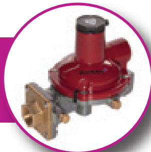
LP-GAS SERVICE TECHNICIAN'S

HANDBOOK

Kosan LINE



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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.

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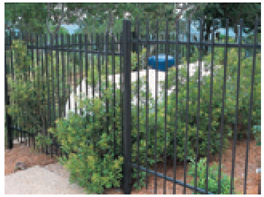
ASME TANKS

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 13 and 14. 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:

Fill Valve - Connects the hose from delivery truck to the tank for re-fueling

Relief Valve - Vents propane in an over-pressure situation

Service Valve - Opening that is connected to the regulator and gas line to provide propane vapor to the appliances

Fixed Liquid Level Gauge - Shows the level of propane is at or above 80% capacity

Float Gauge - Shows propane volume in the tank. Also called a dial gauge

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

Liquid Withdrawal Valve - Used to withdraw liquid propane 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.

Relief Valve - Vents propane in an over-pressure situation

Service Valve - Opening that is connected to the regulator and gas line to provide propane vapor to the appliances

Fixed Liquid Level Gauge - Shows the level of propane is at or above 80% capacity

Float Gauge - Shows propane volume in the tank. Also called a dial gauge

Fill Valve - Connects the hose from the fill source to the cylinder for refilling

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.

The table below assumes the ASME tank is one-half full, the relative humidity is 70% and the tank is under intermittent draw. It shows the intermittent withdrawal (Btu/hr) vaporization rate outside temperature in degrees Fahrenheit and the vapor pressure in pounds per square inch at various temperatures.

ASME Tank

TEMPERATURE	TANK SIZE (GALLONS)			
	150	250	500	1,000
40°F	214,900	288,100	478,800	852,800
30°F	187,900	251,800	418,600	745,600
20°F	161,800	216,800	360,400	641,900
10°F	148,000	198,400	329,700	587,200
0°F	134,700	180,600	300,100	534,500
-10°F	132,400	177,400	294,800	525,400
-20°F	108,800	145,800	242,300	431,600
-30°F	107,100	143,500	238,600	425,000

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:

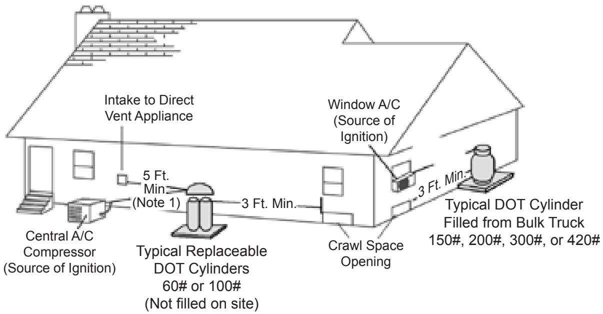
	% Air Remaining	% Propane Remaining
1st Purging	50	50
2nd Purging	25	75
3rd Purging	12.5	87.5
4th Purging	6.25	93.75
5th Purging	3.13	96.87
6th Purging	1.56	98.44

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.



Notes: 1. 5 foot minimum between relief valve discharge and external source of ignition (air conditioner), direct vent, or mechanical ventilation system (attic fan).
2. If the DOT cylinder is filled on-site from a bulk truck, the filling connection and vent valve must be at least 10 feet from any external source of ignition, direct vent, or mechanical ventilation system.

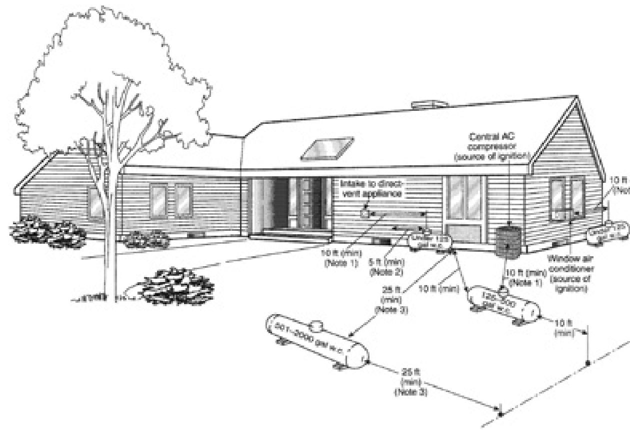
Installation of DOT Cylinders

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

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.



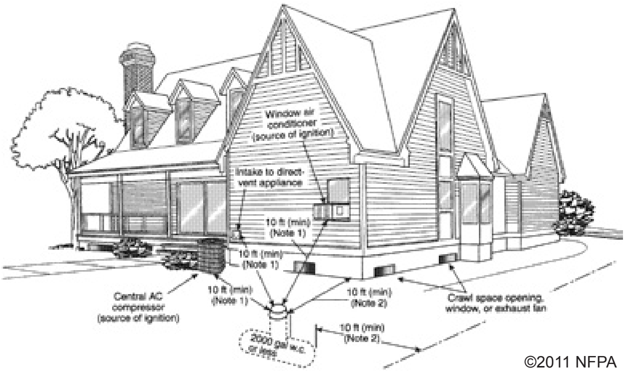
Installation of Aboveground ASME Tanks

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

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

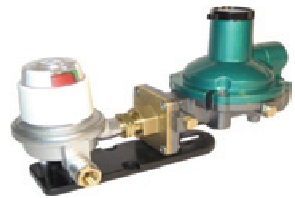
Although there are different size ASME tanks, NFPA 58 requires all underground tanks must be placed on a firm footing and anchored depending on water tables. There are also distance requirements relative to the placement of the tanks in relation to buildings and property lines.

CYLINDER MANIFOLDING

DOT Cylinder manifolding is the hooking or linking together of two to four 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 Services 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 1.52, determine sizing for Copper, Schedule 40 Black Iron, Polyethylene or CSST using Tables A-F on Pages 18-23 for each of the six materials.

TABLE A

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

Tubing Length (ft)	Outside Diameter Copper Tubing, Type L				
	3/8 in. 0.315	1/2 in. 0.430	5/8 in. 0.545	3/4 in. 0.666	7/8 in. 0.785
30	309	700	1303	2205	3394
40	265	599	1115	1887	2904
50	235	531	988	1672	2574
60	213	481	896	1515	2332
70	196	443	824	1394	2146
80	182	412	767	1297	1996
90	171	386	719	1217	1873
100	161	365	679	1149	1769
150	130	293	546	923	1421
200	111	251	467	790	1216
250	90	222	414	700	1078
300	89	201	375	634	976
350	82	185	345	584	898
400	76	172	321	543	836
450	71	162	301	509	784
500	68	153	284	481	741
600	61	138	258	436	671
700	56	127	237	401	617
800	52	118	221	373	574
900	49	111	207	350	539
1000	46	105	195	331	509
1500	37	84	157	266	409
2000	32	72	134	227	350

Note: Capacities are in 1000 Btu/hr.

TABLE B

Pipe Sizing Between First-Stage and Second-Stage Regulators: Outside Diameter Copper Tubing, Type K

Tubing Length (ft)	3/8 in. 0.305	1/2 in. 0.402	5/8 in. 0.527	3/4 in. 0.652	7/8 in. 0.745
30	284	587	1193	2085	2959
40	243	502	1021	1785	2532
50	216	445	905	1582	2244
60	195	403	820	1433	2033
70	180	371	754	1319	1871
80	167	345	702	1227	1740
90	157	374	659	1151	1633
100	148	306	622	1087	1542
150	119	246	500	873	1239
200	102	210	428	747	1060
250	90	186	379	662	940
300	82	169	343	600	851
350	75	155	316	552	783
400	70	144	294	514	729
450	66	136	276	482	654
500	62	128	260	455	646
600	56	116	236	412	585
700	52	107	217	379	538
800	48	99	202	353	501
900	45	93	189	331	470
1000	43	88	179	313	444
1500	34	71	144	251	356
2000	29	60	123	215	305

Notes:
(1) Capacities are in 1000 Btu/hr.
(2) To convert to capacities at a gauge pressure of 5 psi setting with 10 percent (0.5 psi) pressure drop, multiply values by 0.606. To convert to capacities at a gauge pressure of 15 psi setting with 10 percent (1.5 psi) pressure drop, multiply values by 1.380.

TABLE C

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	3 in. 3.068	3 1/2 in. 3.548	4 in. 4.026
30	1843	3854	7259	14904	22331	43008	121180	177425	247168
40	1577	3298	6213	12756	19113	36809	103714	151853	211544
50	1398	2923	5507	11306	16939	32623	91920	134585	187487
60	1267	2649	4989	10244	15348	29559	83286	121943	169877
70	1165	2437	4590	9424	14120	27194	76622	112186	156285
80	1084	2267	4270	8767	13136	25299	71282	104368	145393
90	1017	2127	4007	8226	12325	23737	66882	97925	136417
100	961	2009	3785	7770	11642	22422	63176	92499	128859
150	772	1613	3039	6240	9349	18005	50733	74280	103478
200	660	1381	2601	5340	8002	15410	43421	63574	88564
250	585	1224	2305	4733	7092	13658	38483	56345	78493
300	530	1109	2089	4289	6426	12375	34868	51052	71120
350	488	1020	1922	3945	5911	11385	32078	46967	65430
400	454	949	1788	3670	5499	10591	29843	43694	60870
450	426	890	1677	3444	5160	9938	28000	40997	57112
500	402	841	1584	3253	4874	9387	26449	38725	53948
600	364	762	1436	2948	4416	8505	23965	35088	48880
700	335	701	1321	2712	4063	7825	22047	32280	44969
800	312	652	1229	2523	3780	7279	20511	30031	41835
900	293	612	1153	2367	3546	6830	19245	28177	39253
1000	276	578	1089	2236	3350	6452	18178	26616	37078
1500	222	464	875	1795	2690	5181	14598	21373	29775
2000	190	397	748	1537	2302	4434	12494	18293	25483

Note: Capacities are in 1000 Btu/hr.

TABLE D

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 (0.927)
30	762	5225
40	653	4472
50	578	3964
60	524	3591
70	482	3304
80	448	3074
90	421	2884
100	397	2724
125	352	2414
150	319	2188
175	294	2013
200	273	1872
225	256	1757
250	242	1659
275	230	1576
300	219	1503
350	202	1383
400	188	1287
450	176	1207
500	166	1140
600	151	1033
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) Capacities are in 1000 Btu/hr.
(2) Dimemsions in parentheses are inside diameter.

TABLE E

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	2143	4292	7744	13416	20260	36402
40	1835	3673	6628	11482	17340	31155
50	1626	3256	5874	10176	15368	27612
60	1473	2950	5322	9220	13924	25019
70	1355	2714	4896	8483	12810	23017
80	1261	2525	4555	7891	11918	21413
90	1183	2369	4274	7404	11182	20091
100	1117	2238	4037	6994	10562	18978
125	990	1983	3578	6199	9361	16820
150	897	1797	3242	5616	8482	15240
175	826	1653	2983	5167	7803	14020
200	778	1539	2775	4807	7259	13043
225	721	1443	2603	4510	6811	12238
250	681	1363	2459	4260	6434	11560
275	646	1294	2336	4046	6111	10979
300	617	1235	2228	3860	5830	10474
350	567	1136	2050	3551	5363	9636
400	528	1057	1907	3304	4989	8965
450	495	992	1789	3100	4681	8411
500	468	937	1690	2928	4422	7945
600	424	849	1531	2653	4007	7199
700	390	781	1409	2441	3686	6623
800	363	726	1311	2271	3429	6161
900	340	682	1230	2131	3217	5781
1000	322	644	1162	2012	3039	5461
1500	258	517	933	1616	2441	4385
2000	221	443	798	1383	2089	3753

IPS: Iron pipe size.
SDR: Standard dimension ratio.
Notes:
(1) Capacities are in 1000 Btu/hr.
(2) Dimemsions in parentheses are inside diameter.

TABLE F

Pipe Sizing Between First-Stage and Second-Stage Regulators: Outside Diameter Refrigeration Tubing

Tubing Length (ft)	3/8 in. 0.311	1/2 in. 0.436	5/8 in. 0.555	3/4 in. 0.68	7/8 in. 0.785
30	299	726	1367	2329	3394
40	256	621	1170	1993	2904
50	227	551	1037	1766	2574
60	206	499	939	1600	2332
70	189	459	864	1472	2146
80	176	427	804	1370	1996
90	165	401	754	1285	1873
100	156	378	713	1214	1769
150	125	304	572	975	1421
200	107	260	490	834	1216
250	95	230	434	739	1078
300	86	209	393	670	976
350	79	192	362	616	898
400	74	179	337	573	836
450	69	168	316	538	784
500	65	158	298	508	741
600	59	144	270	460	671
700	54	132	249	424	617
800	51	123	231	394	574
900	48	115	217	370	539
1000	45	109	205	349	509
1500	36	87	165	281	409
2000	31	75	141	240	350

Notes:
(1) Capacities are in 1000 Btu/hr.
(2) To convert to capacities at a gauge pressure of 5 psi setting with 10 percent (0.5 psi) pressure drop, multiply values by 0.606. To convert to capacities at a gauge pressure of 15 psi setting with 10 percent (1.5 psi) pressure drop, multiply values by 1.380.

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 26-27.

Example

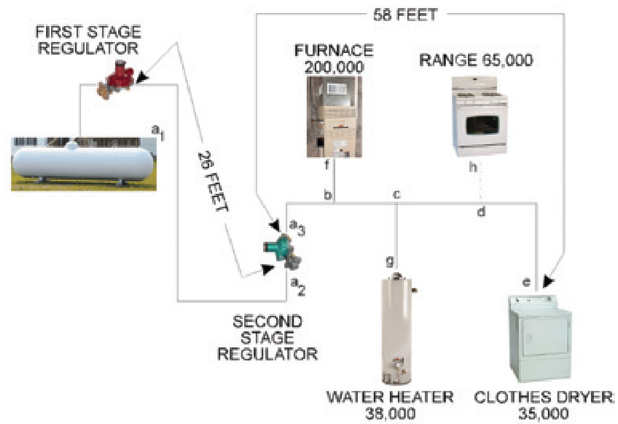
Procedures and information needed for a successful new installation are as follows:

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 7/8" 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"		½"		¾"			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 G

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

Tubing Length (ft)	3/8 in. 0.305	1/2 in. 0.402	5/8 in. 0.527	3/4 in. 0.652	7/8 in. 0.745
10	45	93	188	329	467
20	31	64	129	226	321
30	25	51	104	182	258
40	21	44	89	156	221
50	19	39	79	138	196
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	9	18	37	65	92
250	8	16	33	58	82
300	7	15	30	52	74
350	7	14	28	48	68
400	6	13	26	45	63

Note: Capacities are in 1000 Btu/hr.

TABLE H

Copper Tube Sizing Between Second-Stage Regulator and Appliance: Outside Diameter of Copper Refrigeration Tubing

Tubing Length (ft)	3/8 in. 0.311	1/2 in. 0.436	5/8 in. 0.555	3/4 in. 0.68	7/8 in. 0.785
10	47	115	216	368	536
20	32	79	148	245	368
30	26	63	119	203	296
40	22	54	102	174	253
50	20	48	90	154	224
60	18	43	82	139	203
80	15	37	70	119	174
100	14	33	62	106	154
125	12	29	55	94	137
150	11	26	50	85	124
200	9	23	43	73	106
250	8	20	38	64	94
300	8	18	34	58	85
350	7	17	32	54	78
400	6	16	29	50	73

Note: Capacities are in 1000 Btu/hr.

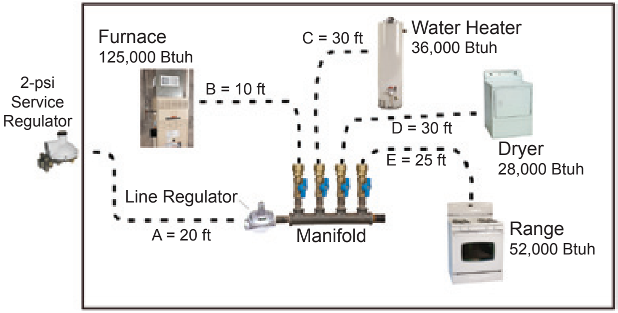
PIPE and TUBING SIZING (Continued)

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).

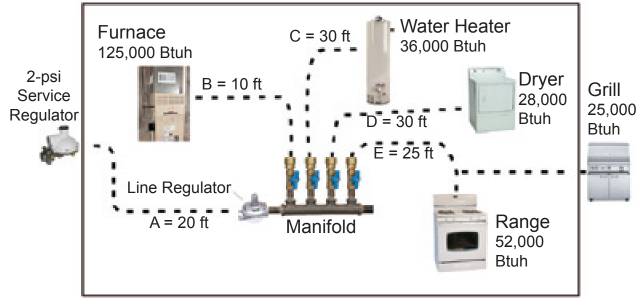
a) Determine the total gas demand for the system, by adding up the Btuh input from the appliance nameplates, and adding demand as appropriate for future appliances. Use this value to determine the size of the "trunk line" (A) running between the outlet of the 2-PSI service regulator and the line regulator.

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.

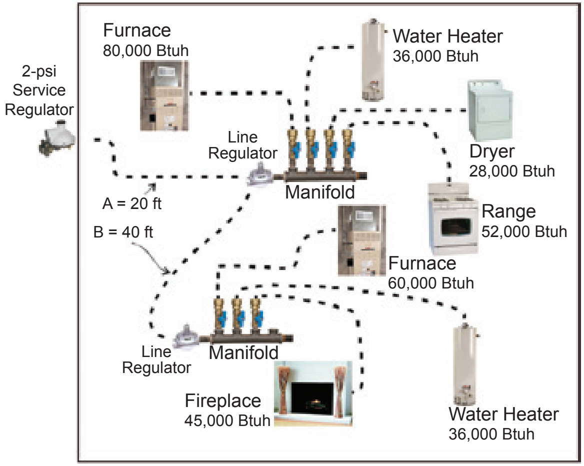
b) Determine the tubing diameter needed for each single-appliance line section using the Btuh input of the appliance and the length of CSST needed to connect the appliance to the manifold.

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.

Section Description	Load Delivered by Section	Length	Longest Run	CSST Tube Size
“A—Trunk	337,000 Btuh at 2 psig	20 feet	60 feet	1/2 inch
“B”—Furnace	141,000 Btuh at 2 psig	40 feet	60 feet	3/8 inch
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.				

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 five types of Residential/Commercial Kosan regulators:

1. First-Stage - 984HP/988HP
2. Second-Stage - 988LP/998LP
3. Integral Two Stage - 988TW/998TW
4. 2PSI - 988TP/998TP
5. Automatic Changeover - 524AC

REGULATORS (Continued)

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

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

All Cavagna Group Kosan 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.

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.

Technical Specifications

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)
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		

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.

Technical Specifications

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	875.000 (9.85)	1/2" NPT	1/2" NPT	9 to 13 (22 to 32)	11 (27)
998LP - 01	1.400.000 (15.76)		3/4" NPT		
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 - 10	2.300.000 (25.89)		3/4" NPT		
998LP - 09		1" NPT	1" NPT		

Inlet/Outlet Configurations

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.

Technical Specifications

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 - 11	450.000 (5.07)	1/4" NPT	1/2" NPT	9.5 to 13 (24 to 32)	11 (27)
988TW - 12'					
988TW - 13		POL			
988TW - 14'					
988TW - 15	750.000 (8.44)	1/4" NPT		9 to 13 (22 to 32)	
988TW - 16'					
998TW - 11	1.400.000 (15.76)		3/4" NPT		
998TW - 12'					
988TW - 17	750.000 (8.44)	POL	1/2" NPT		
988TW - 18'					
998TW - 13	1.400.000 (15.76)		3/4" NPT		
998TW - 14'					

' First and Second-Stage spring case vents opposite gauge taps.

REGULATORS (Continued)

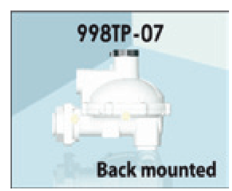
2PSI

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.

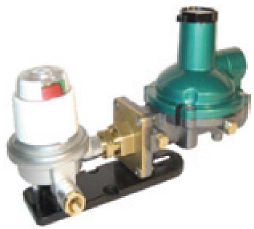
Technical Specifications

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	Non-adjustable	2 (0.14)
998TP - 06	1.680.000 (18.91)	3/4" NPT	3/4" NPT	1 to 2.2 (0.069 to 0.15)	
998TP - 07	1.500.000 (16.88)		3/4" NPT 90°		
998TP - 08	1.460.000 (16.43)	½" NPT	1/2" NPT		



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.

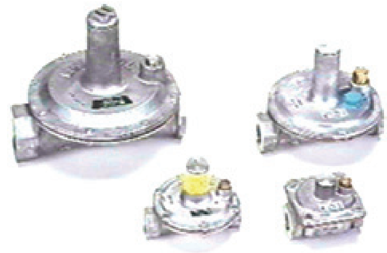
Technical Specifications

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	½ NPT	3/4 NPT

How the Changeover Regulator Works

REGULATORS (Continued)

Line/Appliance



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. Consult the Kosan Regulator brochure to determine the appropriate line regulator to meet system Btu/h load and pressure requirements.

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

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	5 psi= 345 mbar
90	6" w.c	160 (4.5)	200 (5.6)	235 (6.6)	285 (8.0)	350 (9.8)
	7" w.c	155 (4.3)	200 (5.6)	230 (6.4)	280 (7.8)	345 (9.7)
	8" w.c	155 (4.3)	195 (5.5)	230 (6.4)	270 (7.6)	335 (9.4)
	9" w.c	145 (4.1)	190 (5.3)	215 (6.0)	260 (7.3)	325 (9.1)
	10" w.c	135 (3.8)	180 (5.0)	205 (5.7)	245 (6.7)	310 (8.7)
	11" w.c	125 (3.5)	170 (4.8)	195 (5.5)	235 (6.6)	300 (8.4)
	12" w.c	125 (3.5)	165 (5.5)	195 (5.5)	230 (6.4)	295 (8.3)

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)

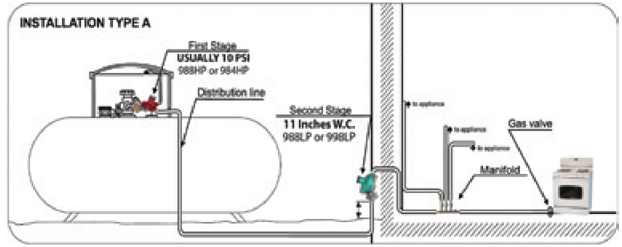
Model	Outlet Pressure	1/2 psi= 34.5 mbar	3/4 psi= 52 mbar	1 psi= 69 mbar	2 psi= 138 mbar	5 psi= 345 mbar
95	7" w.c	364 (10.3)	403 (11.4)	447 (12.7)	517 (14.6)	645 (18.3)
	8" w.c	359 (10.2)	394 (11.2)	447 (12.7)	509 (14.4)	636 (18.0)
	9" w.c	342 (9.7)	381 (10.8)	430 (12.2)	500 (14.2)	636 (18.0)
	10" w.c	329 (9.3)	377 (10.7)	403 (11.4)	496 (14.0)	627 (17.8)
	11" w.c	302 (8.5)	360 (10.2)	372 (10.5)	473 (13.4)	614 (17.8)

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.



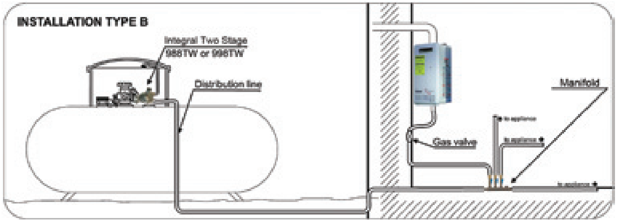
1. Installation Type A - First and Second Stage Regulators

The First Stage regulator is connected to the service valve on the container (See NFPA 58 6.8.1.1.) and reduces the container pressure to 10 PSI. It supplies vapor through the distribution line to the Second Stage regulator mounted at the building service entrance. The Second Stage regulator further reduces the vapor pressure to 11" WC.

Pipe and tubing sizing between the First and Second Stage regulators must be calculated to ensure that proper vapor pressure between the two regulators is constantly maintained. (Refer to the three steps for properly sizing pipe and tubing on Page 17 and Tables A through F on Pages 18 through 23 to select the required pipe and tubing for the installation.)

Connect the first stage regulator at such an angle as to allow the vent to drain any possible water that may enter the regulator. If installed on an underground tank, a vent extension tube must be used to terminate the vent above the local water table. Connect the second stage regulator with the vent facing down and away from the structure on which it's mounted. (See NFPA 58 6.8.1.6.)

Installation

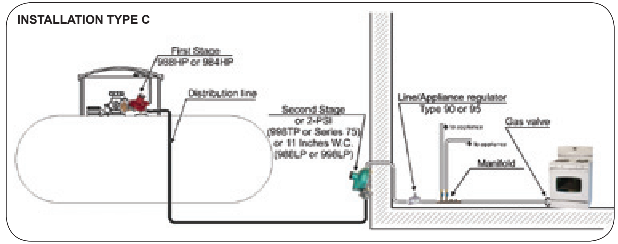


2. Installation Type B - Integral Two Stage Regulators

If the tank or cylinder has a water capacity of less than 125 gallons and is installed next to the building, an Integral Two Stage regulator may be used. If so, install the regulator with the cover facing up.

Pipe and tubing sizing between the Integral Two Stage regulator 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 17 and Tables A through F on Pages 18 through 23 to select the required pipe and tubing for the installation.)

Installation



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

Type C Installations are similar to Type A Installations, except the outlet pressure of the second stage regulator is measured at 2PSI rather than 11" WC. The outlet pressure of the second stage regulator is then stabilized by a line pressure regulator placed inside the building. This regulator will supply gas appliances at a 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 17 and Tables A through F on Pages 18 through 23 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 Low Pressure and High Pressure Testing.

Low Pressure Testing

There are six steps to follow in Low Pressure Testing.

1. Inspect all connections, appliance and pilot valves to be sure they are tightly closed.
2. Connect a water manomenter to the burner orifice and open the valve.
3. Open the service valve at the container to pressurize the system, then tightly close the valve.
4. The low pressure gauge should read at least 11 inches w.c (27mbar). Slowly bleed off pressure by opening the burner valve on the appliance to vent enough gas to reduce the pressure to exactly 9 inches w.c. (22mbar).
5. If the pressure holds at 9 inches w.c. (22mbar) for 3 minutes, the system is leak tight. If the pressure drops, refer to the Leak Detection and Corrective Actions on Page 47 of the handbook.
6. After repairing the leak, repeat steps 3, 4 and 5.

High Pressure Testing

There are also six steps to follow in High Pressure Testing.

1. Inspect all connections, appliance and pilot valves to be sure they are tightly closed.
2. Connect a high pressure test block to the container's service valve between the service valve's outlet and the first stage regulator.
3. Open the service valve at the container to pressurize the system, then tightly close the valve.
4. Open an appliance valve until the monitor pressure gauge drops to 10psig (0.69 bar).
5. The pressure should hold for 3 minutes without an increase or decrease in the reading. If the pressure drops, refer to the Leak Detection and Corrective Actions on Page 47 of the handbook. If the pressure increases, the service valve is leaking.
6. After repairing the leak, repeat steps 3, 4 and 5.

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.

Note - If the tank has either a Cavagna Group 66.1261 or 66.1262 Filler Valve, they feature an All-IN-ONE-SOLUTION where both valves are double back check filler valves; both eliminate the need for a filler hose adaptor; both permit safe filler valve maintenance without tank evacuation; and both can be used with either above ground or underground tanks.

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 F.2, 2002 ed.

LINE SIZING CHART

Table J Line Sizing Chart For Liquid Propane Flow in GPM

Based on 1 psig pressure drop. Propane at 60°F. Based on Schedule 40/80 steel/iron pipe.

Pipe (Ft.)	1/2" 40	1/2" 80	3/4" 40	3/4" 80	1" 40	1" 80	1-1/4" 40	1-1/4" 80	1-1/2" 40	1-1/2" 80	2" 40	2" 80	2-1/2" 40	2-1/2" 80	3" 40	3" 80	4" 40	4" 80
10	7.1	5.0	15.0	11.3	28.3	22.2	58	47.6	87	73	169	143	269	229	475	410	967	846
15	5.8	4.1	12.2	9.2	23.0	18.1	47.5	38.8	71	59	137	116	219	187	387	334	789	690
20	5.0	3.5	10.5	8.0	19.9	15.6	41.0	33.5	62	51	119	100	189	161	335	289	682	597
30	4.1	2.9	8.5	6.5	16.2	12.7	33.4	27.3	50.1	41.6	97	82	154	131	283	235	556	486
40	3.5	2.5	7.4	5.6	14.0	11.0	28.8	23.5	43.3	35.9	84	71	133	114	236	203	481	421
50	3.1	2.2	6.6	5.0	12.5	9.8	25.7	21.0	36.6	32.1	75	63	119	101	211	182	429	376
60	2.8	2.0	6.0	4.5	11.3	8.9	23.4	19.1	35.2	29.2	68	57	109	92	192	166	391	343
70	2.6	1.8	5.5	4.2	10.5	8.2	21.6	17.7	32.5	27.0	63	53	100	85	177	153	362	317
80	2.4	1.7	5.2	3.9	9.8	7.7	20.2	16.5	30.4	25.2	59	49.6	94	80	166	143	338	296
90	2.3	1.6	4.8	3.7	9.2	7.2	19.0	15.5	28.6	23.7	55	46.7	88	75	156	135	319	279
100	2.2	1.5	4.6	3.5	8.7	6.8	18.0	14.7	27.1	22.5	52	44.2	84	71	148	128	302	264
150	1.8	1.2	3.7	2.8	7.1	5.5	14.6	11.9	22.0	18.2	42.5	35.9	68	58	120	104	246	215
200	1.5	1.1	3.2	2.4	6.1	4.8	12.6	10.3	18.9	15.7	36.7	31.0	59	49.9	104	89	212	185
300	1.2	0.9	2.6	1.9	4.9	3.8	10.2	8.3	15.3	12.7	29.7	25.1	47.5	40.4	84	73	172	151
400	1.0	0.7	2.2	1.7	4.2	3.3	8.8	7.1	13.2	10.9	25.6	21.6	40.9	34.8	73	66	149	130

Table K 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 L 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 M 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: Butane: Air:	1.15 1.83 1.42
If you have AIR and want to know equivalent flow capacity of—	Propane: Butane: Air:	0.81 0.71 1.29
If you have PROPANE and want to know equivalent flow capacity of—	Propane: Butane: Air:	0.87 1.59 1.23

TABLE N 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

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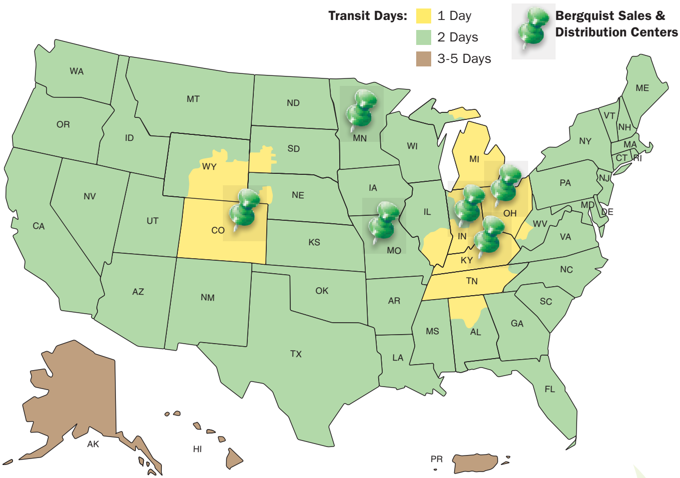

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