

SI ERRATA PAGES (Errata **highlighted**)

SEC 1 — Pages 7 and 8

SEC 4 — Pages 25 and 26

SEC 10 — Pages 7 and 8

SEC 13 — Pages 5 and 6

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Saturated liquid

Liquid which is at its boiling point or is in equilibrium with a vapor phase in its containing vessel.

Saturated vapor

Vapor at its dew point.

Shrinkage

The reduction in volume of a gas stream by removal of some of its constituents such as for recovered products, fuel, or losses.

SNG (Synthetic or Substitute Natural Gas)

The gas product resulting from the gasification of coal and/or gas liquids or heavier hydrocarbons.

Solution gas

Gas which originates from the liquid phase in an oil reservoir.

Sour

Liquids and gases are said to be "sour" if they contain hydrogen sulfide, carbon dioxide, and/or mercaptans above a specified level. It also is used to refer to the feed stream to a sweetening unit.

Sour gas

Gas containing undesirable quantities of hydrogen sulfide, mercaptans, and/or carbon dioxide. It also is used to refer to the feed stream to a sweetening unit.

Splitter

A name applied to fractionators, particularly those separating isomers (e.g., butane splitter refers to a tower producing most of the isobutane in the feed as overhead and most of the normal butane in the feed as bottoms).

Sponge absorbent

An absorbent for recovering vapors of a lighter absorbent that is used in the main absorption process of a gas processing plant.

Stabilized condensate

Condensate that has been stabilized to a definite vapor pressure in a fractionation system.

Stabilizer

A fractionation column designed to reduce the vapor pressure of a liquid stream.

Stage separation system

A system of separators where the liquid portion of the well effluent is separated from formation gas and flash vapors.

Still

The column where the absorbed product is recovered from the lean absorption oil. In plants using a low molecular weight absorption oil, the still is designed as a fractionation column. In plants using a high molecular weight absorption oil, the still may use steam or other fluids as stripping medium. Also used to refer to regenerators in amine treating and glycol dehydration systems.

Strapping

A term applied to the process of calibrating liquid storage capacity of storage tanks in increments of depth.

Stream day

A continuous 24 hour period of plant operation.

Stripper

A column wherein absorbed constituents are stripped from the absorption oil. The term is applicable to columns using a stripping medium, such as steam or gas.

Stripping factor

An expression used to describe the degree of stripping. Mathematically, it is KV/L, the reciprocal of the absorption factor.

Stripping medium

As stated under "stripper", the medium may be steam, gas, or other material that will increase the driving force for stripping.

Sulfur

A yellow, non-metallic chemical element. In its elemental state, it exists in both crystalline and amorphous forms. In many gas streams, sulfur may be found as volatile sulfur compounds, such as hydrogen sulfide, sulfur oxides, mercaptans, and carbonyl sulfide. Reduction of the concentration of these gaseous sulfur compounds is often necessary for corrosion control and possibly for health and safety reasons.

Sulfur dioxide (SO₂)

A heavy, colorless, suffocating gas that is chemically an oxide of sulfur. Conversion of the gaseous sulfur oxides to sulfur is necessary for corrosion control, for health and safety reasons, and for complying with governmental standards.

Sweet

Gas containing essentially no objectionable sulfur compounds. Also, treated gas leaving a sweetening unit.

Sweet gas

Gas which has no more than the maximum sulfur and/or CO₂ content defined by (1) the specifications for the sales gas from a plant; (2) the definition by a legal body. Also, the treated gas leaving a sweetening unit.

Temperature correction factor

A factor for correcting volume at a given temperature to that at a specific reference temperature. Reference temperature most commonly used in the petroleum industry is 15.56 °C.

Therm

A unit of gross heating value equivalent to $(1.055) \times 10^5$ kJ.

Tonne

A unit of mass measurement, commonly used in international petroleum commerce; an expression for the metric ton, or 1000 kilograms.

Trayed column

A vessel wherein gas and liquid, or two essentially immiscible liquids, are contacted, usually counter-currently on trays. Also refer to packed column.

Turboexpander

Refer to definition of "expansion turbine."

Ullage (See outage)**Unsaturated compounds**

Hydrocarbon compounds having one or more unsaturated valence bonds, i.e., ethylene, propylene. These compounds are not found in natural gas streams or gas liquids because of their relatively high chemical reactivity. Unsaturates are produced by a thermal cracking or chemical reaction and can be found in synthetic gas (SNG) or light refinery gases (LRG).

Vapor pressure (true vapor pressure)

The pressure exerted by the equilibrium vapor of a liquid when confined in a closed previously evacuated tank or test apparatus.

Vapor pressure gasoline

A descriptive phrase for natural gasoline meeting a specified vapor pressure.

Vapor pressure, GPA

Vapor pressure as specified by GPA procedures.

Vapor recovery

Equipment or process for the recovery of desired components from stock tank vapors or vapors from some other source.

Volatile sulfur

An obsolete term referring to sulfur compounds that will vaporize readily (See sulfur).

Weathering

The evaporation of liquid caused by exposing it to the conditions of atmospheric temperature and pressure. Partial evaporation of liquid by use of heat may also be called weathering.

Weathering test

A GPA test for LP-gas for the determination of heavy components in a sample by evaporation under specified conditions.

Weight in air

Weight compared to a standard with no correction for air buoyancy.

Wellhead

The assembly of fittings, valves, and controls located at the surface and connected to the flow lines, tubing, and casing of the well so as to control the flow from the reservoir.

Wet gas

(1) A gas containing water, or a gas which has not been dehydrated. (2) A term synonymous with rich gas. Refer to definition of "rich gas".

Wobbe number

A number proportional to the heat input to a burner at constant pressure. In British practice, it is the gross heating value of a gas divided by the square root of its gravity. Widely used in Europe, together with a measured or calculated flame speed, to determine interchangeability of fuel gases.

$$\text{Wobbe No.} = \frac{\text{GHV}}{\sqrt{(\text{MW}/28.9625)}}$$

CONVERSION FACTORS

Energy Units Conversion

In these tables, factors for conversion, including conversions to the International System of Units (SI), are based on ASTM Standard for Metric Practice, E380-91. The latest edition of this publication should be studied for more detail on the SI system, including definitions and symbols.

In calculating derived factors in the tables that follow, exact conversions were used, when available, rather than the 7-digit round-offs listed in ASTM E380 conversion tables. Derived factors given below are rounded to the same number of significant digits as the source factors.

In any conversion of fundamental measurement units, some confusion may result due to redefinition of units used in earlier tables. For example, in 1959 a small refinement was made

in the definition of the yard, which changed its length from 3600/3937 meter (or 1 inch = 25.4000508 mm) to 0.9144 m exactly (or 1 inch = 25.4 mm exactly). The tables below are based on the new definition, but one should be aware that where U.S. land measurements are concerned, the old relationship applies. Refer to ASTM E380-91, note 13, for more detail.

Confusion may arise in the definition of units for heat or energy. In the tables below, the Btu (IT) and calorie (IT) are used. These are the heat units recommended by the International Conference on the Properties of Steam, as defined:

$$1 \text{ Btu (IT)} = 1055.055 \ 852 \ 62 \text{ joule (exactly)}$$

$$1 \text{ Calorie (IT)} = 4.186 \ 800 \text{ joule (exactly)}$$

For information only, other definitions that may be used elsewhere:

$$1 \text{ Btu (Mean)} = 1055.87 \text{ joule}$$

$$1 \text{ Btu (39 °F)} = 1059.67 \text{ joule}$$

$$1 \text{ Btu (60 °F)} = 1054.68 \text{ joule}$$

$$1 \text{ Btu (Thermochemical)} = 1054.350 \text{ joule}$$

$$1 \text{ calorie (Mean)} = 4.190 \ 02 \text{ joule}$$

$$1 \text{ calorie (15 °C)} = 4.185 \ 80 \text{ joule}$$

$$1 \text{ calorie (20 °C)} = 4.181 \ 90 \text{ joule}$$

$$1 \text{ calorie (Thermochemical)} = 4.184 \ 000 \text{ joule}$$

The fundamental relationship between the Btu and the calorie:

$$\begin{array}{c} \text{gram-pound relationship} \\ \hline \text{Fahrenheit-Celsius scale relationship} \end{array}$$

or: $\text{Btu} \times \frac{453.592 \ 29}{1.8} = \text{calorie (IT, mean, or other)}$

$$\begin{aligned} 1 \text{ therm} &= 100,000 \text{ Btu} = 105.5056 \times 10^6 \text{ J} \\ &= 105,505.6 \text{ kJ} = 1.055 \ 056 \times 10^5 \text{ kJ.} \\ &(\text{Btu denotes British Thermal Units}) \\ &(\text{ref: Physical Properties of Natural Gases,} \\ &\text{Gas Unie, 1988 p. 23}) \end{aligned}$$

$$1 \text{ decatherm} = 1,000,000 \text{ Btu} = 1 \text{ MMBtu} = 10^6 \text{ Btu}$$

$$1 \text{ thermie} = 1 \text{ Mcal (15 °C)} = 4.1858 \times 10^6 \text{ J}$$

$$1 \text{ terajoule} = 1 \text{ TJ} = 1 \times 10^{12} \text{ Joule}$$

Gas Volume Relationships

Gas volumes are commonly referred to in "standard" or "normal" units.

Standard conditions commonly refers to gas volumes measured at:

$$15 \text{ °C and } 101.3250 \text{ kPa}$$

$$60 \text{ °F and } 14.696 \text{ psia}$$

These P & T conditions are often indicated as Standard Temperature and Pressure, abbreviated to STP. However standard conditions can refer to other combinations of pressure and temperature as might be agreed between gas buyer and seller. There is no internationally accepted standard for STP. In 1980 GPA adopted 15 °C, 101.3250 kPa (abs) as standard conditions for SI units. Thus standard molar volumes are:

$$\begin{aligned} 23.645 \text{ std m}^3/\text{kmol at } 15 \text{ °C (288.15 K), } 101.3250 \text{ kPa.} \\ \text{GPA SI standard conditions.} \end{aligned}$$

$$379.49 \text{ std ft}^3/\text{lb mol at } 60 \text{ °F (519.67 °R), } 14.696 \text{ psia.}$$

This discussion of liquid sizing will be further restricted to:

1. Turbulent flow streams: There are usually flow streams that are not either high viscosity or low velocity. The majority of process plant control valves do operate in the turbulent regime, however if the Reynolds number for a process is less than 4000 the reader is referred to the ISA standard where a non-turbulent flow correction method can be found.
2. Valve installed without fittings attached to the valve ends: When fittings are present there are, as with the previous gas sizing discussion, necessary modifications to the sizing equations to accommodate the additional disturbance to flow. This discussion will be limited to the case where there are no fittings attached, therefore the valve size and pipe size are the same, $F_p = 1.0$. Refer to the full ISA standard for the proper methods if fittings are present.

Sizing Calculation Procedure —

1. Select the appropriate sizing equations based on the stated inlet conditions and units of measurement from Fig. 4-35.
2. Calculate the C_v required using the equation for non-vaporizing flow.
3. Calculate the C_v using the equation for vaporizing flow. An initial assumed value of F_L can be taken from Fig. 4-32 or the manufacturer's literature. F_F the liquid critical pressure ratio factor, can be found from Fig. 4-33 based on the critical pressure and inlet vapor pressure for subject liquid. Fig. 4-34 lists critical pressures for some common fluids. The user must at this point iterate through this calculation accounting for the variation in F_L and valve-rated C_v due to valve style, size, trim, flow direction, etc.
4. Select the higher of the two calculated C_v 's as the required C_v .

FIG. 4-32
Typical C_v , X_c and F_L Values for Valves*

Valve Style	Body Size, Inches	Flow Characteristic					
		Equal Percentage			Linear		
		C_v	X_c	F_L	C_v	X_c	F_L
Globe	1	8	0.74	0.88	17	0.61	0.84
	1-1/2	17	0.69	0.84	30	0.70	0.82
	2	25	0.70	0.85	62	0.68	0.77
	2-1/2	49	0.66	0.84	84	0.71	0.81
	3	66	0.66	0.82	118	0.70	0.82
	4	125	0.67	0.82	181	0.74	0.82
	6	239	0.74	0.85	367	0.78	0.84
	8	268	0.60	0.85	526	0.74	0.87
Ball	1	16	0.53	0.86	—	—	—
	2	59	0.53	0.81	—	—	—
	3	120	0.50	0.80	—	—	—
	4	195	0.52	0.80	—	—	—
	6	340	0.52	0.80	—	—	—
	8	518	0.54	0.82	—	—	—
	10	1000	0.47	0.80	—	—	—
	12	1530	0.49	0.78	—	—	—
Butterfly	2	60	0.37	0.69	—	—	—
	3	111	0.40	0.69	—	—	—
	4	238	0.40	0.69	—	—	—
	6	635	0.40	0.69	—	—	—
	8	1020	0.40	0.69	—	—	—
	10	1430	0.40	0.69	—	—	—
	12	2220	0.40	0.69	—	—	—
	14	2840	0.40	0.69	—	—	—
	16	3870	0.40	0.69	—	—	—

*At approximately 70% of valve travel. Maximum valve capacity may be estimated using the values given in this figure in conjunction with Fig. 4-29. For a more detailed analysis of capacity capabilities of a given valve at other percentages of travel, consult the valve manufacturer's data.

5. From the valve manufacturer's sizing data, select a specific valve type and size such that the listed C_v is equal to or greater than the calculated C_v .
6. See the previous section on cavitation and consult the manufacturer's data for appropriate valve cavitation operating limits.

INSTALLATION, TROUBLESHOOTING, AND CALIBRATION

Installation and Troubleshooting

Control system troubleshooting logically falls into two categories: (1) the repair of control systems that previously functioned well, and (2) the successful modification of poorly commissioned systems that have never worked properly due to improper application, poor design, faulty hardware, or improper operating procedures (Fig. 4-37). Different techniques are employed for each category.

FIG. 4-33

Critical Pressure Ratios for All Liquids, F_F

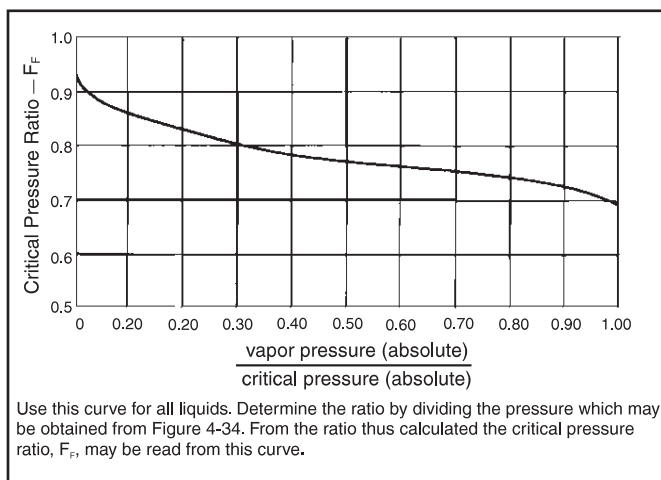


FIG. 4-34

Critical Pressure of Various Liquids

psia			
Ammonia	1636	Isobutane	529
Argon	706	Isobutylene	580
n-Butane	551	Methane	668
Carbon Dioxide	1071	Nitrogen	493
Carbon Monoxide	508	Nitrous Oxide	1048
Chlorine	1118	Oxygen	737
Dowtherm A	465	Phosgene	823
Ethane	708	Propane	616
Ethylene	731	Propylene	667
Fluorine	809	Refrigerant 11	635
Helium	33	Refrigerant 12	597
Hydrogen	188	Refrigerant 22	716
Hydrogen Chloride	1205	Water	3208

Failed Systems

- Control system malfunctions normally are reported by the process operator. A discussion with the operator should yield some clues as to the source of the problem, since he has probably been observing it for several hours, or days.
- The next step is to use the "process of elimination" to localize the problem. If replacement of an element with a known good one causes the problem to disappear, this is usually conclusive! Often this simple approach of parts changing will save time by avoiding a detailed system analysis. However, if the situation permits, the "bad" part should be temporarily re-installed to verify a "hard" failure rather than a "hung-up" condition which is often reset by the procedure of substitution.
- A "detailed system analysis" may be required if a control system has a number of interactive or serially dependent components and especially if more than one component is faulty. The process-of-elimination tests may have shown some conflicting results in this case. A complete control system diagram should be used to help isolate possible problem areas, separate cascade loops, etc. This step usually requires the services of the control engineer or someone familiar with all the control loop components and their functions. Caution should be taken to assure that control system response is observed over a sufficient length of time to detect problems in slow changing processes. Strip chart recorders are very useful in this analysis. Conversely, sequential event recorders may be needed to diagnose intermittent problems which occur only for very brief periods at irregular intervals. Recorders

FIG. 4-35

Liquid Valve Sizing Equations

Use Fig. 4-36 for Value of Numerical Constants, N

Flow Basis and Units	Equation
Nonvaporizing Mass Flow with Specific Weight, γ_1	$w = N_6 F_p C_v \sqrt{(P_1 - P_2) \gamma_1}$
Nonvaporizing Volumetric Flow with Specific Gravity, G_f	$q = N_1 F_p C_v \sqrt{\frac{(P_1 - P_2)}{G_f}}$
Vaporizing Mass Flow with Specific Weight, γ_1	$w = N_6 F_L C_v \sqrt{(P_1 - F_F P_v) \gamma_1}$
Vaporizing Volumetric Flow with Specific Gravity, G_f	$q = N_1 F_L C_v \sqrt{\frac{(P_1 - F_F P_v)}{G_f}}$

FIG. 4-36

Numerical Constants for Liquid Flow Equations

Constant		Units Used in Equations					
N		w	q	$p, \Delta p$	d, D	γ_1	v
N_1	0.0865	—	m^3/h	kPa	—	—	—
	0.865	—	m^3/h	bar	—	—	—
	1.00	—	gpm	psia	—	—	—
N_6	2.73	kg/h	—	kPa	—	kg/m^3	—
	27.3	kg/h	—	bar	—	kg/m^3	—
	63.3	lb/h	—	psia	—	lb/ft ³	—

MULTIPLE SERVICE DISCUSSION

If different services can be placed in the same plot area without excessive piping runs, it is usually less expensive to combine them on one structure, with each service having a separate section, but sharing the same fan and motors. Separate louvers may be placed on each service to allow independent control. The cost and space savings makes this method common practice in the air cooler industry.

In designing multiple service coolers, the service with the most critical pressure drop should be calculated first. This is because the pressure drop on the critical item might restrict the maximum tube length that the other services could tolerate. The burden of forcing more than one service into a single tube length increases the possibility of design errors. Several trial calculations may be needed to obtain an efficient design.

After all service plot areas have been estimated, combine them into a unit having a ratio of 2 or 3 to 1 in length to width (assuming a two fan cooler). After assuming a tube length, calculate the most critical service for pressure drop using the assumed number and length of tubes and a single pass. If the drop is acceptable or very close, calculate the critical service completely. Once a design for the most critical service has been completed, follow the same procedure with the next most critical service. After the second or subsequent services have been rated, it is often necessary to lengthen or shorten the tubes or change the overall arrangement. If tubes need to be added for pressure drop reductions in already oversurfaced sections, it might be more cost effective to add a row(s) rather than widen the entire unit. The fan and motor calculations are the same as for a single service unit, except that the quantity of air used must be the sum of air required by all services.

CONDENSING DISCUSSION

The example given covers cooling problems and would work with straight line condensing problems that have the approximate range of dew point to bubble point of the fluid. Where desuperheating or subcooling or where disproportionate amounts of condensing occur at certain temperatures, as with steam and non-condensables, calculations for air coolers should be done by "zones." A heat release curve developed from enthalpy data will show the quantity of heat to be dissipated between various temperatures. The zones to be calculated should be straight line zones; that is, from the inlet temperature of a zone to its outlet, the heat load per degree temperature is the same.

After the zones are determined, an approximate rate must be found for each zone. Do this by taking rates from vapor cooling, condensing, and liquid cooling, then average these based on the percent of heat load for that phase within the zone. Next, calculate the LMTD of each zone. Begin with the outlet zone using the final design outlet temperature and the inlet temperature of that zone. Continue to calculate the zone as if it were a cooler, except that only one pass and one or two rows should be assumed, depending on the percentage of heat load in that zone. In calculating the pressure drop, average conditions may be used for estimating.

If the calculations for zone one (or later a succeeding zone) show a large number of short tubes with one pass, as is usually the case with steam and non-condensables, recalculate the zone with multiple rows (usually four) and short tubes having one pass that uses only a percentage of the total pressure drop allowed. The total cooler will be calculated as if each zone were a cooler connected in series to the next one, except that only

tube pressure drops should be calculated for the middle zones. Thus, each zone must have the same number of tubes and true ambient must be used in calculating the LMTD. Only the tube length may vary, with odd lengths for a zone acceptable as long as overall length is rounded to a standard tube length.

If the calculations for zone one (and succeeding zones) fit well into a longer tube length, the LMTD must be weighted. After the outlet zone has been calculated, calculate zone two using the inlet temperature for it and its outlet temperature, which is the inlet temperature of zone one. The "ambient" used to find the zone two LMTD will be the design ambient plus the air rise from zone one. Continue in this manner, always using the previous zone's outlet air temperature in calculating the current zone's LMTD. After the cooler size and configuration have been determined, the fan and motor calculations will be made in the normal manner.

The ultimate pressure drop is the sum of the drops for each zone or approximately the sum of the drop for each phase using the tube length and pass arrangement for each phase. An estimated overall tube side coefficient may be calculated by estimating the coefficient for each phase. Then take a weighted average based on the percentage of heat load for each phase. The total LMTD must be the weighted average of the calculated zone LMTDs.

THERMAL DESIGN

The basic equation to be satisfied is the same as given in Section 9, Heat Exchangers:

$$Q = UA (CMTD)$$

Eq 10-1

Normally Q is known, U and $CMTD$ are calculated, and the equation is solved for A . The ambient air temperature to be used will either be known from available plant data or can be selected from the summer dry bulb temperature data given in Section 11, Cooling Towers. The design ambient air temperature is usually considered to be the dry bulb temperature that is exceeded less than 2 to 5 percent of the time in the area where the installation is required. Careful consideration should be given to the choice of design ambient temperature. The optimum choice is highly dependant upon the criticality of the exchanger service and the shape of the temperature probability curve (e.g. the difference between the maximum possible ambient temperature and the desired design ambient air inlet temperature).

As an example, when designing a refrigeration system, the refrigerant compressor outlet pressure is directly determined by the condensing temperature (temperature of refrigerant exiting the refrigerant condenser). If the difference between the maximum possible ambient temperature at the site is vastly different from the temperature expected 95% of the time, the condensing temperature during this small portion of the year would also increase correspondingly. It is possible that the high condensing temperatures during this portion of the year would require more head (or power) than the refrigerant compressor could provide, especially for centrifugal compressors. In this case, the refrigeration system would not be able to operate at all during these warm temperatures, which would likely be to the detriment of the facility. Even if the head could be attained by the refrigerant compressor, the flow of refrigerant would be dramatically lower, and the impact on the facility would likely be compounded by the facility needing more refrigeration during these warmest conditions when compared to the design ambient temperature.

On the contrary, the impact on a compressed gas after-cooler at the same site, and designed for the ambient temperature expected less than 95% of the time, would have a much smaller impact. For this service, a higher temperature would cause the temperature of the compressed gas on the outlet of the cooler to increase accordingly, just as for the refrigerant condenser. However, even if the temperature of this stream were important, the compressed gas rate could be reduced in order to bring temperatures back to acceptable levels.

A complication arises in calculating the corrected LMTD because the air quantity is a variable, and therefore the air outlet temperature is not known. The procedure given here starts with a step for approximating the air-temperature rise. After the air-outlet temperature has been determined, the corrected LMTD is calculated in the manner described in the shell and tube section, except that MTD correction factors to be used are from Figs. 10-8 and 10-9 which have been developed for the cross-flow situation existing in air-cooled exchangers.

Fig. 10-8 is for one tube pass. It is also used for multiple tube passes if passes are side by side. Fig. 10-9 is for two tube passes and is used if the tube passes are over and under each other. A MTD correction factor of 1.0 is used for four or more passes, if passes are over and under each other. A correction factor of 1.0 may be used as an approximation for three passes, although the factor will be slightly lower than 1.0 in some cases.

The procedure for the thermal design of an air cooler consists of assuming a selection and then proving it to be correct. The typical overall heat transfer coefficients given in Fig. 10-10 are used to approximate the heat transfer area required. The heat transfer area is converted to a bundle face area using Fig. 10-11 which lists the amount of extended surface available per square foot of bundle area for two specific fin tubes on two

different tube pitches for 3, 4, 5, and 6 rows. After assuming a tube length, Fig. 10-11 is also used to ascertain the number of tubes. Both the tube side and air side mass velocities are now determinable.

The tube-side film coefficient is calculated from Figs. 10-12 and 10-13. Fig. 10-17 gives the air-side film coefficient based on outside extended surface. Since all resistances must be based on the same surface, it is necessary to multiply the reciprocal of the tube-side film coefficient and tube-side fouling factor by the ratio of the outside surface to inside surface. This results in an overall transfer rate based on extended surface, designated as U_x . The equation for overall heat transfer rate is:

$$\frac{1}{U_x} = \left(\frac{1}{h_t} \right) \left(\frac{A_x}{A_i} \right) + r_{dt} \left(\frac{A_x}{A_i} \right) + r_{mx} + \frac{1}{h_a} \quad \text{Eq 10-2}$$

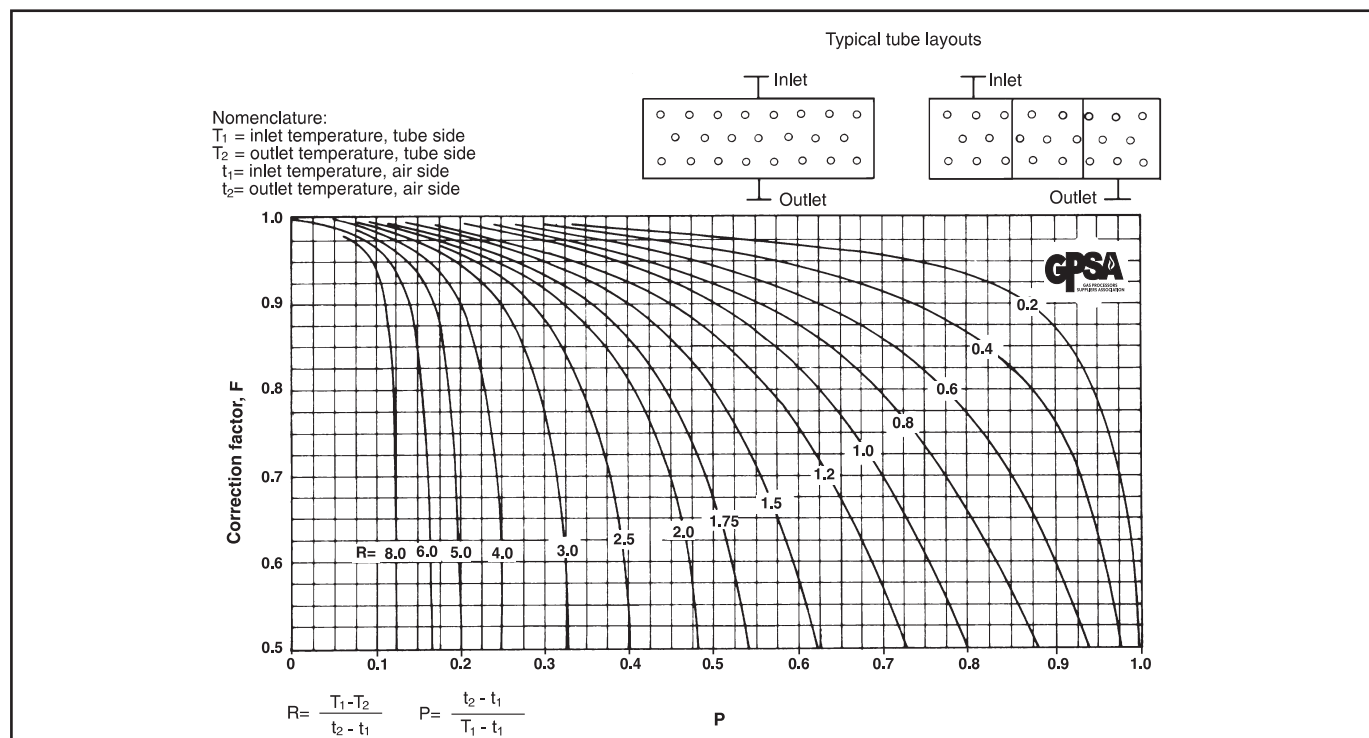
The basic equation will then yield a heat transfer area in extended surface, A_x , and becomes:

$$Q = (U_x) (A_x) \text{CMTD}$$

Either method is valid and each is used extensively by thermal design engineers. Fig. 10-10 gives typical overall heat transfer coefficients based on both extended surface and outside bare surface, so either method may be used. The extended surface method has been selected for use in the example which follows. The air-film coefficient in Fig. 10-17 and the air static pressure drop in Fig. 10-18 are only for 25.4 mm OD tubes with 15.9 mm high fins, 394 fins/m on 64 mm triangular pitch. Refer to Bibliography Nos. 2, 3, and 5 for information on other fin configurations and spacings.

The minimum fan area is calculated in Step 16 using the bundle face area, number of fans, and a minimum fan coverage of 0.40. The calculated area is then converted to a diameter and

FIG. 10-8
MTD Correction Factors (1 Pass — Cross Flow, Both Fluids Unmixed)



1. isentropic reversible path — a process during which there is no heat added to or removed from the system and the entropy remains constant, $pv^k = \text{constant}$
2. polytropic reversible path — a process in which changes in gas characteristics during compression are considered, $pv^n = \text{constant}$

Fig. 13-5 shows a plot of pressure vs. volume for each value of the above exponents. The work, W , performed in proceeding from p_1 to p_2 along any polytropic curve (Fig. 13-5) is

$$W = \int_1^2 V \cdot dp = \int_{p_1}^{p_2} V \cdot dp \quad \text{Eq 13-1}$$

The amount of work required is dependent upon the polytropic curve involved and increases with increasing values of n . The path requiring the least amount of input work is $n = 1$, which is equivalent to isothermal compression, a process during which there is no change in temperature. For isentropic compression, the exponent used is $k = \text{ratio of specific heat at constant pressure to that at constant volume}$.

It is usually impractical to build sufficient heat-transfer equipment into the design of most compressors to carry away the bulk of the heat of compression. Most machines tend to operate along a polytropic path which approaches the isentropic. Most compressor calculations are therefore based on an efficiency applied to account for true behavior.

A compression process following the outer curve in Fig. 13-5 has been widely referred to in industry as “adiabatic”. However, all compression processes of practical importance are adiabatic. The term adiabatic does not adequately describe this process, since it only implies no heat transfer. The ideal process also follows a path of constant entropy and should be called “isentropic”, as will be done subsequently in this chapter.

Equation 13-3 which applies to all ideal gases can be used to calculate k .

$$MC_p - MC_v = R = 8.314 \text{ kJ/(kmole} \cdot \text{K)} \quad \text{Eq 13-2}$$

By rearrangement and substitution we obtain:

$$k = \frac{C_p}{C_v} = \frac{MC_p}{MC_v} = \frac{MC_p}{MC_p - 8.314} \quad \text{Eq 13-3}$$

To calculate k for a gas we need only know the constant pressure molar heat capacity (MC_p) for the gas. Fig. 13-6 gives values of molecular weight and ideal-gas state heat capacity (i.e. at 1 atm) for various gases. The heat capacity varies considerably with temperature. Since the temperature of the gas in-

creases as it passes from suction to discharge in the compressor, k is normally determined at the average of suction and discharge temperatures.

For a multi-component gas, the mole weighted average value of molar heat capacity must be determined at average cylinder temperature. A sample calculation is shown in Fig. 13-7.

The calculation of pP_c and pT_c in Fig. 13-7 permits calculation of the reduced pressure $P_R = P/pP_c$ mix and reduced temperature $T_R = T/pT_c$ mix. The compressibility Z at T and P can then be determined using the charts in Section 23.

If only the molecular weight of the gas is known and not its composition, an approximate value for k can be determined from the curves in Fig. 13-8.

Estimating Compressor Power

Equation 13-4 is useful for obtaining a quick and reasonable estimate for compressor power. It was developed for large slow-speed (300 to 450 rpm) compressors handling gases with a relative density of 0.65 and having stage compression ratios above 2.5.

CAUTION: Compressor manufacturers generally rate their machines based on a standard condition of 100 kPa (abs) rather than the more common gas industry value of 101.325 kPa (abs).

Due to higher valve losses, the power requirement for high-speed compressors (1000 rpm range, and some up to 1800 rpm) can be as much as 20% higher, although this is a very arbitrary value. Some compressor designs do not merit a higher power allowance and the manufacturers should be consulted for specific applications.

$$\text{Brake power} = (0.014) \left(\frac{\text{ratio}}{\text{stage}} \right) (\# \text{ of stages}) (\text{m}^3/\text{h}) (\text{F}) \quad \text{Eq 13-4}$$

Where:

m^3/h = Compressor capacity referred to 100 kPa (abs) and intake temperature

F = 1.0 for single-stage compression

1.08 for two-stage compression

1.10 for three-stage compression

Equation 13-4 will also provide a rough estimate of power for lower compression ratios and/or gases with a higher specific gravity, but it will tend to be on the high side. To allow for this the tendency is to use a multiplication factor of 0.013 instead of 0.014 for gases with a specific gravity in the 0.8 to 1.0 range;

FIG. 13-4
Integral Engine Compressor

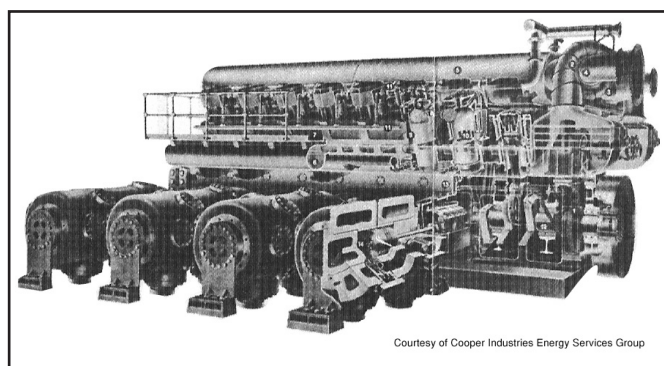


FIG. 13-5
Compression Curves

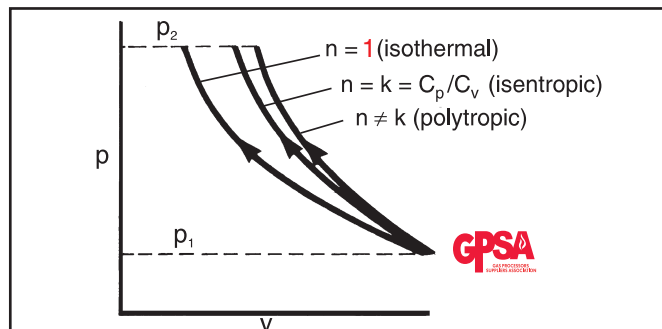


FIG. 13-6
Molar Heat Capacity MC_p (Ideal-Gas State), kJ/kmole $\cdot$ $^{\circ}$ C

*Data source: Selected Values of Properties of Hydrocarbons, API Research Project 44											
Gas	Chemical formula	M	Temperature, $^{\circ}$ C								
			-25	0	10	25	50	75	100	125	150
Methane	CH ₄	16.043	34.301	34.931	35.199	35.717	36.744	37.870	39.201	40.529	41.986
Ethyne (Acetylene)	C ₂ H ₂	26.038	39.888	42.020	42.778	43.926	45.650	47.235	48.720	49.981	51.168
Ethene (Ethylene)	C ₂ H ₄	28.054	38.254	40.906	41.937	45.559	46.115	48.695	51.283	53.753	56.214
Ethane	C ₂ H ₆	30.070	47.131	49.882	50.904	52.666	55.723	58.819	62.114	65.294	68.556
Propene (Propylene)	C ₃ H ₆	42.081	55.878	59.898	61.459	63.895	67.832	71.789	75.762	79.584	83.395
Propane	C ₃ H ₈	44.097	64.176	68.783	70.605	73.524	78.561	83.585	88.820	93.820	98.838
1-Butene (Butylene)	C ₄ H ₈	56.108	73.359	79.583	81.961	85.663	91.509	97.310	103.111	108.493	113.860
cis-2-Butene	C ₄ H ₈	56.108	67.598	73.268	75.461	78.925	84.508	90.154	95.851	101.323	106.800
trans-2-Butene	C ₄ H ₈	56.108	77.329	82.587	84.628	87.823	92.979	98.174	103.387	108.434	113.464
iso-Butane	C ₄ H ₁₀	58.124	83.476	90.078	92.690	96.815	103.624	110.408	117.340	123.932	130.521
n-Butane	C ₄ H ₁₀	58.124	85.277	91.270	93.685	97.447	105.326	110.334	117.024	123.326	130.400
iso-Pentane	C ₅ H ₁₂	72.151	101.897	110.369	113.675	118.792	127.335	135.581	144.029	152.011	159.999
n-Pentane	C ₅ H ₁₂	72.151	105.133	112.603	115.565	120.211	130.686	136.160	144.452	152.182	161.448
Benzene	C ₆ H ₆	78.114	66.435	74.060	77.034	81.675	89.224	96.761	104.324	111.321	118.202
n-Hexane	C ₆ H ₁₄	86.178	123.401	133.303	137.144	143.110	152.709	162.308	171.884	181.080	190.194
n-Heptane	C ₇ H ₁₆	100.205	142.943	154.539	159.011	165.985	177.141	188.293	199.400	210.046	220.585
Ammonia	NH ₃	17.031	35.626	35.636	35.640	35.645	35.653	35.661	35.670	35.678	35.688
Air		28.964	29.048	29.067	29.078	29.098	29.141	29.196	29.262	29.339	29.429
Water	H ₂ O	18.015	33.383	33.474	33.488	33.572	33.678	33.832	34.032	34.207	34.424
Oxygen	O ₂	31.999	29.131	29.240	29.265	29.361	29.481	29.647	29.870	30.045	30.274
Nitrogen	N ₂	28.013	29.079	29.114	29.092	29.114	29.116	29.140	29.196	29.219	29.279
Hydrogen	H ₂	2.016	28.290	28.611	28.687	26.502	28.964	29.065	29.126	29.158	29.178
Hydrogen sulfide	H ₂ S	34.076	33.313	33.673	33.815	34.028	34.379	34.729	35.080	35.434	35.792
Carbon monoxide	CO	28.010	29.087	29.123	29.105	29.146	29.150	29.193	29.263	29.319	29.405
Carbon dioxide	CO ₂	44.010	34.700	35.962	36.411	37.122	38.212	39.261	40.290	41.199	42.095

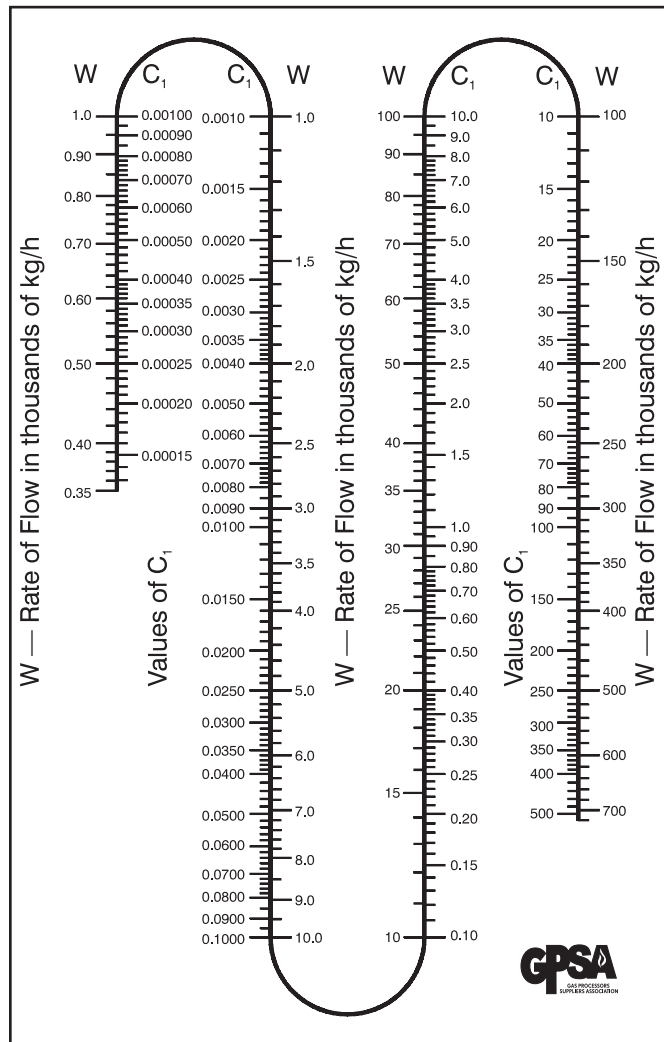
*Exceptions: Air - Keenan and Keyes, Thermodynamic Properties of Air, Wiley, 3rd Printing 1947. Ammonia - Edw. R. Grabl, Thermodynamic Properties of Ammonia at High Temperatures and Pressures, Petr. Processing, April 1953. Hydrogen Sulfide - J. R. West, Chem. Eng. Progress, 44, 287, 1948.

FIG. 13-7
Calculation of k

Example gas mixture		Determination of mixture mol mass		Determination of MC_p , Molar heat capacity		Determination of pseudo critical pressure, P_c , and temperature, T_c			
Component name	Mol fraction y	Individual Component Mol Mass M	y $\cdot$ M	Individual Component MC_p @ 75 $^{\circ}$ C	y $\cdot$ MC_p @ 75 $^{\circ}$ C	Component Critical Pressure P_c , kPa (abs)	y $\cdot$ P_c	Component Critical Temperature T_c , K	y $\cdot$ T_c
methane	0.9216	16.04	14.782	37.870	34.901	4604	4243.05	194	176.0
ethane	0.0488	30.07	1.467	58.819	2.870	4880	238.14	305	14.9
propane	0.0185	44.10	0.816	83.585	1.546	4349	78.61	370	6.8
i-butane	0.0039	58.12	0.227	110.408	0.431	3648	14.23	408	1.6
n-butane	0.0055	58.12	0.320	110.334	0.607	3797	20.88	425	2.3
i-pentane	0.0017	72.15	0.123	135.581	0.230	3381	5.75	460	0.8
Total	1.0000	M Mix =	17.735	MC_p Mix =	40.585	P_c Mix =	4600.66	T_c Mix =	202.4
$k = MC_p/MC_v = 40.585/(40.585 - 8.3145) = 1.26$									

*For values of MC_p other than @ 75 $^{\circ}$ C, refer to Fig. 13-6

FIG. 17-8
Simplified Flow Formula for Compressible
Fluids⁵ Values of C₁



the desired ΔP_{100} and solving for C_2 with a given flow. For a given flow and pipe size, ΔP_{100} can be solved directly.

Example 17-1 — Calculate the pressure drop in a 10-in., Schedule 40 pipe (250 mm) for a flow of 68 400 kg/h of methane. Temperature is 15 °C and pressure is 5200 kPa. The compressibility factor is 0.905 (from Fig. 23-8).

Solution Steps

$$\rho = \frac{16.042 (5200)}{8.3145 (273 + 15) (0.905)} = 38.48 \text{ kg/m}^3$$

C_1 from Fig. 17-8 is 4.7

C_2 from Fig. 17-9 is 78.7

$$\Delta P_{100} = \frac{C_1 C_2}{\rho} = \frac{4.7 (78.7)}{38.48} = 9.61 \text{ kPa/100 m using Equation 17-31}$$

Example 17-2 — Calculate the required line size (of Schedule 40 pipe) to give $\Delta P_{100} = 25$ kPa or less when flowing 34 000 kg/h of methane at 2800 kPa and 38 °C. The compressibility factor is 0.96 (from Fig. 23-5).

Solution Steps

$$\rho = \frac{16.062 (2800)}{8.3145 (273 + 38) (0.96)} = 18.12 \text{ kg/m}^3$$

C_1 from Fig. 17-8 is 1.16

$$C_2 = \frac{(\Delta P_{100}) \rho}{C_1} = \frac{25 (18.12)}{1.16} = 390.5$$

From Fig. 17-9 the smallest size of Schedule 40 pipe with C_2 less than 390 is 8-in. pipe. For 8 in. Sch 40 pipe, C_2 is 257. The actual pressure drop can then be calculated as:

$$\Delta P_{100} = \frac{1.16 (257)}{18.12} = 16.45 \text{ kPa/100 m}$$

using Equation 17-31 for the above flow conditions.

Liquid Flow

For the calculation of pressure drop in liquid lines, the Darcy-Weisbach method, Equation 17-6, can be used. The calculation is simplified for liquid flows since the density can reasonably be assumed to be a constant. As a result, the Darcy-Weisbach calculation can be applied to a long run of pipe, rather than segmentally as dictated by the variable density in gas flow. In addition, several graphical aids are available for pressure drop calculation. Elevation pressure drops must be calculated separately using Equation 17-32. These elevation pressure gains or losses are added algebraically to the frictional pressure drops.

$$\Delta P_e = (0.00981) \rho_L Z_e \quad \text{Eq 17-32}$$

Water — A graph showing pressure drop for water per 100 m as a function of flow rate in m³/h and pipe size is shown in Fig. 17-10. These data are based on the Hazen and Williams empirical formula¹⁰ using a “C” constant of 100 which is commonly used for design purposes in welded and seamless steel pipe.

Hazen and Williams formula for flow of water:

$$q = 3.765 (10)^{-6} d^{2.63} C \left(\frac{P_1 - P_2}{L} \right)^{0.54} \quad \text{Eq 17-33}$$

Where:

$C = 140$ for new steel pipe

$C = 130$ for new cast iron pipe

$C = 100$ is often used for design purposes to account for pipe fouling, etc.

Hydrocarbon — A graph showing pressure drop for hydrocarbons per 100 meters as a function of flow rate in m³/h and pipe size is shown in Fig. 17-11. This graph assumes a relative density of 1.0 (water). To correct for different liquid densities, the value read from Fig. 17-11 must be multiplied by the actual relative density to obtain the correct pressure loss.

FIG. 17-9
Simplified Flow Formula for Compressible Fluids⁵
Values of C₂

Nominal pipe size in.	Schedule number	Value of C ₂	Nominal pipe size in.	Schedule number	Value of C ₂	Nominal pipe size in.	Schedule number	Value of C ₂
1/8	40 s	13 940 000 000	8	20	234.	18	10	4.35
	80 x	46 100 000 000		30	243.		20	4.51
1/4	40 s	2 800 000 000		40 s	257.		... s	4.68
	80 x	7 550 000 000		60	287.		30	4.86
3/8	40 s	561 000 000		80 x	326.		... x	5.05
	80 x	1 260 000 000		100	371.		40	5.24
1/2	40 s	164 600 000		120	444.		60	5.90
	80 x	327 500 000		140	509.		80	6.64
	160	756 800 000		... xx	558.		100	7.66
	... xx	19 680 000 000		160	586.		120	8.87
3/4	40 s	37 300 000	10	20	69.9		140	10.08
	80 x	65 000 000		30	74.1		160	11.77
	160	176 200 000		40 s	78.7	20	10	2.48
	... xx	1 104 000 000		60 x	90.5		20 s	2.65
1	40 s	10 470 000		80	100.1		30 x	2.83
	80 x	17 000 000		100	114.8		40	2.98
	160	39 600 000		120	132.5		60	3.36
	... xx	200 800 000		140	159.3		80	3.82
1 1/4	40 s	2 480 000		160	185.2		100	4.42
	80 x	3 720 000	12	20	27.6		120	5.05
	160	6 140 000		30	29.6		140	5.89
	... xx	24 000 000		... s	30.8		160	6.78
1 1/2	40 s	1 100 000		40	31.7	24	10	0.940
	80 x	1 590 000		... x	34.3		20 s	0.994
	160	2 920 000		60	36.3		... x	1.051
	... xx	8 150 000		80	40.7		30	1.081
2	40 s	297 000		100	47.0		40	1.146
	80 x	415 000		120	54.0		60	1.304
	160	859 000		140	61.6		80	1.470
	... xx	1 582 000		160	74.4		100	1.711
2 1/2	40 s	117 000	14	10	16.70		120	1.970
	80 x	162 000		20	17.53		140	2.242
	160	257 000		30 s	18.41		160	2.600
	... xx	669 000		40	19.34	30	10	0.2959
3	40 s	37 700		... x	20.33		... s	0.3025
	80 x	50 500		60	21.89		20 xs	0.3163
	160	85 000		80	24.92		30	0.3308
	... xx	170 000		100	29.16	36	10	0.1130
3 1/2	40 s	17 600		120	33.40		... s	0.1151
	80 x	23 200		140	38.37		20 xs	0.1194
4	40 s	9 100		160	44.35		30	0.1239
	80 x	11 880	16	10	8.15		40	0.1287
	120	15 730		20	8.50	Note: The letters s, x, and xx in the columns of Schedule Numbers indicate Standard, Extra Strong, and Double Extra Strong pipe respectively		
	160	20 770		30 s	8.87			
	... xx	32 720		40 x	9.66			
5	40 s	2 798		60	10.77			
	80 x	3 590		80	12.32			
	120	4 734		100	14.15			
	160	6 318		120	16.30			
	... xx	8 677		140	19.34			
6	40 s	1 074.		160	21.89			
	80 x	1 404.						
	120	1 786.						
	160	2 422.						
	... xx	3 275.						

FIG. 17-14
Two-Phase Flow Regimes

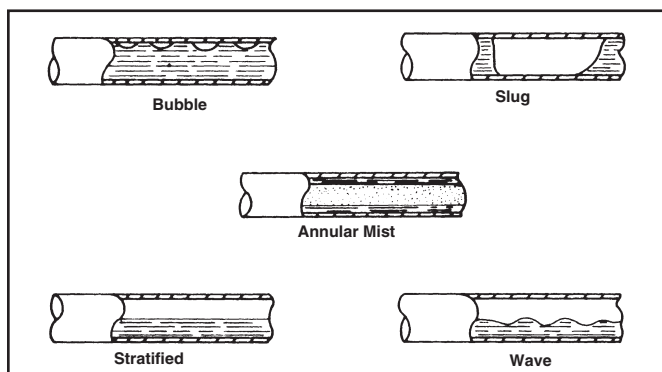
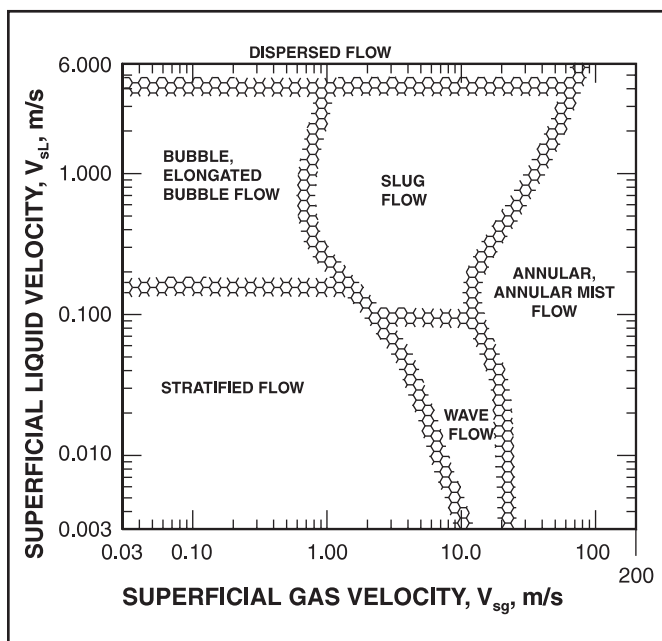


FIG. 17-15
Horizontal Flow Regime Map¹²

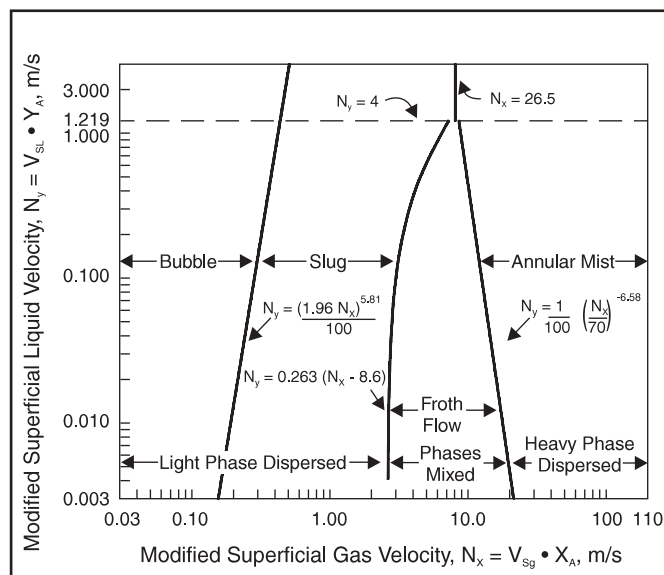


cal downward flow, the flow patterns can be more complicated. A generally accepted vertical down-flow map is not available.

Although the designer frequently does not have the choice, avoidance of the slug flow regime in horizontal flow and the slug and froth flow regimes in vertical flow is desirable. Slug flow introduces a flow rate and pressure intermittency that may be troublesome to process control. In some cases, slug flow may be avoided by the choice of smaller pipe sizes. Of course, frictional pressure drop may be increased by use of this smaller pipe. In vertical upflow, oversizing the pipe may result in a bubble flow regime, and a large liquid inventory. This liquid inventory may cause excessive hydrostatic pressure drops.

Example 17-3 — A vapor-liquid mixture is flowing vertically upward in a pipe having an inside diameter of 200 mm. The fluid is a hydrocarbon liquid-hydrocarbon vapor mixture. The liquid density is 832.8 kg/m^3 and the vapor density is 32.0 kg/m^3 . The interfacial surface tension is $20 (10)^{-7} \text{ N} \cdot \text{m}$. The liquid volumetric flow rate is $17.3 \text{ m}^3/\text{h}$ and the vapor flow rate is 51

FIG. 17-16
Vertical Up-Flow Regime Map¹⁴



m^3/h measured at actual conditions. What flow regime is to be expected?

Solution Steps

$$Y_A = \left[\frac{(832.8) (72.4) 10^{-7}}{(999.5) (20) 10^{-7}} \right]^{0.25} = 1.32 \text{ using Equation 17-40}$$

$$X_A = \left[\frac{(32)}{1.224} \right]^{0.333} (1.32) = 3.91 \text{ using Equation 17-39}$$

$$V_{sg} = \frac{51/3600}{(\pi/4) (200/1000)^2} = 0.451 \text{ m/s using Equation 17-36}$$

$$V_{sl} = \frac{17.3/3600}{(\pi/4) (200/1000)^2} = 0.153 \text{ m/s using Equation 17-35}$$

$$N_x = (0.451) (3.91) = 1.76 \text{ m/s using Equation 17-37}$$

$$N_y = (0.153) (1.32) = 0.202 \text{ m/s using Equation 17-38}$$

Fig. 17-16 shows that this flow is in the slug flow regime.

Pressure Drop Calculation

Calculation of pressure drop in two-phase flow lends itself better to computer calculation than to hand calculation. Several two-phase pressure drop correlations are available for both horizontal and vertical flows.^{15,16,17} Due to the complexity of two-phase flow, uncertainties associated with pressure drop calculations are much greater than uncertainties in single-phase pressure drop calculations. As a result, errors in calculated two-phase pressure drops in the order of plus or minus twenty percent may normally be anticipated, especially in circumstances where fluid velocities are unusually high or low, where terrain is rugged, or where fluid properties are inadequately known. In addition, different two-phase flow correlations may give significantly different pressure drops. In order to evaluate these differences, several correlations should be used. A method suggested by the American Gas Association¹⁸ can serve as a basis for hand calculation generated by Dukler¹⁹ and an elevation pressure drop correlation by Flanigan.²⁰

sure drop calculation method, the frictional pressure drop is given by the equation:

$$\Delta P_f = \frac{f_n f_{tpr} \rho_k V_m^2 L_m}{2 d} \quad \text{Eq 17-41}$$

where

$$\rho_k = \frac{\rho_L \lambda^2}{H_{Ld}} + \frac{\rho_g (1 - \lambda)^2}{(1 - H_{Ld})} \quad \text{Eq 17-42}$$

and

$$\lambda = \frac{Q_L}{Q_L + Q_g} \quad \text{Eq 17-43}$$

The single phase friction factor, f_n , can be obtained from the correlation:¹⁹

$$f_n = 0.0056 + 0.5 (Re_y)^{-0.32} \quad \text{Eq 17-44}$$

This equation is an approximate correlation of the Moody friction factor, f_m for turbulent flow having a Reynolds number higher than 4000 in a smooth pipe. A plot of this Moody friction factor is shown as the axis f_m in Fig. 17-2.

The mixture Reynolds number, Re_y , is calculated according to the equation:

$$Re_y = \frac{(0.001) \rho_k V_m d}{\mu_n} \quad \text{Eq 17-45}$$

Calculation of this Reynolds number requires determination of mixture velocity, V_m , and mixture viscosity, μ_n . These quantities can be determined according to:

$$V_m = V_{sL} + V_{sg} \quad \text{Eq 17-46}$$

$$\mu_n = \mu_L \lambda + \mu_g (1 - \lambda) \quad \text{Eq 17-47}$$

The two-phase friction factor ratio, f_{tpr} , representing a two-phase frictional “efficiency” can be determined by reference to Fig. 17-17 or by the equation:

$$f_{tpr} = 1 + \left[\frac{y}{1.281 - 0.478y + 0.444y^2 - 0.094y^3 + 0.00843y^4} \right] \quad \text{Eq 17-48}$$

where $y = -\ln(\lambda)$.

The remaining quantity to be calculated in the Dukler scheme is an estimate of the liquid holdup, H_{Ld} . This holdup can be estimated using Fig. 17-18. This figure gives liquid holdup as a function of λ and Re_y . Since Re_y is itself a function of liquid holdup, the calculation is, in general, iterative. For most calculations, however, the Re_y line can be used for a first estimate.

Elevation component — The elevation component of pressure drop can be found using the Flanigan method. In this method, the elevation component is calculated using the equation:

$$\Delta P_e = \frac{\rho_L H_{Lf}}{100} \sum Z_e \quad \text{Eq 17-49}$$

where H_{Lf} is determined from Fig. 17-19 or calculated according to the formula:

$$H_{Lf} = \frac{1}{1 + 1.078 (V_{sg})^{1.006}} \quad \text{Eq 17-50}$$

The term Z_e is the vertical elevation rise of a hill. The rises are summed. No elevation drops are considered. This is tantamount to ignoring any possible hydrostatic pressure recoveries in downhill sections of pipeline and may lead to a considerable error in the pressure drop analysis.

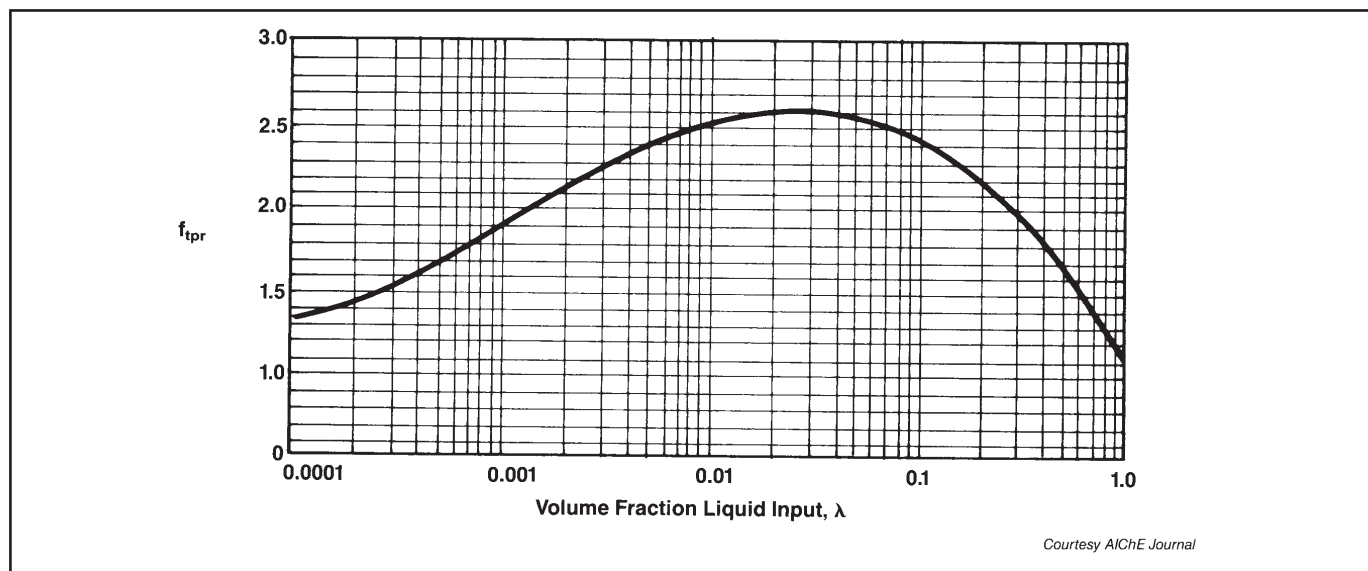
Once the frictional component or pressure drop is found using the Dukler method, and the elevation component is found using the Flanigan method, the overall two-phase pressure drop is found by summing the friction and elevation components.

$$\Delta P_t = \Delta P_e + \Delta P_f \quad \text{Eq 17-51}$$

Since fluid properties and liquid holdups can change rapidly in a two-phase line, accuracy is improved if this AGA calculation procedure is performed segmentally. The need for segmental calculations is one of the reasons why two-phase calculations are best suited for computer calculation.

Liquid holdup — The liquid holdup correlation given in Fig. 17-18 is intended only for use in the Dukler friction pres-

FIG. 17-17
Two-Phase Friction Factor Ratio¹⁸



The slow rate of the reaction leading to bicarbonate is the underlying reason why tertiary amines can be considered for selective H₂S removal. By adjusting absorption contact time, this selectivity can be used to full advantage when near total CO₂ removal is not necessary.

However the slow route to bicarbonate theoretically allows at equilibrium a chemical loading ratio of one mole of CO₂ per mole of amine. Furthermore, at high partial pressure, the physical solubility of CO₂ in tertiary amines is far greater than in the primary and secondary amines, thus enhancing the CO₂ loading by physical solubility under these conditions. Therefore, in the case of gases to be treated for bulk CO₂ removal, large amounts of CO₂ can be liberated from the rich solvent using a simple flash, and thereby, reducing the thermal regeneration duty with consequent energy savings.

Paragraph Deleted

Activated Tertiary Amines

The use of activators mitigates the slow rate of the reaction to bicarbonate for tertiary amines. Activators are generally primary or secondary amines; they are tailored to increase both the hydrolysis of the carbamate, and the rate of hydration of dissolved CO₂, thus making the activated tertiary amines especially suitable for efficient and economic bulk removal when selectivity is not required (see discussion on MDEA).

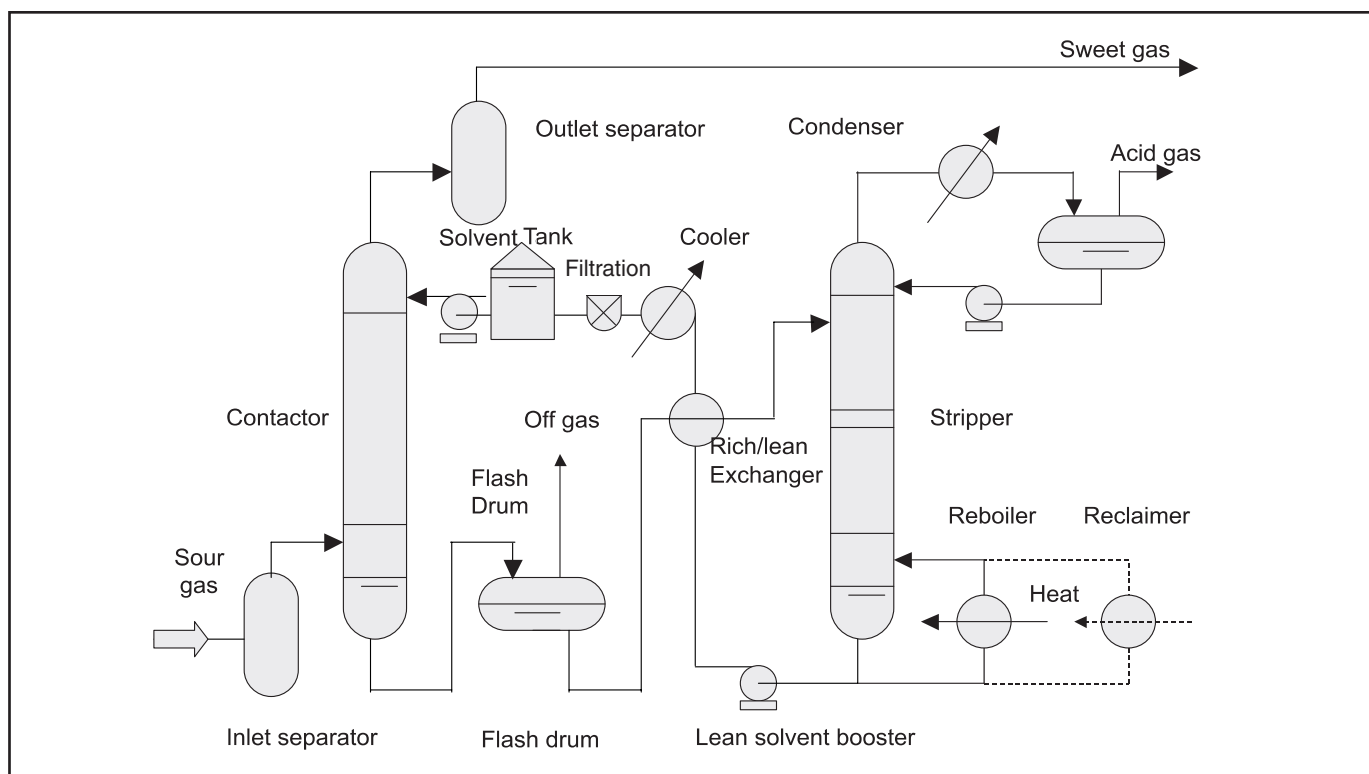
Amine Process Flow Configuration

The general process flow for an amine treating plant is shown in Fig. 21-5. The basic flow configuration varies little for different solutions though some designs incorporate multiple feeds and contactor sections. Note that commercially-available process simulators are available to model these solvent processes.

FIG. 21-4
Approximate Guidelines for Amine Processes¹

	MEA	DEA ⁽⁹⁾	DGA [®]	Sulfinol	MDEA ⁽⁹⁾
Acid gas pickup, m ³ /100L @ 38 °C, normal range ⁽²⁾	2.3–3.2	5.0–5.6	3.5–5.40	3.0–12.75	2.2–5.6
Acid gas pickup, mol/mol amine, normal range ⁽³⁾	0.33–0.40	0.20–0.80	0.25–0.38	NA	0.20–0.80
Lean solution residual acid gas, mol/mol amine, normal range ⁽⁴⁾	0.12 ±	0.01 ±	0.06 ±	NA	0.005–0.01
Rich solution acid gas loading, mol/mol amine, normal range ⁽³⁾	0.45–0.52	0.21–0.81	0.35–0.44	NA	0.20–0.81
Max. solution concentration, wt%	25	40	60	3 components. Varies	65
Approximate reboiler heat duty, kJ/L lean solution ⁽⁵⁾	280–335	235–280	300–360	100–210	220–250
Steam heated reboiler tube bundle, approx. average heat flux Q/A = MJ/(h · m ²) ⁽⁶⁾	100–115	75–85	100–115	100–115	75–85
Direct fired reboiler fire tube, average heat flux Q/A = MJ/(h · m ²) ⁽⁶⁾	90–115	75–85	90–115	90–115	75–85
Reclaimer, steam bundle or fire tube, average heat flux Q/A = MJ/(h · m ²) ⁽⁶⁾	70–100	NA ⁽⁷⁾	70–90	NA	NA ⁽⁷⁾
Reboiler temperature, normal operating range, °C ⁽⁸⁾	107–127	110–127	121–132	110–138	110–132
Heats of reaction; ⁽¹⁰⁾ approximate: kJ/kg H ₂ S kJ/kg CO ₂	1420 1920	1290 1700	1570 2000	N/A N/A	1230 1425
NA — not applicable or not available					
NOTES: - These data alone should not be used for specific design purposes. Many design factors must be considered for actual plant design. - Dependent upon acid gas partial pressures and solution concentrations. - Dependent upon acid gas partial pressures and corrosiveness of solution. Might be only 60% or less of value shown for corrosive systems. - Varies with stripper overhead reflux ratio. Low residual acid gas contents require more stripper trays and/or higher reflux ratios yielding larger reboiler duties. - Varies with stripper overhead reflux ratios, rich solution feed temperature to stripper and reboiler temperature. - Maximum point heat flux can reach 230 to 285 MJ/(h · m²) at highest flame temperature at the inlet of a direct fired fire tube. The most satisfactory design of firetube heating elements employs a zone by zone calculation based on thermal efficiency desired and limiting the maximum tube wall temperature as required by the solution to prevent thermal degradation. The average heat flux, Q/A, is a result of these calculations. - Reclaimers are not used in DEA and MDEA systems. - Reboiler temperatures are dependent on solution conc. flare/vent line back pressure and/or residual CO₂ content required. It is good practice to operate the reboiler at as low a temperature as possible. - According to Total. - The heats of reaction vary with acid gas loading and solution concentration. The values shown are average.¹⁰					

FIG. 21-5
Typical Gas Sweetening by Chemical Reaction



Sour natural gas enters through an inlet separator for the removal of liquids and/or solids. From the separator, the gas stream is often heated about -12°C to reduce the potential for hydrocarbon condensation as discussed earlier in this chapter. The gas then enters the bottom of the contactor where it contacts the amine solution flowing down from the top of the column. The acid gas components in the gas react with the amine to form a regenerable salt. As the gas continues to pass up the contactor, more acid gases chemically react with the amine. The sweetened gas leaves the top of the contactor and passes through an outlet separator to catch any solution which may be carried over.

The sweet gas leaving the contactor is saturated with water so dehydration, discussed in Section 20, is normally required prior to sale. If the amine losses are excessive, a water wash section as shown in Fig. 21-10 is typically added to the column to attempt to recover some of the vaporized and/or entrained amine from the gas leaving the contactor. The water wash section generally consists of three or four trays at the top of the contactor. Trays can be sieve type, valves or other design as recommended by a vendor. Weirs are 63 to 75 mm high. It is recommended to install a demister pad on the vapor outlet.

Amine vapors and small droplets are dissolved and coalesced in water running in a closed loop with a circulation pump. To control amine concentration from building up in the water, some of the water is purged and made up. The purge is normally routed to the Flash Tank (Drum).

Water circulation rate should be 1 liter per 52 m^3 of gas (or 1 liter per minute per $75\text{ MSm}^3/\text{day}$). The recommended make up rate is the largest of 3% of the circulation or the total system make up flow.

A white paper developed by members of GPA's Technical Section A (Facilities Design), titled, "Design Considerations for Water Wash Installations", may be obtained from GPA for a more in depth description of this system and possible design alternatives.

Note that the lean amine coming into the top of the contactor must be at a sufficiently low loading and temperature such that the vapor pressure of the acid gas above the amine is low enough to meet the treated gas specification (e.g., 4 ppm H_2S , and in the case of LNG, 50–100 ppm CO_2). If the loading/temperature criteria are not met, no amount of solvent will reduce acid gas concentration adequately to meet the required specification. This is known as a "lean end pinch," since there is not sufficient mass-transfer driving force to remove the residual acid gases.

As the solvent moves down the column and reacts with the H_2S and CO_2 , the exothermic reactions increase the solvent temperature. Since raw gas coming into the bottom of the contactor cools the solvent, there is usually a temperature "bulge" above the gas inlet. Increased temperatures tend to increase the vapor pressure of acid gases above the enriched solvent, so it is possible that the driving force for mass transfer is reduced to near zero, resulting in a "rich end pinch." In this case, additional solvent will improve the situation by reducing the rich loading and temperature in that portion of the column.

The maximum attainable pure component loading is limited by the equilibrium solubility of H_2S and CO_2 at the absorber bottoms conditions, which may be reached in some high-load applications. Attached as Fig. 21-11 is data from GPA research report RR-104 on MEA, DGA® & MDEA along with the DEA

References 99 through 105 contain most of the experimental data used by the authors of reference 45 and by NIST in their EOS development in REFPROP. The data comprises some 1200 points covering CO₂/H₂S mixtures ranging from 6% to 94% CO₂, over a very wide range of pressures and temperatures. NIST were able to match most of these data points to better than 2%, with a small number of deviations over 10% and a few worst matches in the critical region. Current work is expected to be published later in 2011 by Kunz and Wagner.

A current GPA Research Project, Project No. 042, will include density measurements for acid gas mixtures; its scope is described under "Viscosity".

BOILING POINTS, CRITICAL PROPERTIES, ACENTRIC FACTOR, VAPOR PRESSURE

Boiling Points

Fig. 23-18 shows the interconversion between ASTM D-86 distillation 10% to 90% slope and the different boiling points used to characterize fractions of crude oil to determine the properties; VABP, WABP, CABP, MeABP, and MABP. On the basis of ASTM D-86 distillation data, the volumetric average boiling (VABP) point is:

$$\text{VABP} = (t_{10} + t_{30} + t_{50} + t_{70} + t_{90})/5 \quad \text{Eq 23-12}$$

where the subscripts 10, 30, 50, 70, and 90 refer to the volume percent recovered during the distillation. The 10% to 90% slope used as the abscissa in Fig. 23-18 is:

$$\text{slope} = (t_{90} - t_{10})/(90 - 10) \quad \text{Eq 23-13}$$

To use the graph, locate the curve for the distillation VABP in the appropriate set for the type of boiling point desired. For the known 10–90% slope, read a correction for the VABP from the selected VABP curve.

Example 23-4 — Determine the mean average boiling point (MeABP) and the molecular weight for a 56.8° API petroleum fraction with the following ASTM distillation data.

% Over	Temperature, °C
IBP	37.8
5	54.4
10	67.2
20	88.3
30	102.8
40	117.8
50	137.8
60	159.4
70	195.6
80	240.0
90	311.1
EP	337.8

IBP = initial boiling point EP = end point

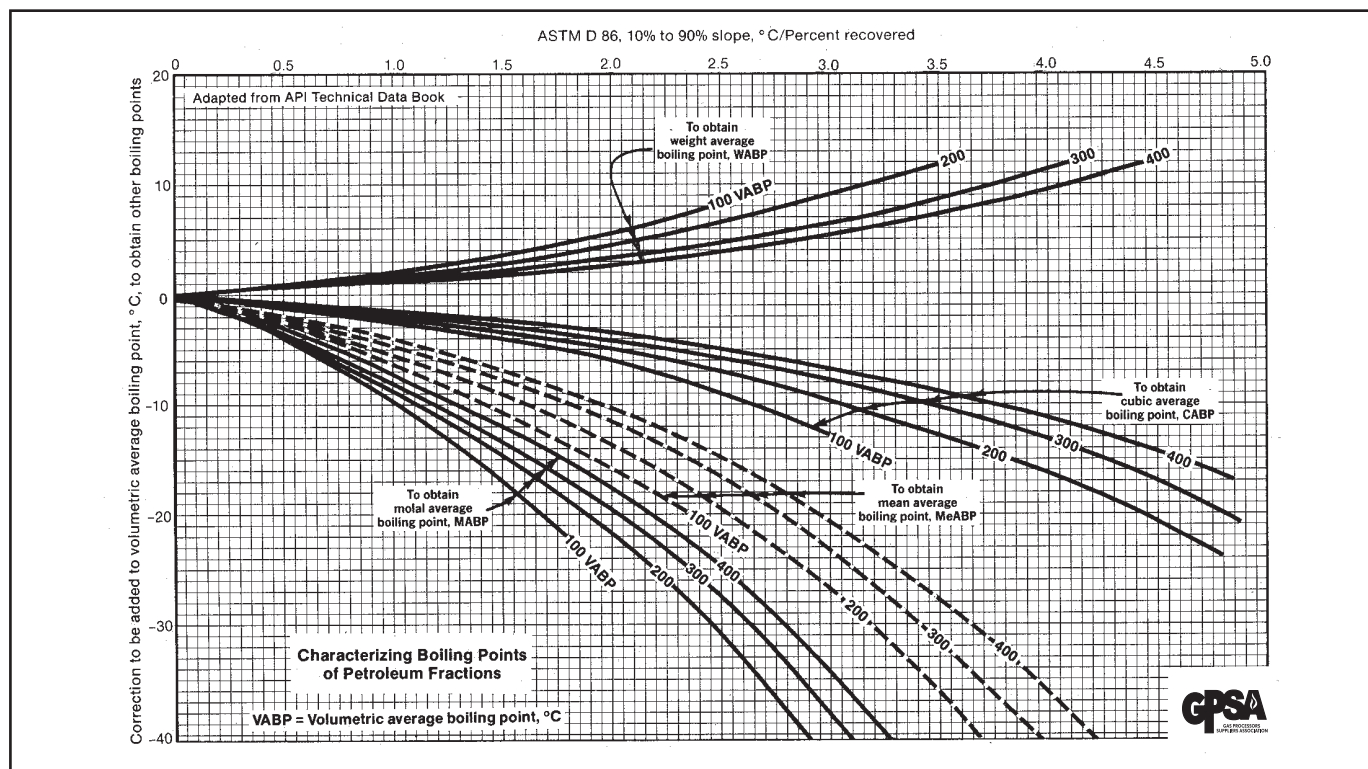
$$\text{Slope} = (311.1 - 67.2)/80 = 3.05$$

$$\text{VABP} = (67.2 + 102.8 + 137.8 + 195.6 + 311.1)/5 = 162.9^\circ\text{C}$$

Refer to Fig. 23-18. Read down from a slope of 3.05 to the interpolated curve to 162.9 °C in the set drawn with dashed lines (MeABP). Read a correction value of -29.5 on the ordinate. Then

$$\text{MeABP} = 162.9 - 29.5 = 133.4^\circ\text{C}$$

FIG. 23-18
Characterizing Boiling Points of Petroleum Fractions



The significance of the various average boiling points, interconversion of D-86 and D-1160 ASTM distillations, and the calculation of true-boiling point and atmospheric flash curves from ASTM distillation data are in Chapters 3 and 4 of the API Technical Data Book.³⁶

Molecular mass can be calculated from Equation 23-14 using MeABP in K and S (relative density at 15 °C):

$$MW = 204.38 [(1.8 \cdot T)^{0.118}](S^{1.88}) (e^{(0.00392T - 3.075 S)}) \quad \text{Eq 23-14}$$

This relationship has been evaluated in the molecular mass range of 70 to 720; the MeABP of 36 to 560 °C; and the API range of 14° to 93°. Its average error was about 7%. Equation 23-14 is best used for molecular masses above 115, since it tends to over-predict below this value.

Example 23-5 — Calculation of molecular mass.

From Example 23-4:

$$S = 0.7515 \text{ for } 56.8^\circ \text{ API}$$

$$\text{MeABP} = 133.4 + 273 = 406.4 \text{ K}$$

Using Equation 23-14,

$$MW = 204.38 [(1.8 \cdot 406.4)^{0.118}] [(0.7515)^{1.88}] [e^{(0.00392 \cdot 406.4 - (3.075 \cdot 0.7515))}] = 127.0$$

Critical Properties

Critical properties are of interest because they are used to find reduced conditions of temperature and pressure as required for corresponding states correlations. Pseudo-critical properties are used in many corresponding states correlations for mixtures.

The following equations taken from the API Technical Data Book^{36a, b} can be used to estimate pseudo critical temperature and pressure for petroleum fractions (pseudo, or undefined components):

$$P_{pc} = [5.5303 (19^9) T^{-2.3125}] \cdot S^{2.3201} \quad \text{Eq 23-15}$$

$$T_{pc} = 19.0623 \cdot T^{0.58848} \cdot S^{0.3596} \quad \text{Eq 23-16}$$

These equations are in terms of T = MeABP (K) and relative density (S) at 15 °C. Both of these correlations have been evaluated over the range of 80 to 690 molecular mass; 20 to 150 °C normal boiling point; and 6.6° to 95° API.

Example 23-6 — Pseudocritical temperature and pressure.

Take the previous mixture (from Example 23-4) with:

$$\text{VABP} = 166.4 \text{ }^\circ\text{C}$$

$$\text{MeABP} = 118.4 \text{ }^\circ\text{C}$$

$$\text{API} = 56.8^\circ$$

$$\text{Molecular Weight} = 127 \text{ (Ex. 23-5)}$$

$$\text{ASTM D-86, 10\% to 90\% Slope} = 3.05$$

Find its pseudocritical temperature.

Solution Steps

From Fig. 23-18 with ASTM D-86 slope = 3.05 find a VABP correction of about - 65 °C (extrapolated from the left-hand group).

$$\text{MABP} = 166.4 - 65 = 101.4 \text{ }^\circ\text{C}$$

Use Equation 23-16 to calculate the pseudocritical temperature as:

$$T_{pc} = 19.0623 (118.4 + 273)^{0.58848} (0.7515)^{0.3596} = 577.1 \text{ K} = 304.1 \text{ }^\circ\text{C}$$

For this 56.8° API fluid, estimate the pseudocritical pressure, using Eq. 23-15 and MeABP = 118.4 °C:

$$P_{pc} = [5.5303 (10^9)] (118.4 + 273)^{-2.3125} (0.7515)^{2.3201} = 2880 \text{ kPa (abs)}$$

Acentric Factor

The acentric factor, ω , is often a third parameter in corresponding states correlations. Fig. 23-2 tabulates it for pure hydrocarbons. The acentric factor is a function of P_{vp} , P_c , and T_c . It is arbitrarily defined as

$$\omega = -\log(P_{vp}/P_c)_{Tr=0.7} - 1.0 \quad \text{Eq 23-17}$$

This definition requires knowledge of the critical (pseudo-critical) temperature, vapor pressure, and critical (pseudo-critical) pressure.

For a hydrocarbon mixture of known composition that contains similar components, a reasonably good estimate for the acentric factor is the molar average of the individual pure component acentric factors:

$$\omega = \sum y_i \omega_i \quad \text{Eq 23-18}$$

If the vapor pressure is not known, ω can be estimated³⁸ for pure hydrocarbons or for fractions with boiling point ranges of 10 °C or less using:

$$\omega = \frac{3}{7} \left[\frac{\log P_c - \log 14.7}{(T_c/T_b) - 1} \right] - 1.0 \quad \text{Eq 23-19}$$

Example 23-7 — Acentric factor.

A narrow-boiling petroleum fraction has a VABP of 214.4 °C, an ASTM slope of 0.75 and an API gravity of 41°. Estimate its acentric factor. In order to use Eq 23-19 we need the average boiling point (MeABP); the pseudocritical temperature (a function of MABP); and the pseudocritical pressure (a function of MeABP).

From Fig. 23-18, the correction to VABP for mean average is -1.7 °C; and the correction for MABP is -2.8 °C. Note that for narrow-boiling fractions, all boiling points approach the volumetric average. Then, MeABP = 212.7 °C and MABP is 211.6 °C.

From Eq. 23-14, the pseudocritical pressure is:

$$T = 212.7 + 273.15 = 485.85 \text{ K}$$

$$S \text{ for } 41^\circ \text{ API} = 141.5/(131.5 + 41) = 0.8203$$

$$P_{pc} = [5.5303 (10^9) (485.85)^{-2.3125}] \cdot (0.8203)^{2.3201}$$

$$P_{pc} = 2141 \text{ kPa (abs)}$$

From Eq. 23-15, the pseudocritical temperature is:

$$T_{pc} = 19.0623 \cdot (485.85)^{0.58848} \cdot (0.8203)^{0.3596}$$

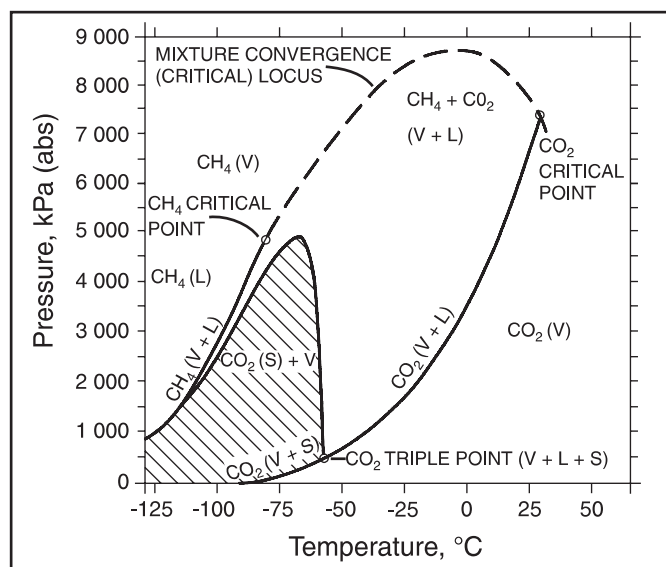
$$T_{pc} = 676.4 \text{ K}$$

$$\omega = \frac{3}{7} \left[\frac{\log (2141) - \log (101.325)}{(676.4/485.5) - 1} \right] - 1.0 = 0.444$$

Vapor Pressure

The vapor pressures of light hydrocarbons and some common inorganics in the temperature range below 38 °C appear in Fig. 23-19. Vapor pressures at higher temperatures, up to 315 °C, are in Fig. 23-20 for the same compounds. Note that, except for ethylene and propylene, the hydrocarbons are all normal paraffins.

FIG. 25-5
Phase Diagram CH₄-CO₂ Binary²¹



by the azeotrope formation between these components. An azeotropic composition of approximately 67% CO₂, 33% ethane is formed at virtually any pressure.²⁴

Fig. 25-7 shows the CO₂-ethane system at two different pressures. The binary is a minimum boiling azeotrope at both pressures with a composition of about two-thirds CO₂ and one-third ethane. Thus, an attempt to separate CO₂ and ethane to nearly pure components by distillation cannot be achieved by traditional methods, and extractive distillation is required.²⁶ (See Section 16, Hydrocarbon Recovery)

Separation of CO₂ and H₂S

The distillative separation of CO₂ and H₂S can be performed with traditional methods. The relative volatility of CO₂ to H₂S is quite small. While an azeotrope between H₂S and CO₂ does not exist, vapor-liquid equilibrium behavior for this binary approaches azeotropic character at high CO₂ concentrations²⁵ (See Section 16, Hydrocarbon Recovery).

FIG. 25-6
Isothermal Dew Point and Frost Point Data for Methane-Carbon Dioxide³²

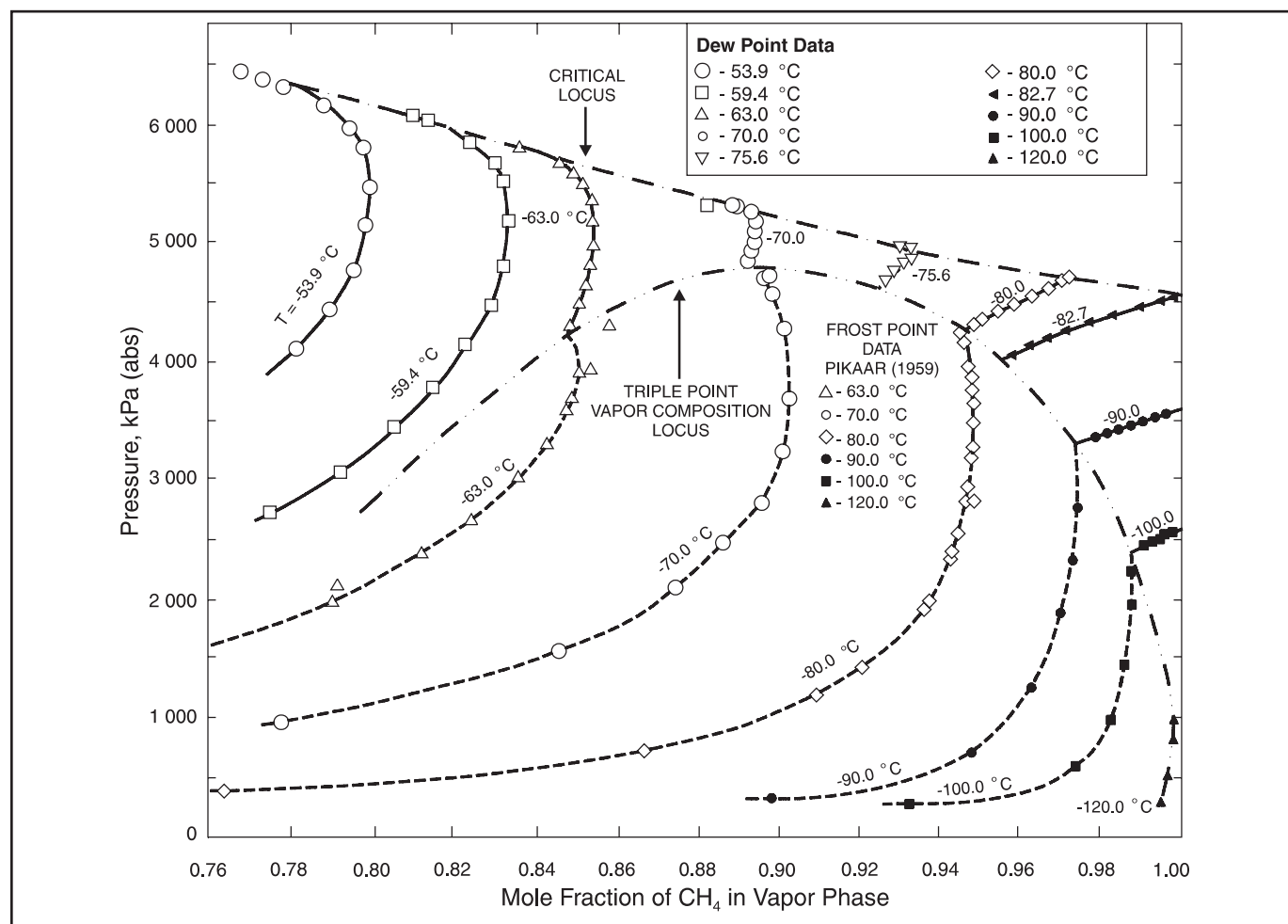
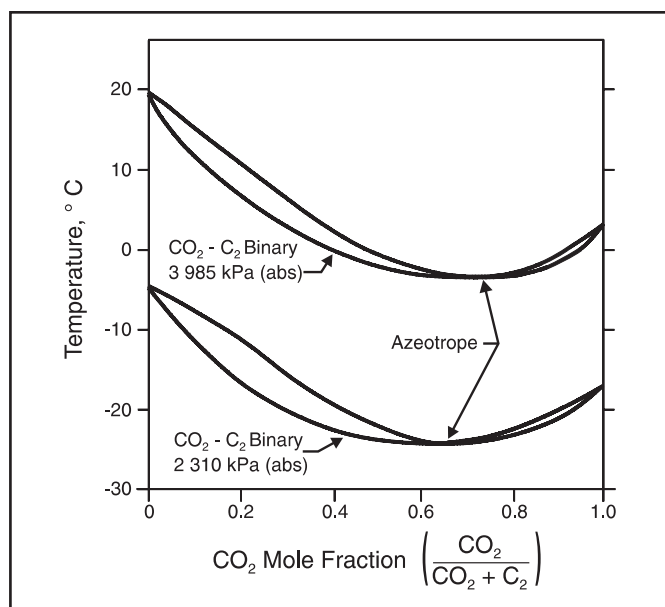


FIG. 25-7
Vapor-Liquid Equilibria CO₂-C₂H₆²¹



PHASE EQUILIBRIA METHODS

Numerous procedures have been devised to predict phase equilibria (K-values) and the corresponding physical properties of the associated phases. These include:

- Equations of state (EOS)
- Activity coefficient models
- Electrolytic models
- Combinations of equations of state with liquid theory or with tabular data
- Corresponding states correlations

A number of methods can be used for the purpose of phase equilibria and thermodynamic property prediction. In modern times, calculations are not typically executed by hand, but instead are solved by the use of thermodynamic simulation software (commercial or proprietary). This section describes several of the more popular procedures currently available. It does not purport to be all-inclusive or comparative.

Equations of State (EOS)

Equations of state have appeal for predicting thermodynamic properties because they provide internally consistent values for all properties in convenient analytical form. The section below discusses the basic capabilities of EOS, historical development, and recent advances.

EOS capabilities — The following summarizes the basic capabilities and describes the applicability for some of the more commonly used EOS methods.

- Although originally developed to describe simple gases, EOS have proven reliable for property prediction of most hydrocarbon-based fluids.

The simple cubic EOS are generally limited to prediction of thermodynamic properties and phase equilib-

ria for ideal or slightly non-ideal systems; they are not suitable for representation of highly non-ideal systems (e.g., methanol/water systems).

They typically are applied only to hydrocarbon mixtures with relatively low concentrations of non-polar or slightly polar fluids.

Recent advancements have made cubic EOS suitable for handling high concentrations of CO₂, H₂S, and N₂.

- Applicable for prediction of phase equilibria for pure components (VLE) and mixtures (VLE and VLLE) and for prediction of all thermodynamic properties for vapor and liquid phases.

Originally developed for handling of pure components, but inclusion and use of various mixing rules, which incorporate binary interaction parameters, have allowed the extension of use to binary and multicomponent mixtures.

Useful over wide ranges of temperature and pressure, including subcritical, supercritical, and retrograde regions.

- Require minimal pure component data. Experimental binary data can be used to “tune” binary interaction parameters, usually by regression of experimental data.
- Major EOS types include cubic, virial, corresponding states, and multi-parameter. Descriptions of the more commonly used cubic and virial types are included below:

Cubic EOS (e.g., van der Waal, Redlich-Kwong, Soave-Redlich-Kwong, Peng Robinson)

Explicit in pressure (P) with respect to temperature (T) and volume (V). They have separate terms to correct ideal gas predictions for attraction and repulsion forces between the molecules (correcting the real vapor pressure and volume predictions, respectively). When considering the pressure and temperature fixed, the EOS can be algebraically rearranged to give a relationship for V that is a cubic (3rd order) polynomial.

These EOS will include other parameters, specific to each chemical species that are generally determined from the critical properties, P_c and T_c, for the chemical species. Additional temperature-dependent functions can be added to more accurately match pure component behavior (i.e., a temperature dependent function correlated to the acentric factor (ω) is normally used to better match a pure component’s vapor pressure versus temperature behavior).

Multicomponent mixtures are treated with the same EOS parameters that are determined for the pure components present in the mixture. The equations used to blend the pure component values are referred to as “mixing rules”, which often include “binary interaction parameters” to account for non-ideal interactions between pairs of unlike molecules.

The EOSs are generally not “tuned” to pure component liquid density data, so they give poor representations of liquid molar volume/liquid den-

SECTION 26

Members

Gas Processors Suppliers Association

6526 East 60th Street
Tulsa, Oklahoma 74145
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<http://gpsa.GPAglobal.org>

The following is a listing of the members of GPSA. Please contact them directly for further information.
Behind this listing of members, the GPSA companies are classified by the type of services and supplies
that they provide to the industry. Services begin on page 26-16; Supplies begin on page 26-28.

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A+ Corporation 41041 Black Bayou Road Gonzales, LA 70737 http://www.geniefilters.com	225-644-5255	225-644-3975
A1 Sheet Metal Inc. 5909 E. 15th St. Tulsa, OK 74112 http://www.a1sheetmetaltulsa.com	918-835-6200	
ABB Inc. 7051 Industrial Blvd. Bartlesville, OK 74006 http://www.abb.com/totalflow	918-338-4888	918-338-4699
Accurate Gas Products L.L.C. 116 Board Road Lafayette, LA 70508 http://www.accurategasllc.com	337-269-1217	337-269-1978
Accurate Lab Audits, LLC P.O. Box 248 Ville Platte, LA 70506	337-280-1003	
Adsorption Technical Service, LLC 15138 Windsdowne Lane Cypress, TX 77429	281-256-0868	281-256-1996
Aeon PEC 505 Aero Drive Sheveport, LA 71107 http://www.aeonPEC.com	318-221-0122	318-425-2943
Afton Pumps, Inc. 7335 Ave. No. Houston, TX 77011 http://www.aftonpumps.com	713-923-9731	713-923-3902
Agilent Instrumentation Inc. 2821 Willow Tree Lane Unit K Ft. Collins, CO 80525 http://www.agilent.com	970-310-0324	

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Air Liquide America Specialty Gases LLC 9810 Bay Area Blvd. Pasadena, TX 77507 http://www.airliquide.com	281-7647-5800	
Air Products and Chemicals, Inc. 7201 Hamilton Blvd Allentown, PA 18195 http://www.airproducts.com	610-481-4544	610-706-5775
Airgas, Inc. 23 Plantation Park Dr. Bluffton, SC 29910 http://www.airgas.com	404-617-9808	
Allied Equipment, Inc. 8000 N. Golder Odessa, TX 79764	432-367-6000	
Alpine Site Services 10875 Dover St., Unit 1100 Westminster, CO 80021 http://www.alpinesites.com	303-420-0048	303-431-4843
AMACS Process Tower Internals 14211 Industry Street Houston, TX 77053 http://www.amacs.com	281-331-5956	
AMCS Corp. 135 US Highway 202-206 Bedminister, NJ 07921 http://www.amcscorp.com	908-719-6560	
AMEC Oil & Gas Americas 10777 Clay Rd. Houston, TX 77041 http://www.amec.com	713-570-1000	
AMETEK Process Instruments 150 Freeport Road Pittsburgh, PA 15238	905-634-4401	

Company& Address	Phone	Fax
Analytical Instruments Corp. 9845 Drysdale Lane Houston, TX 77041 www.aicgc.net	713-460-5757	713-460-1987
Analytical Systems International 9215 Solon Road, Ste. A4 Houston, TX 77064 http://www.asikeco.com	281-516-3950	281-351-8925
Anguil Environmental Systems 8855 N. 55th St. Milwaukee, WI 53223 http://www.anguil.com	414-365-6400	414-365-6410
Angus Measurement Services 4310 SW 33rd St. Oklahoma City, OK 73119	405-375-4970	
Antea Group 9009 Mountain Ridge Drive Austin, TX 78759 http://www.us.anteagroup.com	800-477-7411	
Anvil Corporation 1675 W. Bakerview Road Bellingham, WA 98226 http://www.anvilcorp.com	360-937-0550	360-671-1697
ARC Energy Equipment 252 Judice Road Sunset, LA 70587 http://www.arcenergyequipment.com	337-852-1105	337-662-3153
Ardent Services LLC 170 New Camellia Blvd., Ste. 200 Covington, LA 70433	281-703-4649	
Ariel Corporation 35 Blackjack Road Mt. Vernon, OH 43050 http://www.arielcorp.com	740-397-0311	740-397-3856
ASK Industries 301 Commerce St. Ft. Worth, TX 76102 http://www.askindustries.co	817-810-9102	
Aspen Technology, Inc. 200 Wheeler Road Burlington, MA 01803 http://www.aspentech.com	781-221-6400	
Atlas Copco Gas and Process 3037 Industrial Parkway Santa Maria, CA 93455 http://www.atlascopco-gap.com	805-928-5757	805-925-3861
Audubon 111 Veterans Blvd., Ste. 1200 Metairie, LA 70005 http://www.aechou.com	504-535-2205	
AXH Air-Coolers 9717 East 42nd St., Suite 136 Tulsa, OK 74146 http://www.axh.com	918-663-0811	918-663-1972
AYERS, Michael, P.E. 3130 Walnut Bend #320 Houston, TX 77042-4779	713-575-8164	
Azota Ltd. 9894 Bissonnet, Ste 580 Houston, TX 77036 http://www.azotaltd.com	281-768-4314	281-768-4370

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B.enviroSAFE, Inc. 601 Lonesome Prairie Trail Haslet, TX 76052 http://www.benvirosafe.com/	817-439-4767	817-439-4149
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BAND-IT IDEX, Inc. 4799 Dahlia St. Denver, CO 80216 http://www.band-it-idex.com	303-513-7823	
Barry D. Payne & Associates, Inc. 10707 Corporate Dr. #222 Stafford, TX 77477 http://www.bdpayne.com	281-240-4488	281-240-3913
Bartlett Equipment Co. 4951 S Mingo Rd Tulsa, OK 74146 http://www.bartlettequipment.com	918-627-7040	918-691-7405
BASF Corp. 1111 Bagby Street, Ste. 2600 Houston, TX 77002 http://www.basf.com	713-759-3024	713-759-3001
BCEK Engineering, Inc. 2500 No. Big Spring Midland, TX 79705 http://www.bcek.com	432-685-6095	432-685-7021
Bechtel 3000 Post Oak Boulevard Houston, TX 77056-6503 http://www.bechtel.com	713-235-2000	713-235-4820
Best PumpWorks 8885 Monroe Houston, TX 77061 http://www.bestpumpworks.com	713-956-2002	713-956-2141
Bexar Energy Holdings, Inc. 111 Soledade, Ste. 830 San Antonio, TX 78205 http://www.bexarenergy.com	210-342-7106	210-223-0018
BFX Fabrication, LLC 13465 Midway Road, Ste. 300 Dallas, TX 75244	469-374-5368	
Bilfinger Water Technologies 11811 North Freeway, Ste. 500 Houston, TX 77060 http://www.johnsonscreens.com	281-436-7333	
Bilfinger Westcon Inc. P.O. Box 1735 Bismarck, ND 58502 http://www.westconindustries.com	701-222-0076	
Black & Veatch Corp. Energy Division - Oil & Gas Houston, TX 77056 http://www.bv.com	713-416-9641	
Blue Star Pipe 5700 Granite Parkway, Ste. 430 Plano, TX 75024	214-329-1233	
Boardman LLC 1135 S. McKinley Oklahoma City, OK 73108	405-634-5434	

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Bowden Construction Co. Ltd. P.O. Box 12308 Odessa, TX 79768 http://www.bowdenconstruction.com	432-366-8877	432-366-0936
Brenntag Pacific Inc. P.O. Box 12430 Ogden, UT 84412 http://www.brenntag.com	801-627-4540	802-334-5141
Brice Equipment Co. P.O. Box 7945 Midland, TX 79708	432-697-3111	
Bruker Daltonics 3500 West Warren Ave. Fremont, CA 94538	510-683-1400	
Bryan Research & Engineering, Inc. P.O. Box 4747 Bryan, TX 77805 http://www.bre.com/	979-776-5220	979-776-4818
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Burckhardt Compression U.S. 7240 Brittmoore Rd., Ste. 100 Houston, TX 77041 http://www.burckhardtcompression.com	281-582-1059	
BWFS Industries, LLC 5637 Etheline Houston, TX 77039 http://www.bwfsindustries.com	281-590-9391	281-449-8563
C.R.C. Consulting P.O. Box 736 Perryton, TX 79070 http://www.crc-consulting.com	806-435-3418	
C3 Resources, LLC 2050 No. Loop W., Ste. 227 Houston, TX 77018 http://www.c3resources.com	713-476-9958	713-476-9975
Cameron Process Systems 11210 Equity Dr., Ste. 100 Houston, TX 77041	713-619-7105	
Cameron Valves and Measurement 7200 Interstate 30 Little Rock, AR 72209 http://www.c-a-m.com	501-568-6000	501-570-5785
Catalytic Combustion Corporation 709 21st Avenue Bloomer, WI 54724 http://www.catalyticcombustion.com	715-568-2882	715-568-2884
Catalytic Products International, Inc. 980 Ensell Road Lake Zurich, IL 60047 http://www.cpilink.com	847-483-0334	847-438-0944

Company& Address	Phone	Fax
Catamount Constructors, Inc. 1250 Bergen Parkway B200 Evergreen, CO 80439 http://www.catamountconstructors.com	303-710-3593	
Caterpillar Inc. 13105 NW Freeway, Ste. 1010 Houston, TX 77040 http://www.cat.com	713-329-2207	713-329-2211
CDM Resource Management LLC 20405 Tomball Parkway, Ste. 700 Houston, TX 77070 http://www.cdmm.com	281-376-2980	
CECA Molecular Sieves, Arkema, Inc. 2000 Market Street Philadelphia, PA 19103 http://www.siliporite.com	281-251-4812	281-251-4812, ext. 2
CEI Engineering Associates 3030 LBJ Freeway, Ste. 100 Dallas, TX 75234 http://www.ceieng.com	972-488-3737	
CH2M Hill 14701 St. Mary's Lane, Ste. 300 Houston, TX 77079 http://www.ch2m.com	281-721-8400	281-721-8401
Chapman Corporation 331 South Main Street Washington, PA 15301	724-250-2245	
Chart Energy & Chemicals 8665 New Trails Dr., #100 The Woodlands, TX 77381 http://www.chart-ec.com	612-227-4949	
Chemical Products Industries, Inc. 7649 SW 34th St. Oklahoma City, OK 73179 http://www.chemicalproductsokc.com	405-745-2070	405-745-2276
Chiyoda Corp. 2-12-1 Tsurumichuo Tsurumi-Ku Yokohama, Japan 230-8601 http://www.chiyoda-corp.com/en/		
Chromatic Industries 15B S. Trade Center Pkwy. Conroe, TX 77385 http://www.hemiwedge.com	936-539-5770	
Cimation 10205 Westheimer Rd., Ste. 100 Houston, TX 77042 http://www.cimation.com	713-452-3350	
City Pipe & Supply Corp. 2108 W. 2nd Odessa, TX 79763 http://www.citypipe.com	800-688-7473	432-333-2300
Clear Creek Construction 945 E. Britton Road Oklahoma City, OK 73114 http://www.clearcreekusa.com	405-478-3430	
Coastal Chemical Co., LLC 5300 Memorial Drive, Suite 1020 Houston, TX 77007 http://www.coastalchem.com	281-974-5897	713-865-8788

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Coastal Flow Measurement, Inc. 2222 Bay Area Blvd., Suite 200 Houston, TX 77058 http://www.coastalflow.com	281-282-0622	281-282-0791
Cobbs Allen 115 Office Park Dr. Birmingham, AL 35223 http://www.cobbsallen.com	205-223-3358	
Compressor Engineering Corp. (CECO) 5440 Alder Houston, TX 77081	713-663-1842	
Compressor Systems, Inc. P.O. Box 60760 Midland, TX 79711 http://www.compressorsystems.com	432-563-1170	432-563-0820
COMPRESSORtech 12777 Jones Road, Ste. 225 Houston, TX 77070 http://www.compressor2.com	281-890-5310	281-890-4805
Condit Co. 7255 E 46th ST Tulsa, Ok 74145 http://www.conda.com	918-663-5310	918-610-3451
Conestoga-Rovers & Associates 2270 Springlake Road, Suite 800 Dallas, TX 75234 http://www.craworld.com	972-331-8500	972-331-8501
Connelly-GPM, Inc. 3154 So. California Ave. Chicago, IL 60608	312-247-7237	
Contek Solutions LLC 6221 Chapel Hill Blvd., Ste. 300 Plano, TX 75093 http://www.conteklc.com	469-467-8296	
Cook Compression 2203 Timberlock, Ste. 229 The Woodlands, TX 77380	281-636-8431	
Corpac Steel Products Corp. 20803 Biscayne Blvd., Suite 502 Miami, FL 33021 http://www.corpacsteel.com	305-918-0540	305-931-2251
Credence Gas Services LLC P.O. Box 2388 Alvin, TX 77512 http://www.credencegasservices.com	281-331-2219	281-331-2235
Criterion Catalyst and Technologies LP 16825 Northchase Drive, Ste. 1000 Houston, TX 77060	281-875-7899	
Croft Automation LLC 1001 Loop 340, Bulding 2 Waco, TX 76712 http://www.croftautomation.com	254-714-1740	254-714-1710
Croft Production Systems, Inc. 19230 FM 442 Needville, TX 77461 http://www.croftsystems.net	979-793-2100	
Cummings Electrical, Inc. 14900 Grand River Road, Ste. 124 Fort Worth, TX 76155 http://www.cummingselec.com	817-355-5300	

Company& Address	Phone	Fax
Cummins Inc. 19410 Forest Timbers Ct. Humble, TX 77346 http://www.cumminsoilandgas.com	713-805-4571	
D.F.Bergman Inc. 17714 Mossy Ridge Lane Houston, TX 77095	281-859-9633	
DanCar Energy Construction 10551 Miller Road, Ste. 100 Dallas, TX 75238 http://www.dancargroup.com	972-633-1200	
Daniel Measurement and Control 9720 Old Katy Rd. Houston, TX 77041	713-827-3374	713-827-3886
DCG Partnership 1, Ltd. 4170A S. Main Pearland, TX 77581	281-648-1894	
Delta Tee International, Inc. 1000 Commercial Blvd. South Arlington, TX 76001 http://www.delta-tee.com	817-466-9991	
Desert NDT, LLC 16701 Greenspoint Park Dr., #100 Houston, TX 77060 http://desertndt.com	713-568-3513	832-460-5205
Detection Technologies 24 Greenway Plaza, #802 Houston, TX 77046 http://www.detection.com	800-780-9798	713-559-3059
Det-Tronics 10607 Haddington, Ste 100 Houston, TX 77043 http://www.Detronics.com	713-457-2162	
Devco USA 6846 South Canton, Suite 400 Tulsa, OK 74136 http://devcousa.com	918-281-6033	
Dew Point Control, LLC PO Box 18887 Sugar Land, TX 77479-8887 http://www.dewpointcontrol.com	281-265-0101	281-265-0107
Dexter Field Services 2826 Morning Star New Braunfels, TX 78132	512-432-4754	
Diablo Analytical, Inc. 5141 Lone Tree Way Antioch, CA 94531 http://www.diabloanalytical.com	925-755-1005	925-755-1007
Dickson Process Systems, Ltd. P.O. BOX 60478 Midland, TX 79711 http://www.dicksonprocess.com	432-561-8594	432-561-8990
Distribution Now 7402 North Eldridge Parkway Houston, TX 77041 http://www.distributionnow.com	281-823-4791	
Dresser-Rand Co. 4121 Cross Bend Drive Arlington, TX 76016	214-597-7663	

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Eastman Chemical - Therminol Heat Transfer Fluids 7710-T Cherry Park Dr #126 Houston, TX 77095 http://www.therminol.com	281-213-3472	207-213-3473
Eaton Metal Products Company, LLC 4800 York Street Denver, CO 80216	303-296-5729	
EDG, Inc. 10777 Westheimer Rd., #700 Houston, TX 77042 http://www.edg.net	713-977-2347	713-977-2387
Element Materials Technology 2120 West Willow Scott, LA 70583	337-232-3568	
Elite Compression Services LLC 2209 SW Ben Jordan Victoria, TX 77901	361-894-6320	
Elkhorn Holdings Inc 71 Allegiance Cir Evanston, WY 82930 http://www.elkhornconstruction.com	307-789-1595	307-789-7145
Elliott Group 10940 West Sam Houston Parkway N. Houston, TX 77064 http://www.elliott-turbo.com	281-517-7130	281-955-5072
EMD, Inc. 1411 Twin Oaks Wichita Falls, TX 76302 http://www.emdinc.com	940-322-2206	940-322-1719
Emerson Process Management 11502 Del Monte Houston, TX 77077 http://www.emerson.com	512-466-5968	
EMS USA, Inc. 2000 Bering Drive, Ste. 600 Houston, TX 77057 http://www.emsusainc.com	713-595-7600	713-871-9144
EnDyn, Ltd. 301 West First St. Alice, TX 78332	800-723-6396	361-668-3906
Enerflex 10815 Telge Road Houston, TX 77095	281-345-5021	
Energes 42 Danby Place The Woodlands, TX 77375	512-968-1628	
Energy Management & Services Co. 3100 S. Gessner, Ste. 400 Houston, TX 77063	713-456-7880	713-456-7881
Energy Recovery Inc. 1717 Doolittle Drive San Leandro, CA 94577 http://www.energyrecovery.com	281 633 6662	

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Energy Solutions International (ESI) 7904 N. Sam Houston Pkwy W., Ste. 100 Houston, TX 77064 http://www.energy-solutions.com	281-664-8223	
Engineering, Procurement & Construction, Inc. 101 Glenda Street Whitehouse, TX 75791 http://www.epc0392.com	903-939-1555	903-939-1566
ENGlobal Corporation 12303 Airport Way, Ste. 145 Broomfield, CO 80021 http://www.ENGlobal.com	303-439-4325	
Enovation Controls PO Box 470248 Tulsa, OK 74147 http://www.enovationcontrols.com	918-317-4100	918-317-4266
EnRUD Resources, Inc. 1006 Vista Road Pasadena, TX 77504 http://www.enrud.com	713-943-1600	
Enserca Engineering 165 S. Union Blvd., Ste. 1000 Lakewood, CO 80228	303-468-2720	
Entero Corp. 1040 - 7 Ave SW Suite 500 Calgary, AB T2P 3G9 http://www.entero.com	403-261-1820	403-261-2816
Envirosep 31 Aviation Blvd. Georgetown, SC 29442 http://www.envirosep.com	843-546-7400 x210	843-546-7407
EPCON International Inc. 1250 Wood Branch Park Drive, Ste. 600 Houston, TX 77079	281-398-9400	281-398-9488
EPI Engineering Inc. 9801 Westheimer, Ste. 1000 Houston, TX 77042 http://www.epiengineering.com	832-399-9424	
ESD Simulation Training Inc. One Riverway, Ste. 1700 Houston, TX 77056 http://www.esd-simulation.com	713-300-3757	
eSimulation, Inc. 16516 El Camino Real #248 Houston, TX 77062 http://www.esimulation.com	713-962-3107	281-893-3319
Everest Sciences 7737 E. 42nd Place, Suite H Tulsa, OK 74145 www.everestsciences.com	918-770-7190	
Evonik Corp. 10200 Grogans Mill Road, Ste. 500 The Woodlands, TX 77380 http://www.evonik.com/northamerica	281-298-0290	
Exeltech 7317 Jack Newell Blvd. N. Fort Worth, TX 76118	817-595-4969	817-595-1290

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EXTERRAN 20602 E. 81st St. Broken Arrow, OK 74014 http://www.exterran.com	918-251-8571	918-259-2856
Fabreeka International 13207 Tall Forest Cypress, TX 77429 http://www.fabreeka.com	281-874-5997	281-897-0064
Fabsco Shell & Tube, LLC 2410 Industrial Rd. Sapulpa, OK 74066 http://www.fabscollc.com	918-224-7550	
Fabwell Corp. 8410 S. Regency Drive Tulsa, OK 74131-3621 http://www.fabwell.com	918-224-9060	
Federal Services LLC 120 E. Main Street Oklahoma City, OK 73104 http://www.federalservicesllc.com	405-239-7301	405-232-5438
FESCO, Ltd. 1100 FESCO Avenue Alice, TX 78332 http://www.fescoinc.com	361-661-7015	361-661-7019
FES-Southwest, Inc. 19221 IH-45 South Ste. 340 Conroe, TX 77385 http://www.fessw.com	281-296-7920	281-296-7177
Filtration Technology Corp. 5275 Ashley Ct. Houston, TX 77041 http://www.ftc-houston.com	713-849-0849	
Fisher Controls 205 S Center Street Marshalltown, IA 50158 http://www.fisher.com	641-754-3011	641-754-3026
Flatrock Engineering 18615 Tuscany Stone San Antonio, TX 78258 http://flatrockenergy.com	469-426-2039	
Fluenta Inc. 1155 Dairy Ashford, Suite 211 Houston, Tx 77079 http://www.fluenta.com	281-972-2004	281-497-8687
Fluor Enterprises, Inc. 3 Polaris Way Aliso Viejo, CA 92698	949-349-2231	
FMC Technologies Direct Drive Systems 621 Burning Tree Road Fullerton, CA 92833	720-560-6177	
Foster Wheeler USA Corp. 2020 Dairy Ashford Houston, TX 77077	281-597-3000	281-597-3028
Freese and Nichols, Inc. 4055 International Plaza, Ste. 200 Fort Worth, TX 76109 http://www.freese.com	817-735-7300	
G2 Partners, LLC 10850 Richmond Ave., Ste. 200 Houston, TX 77042 http://www.g2partnersllc.com	713-260-4000	713-260-4099

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Gas Analytical Solutions, Inc. 19330 Highway 155 South Flint, TX 75762	903-825-2136	903-825-2184
Gas and Supply 111 Buras Drive Belle Chasse, LA 70037 http://www.gasandsupply.com	504-234-7700	
Gas Equipment Co., Inc. 11616 Harry Hines Blvd Dallas, TX 75229 http://www.gasequipment.com	972-280-8430	972-620-4142
Gas Packaging Engineering Ltd. 3000, 150-6th Avenue S.W. Calgary, AB T2P 3Y7 http://www.gaspackages.com	403-538-2164	
Gas Technology Corp. 1425 Greenway Drive, Suite 450 Irving, TX 75038 http://www.gastech.net	972-255-7800	972-550-0071
Gas Treatment Services B.V. Timmerfabriekstraat 12, Bergambacht GV, 2861 http://www.gtsbv.com	31 182 621890	31 182 621891
GE Oil & Gas P.O. Box 470305 Ft. Worth, TX 76147	817-307-5129	
GE Power & Water 1101 W. Saint Paul Ave. Waukesha, WI 53188 http://www.dresserwaukesha.com	262-547-3311	262-650-5650
GEA Refrigeration North America Inc. 3475 Board Road York, PA 17406 http://www.geafes.com	717-309-3333	
Genesis Systems 1501 10th Street #100 Plano, TX 75074 http://www.callgenesis.com	972-877-5016	
Geolex, Inc. 500 Marquette Ave. NW #1350 Albuquerque, NM 87102 http://www.geolex.com	505-842-8000	505-842-7380
G-Force and Associates, Inc. 5200 W. Highway 377 Tolar, TX 76476 http://www.gforcetx.com	817-573-3960	
Global Compressor, L.P. 13415 Emmett Road Houston, TX 77084 http://www.globalcompressorparts.com	713-983-8773	713-983-7118
Gly-Tech Services 2054 Paxton St. Harvey, LA 70058 http://www.glytech.com	504-348-8566	504-348-8261
Goar Sulfur Services & Assistance 1522 Hubbard Dr. Tyler, TX 75703	903-561-3008	

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Grace Davison 845 Redwing Street Bridge City, TX 77611	409-363-4165	
Grae-Con Construction, Inc. P.O. Box 1778 Steubenville, OH 43952 http://www.graecon.com	740-282-6830	740-282-6849
Graves Analytical Services LLC P.O. Box 253 Hugoton, KS 67951	620-428-6053	620-428-6069
Great Plains Analytical Services 303 W. 3rd St. Elk City, OK 73644 http://www.gas-stacktesting.com	781-706-9185	
Gregory Gas Services LLC 343592 E. 990 Rd. Chandler, OK 74834 http://www.gregorygasservices.com	918-866-2318	918-866-2263
Guild Associates, Inc. 5750 Shier-Rings Road Dublin, OH 43016 http://www.moleculargate.com	908-752-6420	614-798-1972
Gulf Coast Chemical, LLC 220 Jacquelyn Street Abbeville, LA 70510 http://www.gulfcoastchemical.com	337-898-0213	337-893-9927
Gulf Coast Dismantling, Inc. P.O. Box 5249 Pasadena, TX 77508	281-487-0595	281-487-0597
Gulf Coast Engineered Solutions, Inc. P.O. Box 130723 The Woodlands, TX 77393 http://www.gces-inc.com	281-210-1395	
Gulf Coast Measurement, Inc. P.O. Box 854 Cypress, TX 77410	281-357-0992	281-357-0994
Gulf Interstate Engineering 16010 Barkers Point Lane, Ste. 600 Houston, TX 77079 http://www.gie.com	713-850-3585	
Gulf Publishing Co. 2 Greenway Plaza, Ste. 1020 Houston, TX 77046 http://www.hydrocarbonprocessing.com	713-523-4443	
Gulsby Engineering, Inc. 1250 Indiana St Humble, TX 77396	281-446-4230	281-446-5445
GWD 621 17th Street, Ste. 1200 Denver, CO 80293 http://www.gwdesign.com	303-951-9327	
H & S Valve Inc. 6704 No. County Rd. West Odessa, TX 79702	432-362-0486	432-368-5052
H.J. Baker, PE 1511 Rock Ridge Drive Cleveland, OK 74020	918-358-5286	
Halff TriTex 1201 North/Bowser Road Richardson, TX 75081 http://www.tritextech.com	214-217-6502	972-233-5160

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Halker Consulting LLC 9400 Station Street, Ste. 300 Lone Tree, CO 80124 http://www.halkerconsulting.com	303-515-2700	
Hampel Oil Distributors P.O. Box 12346 Wichita, KS 67277 http://www.hampeloil.com	316-619-6163	
Harris Group Inc 1776 Lincoln, Ste. 1000 Denver, CO 80203 http://www.harrisgroup.com	303-223-6819	303-291-0136
Heatec Inc. 5200 Wilson Road Chattanooga, TN 37410 http://www.heatec.com	432-821-5200	423-821-7673
Heater Specialists 4606 FM 1960 W., #408 Houston, TX 77069 http://www.hsi-llc.com	713-253-6314	
Heath Consultants Incorporated 9030 Monroe Road Houston, TX 77061 http://www.heathus.com	713-844-1300	713-844-1309
HETSCO, Inc. 505 Pushville Rd. Greenwood, IN 46143 http://www.hetsco.com	317-535-4315	317-535-4684
Holloman Corporation 333 N. Sam Houston Pkwy. Houston, TX 77060	432-257-0109	
HSB Solomon Associates LLC One Lincoln Centre, 5400 LBJ Freeway, Ste. 1400 Dallas, TX 75240 http://www.solomononline.com	972-739-1719	972-233-8332
Hunt, Guillot & Associates 603 Reynolds Drive Ruston, LA 71270 http://www.hga-llc.com	318-255-6825	
Huntsman Corp. 3040 Post Oak Blvd. Houston, TX 77056	713-235-6000	713-235-6977
HyBon Engineering 2404 Commerce Drive Midland, TX 79704	432-697-2292	432-697-2310
Hydrocarbon Technology Engineering 802 Merritt St., SE Grand Rapids, MI 49507	616-452-3279	616-452-3290
HydroCat Industries 1734 Clarkson Road, #208 Chesterfield, MO 63017 http://www.hydrocatindustries.com	636-272-8000	
I & S Technical Resources, Inc. 248 Twin Lakes Blvd West Columbia, TX 77486	832-476-5473	
Industrial Distributors, Inc. 4920 Nome St., Unit A Denver, CO 80239 http://www.idiprocess.com	303-375-9070	303-375-0911

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Industrial Gas Technology, Inc. 150 Vanderbilt Ct. Bowling Green, KY 42103 http://www.industrialgastech.com	270-783-0538	
INEOS Oxide 10777 Westheimer Rd, Ste. 210 Houston, TX 77042 http://www.ineos.com	713-243-6200	713-243-6220
International Alliance Group 3657 Briarpark Dr. Houston, TX 77042 http://www.triteniag.com	832-615-1455	
International Oil & Gas Consultants Pte, Ltd. 360 Orchard Road, #12-02 International Bldg. Singapore, 238869 http://www.iog-consultants.com	+65 6235 9030	+65 6235 6180
Intertek 801 Travis, Ste. 1500 Houston, TX 77002 http://www.intertek.com	713-430-8601	
IPD 23231 Normandie Ave. Torrance, CA 90501 http://www.ipdparts.com	310-602-5317	310-530-2708
J MAR & Associates 15455 Dallas Parkway Suite 220 Addison, TX 75001 http://www.jmarassociates.com	972-732-8301	
J. H. Foglietta Consulting LLC 5827 Fairdale Lane Houston, TX 77057	713-962-0470	
J.W. Williams Inc.,a Flint Energy Services Co. 19814 G.H. Circle Waller, TX 77084	936-931-2424	936-931-2225
JEM Resources & Engineering, Inc. 10 Desta Drive, Ste. 175 Midland, TX 79705 http://www.jemengineering.com/	432-352-0802	
JFE Engineering Corporation 2-1 Suehiro-cho, Tsurumi-Ku, Yokohama, 230-8611	81 45 505 07772	81 45 505 08941
JGC Corporation 2-3-1 Minato mirai, Nishi-ku Yokohama, Ka 220-6001 http://www.jgc.co.jp	045-682-8468	045-682-8835
John M. Campbell & Co. 1215 Crossroads Blvd Norman, OK 73072 http://www.jmcampbell.com	405-321-1383	405-321-4533
John Zink Company LLC 11920 E. Apache Tulsa, OK 74116 http://www.johnzink.com	918-234-2999	918-234-1968
Johnson Filtration Products, Inc. P.O. Box 30010 Amarillo, TX 79120	806-371-8033	806-372-5257

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Johnson Matthey P.O. Box 1, Belasis Avenue Billingham Cleveland TS23 1LB UK http://www.jmcatalysts.com		
Jonell, Inc P.O.Box 1092, 900 Industrial Pkwy Breckenridge, Tx 76424 http://www.jonellinc.com	254-559-7591	254-559-9863
Joule Processing, LLC. 3200 Southwest Freeway, Ste. 2390 Houston, TX 77027 http://www.jouleprocessing.com	713-481-1864	713-481-1887
J-W Power Company 7074 S. Revere Parkway Centennial, CO 80112 http://www.jwoperating.com	720-385-3030	866-741-2025
Kahuna Ventures 11400 Westmoor Circle, Ste. 325 Westminster, CO 80021	303-451-7374	
Kams, Inc. 1831 NW 4th Dr. Oklahoma City, OK 73106	405-232-2636	405-232-3107
Kane Environmental Engineering 5307 Oakdale Creek Court Spring, TX 77379	281-370-6580	281-379-3735
KBC Advanced Technologies 15021 Katy Freeway, Ste. 600 Houston, TX 77094 http://www.kbcat.com	281-293-8200	
KBR 601 Jefferson Street, Ste. KT3398B Houston, TX 77002 http://www.kbr.com	713-753-5201	713-753-2000
Ke-Rem Technical Services Ltd. 5222 Whitestone Rd. NE Calgary, AB T1Y 1T6	403-815-5971	
K-FLEX USA 100 Nomaco Drive Youngsville, NC 27596 http://www.kflexusa.com	800-765-6475	800-765-6471
Kimray Inc. 52 NW 42nd Street Oklahoma City, OK 73118	405-525-6601	405-525-5630
Kleinfelder 7805 Mesquite Bend, Suite 100 Irving, Tx 75063 http://www.kleinfelder.com	972-868-5934	972-409-0008
Knighten Industries Inc. 3323 NC Rd. West Odessa, TX 79764	432-362-0468	432-362-9813
Koch-Glitsch LP 4111 East 37th Street North Wichita, KS 67220 http://www.koch-glitsch.com	316-828-7208	316-828-7985
KP Midstream 909 ESE Loop 323, Ste. 777 Tyler, TX 75701 http://www.kpamidstream.com	903-534-9155	903-534-9133

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KW International 1223 Brittmoore Rd. Houston, TX 77043 http://www.kwintl.com	832-320-2607	713-468-2770
L.A. Turbine 28557 Industry Drive Valencia, CA 91355 http://www.laturbine.com	661-294-8290	661-294-8249
Laboratory Services 2609 W. Marland Hobbs, NM 88240	575-397-3713	
LCM Industries, Inc. 1605 S. Marlin Dr. Odessa, TX 79763 http://www.lcmindustries.com	432-332-5516	432-332-5519
Legacy Measurement Solutions 15505 Wright Brothers Drive Addison, TX 75001 http://www.legacymeasurement.com	972-233-8191	
Leidos Engineering One West Third, Ste. 200 Tulsa, OK 74103 http://www.leidos.com/engineering	918-599-4361	
Linde Process Plants, Inc. 6100 S. Yale, Ste. 1200 Tulsa, OK 74136 http://www.lppusa.com	918-477-1200	918-477-1100
LKS Midstream Consulting LLC 5960 West Parker Road #278 - 233 Plano, TX 75093 http://lksmidstream.com	469-443-0637	
Louisiana Valve Source, Inc. 101 Metals Dr. Youngsville, LA 70592 http://www.lavalve.com	337-856-9100	337-857-2969
M & J Valve 4150 S. 100 East Ave., Ste. 200W Tulsa, OK 74146	918-663-9595	
M Chemical Company 850 Colorado Blvd Los Angeles, CA 90041 http://www.mchemical.com	323-254-3600	323-257-6968
M J & H Fabrication 2120 Hall Blvd. Ponca City, OK 74601 http://www.mjhfab.com	580-749-5339	
Martin Energy Consultants P.O. Box 8064 The Woodlands, TX 77387	281-367-9401	
Master Corporation 1330 East 8th St., Suite 105 Odessa, TX 79761-4713 http://www.mastercorporation.com	432-580-0600	432-335-0600
Masters Process Equipment 26118 North IH-45 Spring, TX 77386 http://www.mastersprocess.com	281-367-5699	281-367-5685
Mayekawa USA, Inc. 1770 St. James Place Houston, TX 77056 http://mayekawausa.com	832-547-2320	

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McAfee & Taft 1717 S. Boulder Ave, Ste. 900 Tulsa, OK 74119 http://www.mcafeetaft.com	918-587-0000	
McDaniel Technical Services Inc. P.O. Box 2557 Broken Arrow, OK 74013 http://www.mcdanieltsi.com	918-294-1628	
McJunkin Red Man Corp. P.O. Box 4395 Odessa, TX 79760 www.mcjunkin.com	915-332-8131	
Mechanical Equipment, Inc. P.O. Box 1800 Midland, TX 79702	432-687-0601	
MEGTEC Systems Inc. 830 Prosper Road De Pere, WI 54115	920-339-2787	
MEI, LLC 138 Canal Street, Suite 501 Pooler, GA 31322 http://www.mei-consult.com	912-355-8001	912-355-0065
Merichem 846 East Algonquin Road Schaumburg, IL 60173 http://www.merichem.com	847-285-3865	
MHBT, Inc. 8144 Walnut Hill Lane, 16th Floor Dallas, TX 75201 http://www.mhbt.com	972-770-1655	
Michell Instruments Inc. 14915 Terra Point Cypress, TX 77429 http://www.michell.com/us	281-728-3982	
MidCon Compression LLC P.O. Box 18881 Oklahoma City, OK 73154 http://www.midconcompression.com	405-935-4159	405-849-0003
Mid-States Supply 1716 Guinotte Ave. Kansas City, MO 64120 http://www.midcononline.com	800-825-1410	816-842-3630
Midstream Energy Group, Inc. 10707 Corporate Drive, Ste. 158 Stafford, TX 77477 http://www.midstreamenergygroup.com	713-582-2579	
Midway Laboratory, Inc. 315 Main Street Taft, CA 93268 http://www.midwaylaboratory.com	661-765-6920	
MIRATECH Corp. 420 So. 145th East Ave. Tulsa, OK 74108	918-622-7077	918-622-3928
Mobile Analytical Labs Inc. P.O. Box 69210 Odessa, TX 79769 http://www.mobilelabs.com	915-337-4744	

Company& Address	Phone	Fax
MODEC International Inc. 14741 Yorktown Plaza Houston, TX 77040 http://www.modec.com	281-529-8100	281-529-8102
Monico Monitoring, Inc. 18530 Klein Church Rd. Spring, TX 77379 http://www.monicoinc.com	281-350-8751	888-418-5955
Moore Control Systems, Inc. 1435 Katy-Flewellen Katy, TX 77494 http://www.moore-control.com	281-392-7747	281-392-7727
Morrow Renewables, LLC P.O. Box 61447 Midland, TX 79711 http://www.morrowrenewables.com	918-432-570-4200	
Movilab, S.A. de C.V. Paseo de Francia 163 Pisol Naucalpan, Estado de Mexico 53120 http://www.movilab.com	525-553-442121 Ext. 102	
MPR Services, Inc. 1201 FM 646 Dickinson, TX 77539 http://www.mprservices.com	281-337-7424	
MSES Consultants, Inc. 609 West Main St. Clarksburg, WV 26302 http://www.msproducts.com	304-624-9700	304-622-0981
Mueller Environmental Designs 7607 Wright Rd Houston, TX 77041 http://www.muellerenvironmental.com	832-300-1122	713-465-0997
Mustang Cat 12800 NW Freeway Houston, TX 77040	713-460-7238	
MYNAH Technologies 504 Trade Center Boulevard Chesterfield, MO 63005 http://www.mynah.com	636-728-2036	
Nalco, An Ecolab Company 1601 W. Diehl Road Naperville, IL 60563 http://www.nalco.com	630-305-1000	480-774-0185
Neuman & Esser USA, Inc. 1502 East Summitry Circle Katy, TX 77449 http://www.neuman-esser.com	713-554-9623	281-497-5047
New Gen Products 200 Union Bower Ct., Ste. 210 Irving, TX 75061 http://www.newgenproducts.com	214-792-9280	
New Tech Global Ventures 202 Madison Square Colleyville, TX 76034 www.ntglobal.com	817-821-8107	
Niagara Blower 91 Sawyer, Ave. Tonawanda, NY 14150 http://www.niagarablowner.com	716-875-2000	716-875-1077
Nicholas Consulting Group, Inc. 600 N. Marienfeld, Suite 390 Midland, TX 79701 http://www.thencg.co	432-570-8093	432-683-1993

Company& Address	Phone	Fax
Nitro-Lift Technologies LLC 1200 W. Interstate Drive Norman, OK 73072 http://www.nitrolift.com	405-360-3722	
Nomaco Insulation 3006 Anaconda Road Tarboro, NC 27886 http://www.cryoflexinsulation.com	252-563-1730	
Nomad Field Services 11400 Westmoor Circle Westminister, CO 80021 http://www.nomadfieldservices.com	720-889-9962	
Norwood S&S, LLC 6415 Calle Lozano Dr. Houston, TX 77041-2559 http://www.NorwoodSS.com	281-558-2946	281-558-8405
Nova Molecular Technologies 1 Parker Place, Ste. 725 Janesville, WI 53545	608-754-6682	
NTACT Operations, LLC 12615 West County Road 91 Midland, TX 79707 http://ntactops.com	817-680-0253	
Oil & Gas Awards 60 A George Row, London, SE164WA http://www.oilandgasawards.com	001210591 8471	
OILTECH Via Caviglia 3 Milan, 20139	39 02 568 08 705	39 02 539 2197
Olsson Associates 201 NW 63rd Street, Ste. 130 Oklahoma City, OK 73116 http://www.olssonassociates.com	405-242-6600	405-242-6601
Omni Flow Computers, Inc. 12620 W. Airport Blvd., Ste. 100 Sugar Land, TX 77479 http://www.omniflow.com	281-240-6161	281-240-6162
Onsite Power Inc. 6525 S. Riviera Way Aurora, CO 80016	303-690-8486	
Optimized Gas Treating, Inc. 12337 Jones Rd., Ste. 432 Houston, TX 77070 http://www.ogtrt.com	580-428-3535	580-428-3535
Optimized Pipeline Solutions 59 Joshua Court Lake Jackson, TX 77566	979-583-8839	
Optimized Process Designs 25610 Clay Road Katy, TX 77493 http://www.opd-inc.com	281-371-5909	281-371-7500
Optimized Process Furnaces 3995 S Santa Fe Chanute, KS 66720 http://www.firedheater.com	620-431-1260	620-431-6631
Ortloff Engineers, Ltd. 415 W. Wall, Ste. 2000 Midland, TX 79701 http://www.ortloff.com	432-685-0277	

Company& Address	Phone	Fax
Pantechs Laboratories, Inc. 5915 50th Street Lubbock, TX 79424 http://www.pantechs.com	806-797-4325	806-797-4474
Panton Inc. 24 E. Greenway Plaza, Ste. 1180 Houston, TX 77046	713-589-6852	
Paratherm - Heat Transfer Fluids 31 Portland Road West Conshohocken, PA 19355 http://www.paratherm.com	610-941-4900	610-941-9191
Parker Hannifin Corp. 500 S. Glaspie St. Oxford, MI 48371 www.parker.com	248-628-6400	
PECOFacet 118 Washington Avenue Mineral Wells, TX 76068 http://www.pecofacet.com	940-325-2575	940-325-4622
Peerless Mfg. Co. 14651 N. Dallas Pkwy, Ste. 500 Dallas, TX 75254 http://www.peerlessmfg.com	214-357-6181	
Pennwell Corp. 1455 West Loop S Houston, TX 77027 http://www.pennwell.com	713-963-6276	713-963-6285
Pentair Porous Media 4301 West Davis Conroe, TX 77304 http://www.pentair.com	936-788-1000	936-788-1220
PerkinElmer LAS 1400 Via Grande Drive Austin, TX 78739 http://www.perkinelmer.com	512-289-5588	
Perry Gas Processors LP P.O. Box 13270 Odessa, TX 79768	432-332-0100	
Petral Consulting Co. P.O. Box 42586 Houston, TX 77242 http://www.petral.com	713-977-0144	
Petrin Corporation 1405 Commercial Drive Port Allen, TX 70767 http://www.petrincorp.com	800-256-7876	225-343-0475
Petro-Canada America Lubricants Inc. 4120 S. Juniper Ave. Broken Arrow, OK 74011 http://www.lubricants.petro-canada.ca	918-451-5655	
Petronas TBG 83 KG Kuantan Klang Sclangor 41300 Malaysia http://www.petronas.com.my	603-233-15348	
Plant Eng. Construction Pte. Ltd. 21 Shipyard Road Singapore 628144	65-6268-9788	

Company& Address	Phone	Fax
Plant Maintenance Services, L.L.C. 2606 East Pearl St. Odessa, TX 79761 http://www.pmsone.com	432-559-6944	432-580-5903
POWER Engineers, Inc. 2041 South Cobalt Point Way Meridian, ID 83642 http://www.powereng.com	208-288-6100	208-288-6199
PPI Engineering & Construction Services 2501 Parkview Drive, Ste. 670 Fort Worth, TX 76102	832-506-4524	
Prime Controls, LP 1725 Lakepointe Dr. Lewisville, TX 75057 http://www.prime-controls.com	972-221-4849	
Professional Engineering Consultants, P.A. 303 S. Topeka Wichita, KS 67202 http://www.pecl.com	316-262-2691	
PSI (Process Solutions Integration) 6654-A Canyon Drive Amarillo, TX 79109 http://www.psi-technology.com	806-356-9800	
Puffer Sweiven 4230 Greenbriar Drive Stafford, TX 77477 http://www.puffersweiven.com	281-240-2000	281-274-6438
Q.B. Johnson Manufacturing, Inc. 9000 S. Sunnyslane Rd. Oklahoma City, OK 73189 http://www.qbjohnson.com	405-677-6676	405-670-3270
Q2 Technologies, LLC 14720 Highway 105 West, #200 Montgomery, TX 77356 http://www.q2technologies.com	936-588-2242	936-588-2298
QuantityWare GmbH Zeiloch 1b Bruchsal, 76646 http://www.quantityware.com	49 7251 982 3003	49 7251 982 3116
Questar Energy Services P.O. Box 1129 Rock Springs, WY 82902	307-352-7281	
Quorum Business Solutions, Inc. 811 Main Street, Ste. 2000 Houston, TX 77002 http://www.qbsol.com	713-430-8600	713-430-8697
R & R Engineering Co., Inc. 12585 E. 61st St. Broken Arrow, OK 74012	918-252-2571	
Randall Gas Technologies 2 Riverway, Ste. 1300 Houston, TX 77056	713-375-8266	
Ranger Plant Constructional Co. Inc. 5851 E. Interstate 20 Abilene, TX 79601 http://www.rpcinc.com	325-677-2888	

Company& Address	Phone	Fax
Red Ball Oxygen 609 N. Market Street Shreveport, LA 71107 http://www.redballoxygen.com	318-425-6300	318-425-3211
Ref-Chem L.P. 1128 S. Grandview Ave. Odessa, TX 79761 http://www.ref-chem.com	432-332-8531	432-332-3325
Regard Resources Co., Inc 555 Aero Dr. Shreveport, LA 71107 http://www.regardresources.com	318-425-2533	318-425-1014
RES Energy Solutions 2010 McAllister Rd. Houston, TX 77092 http://www.res-co.com	817-602-2248	
Reset Energy P.O. Box 8601 Midland, TX 79708 http://www.resetenergy.com	432-682-2020	
Rexel Inc. 8042 Katy Freeway, Ste. 100 Houston, TX 77024 http://www.rexelusa.com	713-316-1700	713-686-8906
Rhine Ruhr Pty Ltd Unit 1, 10-30 West Circuit, Sunshine West Melbourne, Vi 3020 http://www.rhineruhr.com.au	61 3 9300 5000	61 3 9300 5001
Richard Industrial Group 11490 Wetheimer, Ste. 1000 Houston, TX 77007 http://www.richardig.com	713-315-7145	
River City Engineering 4830 Bob Billings Parkway, Suite 100B Lawrence, KS 66049 http://www.rivercityeng.com	785-842-4783	785-842-1450
Robert R. Reis, Attorney- Mediator, P.C. 2287 E. 39th St. Tulsa, OK 74105	918-742-2028	
Rockwell Automation 9500 Arboretum Blvd., Ste. 400 Austin, TX 78759 http://www.rockwellautomation.com	512-438-1400	
Rotor-Tech, Inc. 10613 Stebbins Circle Houston, TX 77379 http://www.rotor-tech.com	713-984-8900	713-984-9425
Royal Filter Mfg. Co., Inc. 4327 S. 4th Chickasha, OK 73018 www.royalfilter.com	405-224-0229	
S & B Engineers and Constructors, Ltd. 7825 Park Place Blvd. Houston, TX 77087	713-845-7850	
S&B Infrastructure Private, Ltd. 100 E. 15th St., #650 Fort Worth, TX 76102 http://www.sbinfra.com	817-820-0036	

Company& Address	Phone	Fax
Samson Controls, Inc. 4111 Cedar Blvd. Baytown, TX 77523 http://www.samson-usa.com	281-383-3677	
Samuel Engineering, Inc. 8450 E. Crescent Pkwy., Ste. 2300 Greenwood Village, CO 80111 http://www.samuelengineering.com	303-714-4840	
SANCUS Energy & Power, LLC 11767 Katy Freeway, Ste. 700 Houston, TX 77079 http://www.sancus-ep.com	832-460-1000	
Saulsbury Industries, Inc. 2951 E. Interstate 20 Odessa, TX 79766	432-438-6436	432-368-0061
Saxon Construction, Inc. 790 Brogdon Road Suwanee, GA 30024	770-271-2174	770-271-2176
SCFM Compression Systems Co. 3701 S. Maybelle Ave. Tulsa, OK 74107 http://www.scfm.com	918-663-1309	918-663-6140
Schneider Electric - Invensys 8610 S. 66th E. Ave. Tulsa, OK 74133 http://www.iom.invensys.com	918-492-6301	918-492-6302
Schwob Energy Services 2349 Glenda Lane Dallas, TX 75229 http://www.schwob.com	972-243-7674	
S-CON, Inc. 8326 West State Hwy 21 Bryan, TX 77807 http://www.SCONinc.com	979-822-4466	979-823-4875
Scott Measurement Service Inc P.O. Box 5247 Granbury, TX 76049 http://www.scottmeasurement.com	817-573-0036	817-573-0364
SEC Energy Products & Services, LP 9523 Fairbanks N Houston Houston, TX 77064 http://www.sec-ep.com	281-890-9977	281-955-6346
Select Engineering, Inc. 1717 S. Boulder, Suite 600 Tulsa, OK 74119 http://www.select-engineering.com	918-592-1133	918-592-1134
Sepra-Chem Corp. 10975 Spur 248 Tyler, TX 75707 http://www.sepra-chem.com	903-566-1015	903-566-1094
SERO Pump Systems, Inc. 3727 Greenbriar Drive, Ste. 105 Stafford, TX 77477 http://www.seropumps.com/	281-242-8080	
Setec Astronomy, Inc. P.O. Box 6557 Tyler, TX 75711	903-312-9435	
Shamrock Gas Analysis 1100 South Madden St. Shamrock, TX 79097 http://www.sgalab.com	806-256-3249	806-256-3159

Company& Address	Phone	Fax
Siemens Industry 8850 Fallbrook Drive Houston, TX 77429 http://www.siemens.com	281-827-8957	
Simms Machinery International 2357 A Street Santa Maria, CA 93455 http://simmsmachineryinternational.com	805-349-2540	805-349-9959
SME Associates, LLC 6715 Theall Houston, TX 77066 www.sme-llc.com	281-440-7350	
Smith & Burgess 7600 W. Tidwell Road, Ste. 600 Houston, TX 77040 http://www.smithburgess.com	713-082-2647	
Smithco Engineering, Inc. 6312 S 39th West Avenue Tulsa, OK 74132 http://www.smithco-eng.com	918-446-4406	918-445-2857
SNC-Lavalin E&C 9009 West Loop South, Suite 800 Houston, TX 77096-1719 http://www.snclavalin.com	713-667-9162	713-667-9241
Southern Flow Companies, Inc. 5291 Hanselman Victoria, TX 77905 http://www.southernflow.com	361-575-4528	361-575-9512
Southern Heat Exchanger Services 12210 A US 90 East Houston, TX 77049	281-506-0934	
Spartan Energy Partners 24 Waterway Avenue Ste. 850 The Woodlands, Texas, TX 77380 http://www.spartanep.com	281-466-3310	281-466-3320
Spartan Engineering, Inc. 10820 E. 45th St., Ste. 100 Tulsa, OK 74146 http://www.spartan-eng.com	918-895-7666	
SpectraSensors Inc. 4333 W. Sam Houston Houston, TX 77043 http://www.spectrasensors.com	713-300-2719	713-856-6623
Spitzer Industries 11250 Tanner Road Houston, TX 77459 http://spitzerind.com	713-482-2700	
SPL, Inc. 8880 Interchange Drive Houston, TX 77054 http://www.spl-inc.com	713-660-0901	713-660-6035
Strategic Automation Services LLC 16203 Park Row Road, Ste. 140 Houston, TX 77084 http://www.strategic-automation-services.com	281-945-8900	
Subsurface Technology, Inc. 6925 Portwest Dr., Suite 110 Houston, TX 77024 http://www.subsurfacegroup.com	713-880-4640	713-880-3248

Company& Address	Phone	Fax
Sulfur Operations Support, Inc. P.O. Box 1770 Ocean Springs, MS 39566 www.sultrap.com	228-875-5515	
SULPETRO INC. #600, 600-6th Avenue Calgary, AB T3H 2H5 http://www.sulpetro.com	403-233-9337	866-285-2459
Sulzer Chemtech 8505 E. North Belt Drive Humble, TX 77396	281-216-8562	
Sundyne Corporation 14845 West 64th Ave. Arvada, CO 80007 http://www.sundyne.com	303-425-0800	303-940-2911
Sunland Construction Inc. 315 Country Drive Delcambre, LA 70528 http://www.sunlandconstruction.com	337-685-2167	337-685-2168
Superheat FGH Services, Inc. 680 Industrial Park Drive Evans, GA 30809 http://www.superheatfgh.com	706-790-5353	706-790-3383
SWAGELOK Oklahoma 9421 E. 54th St. Tulsa, OK 74145 http://www.swagelok.com/tulsa	918-258-8661	918-258-1262
T.F. Hudgins Inc. P.O. Box 920946 Houston, TX 77292	713-682-3651	
Taylor Forge Engineered Systems 308 N. Iron Street Paola, KS 66071	913-294-5331	
TEA 7580 East 151st Street Bixby, OK 74008 http://www.teaeng.com	918-394-9444	
Teague Nail and Perkins, Inc. 1100 Macon Street Fort Worth, TX 76102	817-665-7169	
TECHNIP 11700 Katy Freeway, #150 Houston, TX 77079 http://www.TECHNIP.com	281-249-8760	281-249-7646
Tetra Tech 6002 Rogerdale Road, Ste. 310 Houston, TX 77002 http://www.tetrattech.com/oilandgas	281-983-2851	281-983-2860
Tetra Technologies Inc. 24955 I 45 North The Woodlands, TX 77380 http://www.tetrattec.com	281-364-4339	
Texas Turbine, Inc. 624 Profit St Azle, TX 76020 http://www.txturbine.com	817-444-5528	817-444-3925
The Arrington Corporation P.O. Box 3128 Flint, TX 75762 http://www.arringtoncompanies.com	903-894-6157	903-894-7428

Company& Address	Phone	Fax
Thermal & Mechanical Equipment Co. 1423 E. Richey Rd. Houston, TX 77073 http://www.tmec.com	713-688-8834	
Thomas Petroleum Ltd. P.O. Box 1876 Victoria, TX 77902 www.thomaspetro.com	361-573-7662	
Thurmond-McGlothlin, Inc. 1428 N. Banks Pampa, TX 79066 http://www.tm-ems.com	806-665-5700	806-665-2632
TIC - The Industrial Company 9780 Mt. Pyramid Ct., Ste. 100 Englewood, CO 80112	303-880-8083	
Tiger Tower Services 3012 Farrell Road Houston, TX 77073 http://www.tigertowerservices.com	281-951-2500	281-951-2520
Tomcej Engineering Inc. PO Box 1274 Station Main Edmonton, Al T5J 2M8 http://www.tomcej.com	780-483-0248	780-483-0248
Torrent Energy Services 5950 Berkshire Lane Dallas, TX 75225 http://www.torrentenergyservices.com	281-450-4000	
Total Energy Corp. 100 W. Airport Road Stillwater, OK 74075 http://www.totalenergy.com	405-253-4728	405-743-2900
Toyo Engineering Corp. 2-8-1, Akanehama Narashino-shi, Chiba, 275-0024 http://www.toyo-eng.co.jp/	81 47 451 1111	81 47 454 1800
Trailhead Engineering 230 West 200 South Salt Lake City, UT 84101 http://www.trailheadeng.com	385-474-4053	
TRC Companies, Inc. 7761 Shaffer Parkway, Ste. 100 Littleton, CO 80127 http://www.trcsolutions.com	303-395-4021	
Trimeric Corp. P.O. Box 826 Buda, TX 78610 http://www.trimeric.com	512-295-8118	512-295-8448
Trinity Consultants 12770 Merit Drive, Ste. 900 Dallas, TX 75251 http://www.trinityconsultants.com	972-661-8100	
Trinity Containers, LLC 2525 Stemmons Freeway Suite 520 Dallas, TX 75207-2401 http://www.trinitycontainers.com	888-558-8529	214-589-8553
Trinity Contractors 200 Highland Circle Argyle, TX 76226	940-240-5800	

Company& Address	Phone	Fax
TriStar Global Energy Solutions 12600 N. Featherwood, Ste. 330 Houston, TX 77034 http://www.tristarges.com	281-484-2201	713-672-3988
Troy Construction Co. 8521 McHard Road Houston, TX 77053	281-437-6214	
United Steel Structures, Inc. 1330 Enclave Parkway - Suite 400 Houston, TX 77077 http://www.ussi.com	281-496-1300	
United/Wells Inc. P.O. Box 4575 Odessa, TX 79760	915-362-2361	
Univar USA Inc. 11235 FM 529 RD. Houston, TX 77546 http://www.univarusa.com/oil.htm	214-632-4430	713-286-6965
UOP Russell 7050 S Yale, Ste 210 Tulsa, OK 74136 http://www.thomasrussellco.com	918-481-5682	918-481-7427
UOP, A Honeywell Company 25 E. Algonquin Des Plaines, IL 60115 http://www.uop.com/	847-391-2024	
Upstream Development and Engineering, Inc. 11767 Katy FWY, Suite 215 Houston, TX 77079 http://www.upstreamdne.com	281-752-7754	281-752-4559
URS 7800 E. Union Ave. Denver, CO 80237 http://www.urs.com	303-843-2000	303-843-2208
USA Environment, L.P. 10234 Lucore Street Houston, TX 77017 http://www.usaenviro.com	832-488-4088	
Valerus 919 Milam, Ste. 1000 Houston, TX 77002 http://www.VALERUS-co.com	713-744-6100	713-744-6101
ValvTechnologies 5904 Bingle Road Houston, TX 77092 http://www.valv.com	713-715-5601	713-860-0499
Vanco Equipment Co. 7033 E. 40th Street Tulsa, OK 74145	918-627-1920	918-627-6742
Vanderpool Pipeline Engineers Inc. P.O. Box 590 Littleton, CO 80160 http://www.vpeinc.com	303-798-0275	303-484-3880
Vanson Engineering Co. 1240 N. Van Buren St., Ste. 212 Anaheim, CA 92807 http://None	714-630-3344	714-630-0384
Varo Engineers, Inc. 2751 Tuller Parkway Dublin, OH 43017	614-459-0424 x 148	

Company& Address	Phone	Fax
Vavco LLC 101 Mahood Road Butler, PA 16001	724-285-6684	
Vinson Process Controls 2747 Highpoint Oaks Drive Lewisville, TX 75067 http://www.vinsonprocess.com	972-459-8200	972-459-8316
Virtual Materials Group Alastair Ross Technology Centre #300, 3553-31 Street NW Calgary AB Canada T2L2K7 http://www.virtualmaterials.com	281-944-9902	281-369-7751
VME Fabricators 3733 Shiloh Road Tyler, TX 75707 http://www.vmefabricators.com	903-561-4082	903-939-3364
Wagner Power Systems 4000 Osuna Road NE Albuquerque, NM 87109 http://www.wagnerpower.com	505-345-8411	505-344-0397
Waid Environmental 10800 Pecan Park Blvd., Ste. 300 Austin, TX 78750	512-255-9999	
Wanzek Construction, Inc. 2028 2nd Ave. NW West Fargo, ND 58078 http://www.wanzek.com	701-282-6171	
Wasson-ECE Instrumentation 101 Rome Ct. Ft. Collins, CO 80524 http://www.wasson-ece.com	970-221-9179	
Waterfield Energy One West Third Street, Ste. 1115 Tulsa, OK 74103 http://www.waterfieldenergysoftware.com	918-586-6406	
Wedge Energy Services 4730 Bradford Dr., Unit B Dallas, TX 75219 http://www.wedgeenergyservices.com	832-875-0873	
Welker 13839 West Bellfort St. Sugar Land, TX 77498 http://www.welker.com	281-491-2331	281-491-8344
Wellsite Compressor & Equipment Co. 3600 Bent Cedar Trail Edmond, OK 73034 http://www.wellsitecompressor.com	405-282-8590	405-282-8591
Wesco 9400 N. Royal Lane Irving, TX 75063 http://www.wesco.com	972-898-3412	
Western Filter Co., Inc. 10702 E. 11th Street Tulsa, OK 74128 http://www.westernfilterco.com	918-949-4455	918-949-4459

Company& Address	Phone	Fax
Whitlow Professional Services 22164 MCH Rd., Ste. A Mandeville, LA 70471 http://www.whitlowps.com	985-893-1100	
Wier & Associates 701 Highlander Blvd., Ste. 300 Arlington, TX 76015 http://www.WierAssociates.com	817-467-7700	
Wilson Mohr 12610 W Airport Blvd #100 Sugar Land, TX 77478 http://www.wilsonmohr.com	281-295-8850	281-295-8870
WinSim Inc. 8653 FM 2759 Rd. Richmond, TX 77469 http://www.winsim.com	281-565-6700	281-565-7593
Wood Group Mustang, Inc. 16001 Park Ten Place Houston, TX 77077 http://www.mustangeng.com	713-215-8000	281-206-1678
Wood Group PSN 17000 Katy Frwy., Ste. 150 Houston, TX 77094	281-647-8413	281-398-1734
Worley Parsons Resources & Energy 125 W. Huntington Drive Arcadia, CA 91007 www.worleyparsons.com	626-294-3558	
Xodus Group 10111 Richmond, Ste. 150 Houston, TX 77042 http://www.xodusgroup.com	832-775-1620	832-775-1666
Yokogawa Corp. of America 12530 W. Airport Blvd. Sugar Land, TX 77478 http://www.yokogawa.com/us	281-340-3900	
York Process Systems 100 CV Avenue Waynesboro, PA 17268 http://www.johnsoncontrols.com	717-765-2510	210-662-6591
Zachry 527 Logwood Ave. San Antonio, TX 210-588-5285	210-588-5285	
ZAP Engineering & Construction Services, Inc. 333 S. Allison Pkwy, Ste. 100 Lakewood, CO 80226 http://www.zapecs.com	303-565-5533	
Zeeco, Inc. 22151 East 91st Street Broken Arrow, OK 74014	281-345-4110	
Zeochem 1600 West Hill St. Louisville, KY 40210 http://www.zeochem.com	502-634-7600	502-634-8133

Classification of Members

Services

Gas Processors Suppliers Association

6526 East 60th Street
Tulsa, Oklahoma 74145
Phone: 918-493-3872
Fax: 918-493-3875
Email: gpsa@GPAglobal.org
<http://gpsa.GPAglobal.org>

The following is a listing of GPSA member companies classified by the type of services that they provide to the industry.

COMPLIANCE AUDITING

Antea Group
CH2M Hill
Contek Solutions LLC
Gulf Interstate Engineering
H.J. Baker, PE
Joule Processing, LLC
McAfee & Taft
MEI, LLC
Nalco, An Ecolab Company
QuantityWare GmbH
Rockwell Automation
Select Engineering, Inc.
Southern Flow Companies, Inc.
Spitzer Industries
SPL, Inc.
Tetra Tech
TRC Companies, Inc.
Trinity Consultants
Xodus Group

Antea Group
Catalytic Products International, Inc.
CDM Resource Management LLC
Conestoga-Rovers & Associates
Croft Production Systems, Inc.
Federal Services LLC
FESCO, Ltd.
Gly-Tech Services
Heath Consultants Incorporated
SPL, Inc.
TRC Companies, Inc.

COMPLIANCE - CRITICAL INCIDENT/EMERGENCY RESPONSE

Air Products and Chemicals, Inc.
Antea Group
Conestoga-Rovers & Associates
Heath Consultants Incorporated
QuantityWare GmbH
Select Engineering, Inc.
Tetra Tech
USA Environment, L.P.

COMPLIANCE - ENVIRONMENTAL SERVICES

Air Products and Chemicals, Inc.
Anguil Environmental Systems
Antea Group
Catalytic Combustion Corporation
Catalytic Products International, Inc.
CDM Resource Management LLC
CEI Engineering Associates
CH2M Hill
Conestoga-Rovers & Associates
Contek Solutions LLC
Freese and Nichols, Inc.
G2 Partners, LLC
Geolex, Inc.
Gly-Tech Services
Leidos Engineering
McAfee & Taft
MIRATECH Corp.
MSES Consultants, Inc.
Nalco, An Ecolab Company
Olsson Associates
Pantechs Laboratories, Inc.
POWER Engineers, Inc.
Rockwell Automation
SPL, Inc.

COMPLIANCE - EMISSIONS TESTING

Anguil Environmental Systems

Tetra Tech
 TRC Companies, Inc.
 Trimeric Corp.
 Trinity Consultants
 United Steel Structures, Inc.
 USA Environment, L.P.
 Wood Group Mustang, Inc.
 Xodus Group

COMPLIANCE - LEAK DETECTION SERVICES

Air Products and Chemicals, Inc.
 Antea Group
 Conestoga-Rovers & Associates
 Contek Solutions LLC
 Energy Solutions International (ESI)
 Heath Consultants Incorporated
 SPL, Inc.
 Thurmond-McGlothlin, Inc.
 Trinity Consultants
 Xodus Group

COMPLIANCE - LEGAL SERVICES

ENGlobal Corporation
 McAfee & Taft
 Robert R. Reis, Attorney-Mediator, P.C.
 SPL, Inc.

COMPLIANCE - SAFETY CONSULTANT

Air Products and Chemicals, Inc.
 Antea Group
 Cobbs Allen
 Conestoga-Rovers & Associates
 Contek Solutions LLC
 Elkhorn Holdings Inc
 Federal Services LLC
 G2 Partners, LLC
 Gly-Tech Services
 GWD
 H.J. Baker, PE
 MEI, LLC
 MSES Consultants, Inc.
 Nalco, An Ecolab Company
 Select Engineering, Inc.
 Toyo Engineering Corp.
 TRC Companies, Inc.
 Trimeric Corp.
 Wood Group Mustang, Inc.
 Xodus Group

COMPLIANCE - SECURITY

Cimation
 GWD
 McAfee & Taft

POWER Engineers, Inc.
 TRC Companies, Inc.

CONSULTING - COMPUTER SYSTEMS

Analytical Instruments Corp.
 Barry D. Payne & Associates, Inc.
 Cimation
 Conestoga-Rovers & Associates
 Entero Corp.
 eSimulation, Inc.
 Federal Services LLC
 GWD
 MYNAH Technologies
 POWER Engineers, Inc.
 Puffer Sweiven
 QuantityWare GmbH
 Quorum Business Solutions, Inc.
 Select Engineering, Inc.
 Strategic Automation Services LLC
 Toyo Engineering Corp.
 Wilson Mohr
 Wood Group Mustang, Inc.
 Yokogawa Corp. of America

CONSULTING - EXPERT WITNESS

Antea Group
 Baker & O'Brien, Inc.
 Coastal Flow Measurement, Inc.
 Conestoga-Rovers & Associates
 Geolex, Inc.
 Gulsby Engineering, Inc.
 Half TriTex
 HPF Consultants, Inc.
 J. H. Foglietta Consulting LLC
 John M. Campbell & Co.
 KBC Advanced Technologies
 Optimized Gas Treating, Inc.
 Robert R. Reis, Attorney-Mediator, P.C.
 Samuel Engineering, Inc.
 Select Engineering, Inc.
 SPL, Inc.
 The Arrington Corporation
 Thurmond-McGlothlin, Inc.
 TRC Companies, Inc.
 Trimeric Corp.
 Trinity Consultants
 Vanson Engineering Co.
 Varo Engineers, Inc.
 Xodus Group

CONSULTING - FORENSIC ENGINEERING

Baker & O'Brien, Inc.
 Conestoga-Rovers & Associates
 John M. Campbell & Co.
 Varo Engineers, Inc.

CONSULTING - CORROSION

Conestoga-Rovers & Associates
 Desert NDT, LLC
 Federal Services LLC
 Gly-Tech Services
 Gulf Coast Chemical, LLC
 Gulf Interstate Engineering
 GWD
 International Oil & Gas Consultants Pte, Ltd.
 John M. Campbell & Co.
 MSES Consultants, Inc.
 Nalco, An Ecolab Company
 POWER Engineers, Inc.
 Toyo Engineering Corp.
 Trimeric Corp.
 Troy Construction Co.
 Xodus Group

CONSULTING - STRATEGY PLANNING

Antea Group
 Baker & O'Brien, Inc.
 Cobbs Allen
 Conestoga-Rovers & Associates
 Contek Solutions LLC
 eSimulation, Inc.
 G2 Partners, LLC
 Geolex, Inc.
 Gulf Interstate Engineering
 Gulsby Engineering, Inc.
 GWD
 Halff TriTex
 HPF Consultants, Inc.
 International Alliance Group
 J MAR & Associates
 J. H. Foglietta Consulting LLC
 John M. Campbell & Co.
 KBC Advanced Technologies
 LKS Midstream Consulting LLC
 MIRATECH Corp.
 Nalco, An Ecolab Company
 POWER Engineers, Inc.
 QuantityWare GmbH
 SANCUS Energy & Power, LLC
 The Arrington Corporation
 TRC Companies, Inc.
 Yokogawa Corp. of America

DISMANTLE, SURPLUS EQUIPMENT

ARC Energy Equipment
 DanCar Energy Construction
 Elkhorn Holdings Inc
 Gas Technology Corp.
 Gly-Tech Services
 Gregory Gas Services LLC
 GWD

HETSCO, Inc.
 Moore Control Systems, Inc.
 Nicholas Consulting Group, Inc.
 Q.B. Johnson Manufacturing, Inc.
 Ref-Chem L.P.
 Saxon Construction, Inc.
 SCFM Compression Systems Co.
 Schwob Energy Services
 S-CON, Inc.
 Tetra Tech

ENGINEERING - PROCUREMENT AND CONSTRUCTION

Air Products and Chemicals, Inc.
 Allied Equipment, Inc.
 AMCS Corp.
 Anvil Corporation
 Barry D. Payne & Associates, Inc.
 Bilfinger Westcon Inc.
 Bowden Construction Co. Ltd.
 Catamount Constructors, Inc.
 CDM Resource Management LLC
 CH2M Hill
 Cimation
 Conestoga-Rovers & Associates
 Croft Automation LLC
 Cummings Electrical, Inc.
 DanCar Energy Construction
 EDG, Inc.
 Elkhorn Holdings Inc.
 EMD, Inc.
 Engineering, Procurement & Construction, Inc.
 ENGlobal Corporation
 EXTERRAN
 Freese and Nichols, Inc.
 Grae-Con Construction, Inc.
 Gulf Interstate Engineering
 Gulsby Engineering, Inc.
 Halker Consulting LLC
 Hunt, Guillot & Associates
 International Alliance Group
 J.W. Williams Inc., a Flint Energy Services Co.
 JGC Corporation
 Joule Processing, LLC
 KBR
 KP Midstream
 Leidos Engineering
 Linde Process Plants, Inc.
 Master Corporation
 MEI, LLC
 MIRATECH Corp.
 MODEC International Inc.
 Moore Control Systems, Inc.
 Nicholas Consulting Group, Inc.
 Optimized Process Designs
 Petrin Corporation
 POWER Engineers, Inc.
 Ref-Chem L.P.
 Regard Resources Co., Inc

Richard Industrial Group
 Samuel Engineering, Inc.
 SANCUS Energy & Power, LLC
 Saulsbury Industries, Inc.
 Saxon Construction, Inc.
 SCFM Compression Systems Co.
 Schwob Energy Services
 S-CON, Inc.
 SEC Energy Products & Services, LP
 Select Engineering, Inc.
 SNC-Lavalin E&C
 Spartan Energy Partners
 Sunland Construction Inc.
 TECHNIP
 Tetra Tech
 Toyo Engineering Corp.
 Trailhead Engineering
 TRC Companies, Inc.
 Troy Construction Co.
 UOP Russell
 Upstream Development and Engineering, Inc.
 URS
 Valerus
 Vanson Engineering Co.
 Varo Engineers, Inc.
 Wanzek Construction, Inc.
 Whitlow Professional Services
 Wilson Mohr
 Wood Group Mustang, Inc.
 Wood Group PSN
 Yokogawa Corp. of America

ENGINEERING - DRAFTING

Air Products and Chemicals, Inc.
 Allied Equipment, Inc.
 Anvil Corporation
 CEI Engineering Associates
 CH2M Hill
 Conestoga-Rovers & Associates
 Croft Automation LLC
 EDG, Inc.
 EMD, Inc.
 Xodus Group

ENGINEERING, PROCUREMENT & CONSTRUCTION, INC.

ENGlobal Corporation
 EXTERRAN
 Freese and Nichols, Inc.
 G2 Partners, LLC
 Gas Technology Corp.
 Gulf Interstate Engineering
 Gulsby Engineering, Inc.
 GWD
 Halff TriTex
 Halker Consulting LLC
 Harris Group Inc

HPF Consultants, Inc.
 Hunt, Guillot & Associates
 JGC Corporation
 Joule Processing, LLC
 KP Midstream
 Leidos Engineering
 Linde Process Plants, Inc.
 Master Corporation
 MEI, LLC
 Moore Control Systems, Inc.
 MSES Consultants, Inc.
 Nicholas Consulting Group, Inc.
 OILTECH
 Olsson Associates
 Optimized Process Designs
 POWER Engineers, Inc.
 Q.B. Johnson Manufacturing, Inc.
 Ref-Chem L.P.
 Richard Industrial Group
 Samuel Engineering, Inc.
 SANCUS Energy & Power, LLC
 Saulsbury Industries, Inc.
 SCFM Compression Systems Co.
 Schwob Energy Services
 S-CON, Inc.
 SEC Energy Products & Services, LP
 Select Engineering, Inc.
 Simms Machinery International
 SNC-Lavalin E&C
 Spartan Energy Partners
 Toyo Engineering Corp.
 Trailhead Engineering
 TRC Companies, Inc.
 UOP Russell
 Upstream Development and Engineering, Inc.
 URS
 Vanson Engineering Co.
 Varo Engineers, Inc.
 Whitlow Professional Services
 Wier & Associates
 Wood Group Mustang, Inc.
 ZAP Engineering & Construction Services, Inc.

ENGINEERING PIPELINE

Air Products and Chemicals, Inc.
 Bechtel
 CEI Engineering Associates
 CH2M Hill
 Conestoga-Rovers & Associates
 Croft Automation LLC
 Elkhorn Holdings Inc.
 EMD, Inc.
 Energy Solutions International (ESI)
 EXTERRAN
 Fabreeka International
 Freese and Nichols, Inc.
 G2 Partners, LLC
 Gulf Interstate Engineering
 GWD

Halff TriTex
 Halker Consulting LLC
 HPF Consultants, Inc.
 Hunt, Guillot & Associates
 JGC Corporation
 Joule Processing, LLC
 KBR
 Master Corporation
 MEI, LLC
 MSES Consultants, Inc.
 Nalco, An Ecolab Company
 Nicholas Consulting Group, Inc.
 OILTECH
 Olsson Associates
 Richard Industrial Group
 Samuel Engineering, Inc.
 Select Engineering, Inc.
 SNC-Lavalin E&C
 Spartan Energy Partners
 Tetra Tech
 Toyo Engineering Corp.
 TRC Companies, Inc.
 Trimeric Corp.
 URS
 Vanson Engineering Co.
 Varo Engineers, Inc.
 Whitlow Professional Services
 Wier & Associates
 Wood Group Mustang, Inc.
 Xodus Group
 ZAP Engineering & Construction Services, Inc.

ENGINEERING PROCESS

Air Products and Chemicals, Inc.
 Allied Equipment, Inc.
 AMCS Corp.
 Analytical Instruments Corp.
 Anvil Corporation
 Atlas Copco Gas and Process
 Bechtel
 CDM Resource Management LLC
 CEI Engineering Associates
 CH2M Hill
 Conestoga-Rovers & Associates
 Credence Gas Services LLC
 Croft Automation LLC
 Detechtion Technologies
 Dickson Process Systems, Ltd.
 EDG, Inc.
 EMD, Inc.
 Engineering, Procurement & Construction, Inc.
 ENGGlobal Corporation
 Envirosep
 EXTERRAN
 Freese and Nichols, Inc.
 G2 Partners, LLC
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Gly-Tech Services

Gulf Interstate Engineering
 Gulsby Engineering, Inc.
 GWD
 Halff TriTex
 Halker Consulting LLC
 Harris Group Inc.
 HPF Consultants, Inc.
 Hunt, Guillot & Associates
 International Oil & Gas Consultants Pte, Ltd.
 J. H. Foglietta Consulting LLC
 JGC Corporation
 Johnson Matthey
 Jonell, Inc.
 Joule Processing, LLC
 KBC Advanced Technologies
 KBR
 KP Midstream
 KW International
 Leidos Engineering
 Linde Process Plants, Inc.
 LKS Midstream Consulting LLC
 M Chemical Company
 Master Corporation
 MEI, LLC
 Moore Control Systems, Inc.
 MSES Consultants, Inc.
 Mueller Environmental Designs
 MYNAH Technologies
 Nalco, An Ecolab Company
 Nicholas Consulting Group, Inc.
 OILTECH
 Olsson Associates
 Optimized Process Designs
 Ortloff Engineers, Ltd.
 Paratherm - Heat Transfer Fluids
 POWER Engineers, Inc.
 Prime Controls, LP
 Q.B. Johnson Manufacturing, Inc.
 Ref-Chem L.P.
 Regard Resources Co., Inc.
 Rhine Ruhr Pty Ltd
 Richard Industrial Group
 River City Engineering
 Rockwell Automation
 Samuel Engineering, Inc.
 SANCUS Energy & Power, LLC
 Saulsbury Industries, Inc.
 SCFM Compression Systems Co.
 Schwob Energy Services
 S-CON, Inc.
 Select Engineering, Inc.
 SNC-Lavalin E&C
 Spartan Energy Partners
 Tetra Tech
 The Arrington Corporation
 Tomcej Engineering Inc.
 Toyo Engineering Corp.
 Trailhead Engineering
 Trimeric Corp.
 UOP Russell

Upstream Development and Engineering, Inc.
 URS
 Vanson Engineering Co.
 Varo Engineers, Inc.
 Whitlow Professional Services
 WinSim Inc.
 Wood Group Mustang, Inc.
 Wood Group PSN
 Xodus Group
 ZAP Engineering & Construction Services, Inc.
 Zeochem

FACILITIES, EQUIPMENT

Aeon PEC
 Air Products and Chemicals, Inc.
 Allied Equipment, Inc.
 AMCS Corp.
 ARC Energy Equipment
 BAND-IT IDEX, Inc.
 Cameron Valves and Measurement
 CDM Resource Management LLC
 CH2M Hill
 Clear Creek Construction
 Credence Gas Services LLC
 DanCar Energy Construction
 Dew Point Control, LLC
 Dickson Process Systems, Ltd.
 Distribution Now
 Elkhorn Holdings Inc.
 EMD, Inc.
 EXTERRAN
 Fabreeka International
 Gas Equipment Co., Inc.
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Global Compressor, L.P.
 Gregory Gas Services LLC
 Gulsby Engineering, Inc.
 GWD
 Halker Consulting LLC
 Harris Group Inc
 HPF Consultants, Inc.
 J.W. Williams Inc.,a Flint Energy Services Co.
 JGC Corporation
 Joule Processing, LLC
 KP Midstream
 KW International
 Leidos Engineering
 Linde Process Plants, Inc.
 Masters Process Equipment
 Mueller Environmental Designs
 Niagara Blower
 Nicholas Consulting Group, Inc.
 Olsson Associates
 Optimized Process Furnaces
 Peerless Mfg. Co.
 Plant Maintenance Services, L.L.C.
 Q.B. Johnson Manufacturing, Inc.

Ref-Chem L.P.
 Regard Resources Co., Inc
 River City Engineering
 Rotor-Tech, Inc.
 Samuel Engineering, Inc.
 SANCUS Energy & Power, LLC
 SCFM Compression Systems Co.
 Schwob Energy Services
 S-CON, Inc.
 SEC Energy Products & Services, LP
 Select Engineering, Inc.
 Septra-Chem Corp.
 Smithco Engineering, Inc.
 SNC-Lavalin E&C
 Spartan Energy Partners
 Spitzer Industries
 SPL, Inc.
 Texas Turbine, Inc.
 Thermal & Mechanical Equipment Co.
 Thurmond-McGlothlin, Inc.
 Toyo Engineering Corp.
 Trailhead Engineering
 Trimeric Corp.
 UOP Russell
 Upstream Development and Engineering, Inc.
 URS
 Valerus
 Vanson Engineering Co.
 Varo Engineers, Inc.
 Wagner Power Systems
 Wanzek Construction, Inc.
 Welker
 Wesco

GAS COMPRESSION - LEASING

CDM Resource Management LLC
 Compressor Systems, Inc.
 EXTERRAN
 Gas Technology Corp.
 J-W Power Company
 MidCon Compression LLC
 MODEC International Inc.
 SEC Energy Products & Services, LP
 Valerus

GAS COMPRESSION - REPAIR

Air Products and Chemicals, Inc.
 Burckhardt Compression U.S.
 Cameron Valves and Measurement
 CDM Resource Management LLC
 Compressor Systems, Inc.
 DanCar Energy Construction
 Elkhorn Holdings Inc
 Elliott Group
 Gas Technology Corp.
 GEA Refrigeration North America Inc.

Global Compressor, L.P.
 J-W Power Company
 L.A. Turbine
 Moore Control Systems, Inc.
 Neuman & Esser USA, Inc.
 Plant Maintenance Services, L.L.C.
 SEC Energy Products & Services, LP
 Simms Machinery International
 Valerus
 Wagner Power Systems
 Wanzek Construction, Inc.
 Wellsite Compressor & Equipment Co.

GAS COMPRESSION - SALES

Air Products and Chemicals, Inc.
 Burckhardt Compression U.S.
 Cameron Valves and Measurement
 Compressor Systems, Inc.
 Elliott Group
 EXTERRAN
 FES-Southwest, Inc.
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Global Compressor, L.P.
 Guild Associates, Inc.
 International Oil & Gas Consultants Pte, Ltd.
 J-W Power Company
 L.A. Turbine
 MidCon Compression LLC
 Neuman & Esser USA, Inc.
 SCFM Compression Systems Co.
 SEC Energy Products & Services, LP
 Spartan Energy Partners
 Valerus
 Vanco Equipment Co.
 Wellsite Compressor & Equipment Co.
 York Process Systems

INSPECTIONS, TESTING, ANALYSIS - GAS CONTAMINATION TESTING

Analytical Instruments Corp.
 Conestoga-Rovers & Associates
 Gas Analytical Solutions, Inc.
 Intertek
 Nitro-Lift Technologies LLC
 Pantechs Laboratories, Inc.
 PECOFacet
 Scott Measurement Service Inc.
 SPL, Inc.
 Wasson-ECE Instrumentation

INSPECTIONS, TESTING, ANALYSIS - GENERAL

Analytical Instruments Corp.
 Air Products and Chemicals, Inc.
 Burckhardt Compression U.S.

Conestoga-Rovers & Associates
 DanCar Energy Construction
 Desert NDT, LLC
 Elkhorn Holdings Inc.
 GEA Refrigeration North America Inc.
 Geolex, Inc.
 Gulf Interstate Engineering
 Heath Consultants Incorporated
 HPF Consultants, Inc.
 Hunt, Guillot & Associates
 Intertek
 McDaniel Technical Services Inc.
 Monico Monitoring, Inc.
 MSES Consultants, Inc.
 Nalco, An Ecolab Company
 Nitro-Lift Technologies LLC
 Olsson Associates
 Pantechs Laboratories, Inc.
 POWER Engineers, Inc.
 SCFM Compression Systems Co.
 Scott Measurement Service Inc.
 Simms Machinery International
 SNC-Lavalin E&C
 Southern Flow Companies, Inc.
 SPL, Inc.
 Texas Turbine, Inc.
 Thurmond-McGlothlin, Inc.
 URS
 Wasson-ECE Instrumentation
 Zeochem

INSPECTIONS, TESTING, ANALYSIS - PIPELINE

Analytical Instruments Corp.
 Air Products and Chemicals, Inc.
 CEI Engineering Associates
 Conestoga-Rovers & Associates
 DanCar Energy Construction
 Desert NDT, LLC
 Elkhorn Holdings Inc.
 FESCO, Ltd.
 G2 Partners, LLC
 Gulf Interstate Engineering
 GWD
 HPF Consultants, Inc.
 Hunt, Guillot & Associates
 McDaniel Technical Services Inc.
 MSES Consultants, Inc.
 Nalco, An Ecolab Company
 Nitro-Lift Technologies LLC
 Olsson Associates
 Schwob Energy Services
 Southern Flow Companies, Inc.
 SPL, Inc.
 Troy Construction Co.
 Xodus Group

**OPERATION, MAINTENANCE, RELIABILITY -
ANALYTICAL LABORATORIES**

Analytical Instruments Corp.
Diablo Analytical, Inc.
EXTERRAN
FESCO, Ltd.
John M. Campbell & Co.
Midway Laboratory, Inc.
MSES Consultants, Inc.
Nalco, An Ecolab Company
Pantechs Laboratories, Inc.
Scott Measurement Service Inc.
Shamrock Gas Analysis
Southern Flow Companies, Inc.
SPL, Inc.
Thurmond-McGlothlin, Inc.
Yokogawa Corp. of America

SNC-Lavalin E&C
Troy Construction Co.
Whitlow Professional Services
Xodus Group

**OPERATION, MAINTENANCE, RELIABILITY -
INSULATION PAINTING**

BAND-IT IDEX, Inc.
DanCar Energy Construction
Elkhorn Holdings Inc.
Gas Technology Corp.
Grae-Con Construction, Inc.
K-FLEX USA
Nomaco Insulation
Petrin Corporation
Sunland Construction Inc.

**OPERATION, MAINTENANCE, RELIABILITY -
FAILURE ANALYSIS**

Burckhardt Compression U.S.
Conestoga-Rovers & Associates
Gas Technology Corp.
John M. Campbell & Co.
Monico Monitoring, Inc.
MSES Consultants, Inc.
Nalco, An Ecolab Company
Neuman & Esser USA, Inc.
Samuel Engineering, Inc.
SCFM Compression Systems Co.
Simms Machinery International
SNC-Lavalin E&C
Texas Turbine, Inc.
Troy Construction Co.
Whitlow Professional Services
Xodus Group

**OPERATION, MAINTENANCE, RELIABILITY -
MACHINING AND REPAIR**

Air Products and Chemicals, Inc.
Atlas Copco Gas and Process
Best PumpWorks
DanCar Energy Construction
Elkhorn Holdings Inc.
Elliott Group
Gas Technology Corp.
HETSCO, Inc.
KW International
Louisiana Valve Source, Inc.
Neuman & Esser USA, Inc.
SCFM Compression Systems Co.
Simms Machinery International
SPL, Inc.
Wagner Power Systems

**OPERATION, MAINTENANCE RELIABILITY -
INSPECTIONS**

Aeon PEC
Burckhardt Compression U.S.
Conestoga-Rovers & Associates
Desert NDT, LLC
Eaton Metal Products Company, LLC
GWD
HETSCO, Inc.
Hunt, Guillot & Associates
John M. Campbell & Co.
KW International
L.A. Turbine
Nalco, An Ecolab Company
Neuman & Esser USA, Inc.
Nitro-Lift Technologies LLC
Ref-Chem L.P.
Samuel Engineering, Inc.
SCFM Compression Systems Co.

**OPERATION, MAINTENANCE, RELIABILITY -
MEASUREMENT**

ABB Inc.
Analytical Systems International
Cameron Valves and Measurement
Coastal Flow Measurement, Inc.
Detection Technologies
Diablo Analytical, Inc.
Elkhorn Holdings Inc.
Fluenta Inc.
GWD
Heath Consultants Incorporated
Louisiana Valve Source, Inc.
Neuman & Esser USA, Inc.
Omni Flow Computers, Inc.
Samuel Engineering, Inc.
Schneider Electric - Invensys
SPL, Inc.
Thurmond-McGlothlin, Inc.
Welker

OPERATION, MAINTENANCE RELIABILITY - PERFORMANCE ANALYSIS

Air Products and Chemicals, Inc.
 Analytical Instruments Corp.
 AMCS Corp.
 Baker & O'Brien, Inc.
 CECA Molecular Sieves
 Detection Technologies
 EMD, Inc.
 eSimulation, Inc.
 Gas Technology Corp.
 Gly-Tech Services
 GWD
 John M. Campbell & Co.
 KBC Advanced Technologies
 L.A. Turbine
 Monico Monitoring, Inc.
 Neuman & Esser USA, Inc.
 Ortlhoff Engineers, Ltd.
 Pantechs Laboratories, Inc.
 River City Engineering
 Samuel Engineering, Inc.
 SCFM Compression Systems Co.
 Simms Machinery International
 SNC-Lavalin E&C
 Strategic Automation Services LLC
 Texas Turbine, Inc.
 Toyo Engineering Corp.
 Trimeric Corp.
 Welker
 Whitlow Professional Services
 Wood Group Mustang, Inc.
 Yokogawa Corp. of America

OPERATION, MAINTENANCE, RELIABILITY - SERVICES

Aeon PEC
 Air Products and Chemicals, Inc.
 Allied Equipment, Inc.
 Anguil Environmental Systems
 Atlas Copco Gas and Process
 Baker & O'Brien, Inc.
 Bechtel
 Bilfinger Westcon Inc.
 Burckhardt Compression U.S.
 Cameron Valves and Measurement
 Catalytic Products International, Inc.
 CH2M Hill
 DanCar Energy Construction
 Elkhorn Holdings Inc.
 Elliott Group
 EMD, Inc.
 eSimulation, Inc.
 Federal Services LLC
 Gas Technology Corp.
 Gly-Tech Services
 Grae-Con Construction, Inc.

Gregory Gas Services LLC
 GWD
 HETSCO, Inc.
 John M. Campbell & Co.
 KBC Advanced Technologies
 Mid-States Supply
 Mueller Environmental Designs
 Nalco, An Ecolab Company
 Neuman & Esser USA, Inc.
 Nitro-Lift Technologies LLC
 Richard Industrial Group
 SCFM Compression Systems Co.
 Schwob Energy Services
 Shamrock Gas Analysis
 SNC-Lavalin E&C
 Spartan Energy Partners
 Strategic Automation Services LLC
 Sunland Construction Inc.
 Tetra Tech
 TriStar Global Energy Solutions
 URS
 USA Environment, L.P.
 Valerus
 Wanzek Construction, Inc.
 Welker
 Wesco
 Wood Group PSN

PROCESS CONTROLS - INSTRUMENT AND ELECTRICAL CONSTRUCTION

Allied Equipment, Inc.
 Analytical Instruments Corp.
 Analytical Systems International
 Anvil Corporation
 Barry D. Payne & Associates, Inc.
 Bechtel
 Bilfinger Westcon Inc.
 Buffalo Gap Instrumentation & Electrical
 Coastal Flow Measurement, Inc.
 Conestoga-Rovers & Associates
 Croft Automation LLC
 Cummings Electrical, Inc.
 DanCar Energy Construction
 Det-Tronics
 Elkhorn Holdings Inc.
 EMD, Inc.
 ENGlobal Corporation
 Enovation Controls
 Fisher Controls
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Genesis Systems
 GWD
 Halff TriTex
 Halker Consulting LLC
 JGC Corporation
 LCM Industries, Inc.
 Linde Process Plants, Inc.
 Master Corporation

MEI, LLC
 Moore Control Systems, Inc.
 MSES Consultants, Inc.
 Nicholas Consulting Group, Inc.
 Optimized Process Designs
 Prime Controls, LP
 Richard Industrial Group
 Rockwell Automation
 Samuel Engineering, Inc.
 SANCUS Energy & Power, LLC
 SCFM Compression Systems Co.
 Schneider Electric - Invensys
 Select Engineering, Inc.
 SPL, Inc.
 Strategic Automation Services LLC
 Sunland Construction Inc.
 Tetra Tech
 Trailhead Engineering
 UOP Russell
 Varo Engineers, Inc.
 Vinson Process Controls
 Wesco
 Wilson Mohr
 Wood Group Mustang, Inc.
 Yokogawa Corp. of America

PROCESS CONTROLS - LICENSED PROCESSES

Air Products and Chemicals, Inc.
 Allied Equipment, Inc.
 Barry D. Payne & Associates, Inc.
 Bechtel
 Conestoga-Rovers & Associates
 EMD, Inc.
 Envirosep
 EXTERRAN
 GEA Refrigeration North America Inc.
 Prime Controls, LP
 Richard Industrial Group
 Rockwell Automation
 SANCUS Energy & Power, LLC
 Vinson Process Controls

TECHNOLOGY - LNG PROCESSES

Air Products and Chemicals, Inc.
 AMCS Corp.
 Atlas Copco Gas and Process
 Bechtel
 Cameron Valves and Measurement
 Chart Energy & Chemicals
 Elliott Group
 EXTERRAN
 Guild Associates, Inc.
 International Oil & Gas Consultants Pte, Ltd.
 J. H. Foglietta Consulting LLC
 JGC Corporation
 John M. Campbell & Co.

KBC Advanced Technologies
 KBR
 Linde Process Plants, Inc.
 MEI, LLC
 Moore Control Systems, Inc.
 Nalco, An Ecolab Company
 Ortloff Engineers, Ltd.
 Pennwell Corp.
 Q.B. Johnson Manufacturing, Inc.
 Rockwell Automation
 SANCUS Energy & Power, LLC
 S-CON, Inc.
 Simms Machinery International
 Toyo Engineering Corp.
 Trailhead Engineering
 URS
 Zeochem

TECHNOLOGY - NITROGEN REJECTION

Air Products and Chemicals, Inc.
 AMCS Corp.
 Bechtel
 Chart Energy & Chemicals
 Elliott Group
 Guild Associates, Inc.
 Gulsby Engineering, Inc.
 GWD
 International Oil & Gas Consultants Pte, Ltd.
 J. H. Foglietta Consulting LLC
 KBC Advanced Technologies
 Linde Process Plants, Inc.
 Nitro-Lift Technologies LLC
 Ortloff Engineers, Ltd.
 Pennwell Corp.
 Rockwell Automation
 SANCUS Energy & Power, LLC
 S-CON, Inc.
 Toyo Engineering Corp.
 UOP Russell
 URS
 Vanson Engineering Co.
 Zeochem

TECHNOLOGY - OFFGAS RECOVERY

Air Products and Chemicals, Inc.
 AMCS Corp.
 Analytical Instruments Corp.
 Anguil Environmental Systems
 Catalytic Products International, Inc.
 Dickson Process Systems, Ltd.
 Elliott Group
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Gly-Tech Services
 Guild Associates, Inc.

Gulsby Engineering, Inc.
 GWD
 International Oil & Gas Consultants Pte, Ltd.
 J. H. Foglietta Consulting LLC
 JGC Corporation
 KBC Advanced Technologies
 Linde Process Plants, Inc.
 Moore Control Systems, Inc.
 OILTECH
 Ortlhoff Engineers, Ltd.
 Pennwell Corp.
 Rockwell Automation
 SANCUS Energy & Power, LLC
 SCFM Compression Systems Co.
 Simms Machinery International
 Toyo Engineering Corp.
 URS
 Valerus
 Zeochem

TRAINING, PUBLICATIONS - PIPELINE MAPS & DATA

COMPRESSORtech
 G2 Partners, LLC
 John M. Campbell & Co.
 Pennwell Corp.
 SULPETRO INC.

TRAINING, PUBLICATIONS - PROCESS

Air Products and Chemicals, Inc.
 CEI Engineering Associates
 COMPRESSORtech
 Detection Technologies
 Dickson Process Systems, Ltd.
 ESD Simulation Training Inc.
 eSimulation, Inc.
 Federal Services LLC
 Gly-Tech Services
 Gulf Publishing Co.
 J. H. Foglietta Consulting LLC
 John M. Campbell & Co.
 OILTECH
 Optimized Gas Treating, Inc.
 Pennwell Corp.
 QuantityWare GmbH
 River City Engineering
 SULPETRO INC.
 Trimeric Corp.
 Varo Engineers, Inc.

TREATING - GAS

Air Products and Chemicals, Inc.
 Allied Equipment, Inc.
 Anguil Environmental Systems
 Bartlett Equipment Co.

Catalytic Products International, Inc.
 CDM Resource Management LLC
 Credence Gas Services LLC
 Croft Production Systems, Inc.
 Dickson Process Systems, Ltd.
 Evonik Corp.
 EXTERRAN
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Gregory Gas Services LLC
 Guild Associates, Inc.
 Gulf Coast Chemical, LLC
 Gulsby Engineering, Inc.
 GWD
 HydroCat Industries
 Industrial Distributors, Inc.
 INEOS Oxide
 International Oil & Gas Consultants Pte, Ltd.
 John M. Campbell & Co.
 Johnson Matthey
 Joule Processing, LLC
 KP Midstream
 Leidos Engineering
 Linde Process Plants, Inc.
 M Chemical Company
 MEI, LLC
 Merichem
 Nalco, An Ecolab Company
 Optimized Process Designs
 Q.B. Johnson Manufacturing, Inc.
 Q2 Technologies, LLC
 Samuel Engineering, Inc.
 SANCUS Energy & Power, LLC
 SCFM Compression Systems Co.
 Schwob Energy Services
 S-CON, Inc.
 Select Engineering, Inc.
 Sepra-Chem Corp.
 SNC-Lavalin E&C
 Spartan Energy Partners
 Spitzer Industries
 Tomcej Engineering Inc.
 Trailhead Engineering
 Trimeric Corp.
 Troy Construction Co.
 Univar USA Inc.
 UOP Russell
 UOP, A Honeywell Company
 URS
 Valerus
 Vanson Engineering Co.
 Zeochem

TREATING - LIQUID

Air Products and Chemicals, Inc.
 Allied Equipment, Inc.
 Anguil Environmental Systems
 Catalytic Products International, Inc.
 CDM Resource Management LLC

Evonik Corp.
EXTERRAN
Gas Technology Corp.
GEA Refrigeration North America Inc.
Gly-Tech Services
Gregory Gas Services LLC
Gulf Coast Chemical, LLC
Gulsby Engineering, Inc.
GWD
HydroCat Industries
Industrial Distributors, Inc.
INEOS Oxide
John M. Campbell & Co.
Johnson Matthey
Joule Processing, LLC
KP Midstream
Leidos Engineering
Linde Process Plants, Inc.
M Chemical Company
Merichem
Nalco, An Ecolab Company

Optimized Process Designs
Pentair Porous Media
Q2 Technologies, LLC
Samuel Engineering, Inc.
SANCUS Energy & Power, LLC
Schwob Energy Services
S-CON, Inc.
Select Engineering, Inc.
Septra-Chem Corp.
SNC-Lavalin E&C
Spartan Energy Partners
Tomcej Engineering Inc.
Trailhead Engineering
Trimeric Corp.
Troy Construction Co.
Univar USA Inc.
UOP Russell
UOP, A Honeywell Company
URS
Valerus
Vanson Engineering Co.
Zeochem

Classification of Members

Supplies

Gas Processors Suppliers Association

6526 East 60th Street
Tulsa, Oklahoma 74145
Phone: 918-493-3872
Fax: 918-493-3875
Email: gpsa@GPAglobal.org
<http://gpsa.GPAglobal.org>

The following is a listing of GPSA member companies classified by the type of services that they provide to the industry.

ADSORBENTS, CATALYSTS, MOLESIEVES

Anguil Environmental Systems
Analytical Instruments Corp.
Catalytic Combustion Corporation
Catalytic Products International, Inc.
CECA Molecular Sieves
Chemical Products Industries, Inc.
Coastal Chemical Co., LLC
Croft Production Systems, Inc.
Evonik Corp.
EXTERRAN
Gly-Tech Services
Grace Davison
Gregory Gas Services LLC
Guild Associates, Inc.
Gulf Coast Chemical, LLC
HydroCat Industries
Industrial Distributors, Inc.
Johnson Matthey
M Chemical Company
MIRATECH Corp.
Mueller Environmental Designs
Onsite Power Inc.
Q.B. Johnson Manufacturing, Inc.
SANCUS Energy & Power, LLC
SCFM Compression Systems Co.
UOP, A Honeywell Company
Western Filter Co., Inc.
Zeochem

ANALYZERS, SAMPLING SYSTEMS

A+ Corporation
ABB Inc.
Agilent Instrumentation Inc.
Analytical Instruments Corp.

Analytical Systems International
Bechtel
Cameron Valves and Measurement
Croft Automation LLC
ENGlobal Corporation
FESCO, Ltd.
Gly-Tech Services
Heath Consultants Incorporated
Intertek
Michell Instruments Inc.
MIRATECH Corp.
Nalco, An Ecolab Company
SANCUS Energy & Power, LLC
SpectraSensors Inc.
SPL, Inc.
Thurmond-McGlothlin, Inc.
Wasson-ECE Instrumentation
Welker
Yokogawa Corp. of America

AUTOMATION, INSTRUMENTS, PROCESS CONTROLS

Aeon PEC
Analytical Instruments Corp.
Analytical Systems International
Barry D. Payne & Associates, Inc.
Bartlett Equipment Co.
Bechtel
Buffalo Gap Instrumentation & Electrical
Catalytic Combustion Corporation
Catalytic Products International, Inc.
Cimation
Coastal Flow Measurement, Inc.
Croft Automation LLC
DanCar Energy Construction
Det-Tronics
Diablo Analytical, Inc.
Distribution Now

Elliott Group
 EMD, Inc.
 Enovation Controls
 Envirosep
 Federal Services LLC
 Genesis Systems
 Gregory Gas Services LLC
 HPF Consultants, Inc.
 KW International
 LCM Industries, Inc.
 Michell Instruments Inc.
 Mid-States Supply
 MIRATECH Corp.
 Monico Monitoring, Inc.
 Moore Control Systems, Inc.
 Nalco, An Ecolab Company
 Nicholas Consulting Group, Inc.
 Prime Controls, LP
 Puffer Sweiven
 Rexel Inc.
 Rockwell Automation
 SANCUS Energy & Power, LLC
 Schneider Electric - Invensys
 SEC Energy Products & Services, LP
 Select Engineering, Inc.
 SPL, Inc.
 Texas Turbine, Inc.
 Thermal & Mechanical Equipment Co.
 Thurmond-McGlothlin, Inc.
 ValvTechnologies
 Vinson Process Controls
 Wesco
 Wilson Mohr
 Yokogawa Corp. of America

Chemical Products Industries, Inc.
 Coastal Chemical Co., LLC
 Eastman Chemical - Therminol Heat Transfer Fluids
 Evonik Corp.
 Gly-Tech Services
 Gregory Gas Services LLC
 Gulf Coast Chemical, LLC
 INEOS Oxide
 M Chemical Company
 Nalco, An Ecolab Company
 Paratherm - Heat Transfer Fluids
 Q2 Technologies, LLC
 TriStar Global Energy Solutions
 Univar USA Inc.

COMPLIANCE (CONTINGENCY PLANS, EMISSION CONTROLS, SAFETY EQUIPMENT)

Anguil Environmental Systems
 Catalytic Combustion Corporation
 Catalytic Products International, Inc.
 Croft Production Systems, Inc.
 Enovation Controls
 Gly-Tech Services
 H.J. Baker, PE
 Heath Consultants Incorporated
 MIRATECH Corp.
 Monico Monitoring, Inc.
 Onsite Power Inc.
 Peerless Mfg. Co.
 Red Ball Oxygen
 Robert R. Reis, Attorney-Mediator, P.C.
 Western Filter Co., Inc.

BUILDINGS

A1 Sheet Metal Inc.
 BAND-IT IDEX, Inc.
 Bechtel
 Clear Creek Construction
 Croft Automation LLC
 DanCar Energy Construction
 Elkhorn Holdings Inc
 ENGGlobal Corporation
 Grae-Con Construction, Inc.
 Moore Control Systems, Inc.
 SANCUS Energy & Power, LLC
 Schwob Energy Services
 Sunland Construction Inc.
 Thurmond-McGlothlin, Inc.
 United Steel Structures, Inc.
 Wasson-ECE Instrumentation

COMPRESSORS (AND PARTS)

A1 Sheet Metal Inc.
 Ariel Corporation
 Atlas Copco Gas and Process
 Bechtel
 Burckhardt Compression U.S.
 Cameron Valves and Measurement
 CDM Resource Management LLC
 Compressor Systems, Inc.
 Elliott Group
 Envirosep
 Fabreeka International
 FES-Southwest, Inc.
 Gas Equipment Co., Inc.
 GEA Refrigeration North America Inc.
 Global Compressor, L.P.
 Guild Associates, Inc.
 International Oil & Gas Consultants Pte, Ltd.
 J-W Power Company
 L.A. Turbine
 MidCon Compression LLC
 Monico Monitoring, Inc.
 Neuman & Esser USA, Inc.
 Nicholas Consulting Group, Inc.

CHEMICALS

Air Products and Chemicals, Inc.
 Airgas, Inc.
 Bechtel

Rockwell Automation
 SANCUS Energy & Power, LLC
 SCFM Compression Systems Co.
 SEC Energy Products & Services, LP
 Simms Machinery International
 Sundyne Corporation
 Texas Turbine, Inc.
 Valerus
 Vanco Equipment Co.
 Wellsite Compressor & Equipment Co.
 Western Filter Co., Inc.
 York Process Systems

ELECTRIC MOTORS (AND SUPPLIES)

Bechtel
 Buffalo Gap Instrumentation & Electrical
 EMD, Inc.
 Envirosep
 Gas Equipment Co., Inc.
 Mueller Environmental Designs
 Rexel Inc.
 Rotor-Tech, Inc.
 SANCUS Energy & Power, LLC
 SEC Energy Products & Services, LP
 Wellsite Compressor & Equipment Co.
 Wesco

ENGINES (AND PARTS)

A1 Sheet Metal Inc.
 Air Products and Chemicals, Inc.
 Compressor Systems, Inc.
 Croft Automation LLC
 Cummins Inc.
 Global Compressor, L.P.
 IPD
 J-W Power Company
 Monico Monitoring, Inc.
 Mueller Environmental Designs
 SANCUS Energy & Power, LLC
 Valerus
 Wagner Power Systems
 Wellsite Compressor & Equipment Co.
 Western Filter Co., Inc.

FILTERS

Aeon PEC
 Bartlett Equipment Co.
 Bechtel
 Bilfinger Water Technologies
 Croft Automation LLC
 Fabwell Corp.
 Filtration Technology Corp.
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Global Compressor, L.P.
 Gly-Tech Services

Gregory Gas Services LLC
 Industrial Distributors, Inc.
 Jonell, Inc.
 J-W Power Company
 KW International
 MIRATECH Corp.
 Mueller Environmental Designs
 PECOFacet
 Pentair Porous Media
 PSI (Process Solutions Integration)
 Q.B. Johnson Manufacturing, Inc.
 Rotor-Tech, Inc.
 Royal Filter Mfg. Co., Inc.
 SANCUS Energy & Power, LLC
 SCFM Compression Systems Co.
 SEC Energy Products & Services, LP
 Sepra-Chem Corp.
 Thermal & Mechanical Equipment Co.
 Welker
 Western Filter Co., Inc.

FIRED EQUIPMENT (BOILERS, FLARES, HEATERS)

Aeon PEC
 Anguil Environmental Systems
 Bartlett Equipment Co.
 Bechtel
 Catalytic Combustion Corporation
 Catalytic Products International, Inc.
 Croft Automation LLC
 Croft Production Systems, Inc.
 Envirosep
 Gas Technology Corp.
 Gly-Tech Services
 Gregory Gas Services LLC
 Halff TriTex
 Heatec Inc.
 International Oil & Gas Consultants Pte, Ltd.
 John Zink Company LLC
 KW International
 Moore Control Systems, Inc.
 Optimized Process Furnaces
 Plant Maintenance Services, L.L.C.
 Q.B. Johnson Manufacturing, Inc.
 SANCUS Energy & Power, LLC
 Spitzer Industries
 Thermal & Mechanical Equipment Co.

INDUSTRIAL AND SPECIALTY GASSES

Accurate Gas Products L.L.C.
 Air Liquide America Specialty Gases LLC
 Air Products and Chemicals, Inc.
 Airgas, Inc.
 Analytical Instruments Corp.
 Burckhardt Compression U.S.
 Gas and Supply
 Red Ball Oxygen
 SANCUS Energy & Power, LLC

MEMBRANES

Air Products and Chemicals, Inc.
 Evonik Corp.
 Guild Associates, Inc.
 Industrial Distributors, Inc.
 Nitro-Lift Technologies LLC
 SANCUS Energy & Power, LLC
 UOP, A Honeywell Company

ODORIZATION, ODOR CONTROL

Anguil Environmental Systems
 Catalytic Combustion Corporation
 Catalytic Products International, Inc.
 Heath Consultants Incorporated
 HydroCat Industries
 M Chemical Company
 Mueller Environmental Designs
 Nalco, An Ecolab Company
 Peerless Mfg. Co.
 TriStar Global Energy Solutions
 Welker

PACKAGED SYSTEMS

Aeon PEC
 Air Products and Chemicals, Inc.
 Allied Equipment, Inc.
 Analytical Instruments Corp.
 Anguil Environmental Systems
 Bechtel
 Burckhardt Compression U.S.
 Catalytic Combustion Corporation
 Catalytic Products International, Inc.
 Compressor Systems, Inc.
 Credence Gas Services LLC
 Croft Production Systems, Inc.
 Det-Tronics
 Dickson Process Systems, Ltd.
 Distribution Now
 Engineering, Procurement & Construction, Inc.
 Envirosep
 EXTERRAN
 Federal Services LLC
 FES-Southwest, Inc.
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Gly-Tech Services
 Guild Associates, Inc.
 Heatec Inc.
 Hunt, Guillot & Associates
 John Zink Company LLC
 Joule Processing, LLC
 J-W Power Company
 Koch-Glitsch LP
 KP Midstream
 KW International
 Linde Process Plants, Inc.

Louisiana Valve Source, Inc.
 MODEC International Inc.
 Moore Control Systems, Inc.
 Nicholas Consulting Group, Inc.
 Peerless Mfg. Co.
 Pentair Porous Media
 Q.B. Johnson Manufacturing, Inc.
 Regard Resources Co., Inc
 SANCUS Energy & Power, LLC
 SCFM Compression Systems Co.
 S-CON, Inc.
 Spartan Energy Partners
 Spitzer Industries
 SPL, Inc.
 Texas Turbine, Inc.
 Thermal & Mechanical Equipment Co.
 Thurmond-McGlothlin, Inc.
 Valerus
 VME Fabricators
 Wagner Power Systems
 Welker
 Wellsite Compressor & Equipment Co.
 Whitlow Professional Services
 Wilson Mohr
 Yokogawa Corp. of America
 York Process Systems

PIPE, VALVES, FITTING, REGULATORS

Accurate Gas Products L.L.C.
 Aeon PEC
 Airgas, Inc.
 Analytical Instruments Corp.
 ARC Energy Equipment
 BAND-IT IDEX, Inc.
 Bartlett Equipment Co.
 Bechtel
 Cameron Valves and Measurement
 Chromatic Industries
 Corpac Steel Products Corp.
 Croft Automation LLC
 Distribution Now
 Enovation Controls
 Federal Services LLC
 FESCO, Ltd.
 Fisher Controls
 Gas Equipment Co., Inc.
 Gas Technology Corp.
 Genesis Systems
 Gly-Tech Services
 Grae-Con Construction, Inc.
 Gregory Gas Services LLC
 Joule Processing, LLC
 J-W Power Company
 Kimray Inc.
 KW International
 LCM Industries, Inc.
 Louisiana Valve Source, Inc.
 Mid-States Supply
 PSI (Process Solutions Integration)

Scott Measurement Service Inc
SPL, Inc.
Thurmond-McGlothlin, Inc.
ValvTechnologies
Vinson Process Controls
Welker

**PIPELINE EQUIPMENT
(INSTALLATION, PIGGING, REPAIR)**

Air Products and Chemicals, Inc.
BAND-IT IDEX, Inc.
Bechtel
Croft Automation LLC
Fabreeka International
Select Engineering, Inc.
Sunland Construction Inc.
Thurmond-McGlothlin, Inc.
Wagner Power Systems
Western Filter Co., Inc.

PROCESS EQUIPMENT - AIR COOLERS

Aeon PEC
BAND-IT IDEX, Inc.
Bartlett Equipment Co.
Bechtel
CDM Resource Management LLC
Chart Energy & Chemicals
Credence Gas Services LLC
Croft Production Systems, Inc.
EXTERRAN
Fabsco Shell & Tube, LLC
Gas Technology Corp.
GEA Refrigeration North America Inc.
Gly-Tech Services
Gregory Gas Services LLC
Joule Processing, LLC
J-W Power Company
Kimray Inc.
Niagara Blower
Onsite Power Inc.
Ref-Chem L.P.
SANCUS Energy & Power, LLC
Smithco Engineering, Inc.
Spartan Energy Partners
Thermal & Mechanical Equipment Co.
Toyo Engineering Corp.

PROCESS EQUIPMENT - DEHYDRATION

Aeon PEC
Air Products and Chemicals, Inc.
Allied Equipment, Inc.
ARC Energy Equipment
BAND-IT IDEX, Inc.
Bechtel
Bilfinger Water Technologies

CDM Resource Management LLC
Croft Automation LLC
Croft Production Systems, Inc.
Dickson Process Systems, Ltd.
EXTERRAN
Fabwell Corp.
Gas Technology Corp.
GEA Refrigeration North America Inc.
Genesis Systems
Gly-Tech Services
Gregory Gas Services LLC
Guild Associates, Inc.
Gulshy Engineering, Inc.
Heatec Inc.
International Oil & Gas Consultants Pte, Ltd.
J.W. Williams Inc., a Flint Energy Services Co.
Joule Processing, LLC
J-W Power Company
Kimray Inc.
Koch-Glitsch LP
KP Midstream
KW International
Linde Process Plants, Inc.
Louisiana Valve Source, Inc.
Michell Instruments Inc.
Nicholas Consulting Group, Inc.
Norwood S&S, LLC
Q.B. Johnson Manufacturing, Inc.
Ref-Chem L.P.
Regard Resources Co., Inc
Rhine Ruhr Pty Ltd
Rotor-Tech, Inc.
SANCUS Energy & Power, LLC
SCFM Compression Systems Co.
SEC Energy Products & Services, LP
Select Engineering, Inc.
Spartan Energy Partners
Spitzer Industries
Toyo Engineering Corp.
UOP Russell
Valerus
ValvTechnologies
VME Fabricators
Welker

PROCESS EQUIPMENT - MEASUREMENT

A+ Corporation
ABB Inc.
Analytical Instruments Corp.
BAND-IT IDEX, Inc.
Bechtel
Cameron Valves and Measurement
Chromatic Industries
Croft Automation LLC
Distribution Now
EMD, Inc.
Envirosep
Federal Services LLC
FESCO, Ltd.

Fluenta Inc.
 GEA Refrigeration North America Inc.
 Gly-Tech Services
 Heath Consultants Incorporated
 J.W. Williams Inc.,a Flint Energy Services Co.
 J-W Power Company
 Kimray Inc.
 L.A. Turbine
 Louisiana Valve Source, Inc.
 Moore Control Systems, Inc.
 Omni Flow Computers, Inc.
 Select Engineering, Inc.
 Southern Flow Companies, Inc.
 Spitzer Industries
 SPL, Inc.
 Thurmond-McGlothlin, Inc.
 Toyo Engineering Corp.
 ValvTechnologies
 VME Fabricators
 Wasson-ECE Instrumentation
 Welker
 Wilson Mohr

PROCESS EQUIPMENT - TURBOEXPANDERS

Air Products and Chemicals, Inc.
 Atlas Copco Gas and Process
 BAND-IT IDEX, Inc.
 Bartlett Equipment Co.
 Bechtel
 Genesis Systems
 International Oil & Gas Consultants Pte, Ltd.
 Joule Processing, LLC
 KP Midstream
 L.A. Turbine
 SANCUS Energy & Power, LLC
 Simms Machinery International
 Texas Turbine, Inc.
 Toyo Engineering Corp.
 UOP Russell

PROCESS EQUIPMENT - VAPOR RECOVERY UNITS

Air Products and Chemicals, Inc.
 Analytical Instruments Corp.
 BAND-IT IDEX, Inc.
 Bechtel
 Burckhardt Compression U.S.
 Catalytic Combustion Corporation
 CDM Resource Management LLC
 Dew Point Control, LLC
 Engineering, Procurement & Construction, Inc.
 Envirosep
 EXTERRAN
 Fabwell Corp.
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Genesis Systems
 Gly-Tech Services

Gregory Gas Services LLC
 Guild Associates, Inc.
 J.W. Williams Inc.,a Flint Energy Services Co.
 John Zink Company LLC
 Joule Processing, LLC
 J-W Power Company
 Kimray Inc.
 KW International
 Louisiana Valve Source, Inc.
 Norwood S&S, LLC
 Ref-Chem L.P.
 SANCUS Energy & Power, LLC
 Select Engineering, Inc.
 Spartan Energy Partners
 Texas Turbine, Inc.
 Toyo Engineering Corp.
 Valerus
 Welker
 Wellsite Compressor & Equipment Co.

PROCESS EQUIPMENT - VESSELS, TANKS

Aeon PEC
 ARC Energy Equipment
 BAND-IT IDEX, Inc.
 Bechtel
 Bilfinger Water Technologies
 CDM Resource Management LLC
 Credence Gas Services LLC
 Croft Production Systems, Inc.
 Delta Tee International, Inc.
 Dew Point Control, LLC
 Dickson Process Systems, Ltd.
 Eaton Metal Products Company, LLC
 Envirosep
 Fabwell Corp.
 Filtration Technology Corp.
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Genesis Systems
 Gly-Tech Services
 Gregory Gas Services LLC
 Heatec Inc.
 HETSCO, Inc.
 Industrial Distributors, Inc.
 International Oil & Gas Consultants Pte, Ltd.
 J.W. Williams Inc.,a Flint Energy Services Co.
 Joule Processing, LLC
 Kimray Inc.
 Koch-Glitsch LP
 KW International
 Louisiana Valve Source, Inc.
 Mueller Environmental Designs
 Nicholas Consulting Group, Inc.
 Nitro-Lift Technologies LLC
 Norwood S&S, LLC
 PECOFacet
 Peerless Mfg. Co.
 Pentair Porous Media
 PSI (Process Solutions Integration)

Q.B. Johnson Manufacturing, Inc.
 Regard Resources Co., Inc
 Rhine Ruhr Pty Ltd
 SANCUS Energy & Power, LLC
 SCFM Compression Systems Co.
 SEC Energy Products & Services, LP
 Select Engineering, Inc.
 Spitzer Industries
 Toyo Engineering Corp.
 Trinity Containers, LLC
 Valerus
 Welker
 Western Filter Co., Inc.

PROCESS EQUIPMENT - WASTE HEAT RECOVERY

Aeon PEC
 Anguil Environmental Systems
 Atlas Copco Gas and Process
 BAND-IT IDEX, Inc.
 Bartlett Equipment Co.
 Bechtel
 Catalytic Products International, Inc.
 Envirosep
 EXTERRAN
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Genesis Systems
 Gly-Tech Services
 Heatec Inc.
 International Oil & Gas Consultants Pte, Ltd.
 Joule Processing, LLC
 Nalco, An Ecolab Company
 Nicholas Consulting Group, Inc.
 Optimized Process Furnaces
 SANCUS Energy & Power, LLC
 Spartan Energy Partners
 Texas Turbine, Inc.
 Thermal & Mechanical Equipment Co.
 Toyo Engineering Corp.

PROCESS EQUIPMENT - CRYOGENIC

Air Products and Chemicals, Inc.
 Allied Equipment, Inc.
 ARC Energy Equipment
 Atlas Copco Gas and Process
 BAND-IT IDEX, Inc.
 Bechtel
 Burckhardt Compression U.S.
 Chart Energy & Chemicals
 Credence Gas Services LLC
 Engineering, Procurement & Construction, Inc.
 EXTERRAN
 Fabwell Corp.
 GEA Refrigeration North America Inc.
 Genesis Systems
 Heatec Inc.

HETSCO, Inc.
 International Oil & Gas Consultants Pte, Ltd.
 Joule Processing, LLC
 Koch-Glitsch LP
 KP Midstream
 L.A. Turbine
 Linde Process Plants, Inc.
 Norwood S&S, LLC
 Q.B. Johnson Manufacturing, Inc.
 SANCUS Energy & Power, LLC
 SCFM Compression Systems Co.
 S-CON, Inc.
 Select Engineering, Inc.
 Simms Machinery International
 Spitzer Industries
 Texas Turbine, Inc.
 Thermal & Mechanical Equipment Co.
 UOP Russell
 Valerus
 VME Fabricators

PROCESS EQUIPMENT - EXCHANGERS

Aeon PEC
 Air Products and Chemicals, Inc.
 Anguil Environmental Systems
 ARC Energy Equipment
 Atlas Copco Gas and Process
 AXH Air-Coolers
 BAND-IT IDEX, Inc.
 Bartlett Equipment Co.
 Bechtel
 Catalytic Products International, Inc.
 Chart Energy & Chemicals
 Credence Gas Services LLC
 Delta Tee International, Inc.
 Dew Point Control, LLC
 Envirosep
 EXTERRAN
 Fabsco Shell & Tube, LLC
 Federal Services LLC
 FES-Southwest, Inc.
 Gas Technology Corp.
 GEA Refrigeration North America Inc.
 Genesis Systems
 Gly-Tech Services
 Gregory Gas Services LLC
 HETSCO, Inc.
 International Oil & Gas Consultants Pte, Ltd.
 J.W. Williams Inc., a Flint Energy Services Co.
 Joule Processing, LLC
 L.A. Turbine
 Masters Process Equipment
 Nicholas Consulting Group, Inc.
 Peerless Mfg. Co.
 Q.B. Johnson Manufacturing, Inc.
 Ref-Chem L.P.
 Regard Resources Co., Inc
 SANCUS Energy & Power, LLC

Spartan Energy Partners
Thermal & Mechanical Equipment Co.
Toyo Engineering Corp.
York Process Systems

PROCESS EQUIPMENT - LNG

Air Products and Chemicals, Inc.
ARC Energy Equipment
Atlas Copco Gas and Process
BAND-IT IDEX, Inc.
Bechtel
Bilfinger Water Technologies
Burckhardt Compression U.S.
CDM Resource Management LLC
Credence Gas Services LLC
Elliott Group
EXTERRAN
Fabwell Corp.
GEA Refrigeration North America Inc.
Genesis Systems
Guild Associates, Inc.
International Oil & Gas Consultants Pte, Ltd.
Koch-Glitsch LP
KW International
L.A. Turbine
Linde Process Plants, Inc.
MEI, LLC
Norwood S&S, LLC
Q.B. Johnson Manufacturing, Inc.
Ref-Chem L.P.
SANCUS Energy & Power, LLC
S-CON, Inc.
Simms Machinery International
Spartan Energy Partners
Texas Turbine, Inc.
Thermal & Mechanical Equipment Co.
Toyo Engineering Corp.
ValvTechnologies
VME Fabricators

PUMPS

Atlas Copco Gas and Process
BAND-IT IDEX, Inc.
Bartlett Equipment Co.
Bechtel
Best PumpWorks
Compressor Systems, Inc.
Envirosep
Federal Services LLC
Gas Equipment Co., Inc.
Gas Technology Corp.
Gly-Tech Services
Gregory Gas Services LLC
International Oil & Gas Consultants Pte, Ltd.
Joule Processing, LLC

Kimray Inc.
Puffer Sweiven
Rotor-Tech, Inc.
Select Engineering, Inc.
SERO Pump Systems, Inc.
Sundyne Corporation
Valerus
Vanco Equipment Co.
Wagner Power Systems
Welker
Western Filter Co., Inc.

RECONDITIONED, SURPLUS EQUIPMENT

Aeon PEC
Air Products and Chemicals, Inc.
Analytical Instruments Corp.
ARC Energy Equipment
Best PumpWorks
Cameron Valves and Measurement
Croft Automation LLC
Croft Production Systems, Inc.
Gas Technology Corp.
Gly-Tech Services
Gregory Gas Services LLC
HPF Consultants, Inc.
Joule Processing, LLC
KW International
Louisiana Valve Source, Inc.
Regard Resources Co., Inc.
SANCUS Energy & Power, LLC
SEC Energy Products & Services, LP
Simms Machinery International
Thurmond-McGlothlin, Inc.
Vinson Process Controls
Wellsite Compressor & Equipment Co.

SOFTWARE

Aspen Technology, Inc.
Atlas Copco Gas and Process
Bryan Research & Engineering, Inc.
Cimation
Detection Technologies
EMD, Inc.
Energy Solutions International (ESI)
ENGlobal Corporation
Joule Processing, LLC
Monico Monitoring, Inc.
MYNAH Technologies
Panton Inc.
Quorum Business Solutions, Inc.
Rockwell Automation
Virtual Materials Group
Wasson-ECE Instrumentation
Waterfield Energy
WinSim Inc.

NOTES:
