LP-GAS SERVICE TECHNICIAN'S

HANDBOOK

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INTRODUCTION

This Service Technician's Handbook has been developed by Cavagna, Inc., as a quick reference guide to be used by propane technicians performing field installation, operation and maintenance work.

The Handbook has been written in a very straightforward and easy to understand format, with simple tables, diagrams and pictures to help guide service technicians through the process of installing and maintaining a propane gas system.

While the Handbook provides useful and key information, service technicians should also consult their company's policies and procedures; applicable federal, state and local laws; and industry rules and regulations, including the National Fire Protection Association (NFPA) pamphlets 54 and 58.

Additional detailed information regarding regulator descriptions, specifications, installation, maintenance and repair are provided with the instruction manuals for each regulator type.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

ASME TANKS

ASME tanks are used for both aboveground and underground propane service.

While they both serve the same purpose, there are some distinct differences which must be observed when being installed. Refer to the sections on Location and Installation on Pages 15 and 17. ASME tanks also come in many different sizes. Domestic installations usually range from 120 gallons to 1,000 gallons.

All ASME tanks have the same seven common appurtenances as listed below:

Filler Valves - Provide a mechanical connection to allow for the transfer of liquid propane into the container. Filler valves are operated every time a container equipped with one is filled and, in some instances, are used more than any other valve on a container.

Pressure Relief Valve - The valve on a propane container or piping system that releases pressure (vapor and/or liquid) when the container's or piping system's internal pressure exceeds the set pressure of the relief valve.

Service Valves - Permit the transfer of vapor or liquid propane from the container to gas burning equipment. They control the flow of product in and out of a container.

Fixed Maximum Liquid Level Gauge - Indicates when the container is filled to its maximum permitted filling level.

Float Gauge - Continuously indicates the liquid level of propane in the container by a float that moves up and down.

Vapor Equalization Valve - Connection used during propane delivery to remove excess tank pressure

Liquid Withdrawal Valve - The valve installed in an opening in a tank through which liquid propane flows when it is being withdrawn or evacuated from the tank.

DOT CYLINDERS

DOT Cylinders are used in a wide variety of both residential and commercial applications. As noted below, there are four different classes of DOT Cylinders.

PORTABLE MOTOR FUEL EXCHANGE STATIONARY

There are five common appurtenances utilized with DOT cylinders. However, not all the appurtenances are found on each of the cylinders.

Pressure Relief Valve - Releases excess pressure from cylinders in the event of overfilling or exposure to extremely high temperatures.

Service Valve - Permits the transfer of vapor or liquid propane from the cylinder to gas equipment. It controls the flow of product in and out of a container.

Fixed Maximum Liquid Level Gauge - Indicates when the cylinder is filled to its maximum level.

Float Gauge - Continuously indicates the liquid level in a cylinder.

Filler Valve - Provides a connection to allow for the transfer of liquid propane from a supply tank into the cylinder. Some cylinders may have a separate filler valve.

PROPANE GAS PROPERTIES

Propane Gas Properties are the characteristics, qualities and combustion data of propane gas.

The table below lists the important properties for Service Technicians to know.

APPROXIMATE PROPERTIES OF PROPANE GAS

Formula	C_3H_8
Initial Boiling Point, °F	-44
Specific Gravity of Liquid (Water = 1.0) at 60°F	0.504
Weight per Gallon of Liquid at 60°F, LB	4.20
Specific Heat of Liquid, BTU/LB at 60°F	0.630
Cubic feet of Vapor per Gallon at 60°F	36.38
Cubic feet of Vapor per Pound at 60°F	8.66
Specific Gravity of Vapor (Air = 1.0) at 60°F	1.50
Ignition Temperature in Air, °F	920 - 1,120
Maximum Flame Temperature in Air, °F	3,595
Cubic feet of Air Required to Burn One Cubic Foot of Gas	23.86
Limits of Flammability in Air, % of Vapor in Air-Gas Mix: (a) Lower (b) Upper	2.15 9.60
Latent Heat of Vaporization at Boiling Point: (a) BTU per Pound (b) BTU per Gallon	184 773
Total Heating Values After Vaporization: (a) BTU per Cubic Foot (b) BTU per Pound (c) BTU per Gallon	2,488 21,548 91,502

DETERMINING TOTAL LOAD

Determining Total Load is the sum of all propane gas used in an installation and is expressed in Btu's (British Thermal Units).

Determining the Total Load is necessary for sizing the tank or cylinders, regulators and piping for an installation. This is done by adding the Btu input of all appliances being used. The Btu information can be found on the nameplate of the appliance, or in the manufacturer's literature.

To properly determine total load, it's also important to ask the customer about any future appliances which may be added at a later date. By adding in those Btu's now, later revisions in the container and piping can be avoided.

The table below shows the approximate Btu input required for common gas appliances.

Gas Required for Common Appliances

APPLIANCE	APPROX. INPUT BTU/HR
Warm Air Furnace	
Single Family	100,000
Multifamily, per unit	60,000
Hydronic Boiler, Space Heating	
Single Family	100,000
Multifamily, per unit	60,000
Hydronic Boiler, Space & Water Heating	
Single Family	120,000
Multifamily, per unit	75,000
Range, Free Standing, Domestic	65,000
Built-In Oven or Broiler Unit, Domestic	25,000
Built-In Top Unit, Domestic	40,000
Water Heater, Automatic Storage, 30 to 40 gal. Tank	35,000
Water Heater, Automatic Storage, 50 gal. Tank	50,000
Water Heater, On-Demand	
Capacity: 2 gal. per minute	142,800
Capacity: 4 gal. per minute	285,000
Capacity: 6 gal. per minute	428,000
Water Heater, Domestic, Circulating or Side-Arm	35,000
Refrigerator	3,000
Clothes Dryer, Type 1 (Domestic)	35,000
Gas Fireplace direct vent	40,000
Gas log	80,000
Barbecue	40,000
Gas Light	2,500
Incinerator, Domestic	35,000

PROPANE VAPOR PRESSURE

Vapor Pressure is what forces propane gas from the container... through the piping system...to the appliance.

Because the amount of pressure inside a container depends on the outside temperature of the air, lower temperatures mean less pressure and higher temperatures mean more pressure. If the container pressure is too low, not enough gas will flow from the container to the appliances. Container pressure is measured in PSIG (Pounds Per Square Inch Gauge).

The table below shows propane vapor pressures at various outside temperatures.

Vapor Pressures of LP-Gases

Temperature (ºF)	Propane Approximate Pressure (PSIG)
-40	3.6
-30	8
-20	13.5
-10	23.3
0	28
10	37
20	47
30	58
40	72
50	86
60	102
70	127
80	140
90	165
100	196
110	220

VAPORIZATION RATES FOR ASME TANKS and DOT CYLINDERS

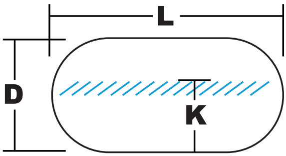
Vaporization is the rate at which liquid propane boils off and becomes vapor.

The larger the wetted surface of the container (that area of the container filled by liquid propane), the faster the liquid boils off into vapor. Therefore, the vaporization rate of a container is dependent upon the temperature of the liquid and the amount of wetted surface of the container.

In determining the proper size container to handle an installations total load, the lowest winter temperature must be taken into account.

It is important to know that because of the various shapes of containers, the wetted surface area will be different and therefore, the vaporization rates will be different.

ASME Storage Containers
Determining Propane Vaporization Capacity
"Rule of Thumb" Guide for ASME LP-Gas
Storage Containers



D - Outside diameter in inches
L - Overall length in inches
K - Constant for percent volume of liquid in container

Percentage of Container Filled	K	Propane Vaporization Capacity at 0°F (BTU/hr)
60	100	D x L x 100
50	90	D x L x 90
40	80	D x L x 80
30	70	D x L x 70
20	60	D x L x 60
10	45	D x L x 45

These formulae allow for the temperature of the liquid to refrigerate -20°F, below zero, producing a temperature differential of 20°F for the transfer of heat to the air to the cotainer's "wetted" surface, and then into the liquid.
The vapor space area of the vessel is not considered. Its effect is negligible.

Vaporizing capacities for Other Air Temperatures
Multiply the results obtained with the above formulae, by one of the following factors for the prevailing air temperature.

Prevailing Air Temperature	Multiplier	Prevailing Air Temperature	Multiplier
-15°F	.25	+15°F	1.25
-10°F	.50	+10°F	1.50
-5°F	.75	+5°F	1.75
0°F	1.00	0°F	2.00

VAPORIZATION RATES FOR ASME TANKS and DOT CYLINDERS
(Continued)

This second table assumes a DOT 100 pound cylinder under maximum continuous draw. Various temperatures and amounts of propane in the cylinder are shown.

DOT 100 Pound Cylinder

Lbs. of Propane In Cyl.	Maximum Continuous Draw in BTU Per Hour At Various Temperatures in Degrees F.				
	0°F	20°F	40°F	60°F	70°F
100	113,000	167,000	214,000	277,000	300,000
90	104,000	152,000	200,000	247,000	277,000
80	94,000	137,000	180,000	214,000	236,000
70	83,000	122,000	160,000	199,000	214,000
60	75,000	109,000	140,000	176,000	192,000
50	64,000	94,000	125,000	154,000	167,000
40	55,000	79,000	105,000	131,000	141,000
30	45,000	66,000	85,000	107,000	118,000
20	36,000	51,000	68,000	83,000	92,000
10	28,000	38,000	49,000	60,000	66,000

PURGING PROPANE GAS CONTAINERS

Purging Propane Gas Containers is the removal of water and air from the containers prior to installation and filling at a customer's site or at the bulk plant.

Water and air in a propane container will seriously contaminate and interfere with an entire propane system, resulting in improper operation of not only the system, but also the customer's appliances. Improper operation will result in costly service calls and needless extra expense.

Both ASME and DOT specifications require water and air be purged from all containers before being placed in service. Further, the procedure MUST always be performed at the bulk plant and NEVER at the customer's location.

Neutralizing Water

Even though the inside of a container may appear to have no visible moisture present, condensation may have formed on the interior walls, plus the air inside the container may have a relative humidity up to 100%.

To neutralize this moisture, use Anhydrous Methanol in amounts according to the chart below. Note the Anhydrous Methanol must be 99.85% pure. Under NO circumstances should any substitute products be used.

Container Type	Minimum Volume Methanol Required
100 lb. ICC cylinder	1/8 pt. (2 fl. ozs.)
420 lb. ICC cylinder	1/2 pt. (8 fl. ozs.)
500 gal. tank	5 pts. (2 1/2 qts.)
1000 gal. tank	10 pts. (1 1/4 gal.)

PURGING PROPANE GAS CONTAINERS (Continued)

Purging Air

There is a natural volume of air in all propane containers that must be removed before the first fill. The correct procedure for purging air is as follows. Note that it MUST be done at the bulk plant site, NEVER at the customer's location.

1. Install an unloading adapter on the double check filler valve, leaving it in the closed position.
2. Install a gauge adapter assembly on the service valve POL outlet connection. Exhaust to atmosphere any air pressure in the container.
3. Attach a propane vapor hose from another container to the vapor return valve on the container to be purged.
4. Open the valve on the outlet end of the vapor hose and carefully observe the pressure gauge.
5. When the gauge reading shows 15 psig, shut off the vapor valve on the hose.
6. Switch the lever on the unloading adapter to open the double check filler valve and blow down to exhaustion.
7. Close the unloading adapter lever, allowing the double check filler valve to close.
8. Repeat steps (4), (5), (6), and (7) four more times. Total required time is 15 minutes or less.

After performing the previous steps, the percent of air in the container is reduced as shown in the following table:

	% Air Remaining	% Propane Remaining
1st Purging	50	50
2nd Purging	25	75
3rd Purging	12.5	87.5
4th Purging	6.25	93.75
5th Purging	3.13	96.87
6th Purging	1.56	98.44

CONTAINER LOCATION and INSTALLATION

While customer preference and marketer ease of exchanging or filling containers is certainly a consideration in Container Location and Installation, precedence MUST be given to state and local regulations, plus NFPA 58.

Location of DOT Cylinders

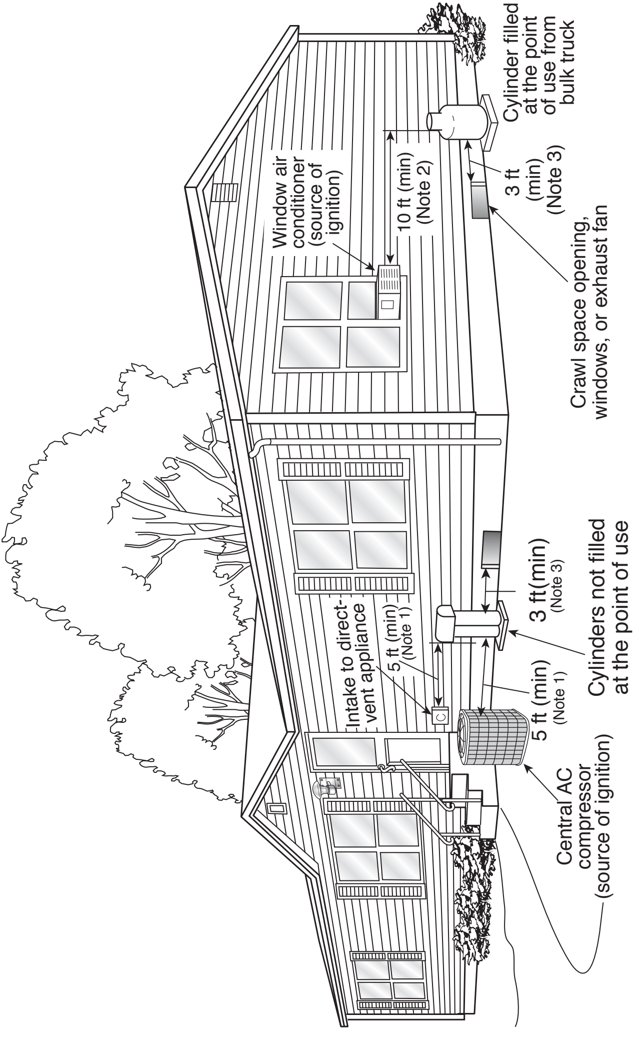
The following diagram from NFPA 58 details distance requirements for the placement of DOT cylinders in relation to buildings and property lines.

Installation of DOT Cylinders

As noted in next page, there are different size DOT cylinders. However, NFPA 58 requires any size cylinder to be placed on a solid non-combustible foundation.

For SI units, 1 ft = 0.03048m.

Notes:
(1) 5 ft minimum from relief valve in any direction away from any exterior source of ignition, openings into direct-vent appliances, or mechanical ventilation air intakes. Refer to Table 6.4.4.3.
(2) If the cylinder is filled at the point of use from a cargo tank motor vehicle, the filling connection and vent valve must be at least 10 ft from any exterior source of ignition, openings into direct-vent appliances, or mechanical ventilation air intakes. Refer to 6.4.4.3.
(3) Refer to 6.4.4.3.


Cylinder filled at the point of use from bulk truck
3 ft (min) (Note 3)
Crawl space opening, windows, or exhaust fan
Window air conditioner (source of ignition)
10 ft (min) (Note 2)
Intake to direct-vent appliance
5 ft (min) (Note 1)
C
3 ft(min) (Note 3)
Cylinders not filled at the point of use
5 ft (min) (Note 1)
Central AC compressor (source of ignition)

CONTAINER LOCATION and INSTALLATION (Continued)

Location of Aboveground ASME Tanks

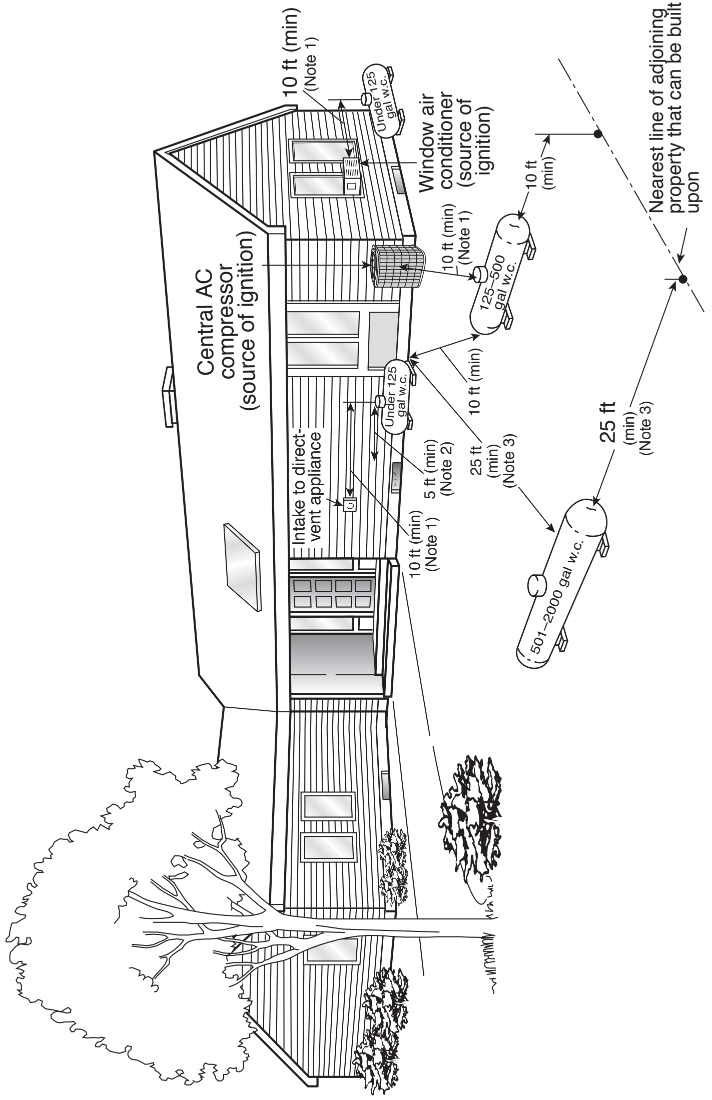
The following diagram from NFPA 58 details distance requirements for the placement of aboveground ASME tanks in relation to buildings and property lines.

Installation of Aboveground ASME Tanks

As noted on next page, there are different size ASME tanks. However, NFPA 58 requires any size tank to be placed on a solid non-combustible foundation.

For SI units, 1 ft = 0.03048m.

Notes:
(1) Regardless of its size, any ASME container filled on site must be located so that the filling connection and fixed maximum liquid level gauge are at least 10 ft from any external source of ignition (e.g., open flame, window AC, compressor), intake to direct-vented gas appliance, or intake to a mechanical ventilation system. Refer to Table 6.4.4.3.
(2) Refer to 6.4.4.3.
(3) This distance can be reduced to no less than 10 ft for a single container of 1200 gal (4.5 m^3) water capacity or less, provided such container is at least 25 ft from any other LP-Gas container of more than 125 gal (0.5 m^3) water capacity. Refer to 6.4.1.3.


10 ft (min)
(Note 1)
Under 125
gal w.c.
Window air
conditioner
(source of
ignition)
Nearest line of adjoining
property that can be built
upon
10 ft
(min)
10 ft (min)
(Note 1)
125–500
gal w.c.
Central AC
compressor
(source of ignition)
10 ft (min)
Under 125
gal w.c.
Intake to direct-
vent appliance
5 ft (min)
(Note 2)
10 ft (min)
(Note 1)
25 ft
(min)
(Note 3)
25 ft
(min)
(Note 3)
501–2000 gal w.c.

CONTAINER LOCATION and INSTALLATION (Continued)

Location of Underground ASME Tanks

The following diagram from NFPA 58 details distance requirements for the placement of underground ASME tanks in relation to buildings and property lines.

Installation of Underground ASME Tanks

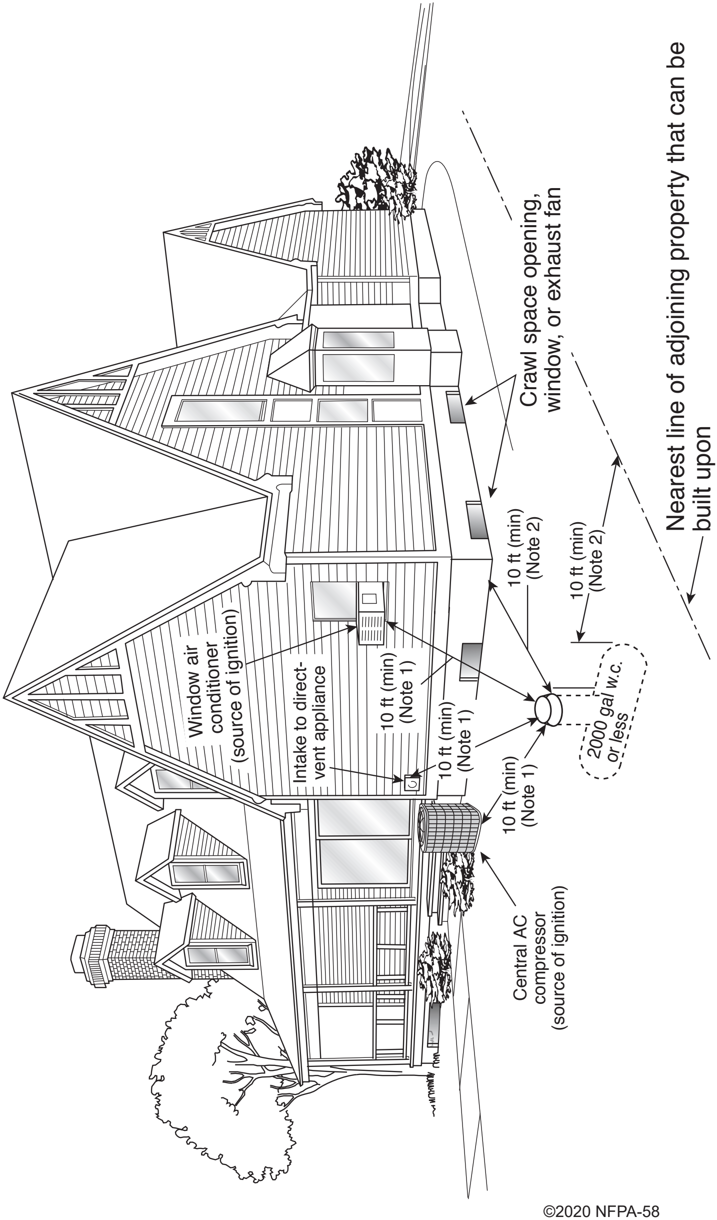
Although there are different size ASME tanks, NFPA 58 requires all underground tanks must be placed on a firm footing and anchored depending on water tables. There are also distance requirements relative to the placement of the tanks in relation to buildings and property lines.

For SI units, 1 ft = 0.03048m.

Notes:

(1) The relief valve, filling connection, and fixed maximum liquid level gauge vent connection at the container must be at least 10 ft from any exterior source of ignition, openings into direct-vent appliances, or mechanical ventilation air intakes. Refer to Table 6.4.4.4.

(2) No part on an underground container can be less than 10 ft from an important building or line of adjoining property that can be built upon. Refer to Table 6.4.1.1.



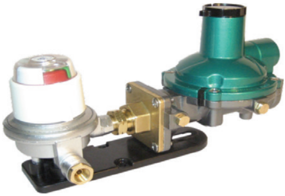
Nearest line of adjoining property that can be built upon
Crawl space opening, window, or exhaust fan
10 ft (min)
(Note 2)
10 ft (min)
(Note 2)
Window air conditioner (source of ignition)
Intake to direct-vent appliance
10 ft (min)
(Note 1)
10 ft (min)
(Note 1)
10 ft (min)
(Note 1)
2000 gal w.c. or less
Central AC compressor (source of ignition)

CYLINDER MANIFOLDING

DOT Cylinder manifolding is combining or linking together two or more cylinders to obtain the required gas capacity needed for a particular installation.

Multiple cylinder manifolds are found on both commercial and residential installations. ASME tank manifolding is also common in certain areas.

When installing a typical multiple cylinder manifold, install an automatic 1st stage changeover regulator at the cylinders.



By virtue of its name, the regulator will automatically change from the supply or service cylinder when its gas is exhausted, to the reserve cylinder which is full.

To achieve the required capacity in a manifold system, run high pressure piping from each cylinder into a common line.

PIPE and TUBING SIZING

Pipe and Tubing Sizing is determining both the right pipe, tubing material and dimensions for a propane gas installation and is critical to the proper and correct operation of that system.

There are several materials used in propane gas installations:

1. Copper - Type L and Type K or Refrigeration
2. Schedule 40 Black Iron
3. Polyethylene - CTS and IPS
4. CSST

There are four sizings to consider:

1. Sizing Between the First and Second Stage Regulator
2. Sizing Between the Second Stage Regulator and Appliances
3. Sizing Between a 2-psi Service Regulator and Line Pressure Regulator
4. Sizing Between a Line Pressure Regulator and Appliances

The following steps, examples and tables will demonstrate each of the four types of sizings you'll experience on the job.

PIPE and TUBING SIZING (Continued)

1. Sizing Between the First and Second Stage Regulator

Steps

1. Measure the required length of pipe or tubing from the outlet of the first stage regulator to the inlet of the second stage regulator.
2. Determine the total load requirements of the system. (Refer to the Table on Page 6 to review Total Load)
3. Select the required pipe or tubing. Refer to Tables A-F on Pages 18-23.

Example

Procedures needed for a successful new installation are as follows:

1. The required length of pipe or tubing from the outlet of the first stage regulator to the inlet of the second stage regulator is 26 feet. (Round off up to 30 feet)
2. The system will supply gas to a:
   Single family warm air furnace............200,000 Btu's
   40 to 50 gallon water heater ....38,000 Btu's
   Free standing domestic range ....65,000 Btu's
   Clothes Dryer.......................................35,000 Btu's

   The Total Load is 338,000 Btu's
3. Assuming undiluted propane gas, an inlet pressure of 10.0 psi, a pressure drop of 1.0 psi and specific gravity of 1.50, determine sizing for Copper, Schedule 40 Black Iron, Polyethylene or CSST using Tables A-F on Pages 21-26 for each of the four materials. The tables capacities are shown in thousands of BTU per Hour.

TABLE A

Copper Tube Sizing Between First-Stage and Second-Stage Regulators

Tubing Length (ft)	Outside Diameter Copper Tubing, Types ACR, K & L				
	3/8 in. 0.305*	1/2 in. 0.402*	5/8 in. 0.525*	3/4 in. 0.652*	7/8 in. 0.745*
30	283	584	1190	2080	2940
40	242	500	1020	1780	2520
50	215	443	901	1570	2230
60	194	401	816	1430	2020
70	179	369	751	1310	1860
80	166	343	699	1220	1730
90	156	322	655	1150	1630
100	147	304	619	1080	1540
150	118	244	497	869	1230
200	101	209	426	744	1060
250	90	185	377	659	935
300	81	168	342	597	847
350	75	155	314	549	779
400	70	144	292	511	725
450	65	135	274	480	680
500	62	127	259	453	643
600	56	115	235	410	582
700	51	106	216	378	536
800	48	99	201	351	498
900	45	93	189	330	468
1000	42	88	178	311	442
1500	34	70	143	250	355
2000	29	60	122	214	304

Note: All table entries are rounded to 3 significant digits.
*Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

TABLE B

Pipe Sizing Between First-Stage and Second-Stage Regulators: Nominal Pipe Size, Schedule 40

Pipe Length (ft)	1/2 in. 0.622	3/4 in. 0.824	1 in. 1.049	1 1/4 in. 1.38	1 1/2 in. 1.61	2 in. 2.067	2 1/2 in. 3.068	3 in. 3.548	4 in. 4.026
30	1480	3090	5820	11900	17900	34500	54900	97100	198000
40	1260	2640	4980	10200	15300	29500	47000	93100	170000
50	1120	2340	4410	9060	13600	26100	41700	73700	150000
60	1010	2120	4000	8210	12300	23700	37700	66700	136000
70	934	1950	3680	7550	11300	21800	34700	61400	125000
80	869	1820	3420	7020	10500	20300	32300	57100	116000
90	815	1700	3210	6590	9880	19000	30300	53600	109000
100	770	1610	3030	6230	9330	18000	28600	50600	103000
150	618	1290	2440	5000	7490	14400	23000	40700	82900
200	529	1110	2080	4280	6410	12300	19700	34800	71000
250	469	981	1850	3790	5680	10900	17400	30800	62900
300	425	889	1670	3440	5150	9920	15800	27900	57000
350	391	817	1540	3160	4740	9120	14500	25700	52400
400	364	760	1430	2940	4410	8490	13500	23900	48800
450	341	714	1340	2760	4130	7960	12700	22400	45800
500	322	674	1270	2610	3910	7520	12000	21200	43200
600	292	611	1150	2360	3540	6820	10900	19200	39200
700	269	562	1060	2170	3260	6270	9990	17700	36000
800	250	523	985	2020	3030	5830	9300	16400	33500
900	235	490	924	1900	2840	5470	8720	15400	31500
1000	222	463	873	1790	2680	5170	8240	14600	29700
1500	178	372	701	1440	2160	4150	6620	11700	23900
2000	152	318	600	1230	1840	3550	5660	10000	20400

TABLE C

Polyethylene Plastic Tube Sizing Between First-Stage and Second-Stage Regulators: Nominal Outside Diameter (CTS)

Plastic Tubing Length (ft)	1/2 in. SDR 7.00 (0.445)	1 in. SDR 11.00 (1.007)
30	762	5230
40	653	4470
50	578	3960
60	524	3590
70	482	3300
80	448	3070
90	421	2880
100	397	2720
125	352	2410
150	319	2190
175	294	2010
200	273	1870
225	256	1760
250	242	1660
275	230	1580
300	219	1500
350	202	1380
400	188	1290
450	176	1210
500	166	1140
600	151	1030
700	139	951
800	129	884
900	121	830
1000	114	784
1500	92	629
2000	79	539

CTS: Copper tube size.
SDR: Standard dimension rating.
Notes:
(1) Dimemsions in parentheses are inside diameter.

TABLE D

Polyethylene Plastic Pipe Sizing Between First-Stage and Second-Stage Regulators: Nominal Outside Diameter (IPS)

Plastic Pipe Length (ft)	1/2 in. SDR 9.33 (0.660)	3/4 in. SDR 11.0 (0.860)	1 in. SDR 11.00 (1.077)	1 1/4 in. SDR 10.00 (1.328)	1 1/2 in. SDR 11.00 (1.554)	2 in. SDR 11.00 (1.943)
30	2140	2390	7740	13420	20300	36400
40	1835	3670	6630	11480	17300	31200
50	1630	3260	5870	10180	15400	27600
60	1470	2950	5320	9220	13900	25000
70	1360	2710	4900	8480	12800	23000
80	1260	2530	4560	7890	11900	21400
90	1180	2370	4270	7400	11200	20100
100	1120	2240	4040	6990	10600	19000
125	990	990	3580	6200	9360	16800
150	897	897	3240	5620	8480	15200
175	826	826	2980	5170	7800	14000
200	778	778	2780	4810	7260	13000
225	721	721	2600	4510	6810	12200
250	681	681	2460	4260	6430	11600
275	646	646	2340	4050	6110	11000
300	617	617	2230	3860	5830	10470
350	567	567	2050	3550	5360	9640
400	528	528	1910	3300	4990	8970
450	495	495	992	3100	4680	8410
500	468	468	937	2930	4420	7950
600	424	424	849	2650	4010	7200
700	390	390	781	2440	3690	6620
800	363	363	726	2270	3430	6160
900	340	340	682	2130	3220	5780
1000	322	322	644	2010	3040	5460
1500	258	258	517	933	1616	4390
2000	221	221	443	498	1383	3750

IPS: Iron pipe size.

SDR: Standard dimension ratio.

Notes:

(1) Dimemsions in parentheses are inside diameter.

TABLE E

Corrugated Stainless Steel Tubing (CSST) Inlet Pressure 5-10 PSI, pressure drop of 3.5 psi.

Tubing Length (ft)	3/8 in.		1/2 in.		3/4 in.		1 in.		1 1/2 in.		2 in.	
	13	15	18	19	23	25	30	31	46	48	60	62
30	461	603	999	1190	1870	2340	4430	5100	16400	18200	31700	36900
40	396	520	867	1030	1630	2030	3820	4400	14200	15800	27600	32000
50	352	463	777	926	1460	1820	3410	3930	12700	14100	24700	28600
75	284	376	637	757	1210	1490	2770	3190	10300	11600	20300	23400
100	243	324	553	656	1050	1300	2390	2760	8930	10000	17600	20300
150	196	262	453	535	866	1060	1940	2240	7270	8210	14400	16600
200	169	226	393	464	755	923	1680	1930	6290	7130	12500	14400
250	150	202	352	415	679	828	1490	1730	5620	6390	11200	12900
300	136	183	322	379	622	757	1360	1570	5120	5840	10300	11700
400	117	158	279	328	542	657	1170	1360	4430	5070	8920	10200
500	104	140	251	294	488	589	1050	1210	3960	4540	8000	9110

EHD: Equivalent hydraulic diameter. A measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

Notes:

(1) Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds 1⁄2 psi (based on 13 in. w.c. outlet pressure), do not use this table. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator may vary with flow rate.

(2) CAUTION: Capacities shown in table may exceed maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.

(3) Table includes losses for four 90 degree bends and two end fittings. Where additional fittings are used, increase the length of tubing according to the following equation: L = 1.3n, where L is additional length (ft) of tubing and n is the number of additional fittings and/or bends.

(4) All table entries are rounded to 3 significant digits.

PIPE and TUBING SIZING (Continued)

2. Sizing Between Second Stage Regulator and Appliances

1. Measure the required length of pipe or tubing from the outlet of the second stage regulator to the furthest appliance.
2. Determine the specific load requirement for each appliance. (Refer to the Table on Page 6 to review Total Load)
3. Make a sketch of the system and piping.
4. Select the required pipe or tubing. Refer to Tables on Pages 29.

Example

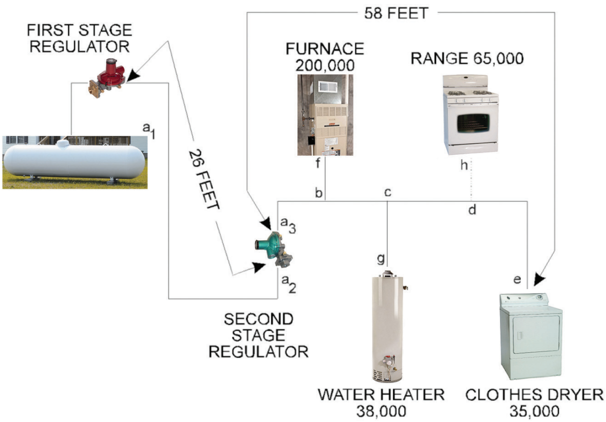
Procedures and information needed for a successful new installation are as follows:

1. The required length of pipe or tubing (main line) from the outlet of the second stage regulator to the furthest appliance (clothes dryer) is 58 feet. Round off to 60 feet.
2. The system will supply gas to a:

   Single family warm air furnace............200,000 Btu's
   40 to 50 gallon water heater ....38,000 Btu's
   Free standing domestic range ....65,000 Btu's
   Clothes Dryer.......................................35,000 Btu's

   The Total Load is 338,000 Btu's
3. Select the required pipe or tubing.
4. Make a sketch of the system and piping.

PIPE and TUBING SIZING (Continued)



Assuming undiluted propane gas, an inlet pressure of 10.0 psi, a pressure drop of 1.0 psi and specific gravity of 1.52, use Tables A-F on Pages 18-23 for Copper, Schedule 40 Black Iron, or CSST. Using the appropriate tables from NFPA 58, select the proper tubing or pipe size for each section of piping, using values in Btuh for the length determined from steps #2 and step #3. If the exact length is not on the table, use the next longer length. Do not use any other length for this purpose! Simply select the size that shows at least as much capacity as needed for each piping section.

Total first-stage piping length = 26 feet (use appropriate table and column)

From a_1 to a_2 demand = 338,000 Btuh: use ½" pipe, or ½" ACR copper tubing, or ½" PE tubing

Total second-stage piping length = 58 feet (use appropriate table and column)

From a_3 to b, demand = 338,000 Btuh: use 1" pipe

From b to c, demand = 138,000 Btuh: use ¾" pipe or ⅞" ACR copper tubing

From c to d, demand = 100,000 Btuh: use ½" pipe or ¾" ACR copper tubing, or ¾" (23 EHD) CSST

PIPE and TUBING SIZING (Continued)

From d to e, demand = 35,000 Btuh: use ½" pipe, or ½" ACR copper tubing, or ½" (18 EHD) CSST

From b to f, demand = 200,000 Btuh: use ¾" pipe

From c to g, demand = 38,000 Btuh: use ½" pipe, or 5/8" ACR copper tubing, or ½" (18 EHD) CSST

From d to h, demand = 65,000 Btuh: use ½" pipe, or 5/8" ACR copper tubing, or ¾" (23 EHD) CSST

The CSST sizing tables in NFPA 54 show CSST diameters expressed in Equivalent Hydraulic Diameter (EHD). Manufacturer EHD comparison charts should be used to convert EHD values to CSST diameters when they are expressed in inches.

COMPARISON OF CSST EHD FLOW DESIGNATION AND TUBE SIZES (for use with CSST Tables)

Flow Designation	13	15	18	19	23	25	30	31	37	47	60
Tubing Size	3/8"	3/8"	½"	½"	¾"	¾"	1"	1"	1¼"	1½"	2"

From c to d, demand = 100,000 Btuh: use ½" pipe or ¾" ACR copper tubing, or ¾" (23 EHD) CSST

From d to e, demand = 35,000 Btuh: use ½" pipe, or ½" ACR copper tubing, or ½" (18 EHD) CSST

From b to f, demand = 200,000 Btuh: use ¾" pipe

From c to g, demand = 38,000 Btuh: use ½" pipe, or 5/8" ACR copper tubing, or ½" (18 EHD) CSST

From d to h, demand = 65,000 Btuh: use ½" pipe, or 5/8" ACR copper tubing, or ¾" (23 EHD) CSST

The CSST sizing tables in NFPA 54 show CSST diameters expressed in Equivalent

Hydraulic Diameter (EHD). Manufacturer EHD comparison charts should be used to convert EHD values to CSST diameters when they are expressed in inches.

TABLE F

Copper Tube Sizing Between Second-Stage Regulator and Appliance: Outside Diameter Copper Tubing, Type ACR, K & L

Tubing Length (ft)	3/8 in.	1/2 in.	5/8 in.	3/4 in.	7/8 in.
10	45	93	188	329	467
20	31	64	129	226	321
30	25	51	104	182	258
40	21	44	89	155	220
50	19	39	79	138	195
60	17	35	71	125	177
80	15	30	61	107	152
100	13	27	54	95	134
125	11	24	48	84	119
150	10	21	44	76	108
200	NA	18	37	65	92
250	NA	16	33	58	82
300	NA	15	30	52	74
350	NA	14	28	48	68
400	NA	13	26	45	63

Note: *Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.

TABLE G

Metallic Pipe Sizing Between Single- or Second-Stage (Low-Pressure) Regulator and Appliance - Schedule 40

Tubing Length (ft)	1/2 in. 0.622	3/4 in. 0.824	1 in. 1.049	1 1/4 in. 1.380	1 1/2 in. 1.610
10	291	608	1150	2350	3520
20	200	418	787	1620	2420
30	160	336	632	1300	1940
40	137	287	541	1110	1660
50	122	255	480	985	1480
60	110	231	434	892	1340
80	101	212	400	821	1230
100	94	197	372	763	1140
125	89	185	349	716	1070
150	84	175	330	677	1010
200	67	140	265	543	814
250	62	129	243	500	749
300	58	120	227	465	697
350	51	107	201	412	618
400	46	97	182	373	560

Note: All table entries are rounded to 3 significant digits.

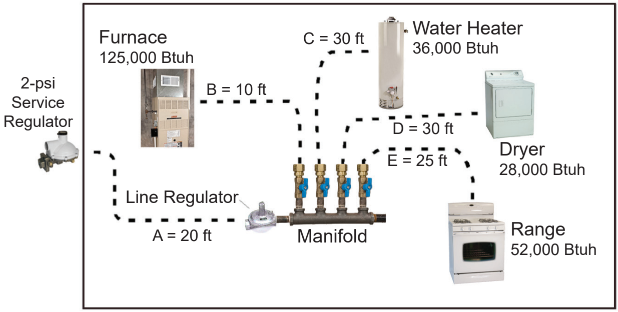
PIPE and TUBING SIZING (Continued)

3. Identifying Distribution Lines for 2-Pound Systems

Distribution lines in 2-psi systems use smaller diameters in the 2-psi sections of the system compared to half-pound (11 inches water column) distribution systems. The same piping materials—schedule 40 metallic pipe, copper tubing, and corrugated stainless steel tubing (CSST) can be used, but run sizing must consider the locations of line regulators that reduce the 2 psig pressure supplied by the 2-psi service regulator. A number of different distribution layouts can be used in 2-psi systems. Examples using different line materials and line regulator locations are illustrated on the following pages.

2-PSI Systems Using Corrugated Stainless Steel Tubing

Example 1:



CSST 2-PSI Pressure System

COMPARISON OF CSST EHD FLOW DESIGNATION AND TUBE SIZES (for use with CSST Tables)

Flow Designation	13	15	18	19	23	25	30	31	37	47	60
Tubing Size	3/8"		½"		¾"			1"	1¼"	1½"	2"

Method for single line regulator systems with no branched runs off a manifold (all lines connect a single appliance directly to the manifold).

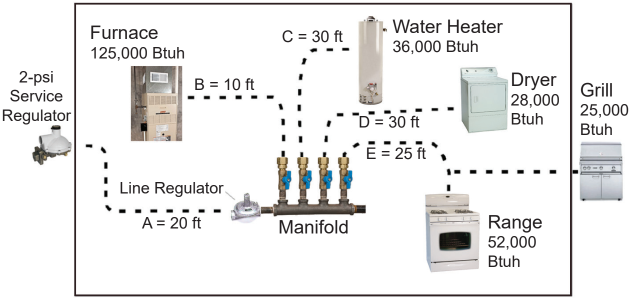
a) Determine the total gas demand for the system, by adding up the Btuh input from the appliance nameplates, and adding demand as appropriate for future appliances. Use this value to determine the size of the “trunk line” (A) running between the outlet of the 2-PSI service regulator and the line regulator.

b) Determine the tubing diameter needed for each appliance line section using the Btuh input of the appliance and the length of CSST needed to connect the appliance to the manifold.

Section Description	Load Delivered by Section	Length	CSST Tube Size
“A—Trunk	241,000 Btuh at 2 psig	20 feet	½ inch
“B”—Furnace	125,000 Btuh at 11 in. w.c.	10 feet	½ inch
“C”—Water Heater	36,000 Btuh at 11 in. w.c.	30 feet	½ inch
“D”—Dryer	28,000 Btuh at 11 in. w.c.	30 feet	3/8 inch
“E”—Range	52,000 Btuh at 11 in. w.c.	25 feet	½ inch
CSST sizes are determined by using the pressure, length and load for each section.			

2-PSI Systems Using Corrugated Stainless Steel Tubing

Example 2:



CSST 2-PSI Pressure System

COMPARISON OF CSST EHD FLOW DESIGNATION AND TUBE SIZES (for use with CSST Tables)

Flow Designation	13	15	18	19	23	25	30	31	37	47	60
Tubing Size	3/8"		½"		¾"			1"	1¼"	1½"	2"

Method for single line regulator systems with a branched run off the manifold.

a) Determine the total gas demand for the system by adding up the Btuh input from the appliance nameplates, and adding demand as appropriate for future appliances. Use this value to determine the size of the "trunk line" (A) running between the outlet of the 2-PSI service regulator and the line regulator.

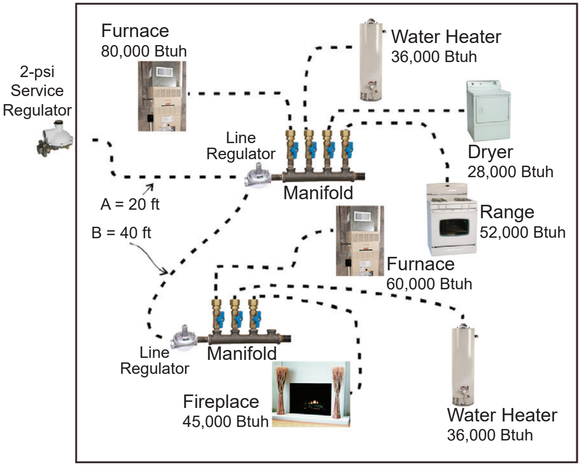
b) Determine the tubing diameter needed for each single-appliance line section using the Btuh input of the appliance and the length of CSST needed to connect the appliance to the manifold.

c) Use the "Longest Run Method" for sizing the appliance lines in the branched runs (E, F, and G).

Section Description	Load Delivered by Section	Length	Longest Run	CSST Tube Size
"A—Trunk	266,000 Btuh at 2 psig	20 feet	20 feet	½ inch
"B"—Furnace	125,000 Btuh at 11 in. w.c.	10 feet	10 feet	½ inch
"C"—Water Heater	36,000 Btuh at 11 in. w.c.	30 feet	30 feet	½ inch
"D"—Dryer	28,000 Btuh at 11 in. w.c.	30 feet	30 feet	3/8 inch
"E"—Grill & Range	77,000 Btuh at 11 in. w.c.	25 feet	40 feet	¾ inch
"F"—Grill	25,000 Btuh at 11 in. w.c.	15 feet	40 feet	½ inch
"G"—Range	52,000 Btuh at 11 in. w.c.	35 feet	35 feet	½ inch
CSST sizes are determined by using the pressure, length and load for each section.				

2-PSI Systems Using Corrugated Stainless Steel Tubing

Example 3:



CSST 2-PSI Multiple Manifold System

COMPARISON OF CSST EHD FLOW DESIGNATION AND TUBE SIZES (for use with CSST Tables)

Flow Designation	13	15	18	19	23	25	30	31	37	47	60
Tubing Size	3/8"		½"		¾"			1"	1¼"	1½"	2"

Method for single line regulator systems with a branched run off the manifold.

a) Determine the total gas demand for the system by adding up the Btuh input from the appliance nameplates, and adding demand as appropriate for future appliances. Use this value to determine the size of the “trunk line” (A) running between the outlet of the 2-PSI service regulator and the line regulator. Use the “longest length” in the trunk line section (A + B) to size both trunk lines.

b) Determine the total gas demand served by trunk line B. Use the “longest length” in the trunk line section (A + B) to size both trunk lines.

c) Determine the tubing diameter needed for each singe appliance line section using the Btuh input of the appliance and the length of CSST needed to connect the appliance to the manifold.

<table>
<tr><th>Section Description</th><th>Load Delivered by Section</th><th>Length</th><th>Longest Run</th><th>CSST Tube Size</th></tr>
<tr><td>“A—Trunk</td><td>337,000 Btuh at 2 psig</td><td>20 feet</td><td>60 feet</td><td>1/2 inch</td></tr>
<tr><td>“B”—Furnace</td><td>141,000 Btuh at 2 psig</td><td>40 feet</td><td>60 feet</td><td>3/8 inch</td></tr>
<tr><td colspan="5">Longest Run for Trunk Section = Distance from 2-PSI service regulator to furthest line regulator
Un-branched appliance runs between the (line regulators) manifolds and appliances are determined using the length and load for each section only.</td></tr>
</table>

Step number 3 for multiple manifold systems is completed in the same manner as illustrated in step number 2 in Example 1.

Although CSST distribution lines were used for Examples 1-3 illustrating 2-PSI systems, remember that steel pipe and copper tubing can be used in 2-psi systems as well. Some system designs may call for a combination of these materials.

Regardless of the materials used in the piping runs, be sure that the correct sizing methods and capacity charts are used when determining the diameter for each type of material used, and its place in the distribution system.

REGULATORS

In both residential and commercial applications, a propane gas regulator controls the flow of gas from an ASME tank or DOT cylinder to the appliance(s) it feeds, compensating for differences in container pressure and a variable load from the intermittent use of appliances.

There are four considerations when selecting a regulator:

1. Appliance Load - The sum of all propane gas used in an installation and is expressed in Btu's (British Thermal Units)
2. Pipe Size - Determining both the right pipe, tubing material and dimensions for a propane gas installation
3. Inlet Pressure - Pressure measured in inches water column to an appliance
4. Outlet Pressure - Pressure measured in psig from any of the regulators

There are six types of Residential/Commercial Kosan LINE regulators:

1. First-Stage - 984HP/988HP
2. Dual Second-Stage - DSS7
3. Second-Stage - 988LP/998LP, with or without dielectric protection
4. Integral Two Stage - 988TW/998TW
5. 2PSI - 988TP/998TP
6. Automatic Changeover - 524AC

HP	High Pressure	Tank Pressure to 10 psi
LP	Low Pressure	10 psi to 11 inches w.c.
DSS	Low Pressure	30 psi to 11 inches w.c. or 2psi
TW	Twin Stage	Tank pressure to 11 inches w.c.
TP	Two Pounds	10 psi to 2 psi
AC	Automatic Changeover	

There are two types of Residential/Commercial Kosan LINE Governor Regulators:

1. Type 90/2psi
2. Type 95/2psi

All Cavagna Group Kosan LINE regulators are compliant with UL144 Standards and are designed to be installed outdoors following manufacturer's instructions. The pressure governor is compliant with ANSIZ2180 Standards and is designed only for indoor use following manufacturer's instructions.

REGULATORS (Continued)

First-Stage

1 - The First-stage regulator is located at the propane storage tank on medium to large Btu/h demand systems. It reduces the high inlet pressure from the tank or cylinder to 10psi, the rate of flow of a second stage regulator.

The First-Stage Regulator must be:

1. Designated as a first-stage regulator suitable for residential applications. DO NOT use high-pressure regulators designed for commercial or industrial applications as a first-stage regulator.
2. Rated with an output capacity in excess of total system demand.
3. Designed to supply outlet pressures within the range needed for the second-stage regulator(s) inlet pressures, typically 5 psig to 10 psig.
4. Equipped with adequate relief capacity to meet the requirements of NFPA codes.

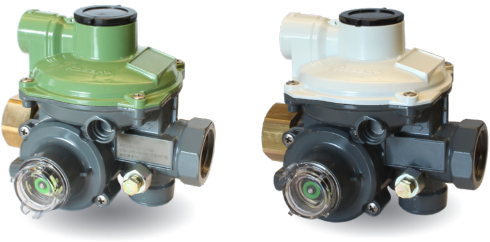
Two first-stage regulators can be used in a parallel installation in unusually high-demand systems.

Type	Capacities in BTU\hr (SCMH) propane	Inlet connection, inches	Outlet connection, inches	Outlet adjustment range, PSIG (bar)	Outlet pressure setting, PSIG (bar)
984HP - 04	1,000,000 (11.26)	1/4” NPT	1/2” NPT	No adjustment	10 (0.69)
984HP - 05	1,000,000 (11.26)	POL		No adjustment	10 (0.69)
984HP - 06[1]	1,000,000 (11.26)	1/4” NPT		No adjustment	10 (0.69)
988HP - 07	2,000,000 (22.51)	1/2” NPT		4 to 6 (0.28 to 0.41)	5 (0.34)
988HP - 08		POL			
988HP - 09	2,250,000 (25.33)		3/4” NPT		
988HP - 04	2,100,000 (23.64)	1/2” NPT	1/2” NPT	8 to 12 (0.55 to 0.83)	10 (0.69)
988HP - 01	2,400,000 (27.01)	3/4” NPT	3/4” NPT		
988HP - 05	2,100,000 (23.64)	POL	1/2” NPT		
988HP - 06	2,250,000 (25.33)		3/4” NPT		

[1] Vent-hole opposite the gauge fittings.

REGULATORS (Continued)

Dual Second-Stage



DSS7 Dual Second Stage Pressure Regulators

Product Description

The DSS7 series regulators are direct action, dual second stage pressure regulators, normally used for domestic or small commercial applications. Installations can be individual or in gas grids (ie LPG Community Systems) and can be directly assembled to a meter configuration, for LP-gas, or other non-corrosive preliminarily treated stable gas.

Key Features

This device will slam shut, shutting off the gas supply when the outlet pressure falls below the UPSO set point (3-4" w.c. for 11" version or 10" w.c. for 2 PSI version) or above the OPSO set point (1.5 PSI for 11" version or 4.5 PSI for 2 PSI version).
This safety is activated when the outlet pressure decreases / increases due to:

- Low regulator outlet pressure (out of gas situations)
- Blockage in the regulator valve seat (overpressure)

The device will shut down preventing gas to flow either downstream or through the vent when activated. It can only be manually reset by a qualified technican after the condition causing the device to activate is resolved.
It will not allow large volumes of gas to be released as traditional relief valves do primarily avoiding a release until the source container can be shut off.

Type	Capacities in BTU\hr propane [1]	Inlet connection, inches	Maximum Inlet pressure	Outlet connection, inches	Outlet pressure range	Outlet pressure setting
DSS7 - M 0090 (07.R.235.0090)	2,300,000	3/4” NPT	30 psi	3/4” NPT	9” - 13” w.c.	11” w.c.
DSS7 - M 0090 (07.R.235.0090)				3/4” NPT 90°		
DSS7 - M 0090 (07.R.235.0090)	2,500,000			1” NPT		
DSS7 - M 0090 (07.R.235.0090)				1” NPT 90°		
DSS7 - M 0090 (07.R.235.0090)	2,300,000	3/4” NPT		3/4” NPT	1 to 2.2 PSIG	2 PSIG
DSS7 - M 0090 (07.R.235.0090)				3/4” NPT 90°		

[1] referred to propane with relative density=0.51

DSS7 - M (in line version)

DSS7 - N (angle version)

Working Temperature: -40°F ÷ 140°F (-40°C ÷ 60°C)

Weight: 3.3 Lbs (1.5Kg)

REGULATORS (Continued)

Second-Stage

2 - The Second-stage regulator is used at building service entrance(s) to reduce the approximately 10 psig vapor pressure supplied by the first-stage regulator to approximately 11 inches water column supply to the half-pound distribution piping.

Inlet/Outlet Configurations

998LP-03
998LP-04
998LP-29

Back Mount

998LP-09
998LP-10

In line

998LP-05

Angle Body

Type	Capacities in BTU\hr (SCMH) propane	Inlet connection, inches	Outlet connection, inches	Outlet pressure range, inches W.C. (mbar)	Outlet pressure setting, inches W.C. (mbar)
988LP - 03	800,000 (9.01)	1/2” NPT	1/2” NPT	9 to 13 (22 to 32)	11 (27)
988LP - 34	650,000 (7.31)		3/4” NPT		
988LP - 35	500,000 (5.63)		1/2” NPT		
998LP - 19	800,000 (9.01)				
998LP - 22	1,000,000 (11.26)				
998LP - 01	1,400,000 (15.76)		3/4” NPT		
998LP - 28 [1]					
998LP - 02		3/4” NPT			
998LP - 05	920,000 (10.36)		3/4” NPT LAT		
998LP - 03	1,000,000 (11.26)	1/2” NPT	3/4” NPT 90°		
998LP - 04		3/4” NPT			
998LP - 29 [1]					
998LP - 10	2,300,000 (25.89)		3/4” NPT		
998LP - 09		1” NPT	1” NPT		

[1] Vent-hole in line with the outlet fitting.

REGULATORS (Continued)

Second-Stage With Incorporated Dielectric Union

2 - The Second-stage Guardian regulators incorporate a dielectric insulation. This regulator is an all in one solution and there is no need to buy separate dielectric unions. The Guardian reduces installation costs and time as well as potential leak points.

In accordance with NFPA 58 (2020 edition)
§ 6.11.3.17 Underground metallic piping, tubing, or both which convey LPG from a gas storage container shall be provided with dielectric fi ttings at the building to electrically isolate it from the aboveground portion of the fixed piping system that enters a building. Such dielectric fittings shall be installed above ground and outdoors.

<table>
<tr><th>Type</th><th>Capacities in BTU\hr (SCMH) propane</th><th>Inlet connection, inches</th><th>Outlet connection, inches</th><th>Outlet pressure range, inches W.C. (Mbar)</th><th>Outlet pressure setting, inches W.C. (Mbar)</th></tr>
<tr><td>988LP - 37</td><td>500,000 (5.63)</td><td rowspan="7">1/2” NPT</td><td>1/2” NPT 90°</td><td rowspan="13">9 to 13
(22 to 32)</td><td rowspan="13">11 (27)</td></tr>
<tr><td>988LP - 36</td><td>650,000 (7.31)</td><td>3/4” NPT 90°</td></tr>
<tr><td>988LP - 24</td><td rowspan="2">800,000 (9.01)</td><td rowspan="3">1/2” NPT</td></tr>
<tr><td>998LP - 39</td></tr>
<tr><td>998LP - 40</td><td>1,000,000 (11.26)</td></tr>
<tr><td>998LP - 41 [1]</td><td rowspan="3">1,400,000 (15.76)</td><td rowspan="3">3/4” NPT</td></tr>
<tr><td>998LP - 31</td></tr>
<tr><td>998LP - 32</td><td rowspan="2">3/4” NPT</td></tr>
<tr><td>998LP - 35</td><td>920,000 (10.36)</td><td>3/4” NPT LAT</td></tr>
<tr><td>998LP - 33</td><td rowspan="3">1,000,000 (11.26)</td><td>1/2” NPT</td><td rowspan="4">3/4” NPT 90°</td></tr>
<tr><td>998LP - 42 [1]</td><td rowspan="2">3/4” NPT</td></tr>
<tr><td>998LP - 34</td></tr>
<tr><td>998LP - 82</td><td>100,000 (1.13)</td><td>1/2” Male Flare</td></tr>
</table>

[1] Vent-hole in line with the outlet fitting.

REGULATORS (Continued)

Integral Two Stage

3 - The Integral 2-stage regulator is for half-pound systems. The regulator is most frequently used for manufactured homes and other installations with relatively small demand loads and short piping runs.

Type	Capacities in BTU\hr (SCMH) propane	Inlet connection, inches	Outlet connection, inches	Outlet adjustment range, inches W.C. (mbar)	Outlet pressure setting, inches W.C. (mbar)
988TW - 15	750,000 (8.44)	1/4” NPT	1/2” NPT	9 to 13 (22 to 32)	11 (27)
988TW - 16[1]					
998TW - 20					
998TW - 11	1,400,000 (15.76)		3/4” NPT		
998TW - 12[1]					
988TW - 28	750,000 (8.44)	POL			
988TW - 17			1/2” NPT		
988TW - 18[1]					
998TW - 21					
998TW - 13	1,400,000 (15.76)		3/4” NPT		
998TW - 14[1]					

[1] First and Second-Stage spring case vents opposite gauge taps.

REGULATORS (Continued)

2PSI Regulator (Standard, dielectric and integral two stage)

4- When selecting the 2PSI regulator:

1. Ensure that the first-stage regulator has sufficient Btu/h capacity to supply all installed and anticipated future appliances total Btu/h demand.
2. Select a 2-PSI service regulator for each required service entrance that has sufficient Btu/h capacity to supply all installed and anticipated future appliances the regulator serves.
3. Ensure that suitable line regulators are selected and properly located to supply connected appliances with adequate gas volume (Btu/h) and pressure.

998TP-07

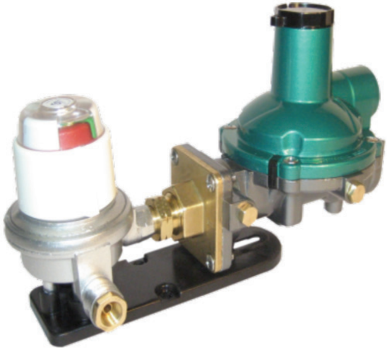
Back Mount

Type	Capacities in BTU\hr (SCMH) propane	Inlet connection, inches	Outlet connection, inches	Outlet adjustment range, PSIG (bar)	Outlet pressure setting, PSIG (bar)
988TP - 22	700,000 (7.88)	1/2” NPT	1/2” NPT	1 to 2.2 (0.069 to 0.15)	2 (0.14)
998TP - 06	1,680,000 (18.91)	3/4” NPT	3/4” NPT		
998TP - 07	1,500,000 (16.88)		3/4” NPT 90°		
998TP - 08	1,460,000 (16.43)	1/2” NPT	1/2” NPT		

988TP - 25	700,000 (7.88)	1/2” NPT	1/2” NPT	Non-adjustable	2 PSIG (0.14 bar)
998TP - 36	1,680,000 (18.91)	3/4” NPT	3/4” NPT	1 to 2.2 PSIG (0.069 to 0.15 bar)	
998TP - 37	1,500,000 (16.88)		3/4” NPT 90°		
998TP - 38	1,460,000 (16.43)	1/2” NPT	1/2” NPT		
988TW - 27	4,500,000 (5.07)	1/4” NPT	3/4” NPT	1 to 2.2 PSIG (0.069 to 0.15 bar)	2 PSIG (0.14 bar)
988TW - 64	5,000,000 (5.07)	POL	1/2” NPT	1 to 2.2 PSIG (0.069 to 0.15 bar)	2 PSIG (0.14 bar)
998TW - 23	1,460,000 (16.43)	1/4” NPT	3/4” NPT	1 to 2.2 PSIG (0.069 to 0.15 bar)	2 PSIG (0.14 bar)

REGULATORS (Continued)

Automatic Changeover



5 - The Automatic Changeover regulator combines first-stage and second-stage regulators with a check valve to receive vapor from manifold cylinders. Cylinder vapor pressure is reduced to approximately 11 inches water column at the second-stage regulator outlet.

Type	Capacities in BTU\hr (SCMH) propane	Inlet connection, inches	Outlet connection, inches	Vent size, inches
524AC	600,000 (6.75)	1/4 Inverted Flare	1/2 NPT	3/4 NPT

How the Changeover Regulator Works

REGULATORS (Continued)

Line/Appliance

Type 90 - 1/2”

Type 95 - 3/4”

Line/Appliance regulators are used in hybrid pressure systems to reduce the 2 psig outlet pressure from the 2-pound service regulator to required appliance inlet pressures, measured in inches water column. They are installed just before manifold piping or tubing runs, or just before individual appliances.

All Kosan Line/Appliance regulators are designed for indoor installation and are compliant with the ANSI1Z2180 Standard.

Capacities bases on 1” w.c. pressure drop from set point 1.52 sp gr gas expressed in BTU (PROPANE stabilizer)

Model	Outlet Pressure	1/2 PSIG	3/4 PSIG	1 PSIG	2 PSIG
90	6” w.c.	250,000	313,000	368,000	447,000
	7” w.c.	243,000	313,000	360,000	439,000
	8” w.c.	243,000	306,000	360,000	423,000
	9” w.c.	227,000	298,000	337,000	407,000
	10” w.c.	211,000	282,000	321,000	384,000
	11” w.c.	196,000	266,000	306,000	368,000
	12” w.c.	196,000	259,000	306,000	360,000

Model	Outlet Pressure	1/2 PSIG	3/4 PSIG	1 PSIG	2 PSIG
95	7” w.c.	570,000	632,000	701,000	810,000
	8” w.c.	563,000	618,000	701,000	798,000
	9” w.c.	536,000	597,000	674,000	784,000
	10” w.c.	516,000	591,000	632,000	777,000
	11” w.c.	473,000	564,000	583,000	741,000

The following tables are for the 90/2psi and 95/2psi Line/ Appliance regulators respectively:

Presure Drop - 0.64 gr Gas Expressed in CFH (m3/h)

Pressure Drop	7.0" psi= 17 mbar	1/2 psi= 34.5 mbar	3/4 psi= 52 mbar	1 psi= 69 mbar
Flow Rate CFH (m3/h)	155 (4.3)	220 (6.1)	280 (7.8)	310 (8.7)

Capacities Based on 1" w.c. Pressure Drop from Set Point 0.64 sp gr Gas Expressed in CFH (m3/h)

Model	Outlet Pressure	1/2 psi= 34.5 mbar	3/4 psi= 52 mbar	1 psi= 69 mbar	2 psi= 138 mbar
90	6" w.c	160 (4.5)	200 (5.6)	235 (6.6)	285 (8.0)
	7" w.c	155 (4.3)	200 (5.6)	230 (6.4)	280 (7.8)
	8" w.c	155 (4.3)	195 (5.5)	230 (6.4)	270 (7.6)
	9" w.c	145 (4.1)	190 (5.3)	215 (6.0)	260 (7.3)
	10" w.c	135 (3.8)	180 (5.0)	205 (5.7)	245 (6.7)
	11" w.c	125 (3.5)	170 (4.8)	195 (5.5)	235 (6.6)
	12" w.c	125 (3.5)	165 (5.5)	195 (5.5)	230 (6.4)

Presure Drop - 0.64 gr Gas Expressed in CFH (m3/h)

Pressure Drop	7.0" psi= 17 mbar	1/2 psi= 34.5 mbar	3/4 psi= 52 mbar	1 psi= 69 mbar
Flow Rate CFH (m3/h)	359 (10.1)	504 (14.3)	627 (17.7)	719 (20.3)

Capacities Based on 1" w.c. Pressure Drop from Set Point 0.64 sp gr Gas Expressed in CFH (m3/h)

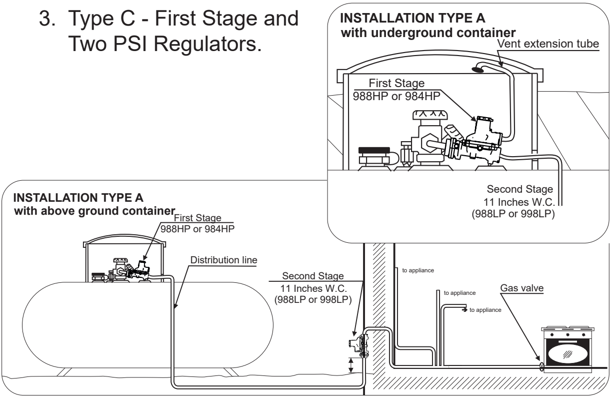
Model	Outlet Pressure	1/2 psi= 34.5 mbar	3/4 psi= 52 mbar	1 psi= 69 mbar	2 psi= 138 mbar
95	7" w.c	364 (10.3)	403 (11.4)	447 (12.7)	517 (14.6)
	8" w.c	359 (10.2)	394 (11.2)	447 (12.7)	509 (14.4)
	9" w.c	342 (9.7)	381 (10.8)	430 (12.2)	500 (14.2)
	10" w.c	329 (9.3)	377 (10.7)	403 (11.4)	496 (14.0)
	11" w.c	302 (8.5)	360 (10.2)	372 (10.5)	473 (13.4)

REGULATORS (Continued)

Installation

There are three types of regulator installations:

1. Type A - First and Second Stage Regulators
2. Type B - Integral Two Stage Regulators
3. Type C - First Stage and Two PSI Regulators.

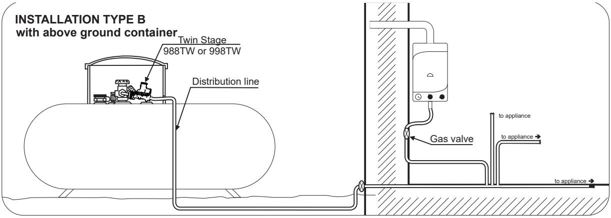


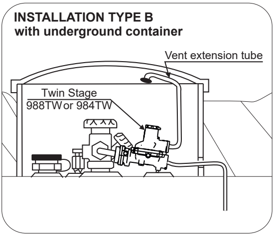
1. Installation Type A - First and Second Stage Regulators

The first stage regulator is connected to the container valve as per NFPA 58. It supplies a second stage regulator that is usually installed nearby the house.
Length and diameter of gas pipes connecting the first stage regulator to the second stage regulator have to be calculated in order to ensure the minimum supplying pressure to the regulator of second stage (5 PSI) and to ensure the maximum allowed capacity to gas appliances. At the same time length and diameter of gas pipes connecting the second stage regulator outlet to gas appliances have to be calculated in order to respect the maximum authorized capacity and pressure drop, as well as to ensure good functioning of the installation.
The first stage regulator must be mounted with cover turned upwards, but slightly bending downwards - please, refer to figure 1 - in order to allow the vent-hole to vent out possible water, which may enter the regulator.
The second stage regulator is installed outdoors and has to have its vent turned downwards, away from eventual openings of the building. See NFPA 58. As far as indoor installation instructions, please refer to the paragraph “Indoor installation”.

REGULATORS (Continued)

Installation



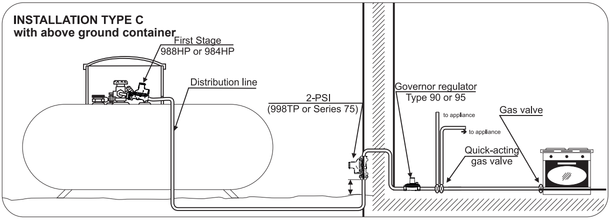


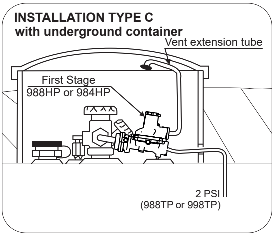
2. Installation Type B - Integral Two Stage Regulators

If the gas container is placed nearby the building, it is possible to use a group of regulation composed by first and second stages integrated, directly connected to gas container valve.
Length and diameter of gas pipes connecting the group of regulation to appliances have to be calculated in order to respect the maximum authorized loss of capacity and to ensure good functioning of the installation.
The group of regulation has to be installed with cover turned upwards, slightly bending forwards.

REGULATORS (Continued)

Installation





3. Installation Type C - First Stage and Two PSI Regulators

Type C installation is similar to Type A installations, however the supplying outlet pressure of the second stage regulator is 2 PSIG rather than 11” WC. The outlet pressure of the second stage regulator is stabilized by a Line Pressure Regulator placed inside the building, which supply gas appliances at normal pressure of 11” WC.
Pipe and tubing sizing between First Stage and Two PSI regulators and each appliance must be calculated to ensure that proper vapor pressure is constantly maintained. (Refer to the three steps for properly sizing pipe and tubing on Page 20 and Tables A through F on Pages 21 through 25 to select the required pipe and tubing for the installation.)

LEAK TESTING

Leak Testing verifies the integrity of the propane piping system from the container to the appliances. NFPA 54 requires a Leak Test with all new installations before they are put into service, when a gas leak is found and repaired, or anytime a system runs out of gas.

Although there are several methods to conduct a leak test, two basic methods are using a manometer and using a Test block gauge.

PERFORMING A LEAK TEST USING A MANOMETER

Step 1: Close the cylinder service valve(s) and proceed according to your company policy.

Step 2: If appropriate, turn off the appliance manual gas shutoff valve.

Step 3: Using the appropriate fitting and hose, connect the water manometer somewhere downstram of the final-stage regulator but before the appliance gas control valve outlet test tap and reopen the appliance manual gas shutoff valve. This example shows an employee tapping into the inlet side of the gas control valve by removing the inlet test tap and installing a barbed adapter to connect the manometer.

Step 4: SLOWLY open the service valve on the propane container. Leave it open for two or three seconds, and then close it.

Step 5: Release enough gas from the vapor distribution system to drop the system pressure to 9” ± ½” w.c. on the water manometer. This ensures that all regulators in the system are unlocked and that a leak anywhere in the system is communicated to the gauging device.

If the gas pressure increases above the 9” ± ½” w.c., you must then check to ensure the service valve is fully closed and then restart the leak check. If you observe another pressure increase, the container service valve will likely need to be repaired or prelaced in order to complete a valid leak check.

Step 6: Allow the vapor distribution system to remain pressurized for **three minutes** without showing an increase or decrease in the reading on the manometer. Once the vapor distribution system is proven to be leak free, record the test pressure and the amount of time it took to perform the test according to your company policy.

Step 7: Close the appliance's manual gas shutoff valve, disconnect the water maometer and any fittings used.

Step 8: Open the service valve(s) on the storage container to repressurize the system.

Step 9: Open the appliance manual gas shutoff valve to repressurize the test point and test for leaks using a suitable leak detector solution or device.

Step 10: Place the appliances into service following your company policy.

USING A TEST-BLOCK GAUGE

A 0-300 psi pressure gauge, such as a test-block gauge, can be used to conduct a leak check. It is installed between the container service valve and the first-stage or integral two-stage regulator.

A test-block gauge is only one type of gauge setup that may be used. Other high-pressure gauges may also be used. Some companies have containers with a test tap located in the container service valve and a gauge is connected directly to it withput disconnecting the inlet side of the first regulator in the system. Some companies use a pressure tap on the inlet side of the first-stage regulator. There are other versions of this type of test tap setup as well.

A significant difference between using a water manometer and the block gauge is that when using the manometer all of the regulators in the system are open and unlocked. When using the block gauge, all regulators in the systems are locked.

For the test-block gauge to indicate a leak in the system, the regulator would need to sense a drop in pressure downstram of it before it would unlock or open.

PERFORMING A LEAK TEST USING A TEST-BLOCK GAUGE

Step 1: Close the container service valve(s) and proceed according to your company policy.

Step 2: Install the block gauge between the container service valve and the inlet of the first regulator in the system by disconnecting the pigtail from the service valve.

Step 3: SLOWLY open the service valve on the propane storage container. Leave it open for two or three seconds, and then close it.

Step 4: Reduce the pressure reading on the block gauge by 10 psig lower than the container pressure. This is done by loosening the bleeder on the test-block gauge. The pressure reading during this step is dependent upon the ambient temperature on the container.

If the gas pressure increases above this reduced pressure, you must then check to ensure all service valves are fully closed and then restart the leak check. **If you observe another pressure increase, the container service valve(s) will likely neet to be repaired or repalced in order to preoperly complete a leak check.**

Step 5: Allow the vapor distribution system to remain pressurized for three minutes without showing an increase or decrease in the reading on the gauge.

Step 6: Once the vapor distribution system is proven to be leak free, record the test pressure and the amount of time it took to perform the test according to your company policy.

Step 7: Remove the block gauge and reconnect the regulator to the container service valve using the appropriate connector.

Step 8: Open the service valve(s) on the container to re-pressurize the system.

Step 9: Check for leaks at the service valve connection and regulator inlet connection using a suitable leak detector solution or device.

Step 10: Place the appliances into service following your company policy.

WHEN YOU DISCOVER A LEAK

If you leak check device shows an increase or decrease in pressure, then propane may be leaking. Keep the following in mind to help determine the location of the leak.

Increase in Pressure

If you leak check device shows an increase in pressure, propane may be leaking into the system from a container service valve.

Check to ensure all service valves are fully closed and restart the leak check. If you observe another pressure increase, the container service valve must be repaired or replaced to complete a valid leak check.

Decrease in Pressure

If you leak check device shows a decrease in pressure, one or more leaks exist in the system.

The source(s) of leakage must be located using a combustible gas indicator, suitable leak detector solution, isolated testing and inspection of piping segments, or a combination of these methods. After the source(s) of leakage are located and repaired, the leak check must be restarted and continued until no change in pressure is observed for 3 minutes, and the vapor distribution system is determine to be gas-tight.

LEAK TESTING (Continued)

Leak Detection and Corrective Actions

Once a leak is found, there are five corrective actions you can take.

1. Use a bubble leak detection solution or a mechanical leak detector to locate the leak. Under absolutely no circumstances should you ever use a match or open flame.
2. Apply the solution over each pipe and tubing connection. If the bubbles expand, that indicates a leak at the connection. A large leak may blow the solution away before bubbles have a chance to form.
3. To correct a leak on flared tubing, try tightening the connection. If this does not work, reflare the tubing.
4. To correct a leak on threaded piping, trying tightening or redoping the connection. If the leak continues, the threads on the connection may be bad. If so, cut new threads.
5. If tightening, reflaring, redoping, or cutting new threads do not work, look for sandholes in pipe or fittings, and splits in tubing. Any defective material needs to be replaced.

Note that leaks caused by faulty equipment or parts requires replacement of the equipment or parts.

TROUBLESHOOTING ASME TANK FITTINGS

Troubleshooting is the process of identifying and fixing a problem which may exist with one or more of the fittings (appurtenances) on an ASME Tank, that prohibits the tank from either correctly being filled, or properly delivering propane vapor through the distribution system.

To reduce the possibility of the malfunctioning of tank fittings, develop a specific inspection and maintenance program with each of your customers. The following four valves should be part of that program.

Filler Valves

Problem - Pressure discharge continues when filling a tank with a filling hose adapter on the end of the hose end valve, even after all pressure between the hose end valve and fill valve has been bled off.

Cause - The filler valve may have malfunctioned.

Fix - First, do **not** remove the fill hose, as the internal parts may be blown out. Try lightly tapping the filler valve to close it. If that does not work, disconnect the filler hose adaptor from the hose end valve, leaving the filling hose adaptor on the fill valve. The tank will probably have to be emptied to replace the fill valve.

Some Fill valve designs allow the seat disc to be replaced while the tank is pressurized. On these designs, make sure the lower back check is still functioning by forcing open the upper back check with an adaptor. Take care to dislodge only the upper back check and not both back checks. If there is little leakage with the upper back check open, then the lower back check is in place and the disc can be replaced by following the manufacturer's instructions.

TROUBLESHOOTING ASME TANK FITTINGS (CONTINUED)

Relief Valves

Problem - The valve discharges substantially below 240 psig (16.5 to 17.9), or it does not reseat when the tank pressure is lowered.

Cause - The valve will not close.

Fix - Lower the tank pressure by withdrawing gas or cooling the outside of the tank.

Note - Always keep a rain cap on the relief valve to help keep dirt, debris and moisture out of the valve. Also, DO NOT STAND OVER A RELIEF VALVE WHEN TANK PRESSURE IS HIGH, as a relief valve's purpose is to relieve excessive tank pressure.

Liquid Withdrawal Valves

Problem - When the closing cap is loosened, an excessive amount of liquid may discharge.

Cause - The seat may be damaged or there may be missing internal parts.

Fix - Should only vapor be leaking from under the cap, the connection to the withdrawal

valve can usually be made. However, if after 30 seconds a significant amount of liquid continues to vent from beneath the cap, do not remove the cap. The tank will probably have to be emptied to replace the fill valve.

Note - Because liquid may spray while opening the withdrawal valve, protective clothing should be worn and extreme care taken during the entire procedure.

Service Valves

Problem - Escaping gas.

Cause - A gas leak from any of the appurtenances.

Fix - Show the custom how to turn off the gas supply at the service valve of the tank. Instruct them that when they do have to turn off the gas supply, to also stay outside the building and away from the tank until a service technician arrives

Remember, under each of these situations to apply your company's policies and procedures when responding to and documenting a troubleshooting process.

Table I LP-Gas Orifice Capacities LP-Gases (BTU/HR at Sea Level)

ORIFICE OR DRILL SIZE	PROPANE	BUTANE	ORIFICE OR DRILL SIZE	PROPANE	BUTANE
0.008	519	589	51	36,531	41,414
0.009	656	744	50	39,842	45,168
0.01	812	921	49	43,361	49,157
0.011	981	1,112	48	46,983	53,263
0.012	1,169	1,326	47	50,088	56,783
80	1,480	1,678	46	53,296	60,420
79	1,708	1,936	45	54,641	61,944
78	2,080	2,358	44	60,229	68,280
77	2,629	2,980	43	64,369	72,973
76	3,249	3,684	42	71,095	80,599
75	3,581	4,059	41	74,924	84,940
74	4,119	4,669	40	78,029	88,459
73	4,678	5,303	39	80,513	91,215
72	5,081	5,760	38	83,721	94,912
71	5,495	6,230	37	87,860	99,605
70	6,375	7,227	36	92,207	104,532
69	6,934	7,860	35	98,312	111,454
68	7,813	8,858	34	100,175	113,566
67	8,320	9,433	33	103,797	117,672
66	8,848	10,031	32	109,385	124,007
65	9,955	11,286	31	117,043	132,689
64	10,535	11,943	30	134,119	152,046
63	11,125	12,612	29	150,366	170,466
62	11,735	13,304	28	160,301	181,728
61	12,367	14,020	27	168,580	191,114
60	13,008	14,747	26	175,617	199,092
59	13,660	15,846	25	181,619	205,896
58	14,333	16,249	24	187,828	212,935
57	15,026	17,035	23	192,796	218,567
56	17,572	19,921	22	200,350	227,131
55	21,939	24,872	21	205,525	232,997
54	24,630	27,922	20	210,699	238,863
53	28,769	32,615	19	223,945	253,880
52	32,805	37,190	18	233,466	264,673

BTU Per Cubic Foot =	**Propane—2,516**	**Butane—3,280**
Specific Gravity =	**Propane—1.52**	**Butane—2.01**
Pressure at Orifice, Inches Water column =	**Propane—11**	**Butane—11**
Orifice Coefficent =	**Propane—0.9**	**Butane—0.9**

Reprinted from NFPA 54, Table E.1.1(b), 2018 ed.

Table J CONVERSION FACTORS

Multiply	By	To Obtain
LENGTH & AREA		
Millimeters	0.0394	Inches
Meters	3.2808	Feet
Sq. Centimeters	0.155	Sq. Inches
Sq. Meters	10.764	Sq. Feet
VOLUME & MASS		
Cubic Meters	35.315	Cubic Feet
Liters	0.0353	Cubic Feet
Gallons	0.1337	Cubic Feet
Cubic cm.	0.061	Cubic Inches
Liters	2.114	Pints (US)
Liters	0.2642	Gallons (US)
Kilograms	2.2046	Pounds
Tonnes	1.1024	Tons (US)
PRESSURE & FLOW RATE		
Millibars	0.4018	Inches w.c.
Ounces/sq. in.	1.733	Inches w.c.
Inches w.c.	0.0361	Pounds/sq. in.
Bars	14.50	Pounds/sq. in.
Kilopascals	0.1450	Pounds/sq. in.
Kilograms/sq. cm.	14.222	Pounds/sq. in.
Pounds/sq. in.	0.068	Atmospheres
Liters/hr.	0.0353	Cubic Feet/hr.
Cubic Meters/hr.	4.403	Gallons/min.
MISCELLANEOUS		
Kilojoules	0.9478	BTU
Calories, kg	3.968	BTU
Watts	3.414	BTU/HR
BTU	0.00001	Therms
Megajoules	0.00948	Therms

Table K CONVERSION FACTORS

Multiply	By	To Obtain
LENGTH & AREA		
Inches	25.4	Millimeters
Feet	0.3048	Meters
Sq. Inches	6.4516	Sq. Centimeters
Sq. Feet	0.0929	Sq. Meters
VOLUME & MASS		
Cubic Feet	0.0283	Cubic Meters
Cubic Feet	28.316	Liters
Cubic Feet	7.481	Gallons
Cubic Inches	16.387	Cubic cm.
Pints (US)	0.473	Liters
Gallons (US)	3.785	Liters
Pounds	0.4535	Kilograms
Tons (US)	0.9071	Tonnes
PRESSURE & FLOW RATE		
Inches w.c.	2.488	Millibars
Inches w.c.	0.577	Ounces/sq. in.
Pounds/sq. in.	27.71	Inches w.c.
Pounds/sq. in.	0.0689	Bars
Pounds/sq. in.	6.895	Kilopascals
Pounds/sq. in.	0.0703	Kilograms/sq. cm.
Atmospheres	14.696	Pounds/sq. in.
Cubic Feet/hr.	28.316	Liters/hr.
Gallons/min.	0.2271	Cubic Meters/hr.
MISCELLANEOUS		
BTU	1.055	Kilojoules
BTU	0.252	Calories, kg
BTU/HR	0.293	Watts
Therms	100,000	BTU
Therms	105.5	Megajoules

FLOW EQUIVALENTS AND TEMPERATURE CONVERSION

TABLE L Flow Equivalents

To convert flow capacities of one kind of gas to flow capacities of a different kind of gas.

		MULTIPLY BY:
If you have a flow capacity (CFH, etc.) in NATURAL GAS and want to know equivalent flow capacity of—	Propane: Butane: Air:	0.63 0.55 0.77
If you have BUTANE and want to know equivalent flow capacity of—	Propane: Natural Gas: Air:	1.15 1.83 1.42
If you have AIR and want to know equivalent flow capacity of—	Propane: Butane: Natural Gas:	0.81 0.71 1.29
If you have PROPANE and want to know equivalent flow capacity of—	Natural Gas: Butane: Air:	0.87 1.59 1.23

TABLE M Temperature Conversion

°F	°C	°F	°C	°F	°C
-40	-40	30	-1.1	90	32.2
-30	-34.4	32	0	100	37.8
-20	-28.9	40	4.4	110	43.3
-10	-23.3	50	10.0	120	48.9
0	-17.8	60	15.6	130	54.4
10	-12.2	70	21.1	140	60.0
20	-6.7	80	26.7	150	65.6

Founded as a family-run business in 1949, the Cavagna Group is today a key industrial partner for gas companies, utility companies and OEMs, supplying them with technology for the regulation, control and metering of gases (gas for energy; industrial, medical and specialty gases; alternative fuels).

The Cavagna Group produces a wide range of products meeting international standards including:

- LPG Valves, Equipment and Regulators
- Engineering and Services dedicated to the LPG industry
- ASME, Fork Lift and Motor Fuel Tank Valves
- Natural Gas regulators for domestic, commercial and industrial use
- Gas meters
- Compressed Gases Cylinder Valves
- Specialty Gases Cylinder Valves
- Refrigerant Gases Cylinder Valves
- Regulation Equipment for Industrial Gases
- Regulation Equipment for Medical Gases
- Comprehensive Range of Welding, Cutting Equipment
- CNG - H2 - AUTOGAS cylinder valves and filling valves
- CNG - AUTOGAS systems

The Group's design engineers and laboratory technicians closely cooperate with worldwide regulatory institutions, both in the writing of international performance standards and in the creation of new products.

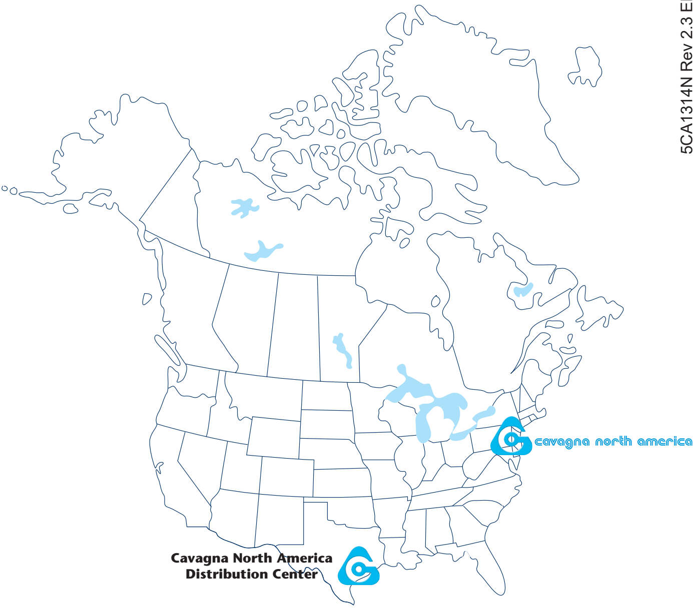
The Cavagna Group of companies has invested heavily in personnel, individual training, and robotic technology to meet the quality standards required by our customers and the 145 countries we serve.

NOTE

NOTE

Wherever gas is used, we are there

5CA1314N Rev 2.3 ENG - 02/22



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