3	460	
Spain	M60A3	260	154 + 106 TTS
	M60A1	50	
Sudan	M60A3	20	delivered in 1982, current status unclear
Taiwan	M60A3	360	delivered between 1994 and 1996
Thailand	M60A3	125	
	M60A1	53	

DU ammunition exports

Most important is to get insight in the proliferation of DU ammunition. Many tanks with 105 mm tank guns (M60 series MBT and their local variants) and 120 mm tank guns (M1A1, M1A2, Challenger, Leclerc, Leopard 2, etc.) can fire DU rounds, however, it is difficult to prove the presence of DU ammunition in the national inventories. Much more research has to be done in this field.

US exports of DU ammunition

Foreign Military Sales

Type	Amount	Destination	Source
105 mm M774	1,000	Taiwan	Jane's
	84,451	Turkey	Jane's
120 mm M833	300	Israel	Jane's
	2,130	Jordan	Jane's
	10,025	Pakistan	Jane's
	320	Saudi Arabia	Jane's
	22,920	Turkey	Jane's
120 mm M829A2 Contract was placed with Primex Technologies in June 1995	23,278	US Army	

Developments in Israel and Turkey

Outside the US, the Israeli Defence Force (IDF) is the largest user of the M60 series. As of 1993, they probably had about 1000 M60/M60A1 tanks and about 600 M60A3s. The Israeli designation of the M60 is the Magach-7. Israel has undertaken several upgrades of its Magach-7 fleet, which includes M60/M60A1s and the M60A3s. The 105 mm M68 rifled tank gun, made by Israel Military Industries (IMI), also fitted to most other Israeli tanks, like the Merkava Mk1. The Israeli made 105 mm tungsten APFSDS-T M111 round is claimed to be superior to the US M735.

The M68 main 105 mm gun is standard on all M60s, but also on the Centurions, and Merkavas Mk I and II of the Israeli tank fleet. Military analysts remarks that although the 105 mm main gun on the M60s was much smaller than the 155-mm gun on the T-62, and the 125-mm gun on the T-72, it was very effective against these targets at both long and short ranges. The M68 gun is locally produced by Israeli Military Industries (IMI), formerly TAAS Israel Industries Ltd.

The Israelis still retain the 105 mm main gun on the M60 series tank, but the turret is modified to be able to take the 120 mm gun if needed. The Israelis have been constantly improving their 105 mm rounds, so they are now almost as deadly as most 120mm rounds. The M111 "arrow " round is constantly being upgraded, and Israel has shown a third generation M111 round recently.

Panzergruppe, the monthly newsletter of the Washington Armour Club stated in their first issue of 1996: *"Israelis are reported developing a depleted uranium round which will probably be able to defeat the armour of almost any vehicle in any service in the Middle East. To accompany this new and improved gun, a new fire control system has been installed for greater accuracy at both shorter and longer ranges."*

On 3 September, 1999, IMI unveiled the "SABRA" – an upgraded M60A3 tank developed for the Israeli Army. The modernisation programme, includes, among others, the following systems:

- 120 mm gun system interoperable with NATO weapon systems and ammunition.
- Passive add-on ballistic protection, providing level against shape charges and kinetic energy projectiles.

On 26 June 2000 Jane's Defence Weekly's correspondent in Ankara reports Turkey's decision to open negotiations with Israel Military Industries (IMI) for the modernisation of its US-made M60A1 MBTs. Which brought Washington to propose that the project could be done by US companies under the Foreign Military Sales (FMS) programme.

"US Deputy Under-secretary of the Army for International Affairs Gayden Thompson has written to Ankara asking that US companies should be able to compete for the project. The Turkish Land Forces Command has also been urged to reconsider the long-standing US government offer to lease 96 General Dynamics Land Systems (GDLS) M1A1 MBTs." A senior GDLS source said "linking the modernisation project with an M1A1 lease would offer training and logistics benefits as its M60-2000 modernisation proposal involves the installation of M1A1 turrets." On 2 June 2000 the Turkish Defence Industries Under-secretariat (SSM) decided that IMI would be the sole source for the M60 modernisation programme. An SSM official stated that although the committee had decided to ask IMI to build a prototype, it did not mean that a decision to award the full contract to the Israeli firm had been made. Besides GDLS, also German firms like Krauss-Maffei Wegmann are competing in the M60 modernisation programme. The requests for proposals call for four prototypes and an initial production batch of 250 vehicles out of a planned total of 1,000.