HELIUM

By Joseph B. Peterson

Grade-A helium (99.995% or better) sales volume in the United States by private industry and the U.S. Bureau of Mines (USBM) was 68.4 million cubic meters [2,466 million cubic feet (MMcf)] in 1995.[1] Grade-A helium exports by private producers were 27.7 million cubic meters (999 MMcf) for total sales of 96.1 million cubic meters (3,465 MMcf) of U.S. helium, about 4.3% less than in 1994. The USBM price for Grade-A helium, f.o.b. plant, was $1.983 per cubic meter [$55 per thousand cubic feet (Mcf)], and bulk liquid helium was $2.524 per cubic meter ($70 per Mcf) on January 1, 1995, with additional costs for container services and rent.

Legislation and Government Programs

The Federal Helium Program is designed to provide all Federal agencies with current and estimated future helium needs to carry out other Government programs authorized and funded by Congress. The USBM major helium customers were the Department of Defense (DOD), the National Aeronautics and Space Administration (NASA), and the Department of Energy (DOE).

In accordance with the Vice President's National Performance Review (NPR), the Federal Helium Program is being reengineered to run more efficiently. NPR suggestions to discontinue nonrevenue-producing functions and increase efficiencies of helium operations have been implemented into the operation of the Helium Program. In addition, implementation continues on other streamlining and revenue enhancing suggestions for Helium Field Operations.

Proposed legislation has been introduced in subcommittees of the 104th Congress that would dramatically affect the Federal Helium Program. This legislation contains variations of the following points:

- Cease production and sales of Grade-A helium, allowing Federal customers to purchase helium from private industry;
- Dispose of all helium production, refining, and sales-related assets;
- Sell crude helium from the helium reserve in an orderly manner;
- Continue operation of the helium storage system, which includes the storage field and the pipeline system, for storage and distribution of both government-owned and privately owned crude helium;
- Continue contracting for helium extraction on federal lands; and
- Repayment of the helium debt by 2015 using a cost recovery program based on sales of government-owned crude helium to private companies.

In September 1995, the USBM was slated for closure effective January 1996. Minerals information and analysis functions were transferred to U.S. Geological Survey, and Helium Field Operations was transferred to U.S. Bureau of Land Management.

Production

In 1995, 19 privately owned domestic helium plants were operated by 14 companies. Thirteen of the privately owned plants and the USBM plant extracted helium from natural gas. All extraction plants except two use cryogenic extraction processes. The volume of helium recovered from natural gas decreased 10.0%, while total sales of U.S. produced helium decreased about 4.3% in 1995. All natural gas processed for helium recovery came from gasfields in Colorado, Kansas, Oklahoma, Texas, Utah, and Wyoming. Ten private plants and the USBM plant purified helium this year. Pressure-swing adsorption is used for helium purification at 8 of the 10 private helium plants and at the USBM plant. The USBM also used cryogenic purification for backup. The USBM and eight private plants that produce Grade-A helium also liquefy helium. The plant operators and locations are Air Products and Chemicals Inc., Hansford County, TX, and Liberal, KS; BOC Gases Inc., Otis, KS; Exxon Co., U.S.A., Shute Creek, WY; Keyes Helium, Keyes, OK; Praxair, Inc., Bushton and Ulysses, KS; and Unocal, Moab, UT. Nitrotec's helium plants near Burlington, CO, and near Cheyenne Wells, CO, produce Grade-A helium but do not liquefy it. (*See tables 1, 2, and 3, and figures 1 and 2*.)

Domestic production data for helium were developed by the USBM from records of its own operations as well as the High Purity Helium Survey, a single, voluntary canvass of private U.S. operations. Of the seven operations to which a survey request was sent, 100% responded, and those data plus data from USBM operations represent 100% of the total helium sales and recovery shown in table 2.

Domestic measured and indicated helium resources as of January 1, 1994, (the latest figures available) are estimated to be 13.0 billion cubic meters [469 billion cubic feet (Bcf)]. The resources include measured reserves and indicated resources estimated at 6.7 billion cubic meters (241 Bcf) and 0.9 billion cubic meters (32 Bcf), respectively, in natural gas with a minimum helium content of 0.3%. The measured reserves included nearly 1 billion cubic meters (34 Bcf) stored by the USBM in the helium conservation storage system. Measured helium resources in natural gas with a helium content of less than 0.3% are estimated to be 1.3 billion cubic meters (46 Bcf).

Indicated helium resources in natural gas with a helium content of less than 0.3% are estimated to be 3.9 billion cubic meters (140 Bcf). Approximately 4.4 billion cubic meters (157 Bcf) or 91% of the domestic helium resources under Federal ownership are in the Riley Ridge area and the Church Buttes Field in Wyoming and in the Cliffside Field in Texas.

Most of the domestic helium resources are in the midcontinent and Rocky Mountain regions of the United States. The measured helium reserves are in approximately 102 gasfields in 11 States. About 86% of these reserves is contained in the Hugoton Field in Kansas, Oklahoma, and Texas; the Keyes Field in Oklahoma; the Panhandle and Cliffside Fields in Texas; and the Riley Ridge area in Wyoming. The USBM analyzed a total of 49 natural gas samples from 16 States during 1995 in conjunction with its program to survey and identify possible new sources of helium.

Consumption

The major domestic end uses of helium were cryogenics, welding, and pressurizing and purging. Minor uses included synthetic breathing mixtures, chromatography, leak detection, lifting gas, heat transfer, and controlled atmospheres. (*See figure 3.*) The Pacific and Gulf Coast States were the principal areas of helium consumption.

The USBM sales to Federal agencies and its contractors totaled 7.21 million cubic meters (260 MMcf) in 1995, an increase of 9.2% when compared with the prior year's sales. The Federal agencies purchase its major helium requirements from the USBM. Direct helium purchases by DOD, NASA, and DOE constituted most of the USBM Grade-A helium sales. Most remaining helium sales to Federal agencies were made through USBM contract distributors, who purchased equivalent volumes of USBM helium under contracts described in the Code of Federal Regulations (30 CFR 602). Some of the contract distributors also have General Services Administration helium supply contracts. These contracts make relatively small volumes of helium readily available to Federal installations at lower freight charges by using the contractors' existing distribution systems.

Estimated 1995 domestic consumption by end use was based on a 1991 domestic end-use survey conducted to determine the trends in helium usage.[2] The information from that survey showed that welding, pressure/purging, lifting gas, leak detection, and inert atmosphere applications were the leading usages of gaseous helium. Magnetic resonance imaging applications dominated liquid helium usage. (*See figure 3.*)

Stocks

The volume of helium stored in the USBM helium conservation storage system, including the conservation pipeline network and Cliffside Field, totaled 965 million cubic meters (34.8 Bcf) at yearend. The storage system contains crude helium purchased under contract by the USBM from 1962 to 1973 and privately owned helium stored under contract. Excess private helium is extracted from natural gas supplying fuel markets and stored by the USBM under contract. This privately owned crude helium is returned to the owners as needed for purification to supply private demand. During 1995, 36.1 million cubic meters (1,301 MMcf) of private helium was delivered to the USBM's helium conservation storage system and 23.2 million cubic meters (836 MMcf) was withdrawn for a net increase of 12.9 million cubic meters (465 MMcf) of private helium in storage. (*See table 4.*)

Transportation

All Grade-A gaseous helium sold by the USBM was shipped in modules (large gas cylinders), special railway tankcars, or highway tube semitrailers from either Amarillo or Exell plants. USBM liquid helium was shipped in dewars and semitrailers from the Exell plant. Private producers and/or distributors shipped helium predominantly as a liquid in semitrailers. These semitrailers delivered the liquid helium to distribution centers where some of it was gasified and compressed into trailers and small cylinders for delivery to the end user. The remaining liquid helium was sold as bulk liquid or repackaged in dewars of various sizes for delivery.

Prices

The USBM price for Grade-A helium, f.o.b. plant, was $1.983 per cubic meter ($55 per Mcf) and bulk liquid helium was $2.524 per cubic meter ($70 per Mcf) on January 1, 1995, with additional costs for container services and rent.

Foreign Trade

Exports of Grade-A helium, all by private industry, increased by 10.8% in 1995 to 27.7 million cubic meters (999 MMcf). (*See table 3.*) About 30% of the exported helium was shipped to Europe. Belgium, France, Germany, and the United Kingdom, collectively, received about 93% of the European exports. About 43% of the U.S. helium exports went to Asia, with Japan receiving about 86%. Other exports were as follows: about 10% to North America; about 1% to Australia-New Zealand, 4% to the Middle East; 6% to South America; 3% to Central America; about 1% to Africa; and the remainder to the Caribbean. Shipments of large volumes of helium to Western Europe were attributed to helium uses in cryogenic research and superconducting applications. Significant volumes also were used in breathing mixtures for diving, welding, and as a lifting gas. Although no helium was imported by the United States in 1995, import tariffs on helium remained at the 3.7% rate for most favored nations established on January 1, 1987. The non-most-favored-nation tariff also remained unchanged at 25%. No changes in import tariffs are scheduled at this time.

World Review

World production capacity of helium, excluding the United

States, was estimated to be 29 billion cubic meters (1,045 MMcf). Most of the helium produced outside of the United States was extracted in Russia and Poland. The remainder was produced in small plants in China and India. A new plant in Algeria has doubled non-U.S. helium production capacity. However, political concerns in the region may delay production schedules. Once fully operational, the Algerian plant is expected to decrease current levels of U.S. exports to Europe and Asia. (*See table 5.*)

Current Research and Technology

Technology that uses liquid helium to produce superconducting temperatures continues to be developed and utilized. Liquid helium continues to be used at Fermi National Accelerator Laboratory for Tevatron/Tevatron 1, which was the world's first superconducting particle accelerator. The liquid helium-cooled superconducting magnets used in this accelerator provide an intense and extremely steady magnetic field using only a fraction of the energy required by conventional electromagnets. The Tevatron is presently the second most energetic particle accelerator in the world (1.6 trillion electron volts).

Argonne National Laboratory is developing magneto-hydrodynamic (MHD) propulsion system for military and commercial use. This system has no moving parts, but uses magnetic fields and electricity to pump water through a tube. Researchers at Argonne used the world's largest liquid-helium-cooled superconducting dipole magnet to study this propulsion system. One benefit of this research has been the development of multi-dimensional MHD computer codes for analyzing flow development in and performance of MHD systems. Development of MHD technology could lead to a new generation of water transportation vessels that would travel more quickly, quietly, and efficiently than present ships.

Liquid helium use in magnetic resonance imaging (MRI) continues to increase as the medical profession develops new uses for this equipment. The MRI equipment is providing accurate diagnoses of medical problems where exploratory surgery was previously required. Another medical application being developed uses MRI to determine through blood analysis if a patient has any form of cancer. Most researchers seem to think it will be at least 4 to 8 years before uses of the new high-temperature (about -184° C or -300° F) superconducting materials affect liquid helium demand.

Lifting gas applications are increasing. The U.S. Navy and U.S. Air Force are investigating the use of airships to provide early warning systems to detect low-flying cruise missiles. The Drug Enforcement Administration has installed six tethered radar blimps along the southern border of the United States to detect drug smugglers. U.S. Border Patrol agents plan to use blimps to detect illegal aliens entering the United States. In addition, NASA is using helium-filled balloons to sample the atmosphere in Antarctica to determine what is depleting the ozone layer that protects the Earth from harmful ultraviolet radiation, and to obtain information on early structures in the universe. In the commercial market, several companies in addition to Goodyear continue using "blimps" for advertising.

The development of Strategic Defense Initiative (SDI) weapons such as the antisatellite (ASAT) rocket, chemical laser, and rail gun has slowed with the decline in national defense spending. However, the United States and Russia are joining together to build a nuclear reactor that will destroy the plutonium stockpiles at the Tomsk-7 production facility in Russia and to produce electricity for the district. Helium coolant sent through the reactor core will pick up heat energy from the fuel rods and transfer that energy directly to a turbogenerator to generate electricity. If successful, the helium-cooled reactor could become an important alternative energy source in the future. Superconducting magnetic energy storage (SMES) also is being investigated to provide power for laser systems and electric power peak shaving in commercial applications. SMES allows the accumulation and storage of electrical energy over the long term (hours) when excess capacity is available and discharges it in minutes or as needed to provide for peak demands. Some small commercial units are already in service.

Other evolving technologies that require the unique properties of helium are (1) metastable helium for energy storage, which involves raising helium electrons to an excited energy state and then stabilizing the atom there; (2) fiber-optic production, where an ultra pure inert atmosphere is required; (3) helium ion tumor treatment, where large inert particles are required; (4) liquid helium-cooled superconducting microswitches, called Josephson junctions, which are much faster than conventional semiconductors and use less power; (5) "Aneutronic" nuclear fusion, where nuclear energy is produced by fusion of deuterium and helium-3, results in few or no neutrons; and (6) helium-hydrogen breathing mixtures that enable deep-sea divers to reach depths below 580 meters (1,700 feet).

Outlook

The total market for U.S. produced helium decreased 4.3% from 1994 sales level. Consequently, the market growth rate has flattened to 1.75% for the 5-year period 1991-95. In addition, market growth rate for private industry helium has fallen to 2.5% for the 5-year period 1991-95.

In 1995, private industry supplied about 89.5% of the domestic demand, while the Federal government supplied the remaining 10.5%. Helium exports increased 10.8% from that of 1994, accounting for 28.8% of U.S. produced helium sales. Private industry supplied all of the U.S. helium exports. The outlook for helium remains slow in the Federal sector with cutbacks and elimination of programs that use large volumes of helium. Helium sales in the private sector are expected to continue moderate growth over the next 3 years. Use of high-temperature superconductor materials in electric motor windings and innovative applications of supercritical/cryogenic processing is expected to increase helium demand.

[1]All metric helium volumes herein reported are at 101.325 kilopascals absolute (14.696 psia) and 15° C (59° F). Helium volumes, reported in parentheses following metric units, are measured in cubic feet at 14.7 psia and 70° F. One thousand cubic feet (1 Mcf) at 14.7 psia and 70° F = 27.737 cubic meters at 101.325 kilopascals absolute and 15° C. One cubic meter at 101.325 kilopascals and 15° C = 36.053 ft^3 at 14.7 psia and 70° F.

[2]Currently undergoing study to update end-use data.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Helium. Ch. in Mineral Commodity Summaries, annual.

Information Circular 9129, Analyses of Natural Gases, 1917-85, by B. J. Moore and S. Sigler.

Information Circular 9301, Analyses of Natural Gases, 1986-90, by J. E. Hamak and S. Sigler.

Information Circular 9318, Analyses of Natural Gases, 1991, by J. E. Hamak and B. D. Gage.

Information Circular 9356, Analyses of Natural Gases, 1992, by J. E. Hamak and S. Sigler.

Information Circular 9342, Helium Resources of the United States, 1991, by J. E. Hamak and B. D. Gage.

Information Circular 9400, Analyses of Natural Gases, 1993, by S. Sigler.

TABLE 1
OWNERSHIP AND LOCATION OF HELIUM EXTRACTION PLANTS
IN THE UNITED STATES IN 1995

Category and owner or operator	Location	Product purity
Government-owned:		
U.S. Bureau of Mines	Masterson, TX	Grade-A helium 1/
Private industry:		
Air Products Helium, Inc.	Hansford County, TX	Do.
Do.	Liberal, KS	Do.
BOC Gases	Otis, KS	Do.
Enron Helium Co.	Bushton, KS	Crude helium
Exxon Co., U.S.A.	Shute Creek, WY	Grade-A helium 1/
GPM	Dumas, TX	Crude helium 2/
Do.	Hansford County, TX	Do.
Keyes Helium Company	Keyes, OK	Grade-A helium 1/
KN Energy, Inc.	Scott City, KS	Crude helium 3/
Maxus Energy Corp.	Sunray, TX	Do.
Mesa, Inc.	Fain, TX	Do.
Do.	Satanta, KS	Do.
National Helium Corp.	Liberal, KS	Do.
Nitrotec	Burlington, CO	Grade-A helium
Do.	Cheyenne Wells, CO	Do.
Praxair, Inc.	Bushton, KS	Do. 1/
Do.	Elkhart, KS	Deactivated
Do.	Ulysses, KS	Grade-A helium 1/
Trident NGL, Inc.	do.	Crude helium
Unocal	Moab, UT	Grade-A helium 1/

1/ Including liquefaction.
2/ Closed Dec. 1995.
3/ Output is piped to Ulysses, KS, for purification.

TABLE 2
HELIUM RECOVERY IN THE UNITED STATES 1/ 2/

(Thousand cubic meters)

	1991	1992	1993	1994	1995
Crude helium:					
U.S. Bureau of Mines total storage	(9,550)	(9,360)	(8,850)	(7,200)	(7,600)
Private industry:					
Stored by U.S. Bureau of Mines	26,600	25,300	29,600	38,800	36,100
Withdrawn	(18,100)	(17,900)	(16,400)	(19,500)	(23,200)
Total private industry storage	8,500	7,400	13,200	19,300	12,900
Total crude helium	(1,050)	(1,960)	4,350	12,100	5,300
Stored private crude helium withdrawn from storage and purified by the U.S. Bureau of Mines for redelivery to industry	(613)	(510)	(638)	(610)	(69)
Grade-A helium:					
U.S. Bureau of Mines sold	9,400	8,630	7,930	6,610	7,210
Private industry sold	78,700	85,800	87,600	93,800	88,900
Total sold	88,100	94,400	95,500	100,000	96,100
Total stored	(1,660)	(2,470)	3,710	11,500	5,230
Grand total recovery	86,400	91,900	99,200	112,000	101,000

1/ Negative numbers are enclosed in parenthesis ( ) to denote net withdrawal from the USBM underground storage facility, a partially depleted natural gas reservoir in Cliffside Field near Amarillo, TX.
2/ Data rounded to three significant digits; may not add to totals shown.

TABLE 3
TOTAL SALES OF GRADE-A HELIUM PRODUCED
IN THE UNITED STATES

(Million cubic meters)

	Volume		
Year	Domestic sales	Exports 1/	Total sales
1991	61.0	27.1	88.1
1992	63.7	30.7	94.4
1993	67.6	28.0	95.6
1994	75.4	25.0	100.4
1995	68.4	27.7	96.1

1/ Source: Bureau of the Census.

TABLE 4
SUMMARY OF U.S. BUREAU OF MINES HELIUM CONSERVATION STORAGE SYSTEM OPERATIONS 1/ 2/

(Thousand cubic meters)

	1993	1994	1995
Helium in conservation storage system at beginning of period:			
Stored under U.S. Bureau of Mines conservation program	894,000	885,000	878,000
Stored for private producers under contract	56,100	68,700	87,500
Total	950,000	954,000	965,000
Input to system:			
Net deliveries from U.S. Bureau of Mines plants 3/	(8,850)	(7,200)	(7,600)
Stored for private producers under contract	29,600	38,800	36,100
Total	20,800	31,600	28,500
Redelivery of helium stored for private producers under contract 3/	(17,000)	(20,000)	(23,200)
Net addition to system 3/	3,780	11,500	5,300
Helium in conservation storage system at end of period:			
Stored under U.S. Bureau of Mines conservation program	885,000	878,000	870,000
Stored for private producers under contract	68,700	87,500	100,000
Total	954,000	966,000	970,000

1/ Crude helium is injected into or withdrawn from the USBM underground storage facility, a partially depleted natural gas reservoir in Cliffside Field near Amarillo, TX.

2/ Data rounded to three significant digits; may not add to totals shown.

3/ Numbers in parentheses indicate net withdrawl from storage.

TABLE 5
WORLD GRADE-A HELIUM PRODUCTION
CAPACITY, DECEMBER 31, 1995

(Million cubic meters)

	Capacity
United States 1/	114
Rest of world e/	29
Total e/	143

e/ Estimated.

1/ Includes capacity of plants on standby as well as operating plants.

Figure 1

HELIUM RECOVERY IN THE UNITED STATES

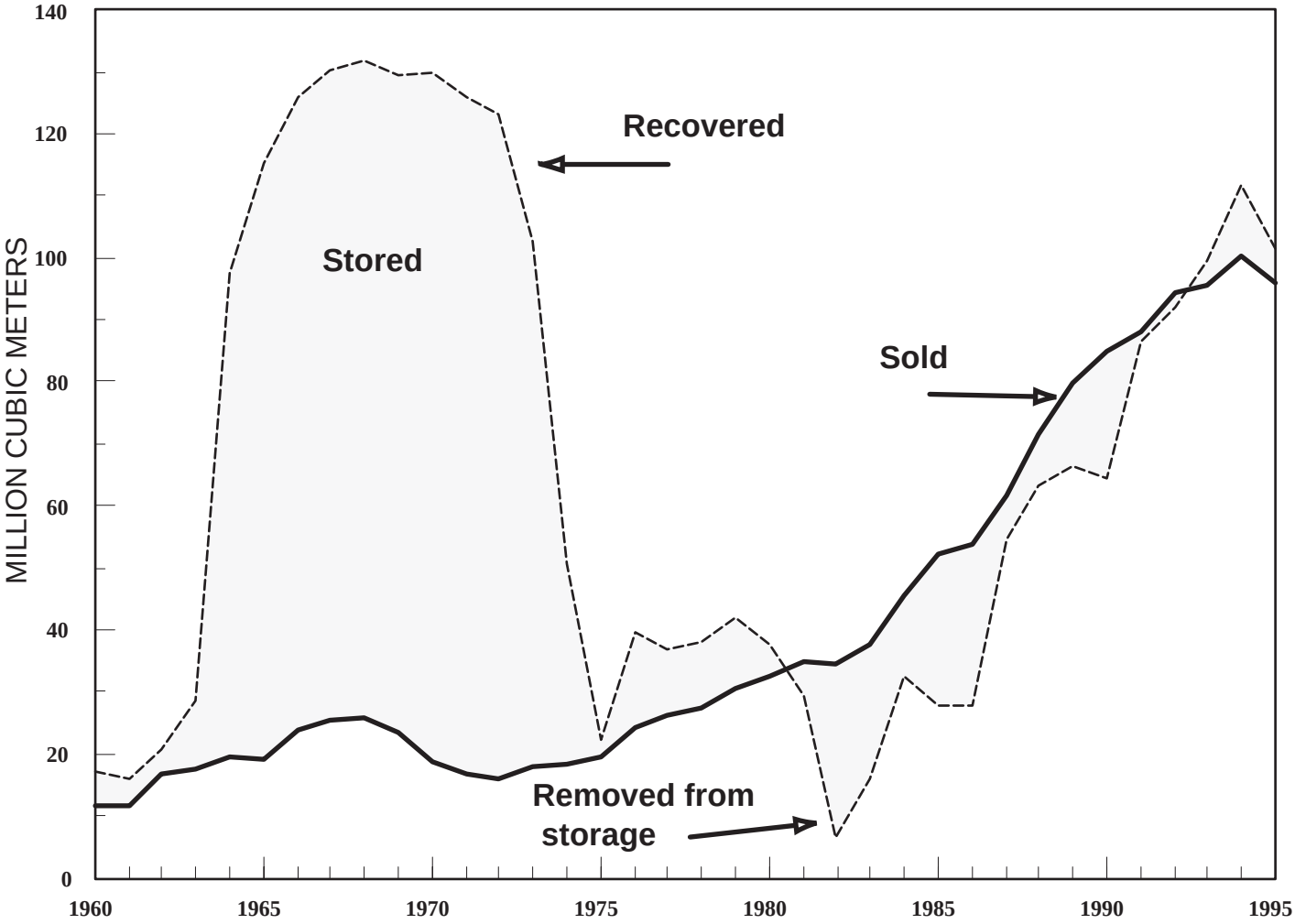


FIGURE 2

MAJOR U.S. HELIUM-BEARING NATURAL GAS FIELDS

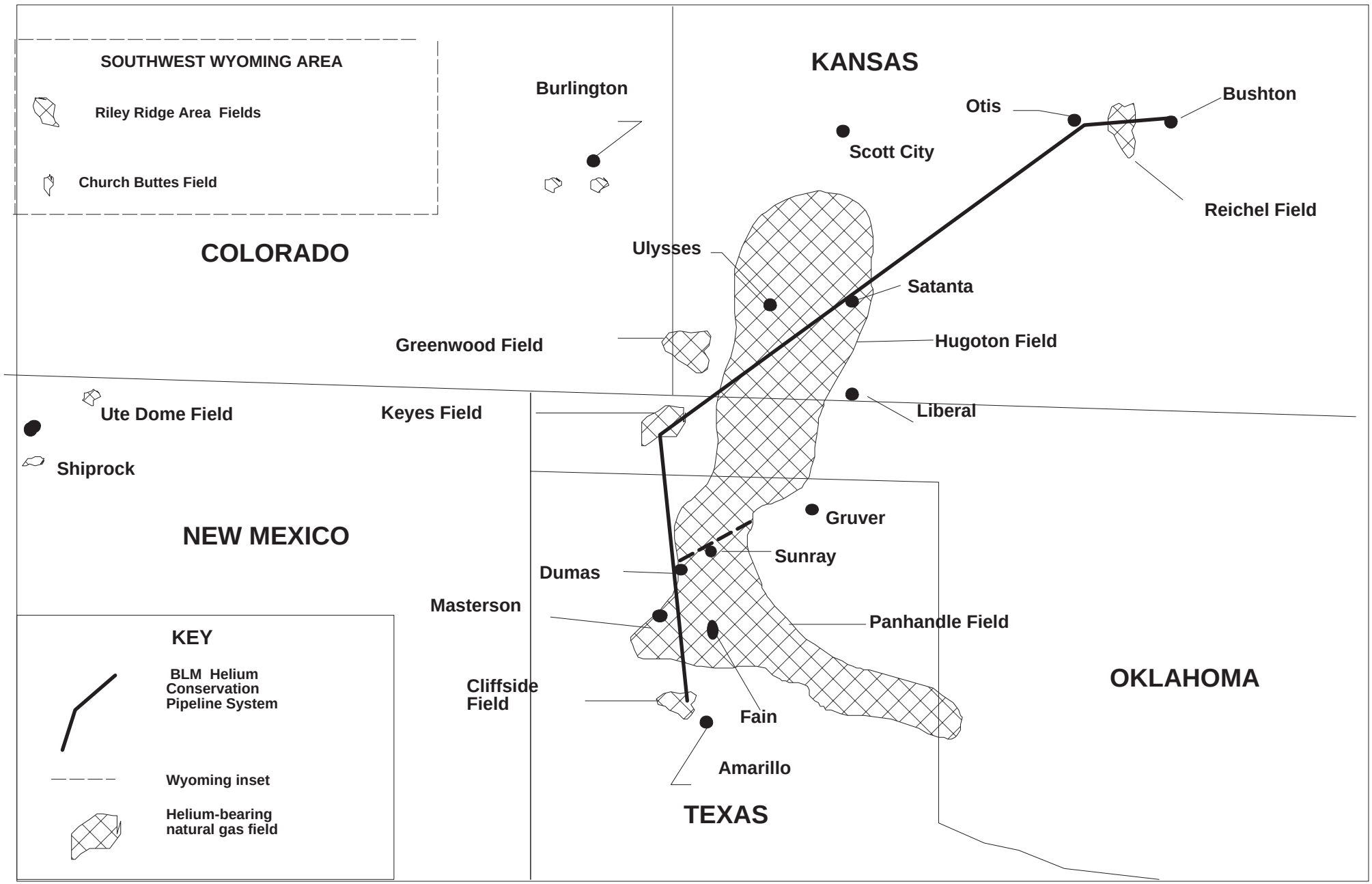
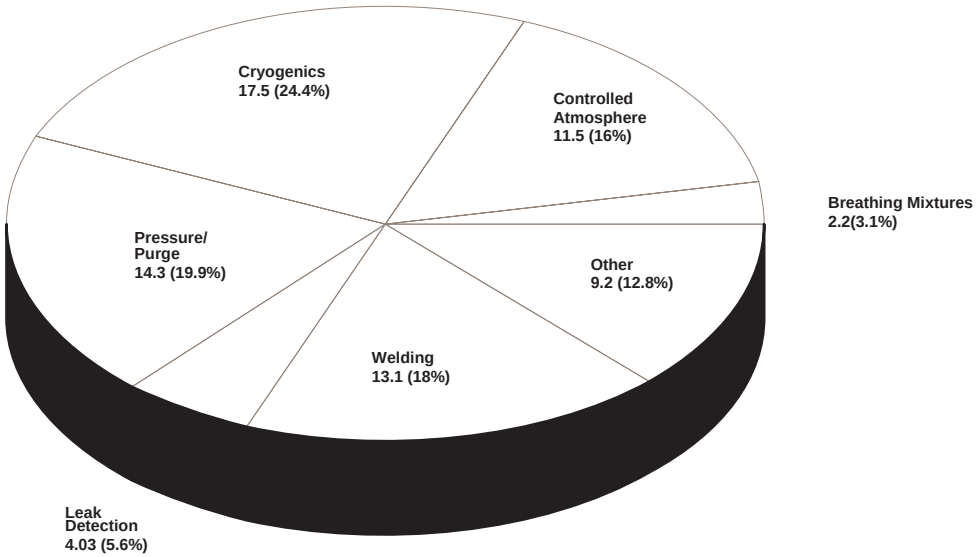


FIGURE 3
ESTIMATED HELIUM CONSUMPTION, BY END USE, IN THE UNITED STATES IN 1995
(Million cubic meters)



Estimated total helium used
(68.4 million cubic meters)