# Uranium (Depleted)

By William S. Kirk[1]

Depleted uranium hexafluoride ($UF_6$), resulting from the enrichment of natural uranium for nuclear applications by the Department of Energy (DOE), was the sole source of uranium for nonenergy applications. The quantity of depleted $UF_6$ that can be made available greatly exceeds current demand. DOE converts some of the $UF_6$ to the tetrafluoride ($UF_4$ or greensalt) which is shipped to several domestic companies and a company in Canada for reduction to uranium metal for use in ordnance applications. This use is believed to account for about 90% of total consumption. Commercial sales of depleted $UF_6$ or $UF_4$ for use in containers for spent nuclear reactor residues, other radiation shielding applications, as counterweights and ballast for aircraft and ships, and in research, accounted for the remaining 10% of demand.

**Legislation and Government Programs.**—Depleted uranium, though less radioactive than the enriched product, is treated as a source material in the Code of Federal Regulations and is referred to in sections 10 CFR 40.25 and 10 CFR 110.23.[2]

## DOMESTIC PRODUCTION

DOE is the sole domestic processor of uranium to produce a uranium product that is enriched in the isotope uranium 235 ($U_{235}$) used for nuclear applications. About 4.5 tons of depleted $UF_6$, which still contains some $U_{235}$, is generated for each ton of commercial power reactor-grade enriched $UF_6$ produced. If a more enriched product is required, such as for weapons use, a considerably larger quantity of depleted uranium product is generated for each ton of the enriched product. Expressed as uranium equivalent, DOE, in 1977, generated 32,140 tons of depleted $UF_6$, 0.25% of which was the hexafluoride of $U_{235}$, and 526 tons of depleted $UF_6$, 0.30% of which was the hexafluoride of $U_{235}$. In 1977, 2,764 tons (uranium equivalent) of depleted $UF_6$ was converted by DOE to $UF_4$, 0.25% of which was the tetrafluoride of $U_{235}$.

## CONSUMPTION AND USES

Expressed as the uranium equivalent, 7,974 tons of depleted $UF_4$ was shipped in 1977 for eventual conversion to metal. Some 90% of depleted uranium metal is used in ordnance applications. Due to its high density and pyrophoricity, depleted uranium metal is used by the Army for 120-mm antitank ammunition, by the Air Force for 30-mm ammunition on the A-10 aircraft, and by the Navy in its Phalanx antimissile system. Depleted uranium metal ammunition is reported to be more effective than tungsten alloy ammunition. Depleted uranium metal is also used in making containers for spent nuclear reactor residues and other radiation shielding applications. Other uses are as ballast and counterweights on aircraft control surfaces and research.

## PRICES AND STOCKS

The price of depleted $UF_6$ charged by DOE since August 14, 1973, was $2.50 per kilogram, or about $1.25 per pound. The price of depleted uranium metal was about $2.50 per pound.

The yearend inventory of depleted $UF_4$, expressed as the uranium equivalent, held by DOE dropped 7% from 1976, from 79,085 to 73,423 tons. DOE stocks of depleted $UF_6$ rose 8.7% in the same period, from 180,466 to 196,205 tons. Depleted $UF_6$ held by DOE at the end of 1977 by assay was: 0.20% $U_{235}$, 76,417 tons; 0.25% $U_{235}$, 77,725 tons; 0.30% $U_{235}$, 42,063 tons.

## WORLD REVIEW

The United Kingdom had some 15,000 to 20,000 tons of depleted uranium in various forms on hand. The quantity of depleted $UF_6$ reported to be held by the Netherlands was several thousand tons. Data on stocks of depleted uranium products in other countries with enriching facilities, such as France and the Federal Republic of Germany, were not available.

## TECHNOLOGY

Uranium ore is mined and sent to milling plants where it is mechanically and chemically processed to upgrade the uranium content. The product from the milling plant is called yellow cake (uranium oxide or $U_3O_8$). The yellow cake is converted to $UF_6$, which is a gas at about 56°C at atmospheric pressure. The $UF_6$ is shipped to any one of three DOE enrichment facilities (Oak Ridge, Tenn., Paducah, Ky., or Portsmouth, Ohio), where it is enriched by a process known as gaseous diffusion. Gaseous diffusion operates on the principle that the average velocities of gas molecules at a given temperature depend on their molecular mass. The molecules of the lighter isotopes of uranium will contact the walls of a porous containment vessel more frequently than the molecules of the heavier isotopes. The molecules of the lighter isotopes will therefore diffuse through the containment vessel faster than those of the heavier isotopes. The barrier contains hundreds of millions of submicroscopic openings per square inch. The degree of enrichment in a single stage is very small, but the desired enrichment level is achieved by repeating the process through hundreds of stages arranged in cascade. A portion of the enriched $UF_6$ is shipped in 2-1/2-ton steel containers to facilities where it is converted to uranium oxide ($UO_2$) for use in power reactors. A portion of the depleted $UF_6$ is converted to $UF_4$ and reduced to depleted uranium metal by using magnesium metal.

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[2]U.S. Code of Federal Regulations. Title 10—Energy; Chapter I—Nuclear Regulatory Commission; Sections 40.25, 110.23, under General Licenses.