Particle Accelerators, 1990, Vol. 26, pp. 187–192
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HELIUM: CURRENT STATUS AND FUTURE OUTLOOK

WILLIAM B. FOWLER
Fermi National Accelerator Laboratory,* Batavia, Illinois, U.S.A.

Abstract Continuation of present activities and further developments in the application of superconductivity is crucially dependent on the continued availability of helium. Even the changes that are likely to occur due to the use of higher temperature superconductors will probably not effect the need for helium since in order to attain appropriate current carrying capacity in the new materials liquid helium temperatures may well be needed.

World wide use of helium in 1988 is estimated to have been 2.3 to 2.4 x 10^9 std. cubic feet; up from 2.1 x 10^9 scf estimated for 1987. The 1989 use is expected to expand by ~10%. On September 30, 1987 the date of the last report, 36 x 10^9 scf of helium was in the U.S. storage facility. One has to conclude that even with the estimated 10% annual increase in the use of helium ~10 years of product is in reserve. Using the simplest model where a constant recovery of helium from natural gas accounts for a portion of the yearly use one still finds the U.S. reserve exhausted by the year 2001. The crisis can only be avoided by a less than 10% yearly growth in use or by new extraction plants recovering more helium from natural gas use.

A major change has recently occurred when the former Reagan administration decided to sell the helium assets in an effort to reduce the U.S. budget deficit. The Bush administration and congress are in the process of reviewing this decision, and if they agree one could almost certainly forecast an immediate escalation in the price of helium currently ~$37/1000 scf before transportation costs are added.

Two new factors important to demand estimates are:

1. The interruption of the space shuttle program in January 1987 reduced the demand for helium by ~10 X 10^6 scf per launch. Now with the shuttle activity resumed and more non-manned rockets being used, substantial use by the space program is projected.
2. High energy physics applications continue to expand. The largest projected user will be the SSC Accelerator complex whose current design calls for a total inventory of 52 x 10^6 scf. Projected loss rate is 1/4 of this per year.

A critical review will be presented covering the trends in other uses, estimation of reserve depletion and availability of new plants utilizing new sources. This will include an estimate of the onset of the crisis in availability and cost of helium.

To the accelerator scientist helium is a material that is used in accomplishing the technical objectives in which he or she is involved, much like electrical power. In fact only a fraction of accelerator specialists directly use helium in activities such as high vacuum leak checking, RF superconducting cavities and superconducting accelerator magnets. Even so if the supply of helium were to be cut off almost all of the world's accelerator labs would be immobilized and the future would be extremely bleak in such activities' as the United States SSC and Cern's LHC projects.

* Operated by Universities Research Association, Inc., under contract with the U.S. Department of Energy.

Helium was first detected by the observation of it's optical spectral lines during the solar eclipse of 1869. Consequently it's name comes from Helios the greek name for the sun. It was not until 1895 when Sir William Ramsey reported traces of helium from radioactive material subjected to high temperature that the lightest of the Nobel gases was observed on earth. But the more important development, the discovery of large percentages of helium in some natural gas wells had to wait until 1905. H.P. Cady of the University of Kansas was studying the lower than normal heating resulting from burning gas from a natural gas well in Dexter, Kansas and came up with the surprising result that approximately two percent of the gas was helium. This made possible the production of large quantities of helium by separating it from the natural gas. During World War I a program was initiated to produce helium gas for lighter-than-air craft i.e. observation balloons and dirigibles. Although not utilized to any great extent due to the end of the war, the feasibility of production of large quantities of helium at an acceptable cost was demonstrated.

Figure 1 shows the U.S. Helium Sales for the years 1925-1989 where 1987

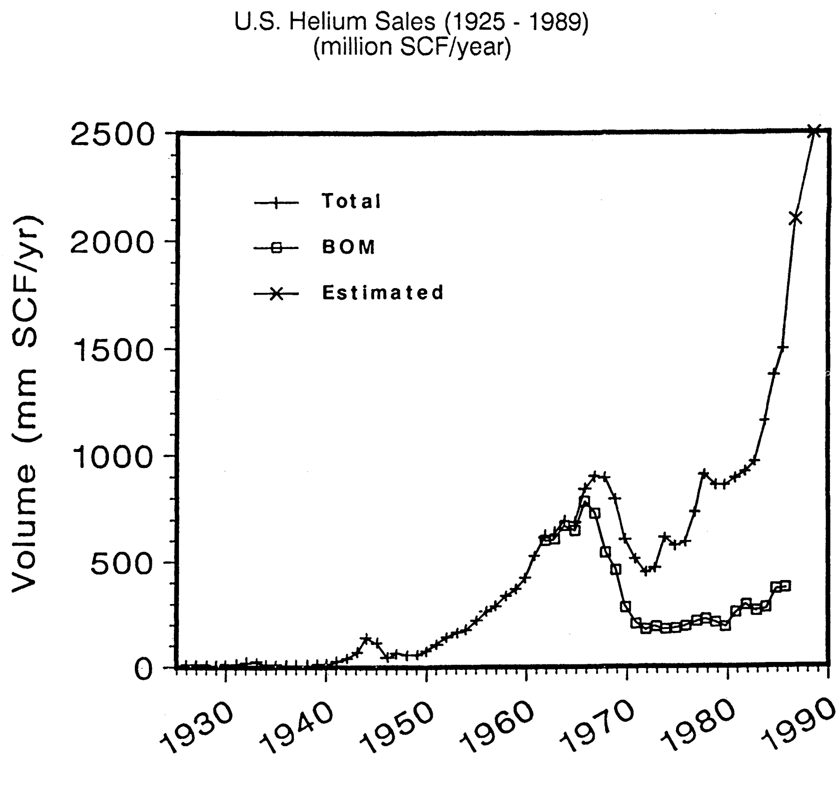

FIGURE 1. Adopted from a figure in Helium Program Study, Bureau of Mines U.S. Department of Interior by J.R. Campbell and Associates, March 1988.

and 1989 are estimates. Gross features of this graph are related to World War II (1941-1945), post World War II technology progress such as heliarc welding, U.S. Apollo program 1960-1968, phase down of NASA efforts 1969-1972, and finally a growth that is broadly based.

Official records are kept by the Bureau of Mines of the U.S. Department of Interior and each year in the Minerals Yearbook detailed data is presented. The most recent issue is 1986. Figure 2 shows estimated helium consumption by use. The category cryogenics includes superconducting accelerators and magnetic resonance imaging magnets which have contributed to the growth in the last few years.

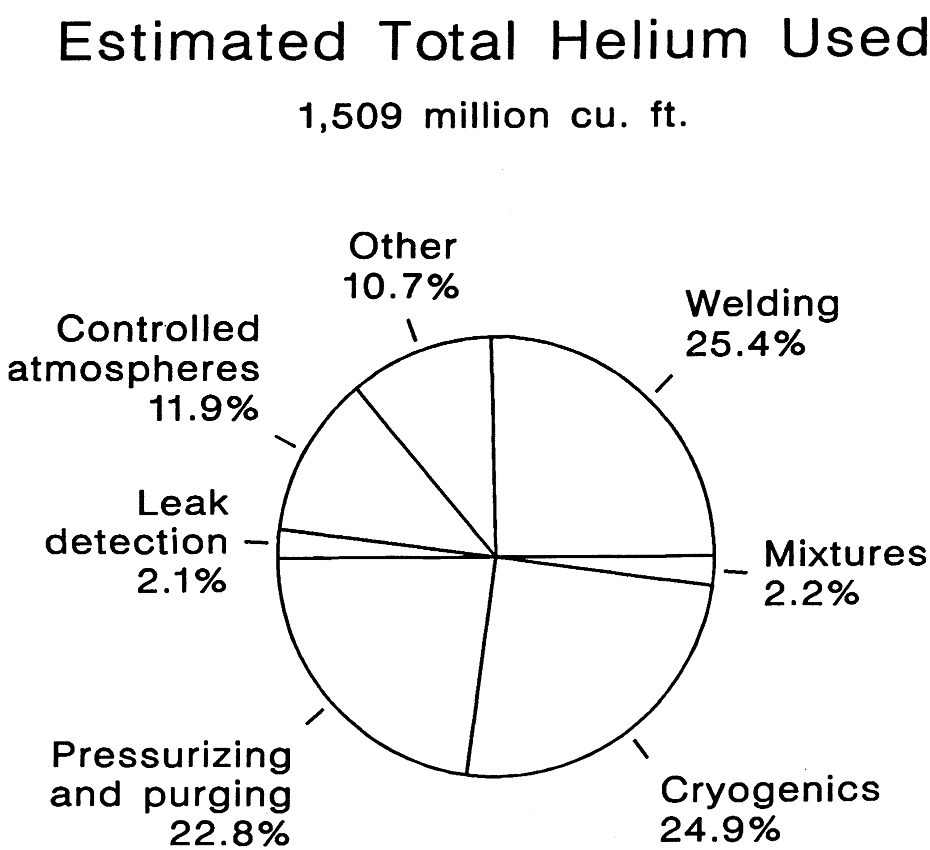

FIGURE 2. Estimated helium consumption in the United States in 1986, by end use (million cubic feet). From the Department of Interior Minerals Yearbook (1986)

Another growth area is the use of helium for the preparation of breathing mixtures for use in deep sea diving in particular for oil and gas platforms in the North Sea. An example of how future activities might compare to present can be seen in Table I where the helium inventory of Fermilab's Tevatron accelerator is listed along side of the proposed SSC collider. As the conceptual design report for the SSC emphasizes "Handling the inventory prudently is a major consideration for the SSC, and its systems must be designed with this in mind."

TABLE I Helium Inventory

	Tevatron		SSC
Magnets	20,000 liters		1,450,000 liters
Other ring Components	2,000 liters		200,000 liters
Transfer Lines	10,000 liters		70,000 liters
Storage Tanks	18,000 liters		200,000 liters
		Margin	80,000 liters
	50,000 liters		2,000,000 liters

Fermilab's Tevatron is a low pressure system and losses amount to approximately one inventory per month of operation. The SSC inventory value of about $3,500,000 means that a much lower loss rate is needed and therefore a high pressure capability is part of the design. This along with closer attention to components should result in a low loss rate.

Several new factors are important in assessing the future availability of helium. The traditional source of helium has been since the 1920's the Hugoton-Panhandle gas field in Texas, Oklahoma and Kansas. This field is shown in Figure 3 taken from the Department of Interior Mineral's Yearbook (1986). This field was estimated to originally contain $4X10^{11}$ cf of helium. A wise group of scientist, engineers, conservationists and Bureau of Mines staff persuaded the congress to arrange for the separation and storage of $40X10^{9}$ scf of helium before it was lost and before the program was terminated in 1971 due to financial problems. Even though some of the stock pile has been drawn down on the latest reporting date Sept. 30, 1987, 36.0 Billion cubic feet was in storage.

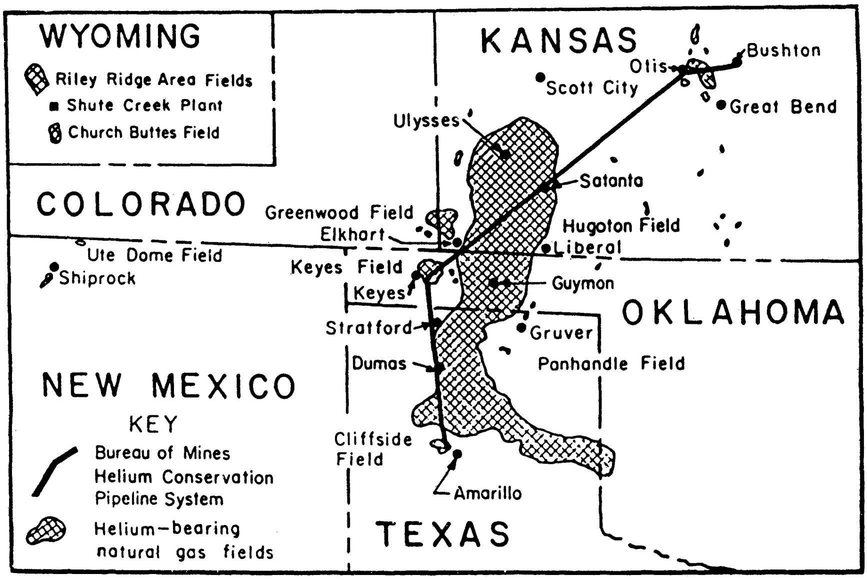

FIGURE 3. Major U.S. helium-bearing natural gas fields.

The Hugoton-Panhandle field continues to supply natural gas with most of the recovery plants shutdown and consequently most of the remaining helium being lost. Some correction to this problem was forth coming when on June 1, 1989, Panhandle Eastern Crop. and Air Products and Chemical, Inc. announced a new program. They plan to build new equipment to be installed at Liberal, Kansas which will extract 800 million cubic feet per year of crude helium (i.e. 50% or more helium and the rest nitrogen). Construction has begun and operations are scheduled for the fall of 1990.

Already we have seen some decrease dependence on the Hugoton-Panhandle field with the development of an over thrust belt natural gas field in Wyoming. During the period that the conservation program was being approved (1960) it was emphasized, that no new major helium-bearing natural gas fields had been discovered in the U.S. for almost 20 years even though 700,000 new gas wells had been drilled and tested for helium.

From 1961 through 1965 the U.S. Bureau of Mines tested an additional 2300 well samples without finding significant helium content. In 1965 the situation dramatically changed when the Mobil Oil Corp. drilled a new well in Southwest Wyoming which showed substantial quantities of helium. This field called Riley Ridge has now been developed by Exxon Corp. The initial helium production occurred in Oct. 1986. The facility is composed of two parallel plants, each of which has the capacity to process $240X10^9$ cf per day of Riley Ridge gas from which $1.5X10^9$ cf of helium is captured. Essentially all of the $3X10^9$ cf of helium produced by the two plants is liquefied into ~10,000 gal. transport trailer for delivery world wide. The liquid is either used directly or regasified and compressed into gas bottles depending on the need. No formal estimate exists for the reserves in Wyoming however there seems to be some basis for the statement that at the present use the gas field will only have lost 5 to 10% of it's helium content in a 20 year period.

From this summary one is perhaps over confident that there is plenty of helium gas available for accelerator applications well into the future. For a more complete discussion see E.H. Hammel, M.C. Krupka and K.D. Williamson Jr. paper in the Proceeding of the XI International Cryogenic Engineering Conference, p. 6 Berlin 1986.

Another development has surfaced recently which will likely affect world wide availability of Helium. In Chemical Week, August 2, 1989 the following report. "ALGERIAN He, MTBE VENTURES, Chemical projects figure high in the Algerian government's push to bring in foreign investment to help develop projects based on natural resources. Extraction of helium from Algeria's natural gas liquefaction plants- a long proposed project is back in serious discussion. potential partners include Air Products and L'Air Liquide. Algerian helium would supplement supplies to Western Europe, now obtained from Poland." W.K. Kellog, Inc. is designing this facility and negotiations are said to be in the final stage with a formal announcement within weeks.

In the U.S. current plans are to conserve the $37X10^9$ cf reserve and let private gas companies supply all of the product. Legislation has been submitted to congress to carry out this program with a three year transition period.