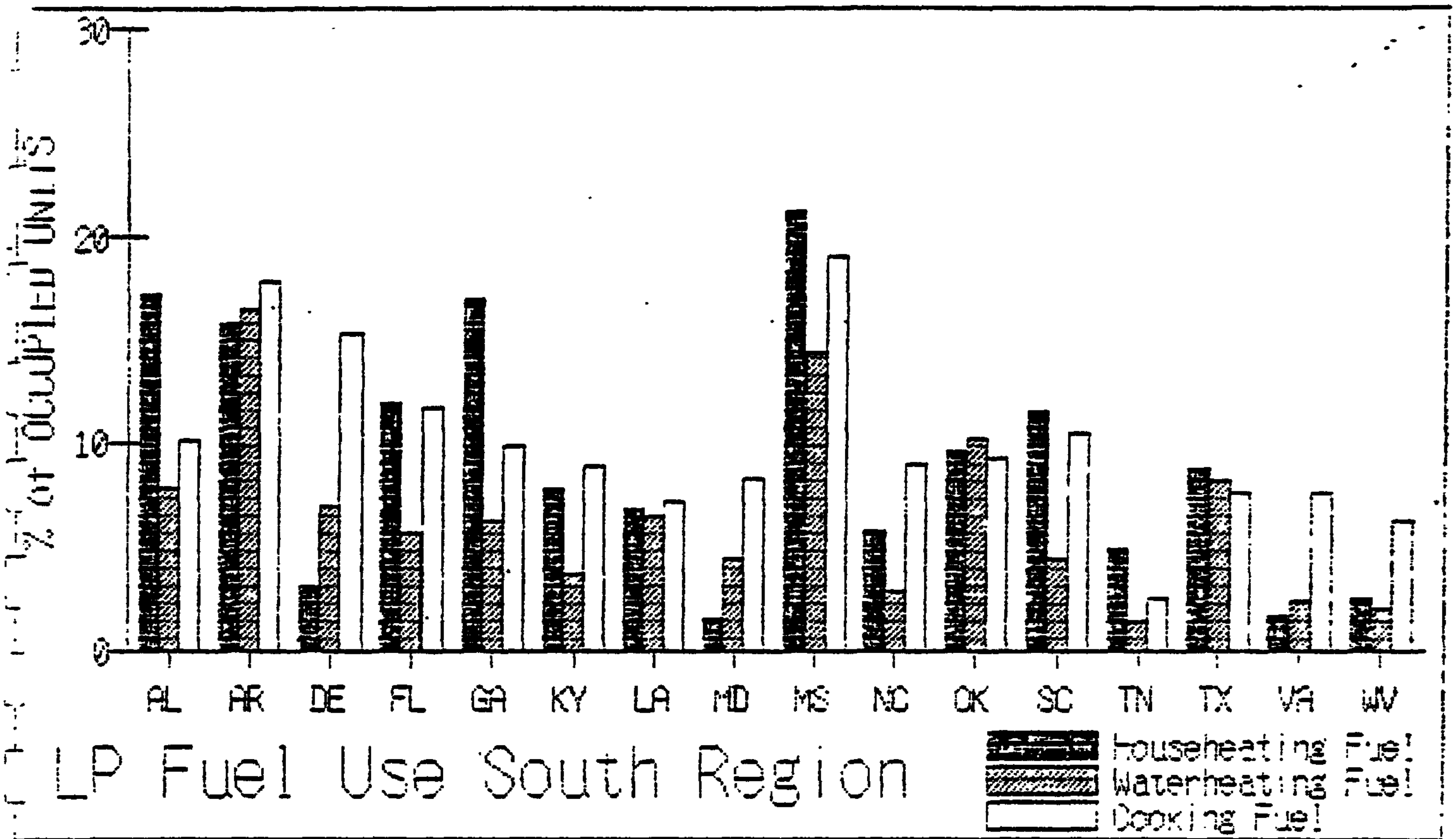

Fig. 18

Source: 1980 Census Of Housing, Vol. 1
Characteristics Of Housing Units, Chapter B
Detailed Housing Characteristics, Part 1
United States Summary HC80-1-B1, Issued
December 1983.

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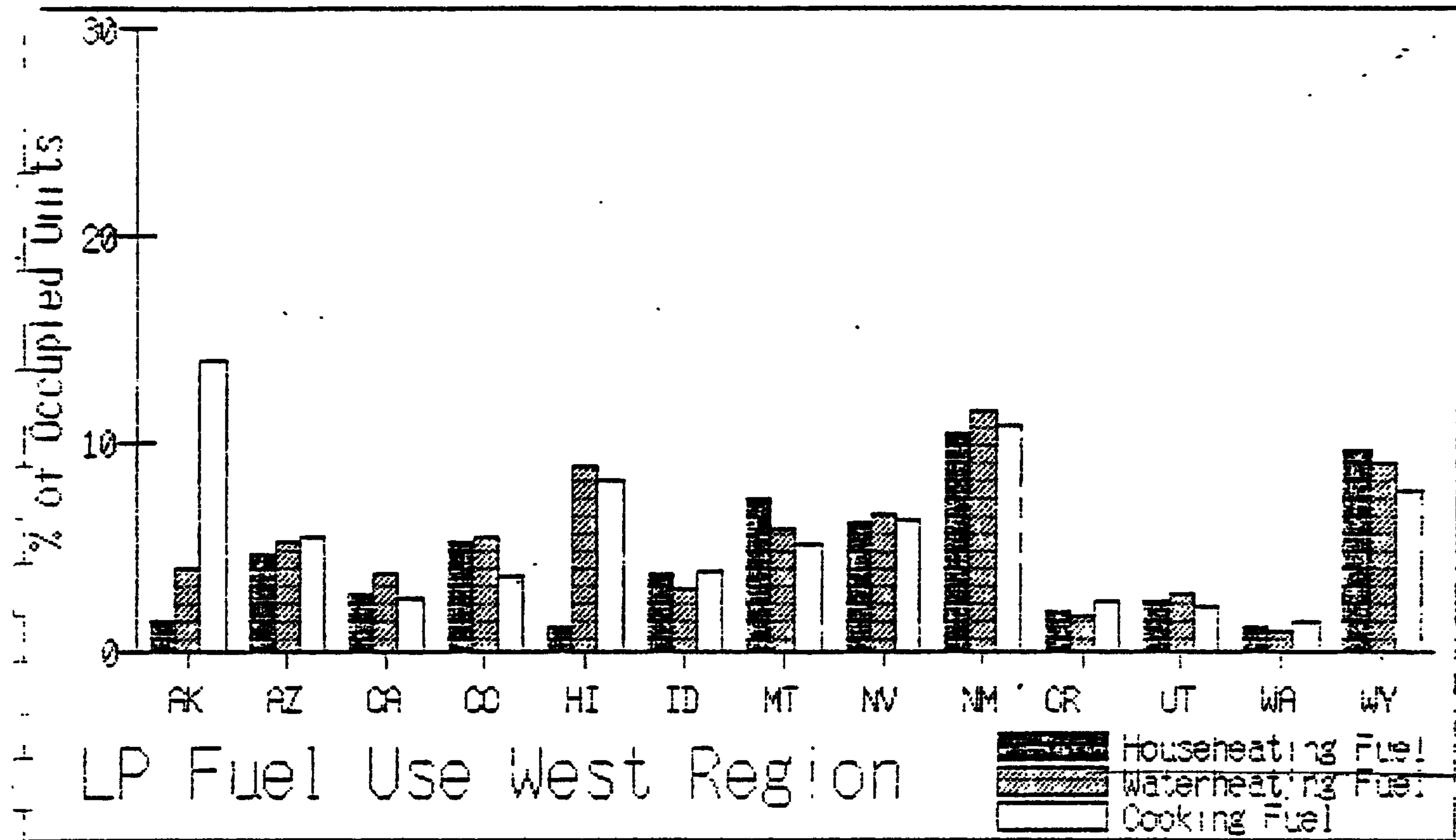

Fig. 19 Source: 1980 Census Of Housing, Vol. 1 Characteristics Of Housing Units, Chapter B Detailed Housing Characteristics, Part 1 United States Summary HC80-1-B1, Issued December 1983.

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Fig. 20 Cooking Fuel Use Of Bottled, Tank Or LP Gas By State

National Total 5,560,346 / 6.93%

Occupied Housing Units Utilizing LP For Cooking
Expressed As A % Of Total
Occupied Housing Units In State

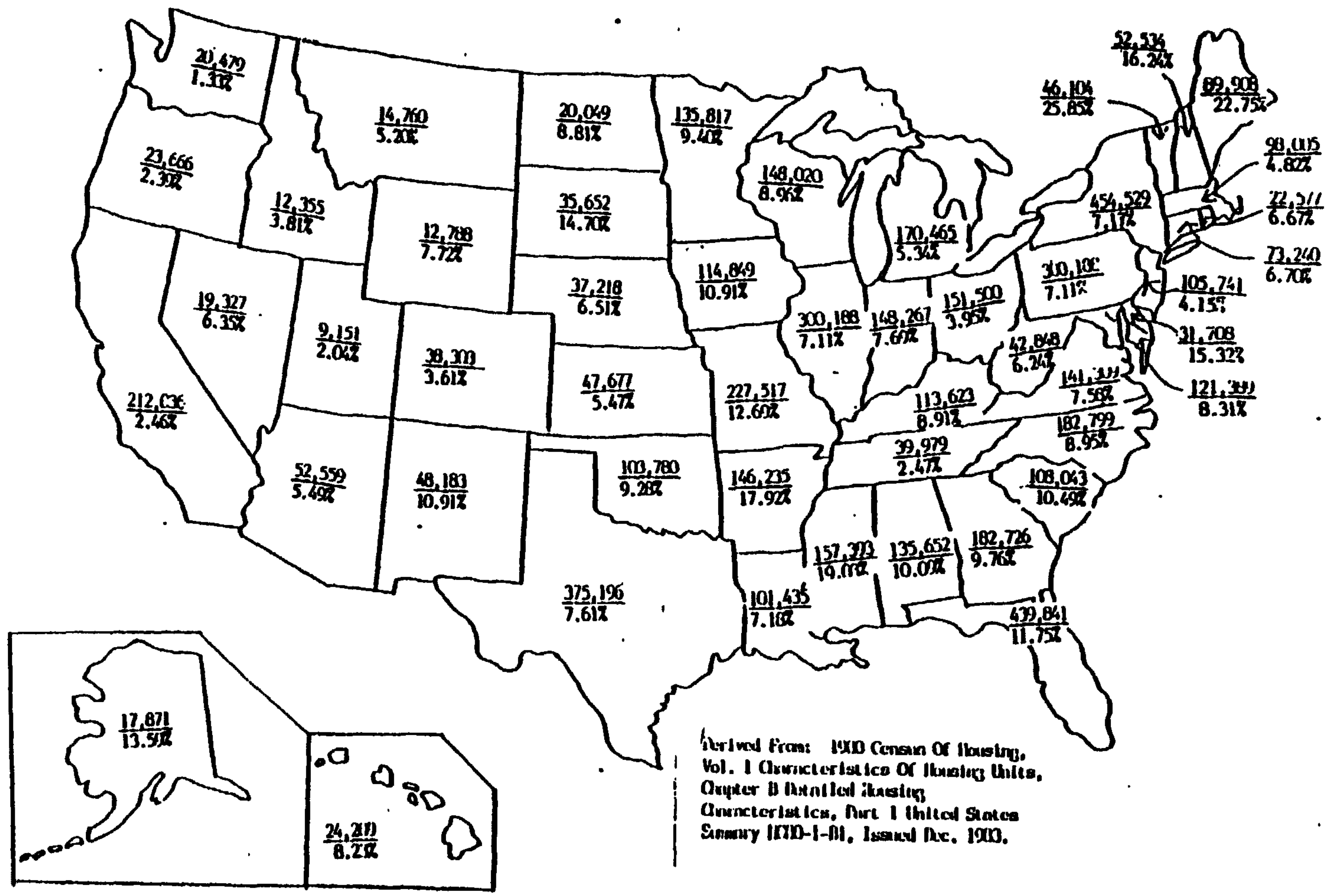

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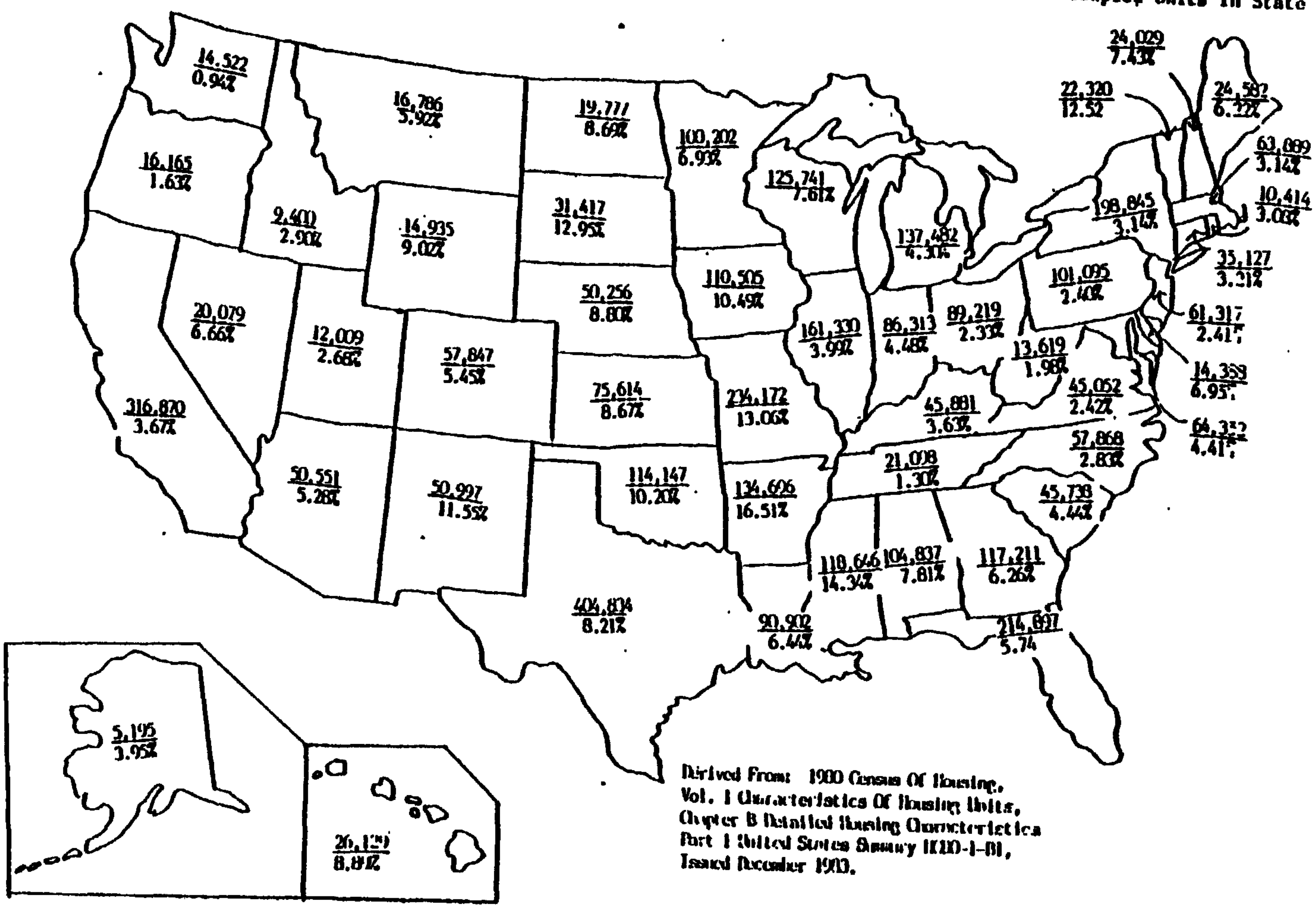
Fig. 21 Water Heating Fuel Use Of Bottled, Tank Or LP Gas By State

Occupied Housing Units Utilizing LP For Water Heating

Expressed As A % Of Total Occupied Units In State

National Total 3,920,045 / 4.96%



Derived From: 1980 Census Of Housing,
Vol. 1 Characteristics Of Housing Units,
Chapter B Detailed Housing Characteristics
Part 1 United States Summary HC80-1-B1,
Issued December 1983.

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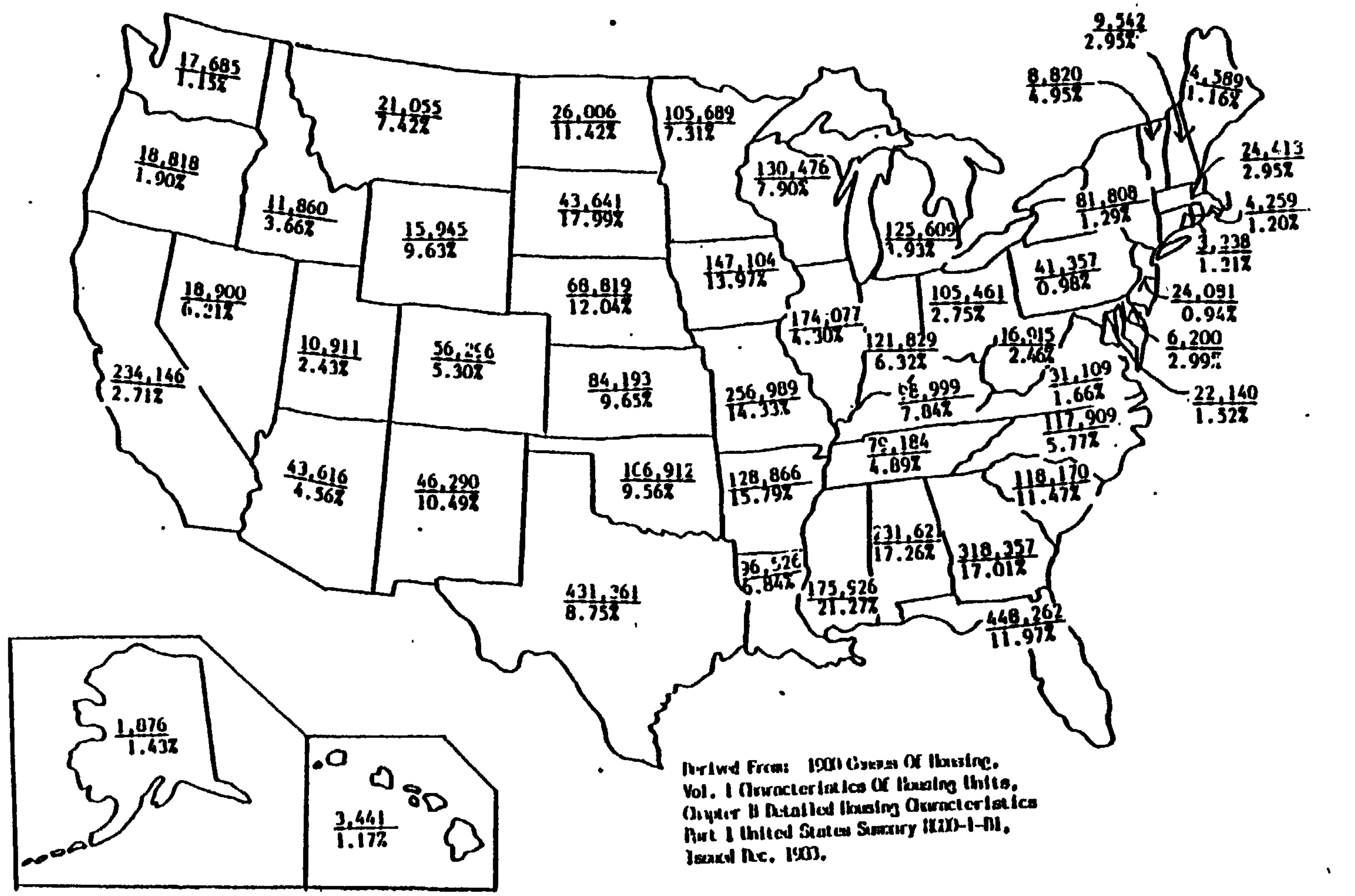
Fig. 22 House Heating Fuel Use Of Bottled, Tank, Or LP Gas By State

National Total 4,534,825 Units
5.64%

Occupied Housing Units
Utilizing LP For Heating
Expressed As A % Of
Total Occupied Unit In State



Derived From: 1980 Census Of Housing,
Vol. 1 Characteristics Of Housing Units,
Chapter B Detailed Housing Characteristics
Part 1 United States Summary HC80-1-B1,
Issued Dec. 1983.

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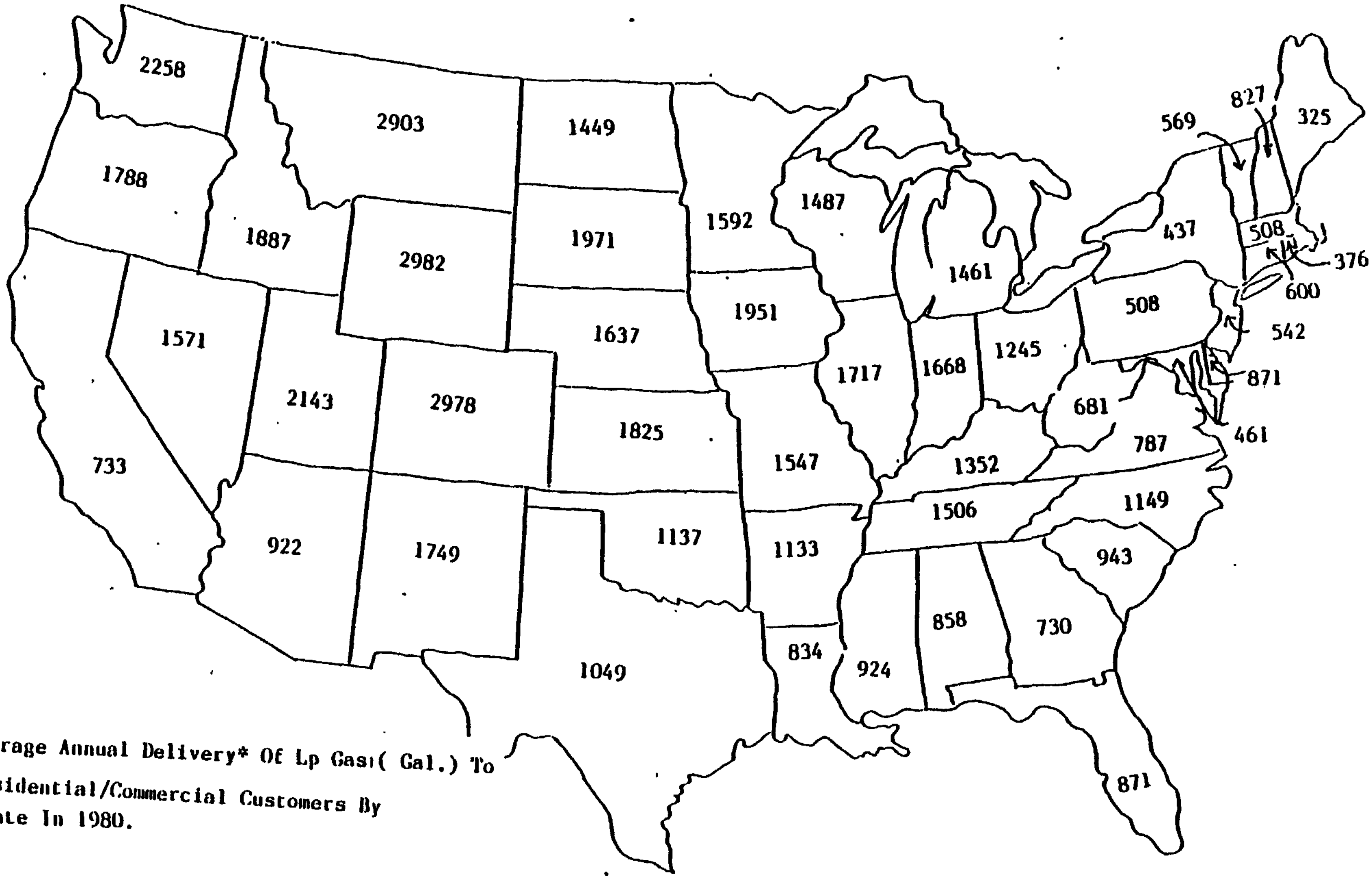

Average Annual Delivery* Of Lp Gas(Gal.) To Residential/Commercial Customers By State In 1980.

* Estimate From Bureau of Census Data and 1983-84 LP-Gas Market Facts, National LP-Gas Association.

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State By State Annual Delivery To Residential/Commercial Customer of LP Gas in 1980.

STATE	LP Gas Delivered (A) 1,000 Gal	Estimated Customers	Maximum Type of Use	Estimated Consumption (C) Gal/Yr
Alabama	198,788	231,621	House	858
Arizona	48,456	52,559	Cook	922
Arkansas	165,679	146,235	Cook	1133
California	232,420	316,870	Water	733
Colorado	172,275	57,847	Water	2978
Connecticut	43,950	73,240	Cook	600
Delaware	27,624	31,708	Cook	871
Florida	327,179	448,262	House	730
Georgia	231,963	318,357	House	729
Idaho	23,314	12,355	Cook	1887
Illinois	298,966	174,077	House	1717
Indiana	247,310	148,267	Cook	1668
Iowa	287,015	147,104	House	1951
Kansas	153,662	84,193	House	1825
Kentucky	152,226	112,623	Cook	1352
Louisiana	84,635	101,435	Cook	834
Maine	29,191	89,908	Cook	325
Maryland & DC	58,187	126,307	Cook	461
Massachusetts	49,828	98,005	Cook	508
Michigan	249,008	170,465	Cook	1461
Minnesota	216,160	135,817	Cook	1592
Mississippi	162,479	175,926	House	924
Missouri	397,578	256,989	House	1547
Montana	61,125	21,055	House	2903
Nebraska	112,651	68,819	House	1637
Nevada	31,542	20,079	Water	1571
New Hampshire	43,428	52,534	Cook	827
New Jersey	57,338	105,741	Cook	542
New Mexico	89,207	50,997	Water	1749
New York	198,788	454,539	Cook	437
North Carolina	210,021	182,799	Cook	1149
North Dakota	37,681	26,006	House	1449
Ohio	188,666	151,500	Coox	1245
Oklahoma	129,826	114,147	Water	1137
Oregon	42,318	23,666	Cook	1788
Pennsylvania	152,422	300,168	Cook	508
Rhode Island	8,490	22,577	Cook	376
South Carolina	111,410	118,170	House	943
South Dakota	86,007	43,641	House	1971
Tennessee	119,247	79,184	House	1506
Texas	452,434	431,361	House	1049
Utah	25,730	12,009	Water	2143
Vermont	26,252	46,104	Cook	569
Virginia	111,149	141,309	Cook	787
Washington	46,236	20,479	Cook	2259
West Virginia	29,191	42,848	Cook	681
Wisconsin	220,078	148,020	Cook	1487
Wyoming	47,542	15,945	House	2982
TOTAL	6,496,672	6,203,867		1047

A) Source 1983-84 LP-Gas Market Facts: National LP-Gas Association

B) Reviewed 1980 Census Data "Characteristics of Housing Units; Detailed Housing Characteristics United States Summary", HC80-1-B1 And Selected the Number of Housing Units Utilizing Bottled, Tank; or LP Gas For House Heating Fuel, Water Heating Fuel and Cooking Fuel Based on Taking The Highest Number.

C) Divide Column 1 By Column 2

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State By State Average Annual Delivery To Residential/Commercial Customers of LP Gas in 1980
Grouped by Census Region.

	LP Gas Delivered 1,000 Gals	Estimated Customers	Maximum Type Of Use	Estimated Consumption Gal/Yr
North Central				
Illinois	298,966	174,077	House	1,717
Indiana	247,310	148,267	Cook	1,668
Iowa	287,015	147,104	House	1,951
Kansas	153,662	84,193	House	1,825
Michigan	249,008	170,465	Cook	1,461
Minnesota	216,160	135,817	Cook	1,592
Missouri	397,578	256,989	House	1,547
Nebraska	112,651	68,819	House	1,637
North Dakota	37,681	26,006	House	1,449
Ohio	188,666	151,500	Cook	1,245
South Dakota	86,007	43,641	House	1,971
Wisconsin	220,078	148,020	Cook	1,487
TOTAL	2,494,782	1,554,898		1,604
% National Total	38.4%	25.1%		
North East				
Connecticut	43,950	73,240	Cook	600
Massachusetts	49,828	98,005	Cook	508
Maine	29,191	89,908	Cook	325
New Hampshire	43,428	52,534	Cook	827
New Jersey	57,339	105,741	Cook	542
New York	198,788	454,539	Cook	437
Pennsylvania	152,422	300,168	Cook	508
Rhode Island	8,490	22,577	Cook	376
Vermont	26,252	46,104	Cook	569
TOTAL	609,687	1,242,816		491
% National Total	9.4%	20%		
South				
Alabama	198,788	231,621	House	858
Arkansas	165,679	146,235	Cook	1,133
Delaware	27,624	31,708	Cook	871
Florida	327,179	448,262	House	730
Georgia	231,963	318,357	House	729
Kentucky	152,226	112,623	Cook	1,352
Louisiana	84,633	101,435	Cook	834
Maryland & DC	58,187	126,307	Cook	461
Mississipi	162,479	175,926	House	924
North Carolina	210,021	182,799	Cook	943
Oklahoma	129,826	114,147	Water	1,137
South Carolina	111,410	118,170	House	943
Tennessee	119,247	79,184	House	1,506
Texas	452,434	431,361	House	1,049
Virginia	111,149	141,309	Cook	787
West Virginia	29,191	42,848	Cook	681
TOTAL	2,572,038	2,802,292		918
% National Total	39.6%	45.2%		

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West				
(Northern)				
Colorado	172,275	57,847	Water	2,978
Idaho	23,314	12,335	Cook	1,887
Montana	61,125	21,055	House	2,903
Oregon	42,318	23,666	Cook	1,785
Utah	25,730	12,009	Water	2,143
Washington	46,236	20,479	Cook	2,258
Wyoming	47,542	15,949	House	2,982
TOTAL	418,540	163,360		2,562
% National Total	6.4%	2.6%		
(Southern)				
Arizona	48,456	52,559	Cook	922
California	232,420	316,870	Water	733
Nevada	31,542	20,079	Water	1,571
New Mexico	89,207	50,997	Water	1,749
TOTAL	401,625	440,505		912
% National Total	6.2%	7.1%		
Overall Total	820,165	603,861		1,358
% National Total	12.6%	9.7%		

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APPENDIX C: SELECTED ORGANIZATIONS WITH DIRECT INTERST IN LP-GAS INDUSTRY

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American Gas Association (AGA)

Location: 1515 Wilson Blvd.
Arlington, VA 22209
(703) 841-8400

Founded in 1918 the American Gas Association has a staff of approximately 420 individuals and approximately 4700 members including individuals, distributors and transporters. This organization provides information on such areas as sales, finance, utilization, research, management, safety and all phases of gas transmission and distribution. AGA is involved in promoting employee and public safety. The American Gas Association also complies national and regional statistics.

The AGA maintains an independent committee which complies standards on construction and performance of appliances and equipment as well as other areas. AGA's facilities includes a 20,000 book reference library. In cooperation with the Gas Manufactures Association, the AGA helped establish the Gas Appliance Improvement Network (GAIN).

Publications: 1) Gas Energy Review (Monthly)
2) Gas Facts (Annual)
3) Operating Section Procedure (Annual)

4) Public Information Bulletins

5) Newsletters

6) AGA Rate Service

American Insurance Association (AIA)

Located: 85 John St.
New York, NY 10038
(212) 669-0400

Founded in 1964, the American Insurance Association is made up of 170 companies which provide property and liability insurance. This organization seeks to aid member companies through legislative lobbying. The AIA also publishes information bulletins on industrial safety rules, fire prevention, suggested codes and ordinances, special hazards, workers' compensation, state financial responsibility laws and various law compilations.

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American National Standards Institute (ANSI)

Location: 1430 Broadway
New York, NY 10018
(212) 354-3300

Founded in 1918, the ANSI consists of approximately 1100 members and serves as a clearinghouse for nationally coordinated voluntary safety, engineering and industrial standards. The ANSI gives status as American National Standards to standards developed by agreement from all groups concerned in such areas as: definitions, terminology, symbols & abbreviations, materials, methods of rating and testing, safety and health.

Publications: (1) Reporter (bi-weekly)
(2) Standards Action (bi-weekly)
(3) Catalog of Standards (Annual)

American Society of Mechanical Engineers (ASME)

Location: 345 E. 47th St.
New York, NY 10017
(212) 705-7722

The American Society of Mechanical Engineers is a large organization consisting of approximately 103,000 members including approximately 23,000 student members. The society conducts research, develops boiler pressure vessel codes and sponsors the American National Standards Institute. The ASME maintains 19 research committees, consists of 31 divisions and has an 180,000 volume library.

Publications:
(1) Applied Mechanics Reviews (Monthly)
(2) Mechanical Engineering (Monthly)
(3) Transactions (Quarterly)
(4) Biographical Dictionary - Engineers Before 1860

Compressed Gas Association (CGA)

Location: 1235 Jefferson Davis Highway
Arlington, Va 22202
(703) 979-0900

Founded in 1913, the Compressed Gas Association consists of approximately 300 producers and distributors of compressed, liquefied and cryogenic gases and/or equipment. This organization submits it's recommendations to appropriate government agencies to improve safety standards and methods of handling, transporting and storing gases. The CGA has also acted as an adviser to regulatory agencies and conducted national and regional technical meetings.

Publications: (1) Compressions (Monthly)
(2) Annual Report
(3) Handbook of Compressed Gases
(4) News Bulletins

Cylinder Manufacturers Association (CMA)

Location: 1055 Thomas Jefferson Hy., NW
Washington, DC 20007
(202) 342-8400

Founded in 1977, the Cylinders Manufacturers Association consists of 15 members. The main purpose of the organization is to monitor, analyze and influence federal legislative and regulatory activities which affect the compressed gas cylinder industry. The CMA also complies import statistics and domestic production surveys.

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Manufactured Housing Institute (MHI)

Location: 1745 Jefferson Davis Hwy.
Suite 511
Arlington, VA 22202

Founded in 1936, the Manufactured Housing Institute has 380 members in such areas as manufacturers of mobile/manufactured homes, and suppliers of mobile home equipment. Annually in January, the MHI sponsors its annual Manufactured Housing Show. This organization also presents awards, maintains speakers bureau, conducts reseach and complies statistics.

Publication: (1) Newsletter (Bi-Weekly)

(2) Buyer's Guide (Annual)

(3) Membership Direcotry (Annual)

(4) Quick Facts (Annual)

National Fire Protection Association (NFPA)

Location: Batterymarch Park
Quincy MA 02269
(617) 770-3000

Founded in 1896, the National Fire Protection Association consists of approximately 31,500 members and a staff of 240. Members work in such fields as fire service, businesss & industry, health care, education, insurance, architecture, government and engineering. The NFPA main purpose is to develop publish and disseminate standards prepared by their approximately 175 technical committees. The NFPA also conducts fire safety education programs (including sponsoring a National Fire Protection Week) and complies annual statistics on causes, losses and deaths related to fires. This organization maintains a 50,000 book library.

Publications (1) Fire Command (Monthly)
(2) Fire News (8 year)
(3) Fire Journal (Bi Monthly)
(4) Fire Technology (Quarterly)
(5) Technical Committee Reports (Semi-annual)
(6) Catalogs of Publications (Annual)
(7) Fire Protection Reference Directory (Annual)
(8) National Fire Codes (Annual)

(9) Yearbook

(10) Committee Lists

(11) Fire Protection Handbook

National LP-Gas Association (NLPGA)

Location: 1301 W 22nd St.
Oak Brook, IL 60521
(312) 986-4800

The National LP-Gas Association was founded in 1962 and consists of approximately 5000 members in the fields of production and distribution of LP gas and equipment. This organization develops standards, conducts safety programs, researches market conditions and develops industry standards. The NLPGA also works as a liaison for the government and conducts national advertising promotions.

Publications: (1) NLGA Reports (Weekly)
(2) Reports of Proceeding (Annual)
(3) Marketing Statistics
(4) Manuals

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Underwriters Laboratories (UL)

Location: 333 Pfingsten Road
Northbrook, IL 60062
(312) 272-8800

Founded in 1894, Underwriters Laboratories is a testing laboratory with a staff of approximately 2800. Their purpose is "By scientific investigation, study, experiments and tests, to determine the relation of various metals, devices, products, equipment, constructions, methods and systems to hazards appurtenant thereto or to the use thereof affecting life and property, and to ascertain, define, products, equipment, constructions, methods and systems affecting such hazards, and other information tending to reduce loss of life and property from such hazard."

Publications: (1) Lab Data (Quarterly)
(2) Trends (Quarterly)
(3) Product Directory (Annual)

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APPENDIX D : MEMBERSHIP OF KEY LP-GAS STANDARDS COMMITTEES

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NLPGA TECHNOLOGY AND STANDARDS COMMITTEE

MEMBERS

Robert Reed, Chairman	Petrolane, CA
T. J. Akers	Shell Development , TX
Ray Boyette	Blue Flame Gas, NC
Verle Brown	International Gas System, WA
V.A. Brunson	Blackmer Pump, MI
Charles Chapman	American Welding & Tank,FL
Dewey Dearman	Mississippi Tank Co, MS
W.P. Freeman	Southwest Instruments, TX
Charlie Gardner	Gardner-Marsh, NC
O.L. Garretson	Farmington, NM
W.J. Glidden	Pro-Chem Co., NJ
George Hall	LP-Gas Equipment, IL
J.F. Hirshfeld	Waywick Corp., MI
Casey Jarvis	Jarco Inc., CA
Walt Johnson	NLPGA , IL
Don Jones	Pargas Inc., MD
Robert Jones	Goodall Rubber Co., NJ
Ron Katz	Mobile Gas, FL
Gary Koch	Squibb Taylor, TX
John Kukucka	Suburban Propane, NJ
Charles Lamar	Lamar Consultanta, IL
Al Linder	Coast Gas, CA
William McComas	AmeriGas, PA
L.D. McElroy	Trinity Industries, TX
Sam McTier	McTier Supply, IL
Warren Meyers	Divserco Inc.,NJ
David Parris	Enmarc Corp., WI
Larry Pearce	RegO, IL
T.E. Perkins	Commonwealth Propane, VA
Don Rice	Fisher Controls, TX
Don Schultz	Schultz Gas Service, IL
B.G. Schulz	Warren Petroleum, OK
Martin Simon	Skelgas Inc., IN
A.O. Simpkins	Rutherford Equipment, GA
Felix Smist	Sherwood-Selpac, NY
C.L. Smith	Riley-Beaird, LA
John Snapp	Manchester Tank & Equip., CA
Robert Taylor	R.J. Taylor, Inc. FL
H. Emerson Thomas	Thomas Associates, NJ
W.L. Thompson	Boyd Service Inc., KY
Don Waits	Union Texas Petroleum, TX

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ADVISORY MEMBERS

Stan Blachman	AGA Labs., OH
R.R. Czischke	Underwriters Labs., IL
Joe Farris	Ranger Co., GA
J.P. Langmead	GAMA, VA
Leonard Pakruda	Alabama LP-Gas Board, AL
Larry Wyatt	Grinnell Mutual, IA

STAFF

W.H. Butterbaugh	NLPGA, IL
Hal Faulconer	NLPGA, IL
D.N. Myers	NLPGA, IL

NFPA LIQUEFIED PETROLEUM GASES

TECHNICAL COMMITTEE

CHAIRMAN: Connor L Adams Mechanical Inspections City of Miami Bldg Dept 275 NW 2nd Street Miami, FL 33128

PRINCIPALS

J A Cedervall Casualty & Chemical Hazards Dept Underwriters Laboratories Inc 333 Pfingsten Rd Northbrook, IL 60062
W John Glidden Pro-Chem Co Inc PO Box M 730 South Ave Middlesex, NJ 08846 (Rep Natl LP-Gas Assn)
Howard J Haiges Jr Professional Support Div US Natl Park Service PO Box 25287 755 Parfet St Denver, CO 80225
H T Jones Ministry of Consumer & Commercial Relations 3300 Bloor St W Toronto, Ont M8X 2X4
Jerrold Juergens Federated Mutual Insurance Co PO Box 328 Owatonna, MN 55060 (Rep Alliance of American Insurers)
Hugh F Keepers Railroad Commission of Texas 2600 Clarkdale Ln Austin, TX 78758
John Kukucka Suburban Propane Gas Corp PO Box 206 Whippany, NJ 07981 (Rep Natl LP-Gas Assn)
Charles C Lamar Lamar Consultants Inc 531 Jefferson St Hinsdale, IL 60521
Robert F Langley US DOT/Research & Special Programs Admin 400 7th St SW Washington, DC 20590 (Rep Pipeline Safety Reg-US Dept of Transportation)
Donald Maddock Ansul Co PO Box 6007 Concord, CA 94524 (Rep Fire Equipment Manufacturers Assn)
E N Proudfoot Goodyear Tire & Rubber Co 1144 E Market St Akron, OH 44316 (Rep NFPA Industrial Fire Protection Section)
Frank E Rademacher Industrial Risk Insurers 175 W Jackson Blvd Suite A2000 Chicago, IL 60604
Phani Raj Technology & Mgmt Systems Inc 279 Cambridge St Suite 102 Burlington, MA 01803
Bruce A Schwartz Washington Gas Light Co 6801 Industrial Rd Springfield, VA 22151 (Rep American Gas Assn)
Henry C Scuoteguazza Factory Mutual Research Corp 1151 Boston-Providence Tpke Norwood, MA 02062
James E Stockton James E Stockton & Associates 100 Chevy Chase Dr Wayzata, MN 55391 (Rep Fire Marshals Assn of N America)
H Emerson Thomas Thomas Associates PO Box 550 200 North Ave E Westfield, NJ 07091 (Rep Natl LP-Gas Assn)
J Herbert Witte Registered Professional Engineer 6531 Drake Ave Lincolnwood, IL 60645 (Rep Gas Vent Inst)

ALTERNATES

John A Davenport Industrial Risk Insurers 85 Woodland St Hartford, CT 06102 (Alt to F E Rademacher)
Walter H Johnson Natl LP-Gas Assn 1301 W 22nd St Oak Brook, IL 60521 (Alt to J Kukucka & H Thomas)
Norman O Nobbe Insurance Co of North America 3924 Tonkawood Rd Minnetonka, MN 55343 (Alt to AISG Rep)
Walter C Retzsch American Petroleum Institute 1220 L St NW Washington, DC 20005 (Alt to API-Refining Dept Rep)
Don J Slee Compressed Gas Assn Inc 1235 Jefferson Davis Hwy Suite 501 Arlington, VA 22202 (Alt to CGA Rep)

NON-VOTING

L L Bergonia Allis Chalmers Corp 21800 S Cicero Ave Matteson, IL 60443 (Rep Industrial Truck Assn)
Chappell D Pierce Office of Standards Development US Occupational Safety & Health Admin 200 Constitution Ave NW Rm N3463 Washington, DC 20210

Scope: To develop documents covering the design, construction, installation and operation of fixed and portable liquefied petroleum gas systems in bulk plants, in domestic, commercial, industrial (with specified exceptions), institutional, and similar properties; truck transportation of liquefied petroleum gas; engine fuel systems on motor vehicles and other mobile equipment; storage of containers awaiting use or resale; installation on commercial vehicles, liquefied petroleum gas service stations and utility gas plants.

Responsible for Storage and Handling of Liquefied Petroleum Gases (No. 58), and Liquefied Petroleum Gases at Utility Gas Plants (No. 59).

Staff Liaison: Theodore C Lemoff

APPENDIX E : LP-GAS CODES AND STANDARDS CROSS-REFERENCED

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Cross References in ANSI Z21.58-1982 - Outdoor Cooking Appliance

ANSI Z21.15-1974	Standard for Manually Operated Gas Valves
ANSI Z21.18-1973	Standard for Gas Appliance Pressure Regulators
NFPA #70-1981	National Electric Code
ANSI Z223.1-1974 (NFPA #54)	National Fuel Gas Code
ANSI B1.1-1974	Unified Inch Screw Threads
ANSI B18.2.1-1972	Standard for Square and Hex Bolts
ANSI B18.2.2-1972	Standard for Square and Hex Nuts
ANSI B2.1-1968	Standard for Pipe Threads
ANSI B36.10-1979	Standard for Welded & Seamless Wrought Steel Pipe
ANSI CGA-V-1-1977	Standard for Compressed Gas Cylinder Valve Outlet & Inlet Connections
ANSI C101.1-1973	Standard for Leakage Current for Appliances
ANSI/NFPA #58-1979	Storage and Handling LP Gas
UL #144	Standards for Pressure Regulating Valves for LP-Gas
UL #125	Standard for Valves for Anhydrous Ammonia and LP Gas
UL #569-1980	Safety Standard for Pigtails & Flexible Hose Connectors for LP Gas

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In:	Reference To: NFPA #54 National Fuel Gas Code	NFPA #58 Storage & Handling LP Gases	ASME Code	49 CFR
NFPA #54 National Fuel Gas Code	–	X		
NFPA #58 Storage & Handling LP Gases	X	–	X	X
UL #21 LP Gas Code		X		
UL #125 Valves for Anhydrous Ammonia & LP Gas		X		
UL #132 Safety Relief Valves		X		
UL #144 Pressure Regulating Valves		X		
UL #565 Liquid Level Gauges & Indicators		X		
UL #567 Pipe Connectors		X		
UL #569 Pigtails & Flexible Hose Connectors For LP-Gas		X		
UL #644 Container Assemblies for LP Gas		X		
CGA-S-1.2 Pressure Relief Device Standards			X	X
CGA-C-15 Procedures for Cylinder Design Proof & Service Performance Tests				X
CGA-C-14 Procedures for Fire Testing D.O.T. Cylinder Safety Device System				X

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Reference to:	In: NFPA #54	NFPA #58	UL #125	UL #132	UL #565
NFPA #10		X			
NFPA #15		X			
NFPA #30	X	X			
NFPA #37	X	X			
NFPA #50		X			
NFPA #51		X			
NFPA #54	–	X			
NFPA #58	X	–	X	X	X
NFPA #59		X	X	X	X
NFPA #61		X			
NFPA #68	X				
NFPA #70	X	X			
NFPA #77		X			
NFPA #78		X			
NFPA #80		X			
NFPA #82		X			
NFPA #90	X				
NFPA #96		X			
NFPA #251		X			
NFPA #211	X				
NFPA #302		X			
NFPA #321		X			
NFPA #501		X			
ASME Code		X			
49 CFR		X			

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APPENDIX "F" Comment on Sediment Trap Standard Development

The desired characteristic for a sediment trap is to insure that no particulate matter of sufficient size and quantity to impair the safety function of the automatic shut-off (ASO) be permitted to enter the control valve. In a generic sediment trap standard it will be critical, then, to define the performance requirements and set up the test procedures to produce accurate results regardless of the mechanism the device employs to remove matter from the gas stream. A standard based upon a trap using a screen for separation may produce invalid results for a trap using purely inertial forces for separation, for example. The reverse case can also be true, a point to remember if the conventional pipe "drip leg" is used as the reference separating device.

Consider that a screen will have a relatively sharp upper size cut-off on particulates passing, irrespective of gas velocity or particle density, whereas a purely inertial separation device will be affected exponentially with gas velocity and directly with density over a continuum. Consider further that particles smaller than the opening diameter in a screen tend to be removed by inertial impact, which will be influenced by particle density, flow velocity and ratio of closed to open screen area. High filtering efficiencies with a screen can be achieved by permitting a filter "cake" of particulates to build on the screen. However, a design permitting such a buildup could introduce pressure drops which adversely, and perhaps dangerously affect burner operation. Moreover, gas viscosity, density, and flow velocity at a given load vis a vis natural gas and propane significantly affect screen parameters which may be chosen with acceptable pressure drop characteristics.

Tests at steady-state flow conditions can be a very poor predictor of performance under cyclic conditions. Some steady state tests will greatly underestimate the potential entry of larger particles. In a system subject to step change from zero to full flow, momentary eddies and vortices created can produce localized energy conditions to move particles in excess of that provided by the bulk stream conditions. The energy levels to maintain particulates continuously airborne are also different than those necessary to move a particle in discrete jumps down a pipe over time. An additional factor in cyclic operation includes momentary pressure differentials across the system and resultant flow velocities higher than those experienced with steady state appliance operation. Also, irregularly shaped particles being accelerated from rest may initially present a high "drag" area to the gas stream and move more easily than their effective aerodynamic diameter under steady state conditions would indicate.

Irrespective of whether steady state or cyclic conditions prevail, an additional "drag" factor that must be considered in selecting a test medium is the difference in gas density at flowing conditions. For given particles of equivalent aerodynamic diameter and weight, propane, for example, will provide more propulsive force than natural gas.

The preceding was presented in condensed and simplified form, but serves to illustrate among other things the fact that it is possible to develop a test procedure capable of giving reproducible, but unfortunately meaningless---or worse, deceptive,---results with respect to determining relative effectiveness in the real world.

There has been substantial effort by GAMA members to develop a sediment trap standard for ANSI Z21 Committee consideration. In essence an attempt was made to develop a specific test procedure whereby the pass/failure criterion was based on particulate removal efficiency expressed as a percentage. Great difficulty has been experienced.

It is perhaps easier to design an effective trap to protect a specific control than it is to design a generic sediment trap test standard based on percentage particulate removal efficiency from a gas stream. The reasons supporting what may appear at first to be a contradiction include the following: particulate matter below a certain size is unlikely to result in blocking safety elements of a control, or at least the build-up would be so slow that the chance for severe leakage to develop undetected would be low. Hence, at this size regime one may have 100% of the material passing the trap without excessive danger. Therefore, an effective trap would have an absolute size cutoff at a point within the tolerance or "accommodation" range of the control valve sealing elements--presumably of the soft seat type capable of sealing over an area large enough to function despite some surface irregularities. A screen is one form of absolute upper limit, size cut-off device. However, it is critically important not to blind the screen and produce deleterious pressure drop conditions. An effective method is to introduce upstream settling and impingement devices using gravimetric and aerodynamic prinicples to reduce the particulate loading reaching and/or staying on the screen.

The above approach using inertial separation with a final screen is one currently used by manufacturers of water-heater controls intended for LP Gas service. Just as venting capability requirements in a specific appliance standard must be complementary with ANSI Z223.1 vent system standards, so must a sediment trap standard be complementary with a control standard. This suggests, then, that the control standard must have a <u>defined</u> level of contamination that the control must tolerate. Once that is defined a sediment trap standard can be established. One component of the trap standard would be an absolute size cut off above a certain size range. A second component of the sediment trap standard could define an efficiency of removal for material above that size range in a manner to prevent excessive loading of a final trapping or filtering element. In order to accomplish this, recognizing inertial separation may be used, it would be crucial to specify the density and particle size distribution (not just limits) of the contaminant material introduced in the test gas stream.

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APPENDIX "G"

Derivation of Safety-Relief Flow Capacity Formula For Liquefied Petroleum Gases

Compressed Gas Association Standard CGA S-1.2 states the capacity requirement for LPG follows the formula

$$Q_a = G_u A^{0.82}$$

where Q_a = Flow Capacity in ft^3/min Air

G_u = 53.6 for LPG

A = Outside Surface Area of Container in square feet

G_u(any gas) = (633,300/LC) $(ZT/M)^{1/2}$, Hence

The general formula is

$$Q_a = \frac{633,000}{LC} \sqrt{\frac{ZT}{M}} A^{0.82}$$

where

A = Total outside surface area of tank in square feet

C = Gas constant which is a function of the ratio of specific heats (k). $C = 520 \sqrt{k \left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$

L = Latent heat of gas at flowing conditions (Btu/lb)

Q_a = Required flow capacity in ft^3/min of air at standard conditions defined as 14.7 lb/in^2 absolute and 60°F (520°R)

M = Molecular weight of gas

T = Temperature in degrees Rankine (°R) of gas at flowing conditions

Z = Compressibility factor at flowing conditions

Examining the theoretical basis for this formula, the equation for weight flow of vapor through an orifice given sonic flow conditions--predominant conditions during the period of interest--is

$$W_g = CKaP \sqrt{\frac{M}{ZT}}$$

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where

W_g = Weight flow in lb/h of gas

K = Coefficient of discharge (dimensionless)

a = Discharge area in in^2

P = Upstream pressure in lb/in^2 absolute

Other variables as previously defined.

Vaporization rate of a liquid in response to a thermal load may be described by Equation (3).

$$W_g = \frac{qA'}{L} \tag{3}$$

where

q = Unit heat flux in $Btu/h.ft^2$

A' = Effective heat transfer area in ft^2

Equating (2) and (3) gives the relationship for orifice size at P&T to relieve at the vapor generation rate. Following through conversion steps, one arrives at the equivalent flow capacity of air (Q_a) at S.T.P.

Conditions: constant flow area , weight flow of any gas at P&T

Convert to weight flow of air at P and standard T

$$\frac{W_{air}}{W_g} = \frac{C_{air} K a P \sqrt{\frac{M_{air}}{Z_{air} T_{STD}}}}{C \quad K a P \sqrt{\frac{M}{ZT}}}$$

$$M_{air} = 28.97 \quad C_{air} = 356 \, (k = 1.4) \quad Z_{air} \cong 1$$

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$$W_{air} = W_g \times \frac{336}{C} \times \frac{(28.97)^{1/2}}{(M)^{1/2}} \times \frac{(zo)^{1/2}}{1} \times \frac{(T)^{1/2}}{(520°R)^{1/2}}$$

$$W_{air} = 84 \frac{W_g}{C} (ZT/M)^{1/2} \qquad (4)$$

convert to volumetric flow of air

$$Q_a\left(\frac{ft^3}{min}\right) = W_{air}\left(\frac{lbs}{hr}\right) \times \frac{1}{28.97}\left(\frac{lb\ mole}{lb}\right) \times \frac{1}{60}\left(\frac{hr}{min}\right) 379.4 \frac{ft^3}{lb/mole} \text{ air @ 14.7 psia \& 60F}$$

or $Q_a = 0.2183\ W_{air}$

substituting in (4)

$$Q_a = 18.34 \frac{W_g}{C} (ZT/M)^{1/2} \qquad (5)$$

Substituting equation (3) in (5) gives

$$Q_a = 18.34\ q\ (ZT/M)^{1/2}\ A$$ general capacity formula (6)
for any thermal flux (vapor)

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$$W_{air} = W_g \times \frac{356}{C} \times \frac{(28.97)^{1/2}}{(M)^{1/2}} \times \frac{(Zg)^{1/2}}{1} \times \frac{(T)^{1/2}}{(520°R)^{1/2}}$$

$$W_{air} = 84 \frac{W_g}{C} (ZT/M)^{1/2} \qquad (4)$$

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$$Q_a \left(\frac{ft^3}{min}\right) = W_{air}\left(\frac{lbs}{hr}\right) \times \frac{1}{28.97} \left(\frac{lb\ mole}{lb}\right) \times \frac{1}{60} \left(\frac{hr}{min}\right) 379.4 \frac{ft^3 \text{ air @ 14.7 psia \& 60F}}{lb/mole}$$

or $\quad Q_a = 0.2183\ W_{air}$

substituting in (4)

$$Q_a = 18.34 \frac{W_g}{c} (ZT/M)^{1/2} \qquad (5)$$

Substituting equation (3) in (5) gives

$$Q_a = 18.34\ q\ (ZT/M)^{1/2} A$$ general capacity formula (6)
for any thermal flux (vapor)

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Comparing again with Equation (1), we may determine the empirical value utilized in the sizing formula, namely the value of the total thermal flux (H)—the product of q A'

$$q=\frac{633,000}{18.34} = 34,500 \text{ Btu/hrft}^2$$

$$A' = A^{0.82} \text{ ft}^2$$

and $H = 34,500\ A^{0.82}$ btu/hr

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The area of the tank exposed to fire and effective in heat transfer of the contents is assumed by the formula to be related to vessel size. Thus, the exponent 0.82 represents a regression computation from experimental data (ref. 19). Unfortunatley data was used from a number of tests where the area exposed was fixed by the particular test conditions, and therefore inappropriate for inclusion.[20] Evaluation of experimental data since adoption of the CGA formula based on pre-1951 data support this finding.[21,22]

The net effect of the current formula is to progressively undersize relief capacity with larger vessels exposed to severe fire. However, unprotected vessels will tend to fail structurally from fire exposure to unwetted surfaces, anyway. Vessels exposed to less severe fires require less relief capacity. Therefore, although the formula is based on a faulty premise and treatment of data, the effect of the error is severe only in some cases.

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