Optional Accessories **Chapter 7**

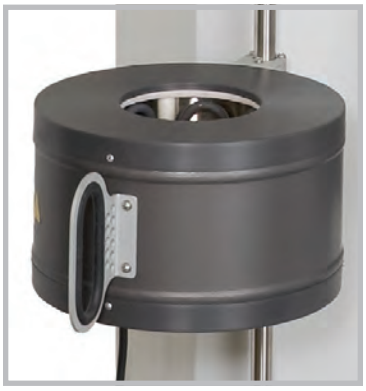
Inside This Chapter You Will Find:

Heaters

Standard Heaters

Parr has designed standard electrical heaters for all of the reactors in our product line. Different types of heaters are used for individual reactors to best meet the operational needs, heating load, and expected operating temperatures. The standard heater type and power rating for each reactor model is listed in the reactor specification tables.

Ceramic Heaters
These are special purpose heaters with an electric element embedded in a shaped ceramic body which is held within an insulated metal housing. They are used for reactors designed for temperatures to 600 °C and for large multi-zone heaters.



Calrod-Type Sheathed Element Heaters
These are rugged heaters with Calrod-type elements held within a metal shell. They are used for medium to large reactors for operating temperatures to 350 °C. In some cases the heater shell itself forms a part of the reactor support. An advantage of Calrod heaters is that the heating elements are easily replaceable.

Rigid Heating Mantles
These are quartz fabric mantles housed in aluminum shells. They are used for moderate sized reactors in designs where the heater can be moved on or off the vessel. They are light weight and easy to handle, but they are not used to support the weight of the vessel and they are generally limited to operating temperatures of 350 °C or less.

Optional and Custom Heaters

Parr offers a variety of heater designs which can be substituted for the standard heater normally furnished with each reactor. Most of these can also be used with Parr non-stirred pressure vessels as well.

Clamp-On Band Heaters
These are normally used for very small reactors where maximum watt densities and heat transfer are required due to the limited surface area available on the vessel.

Aluminum Block Heaters
Aluminum block heaters are available as an option for vessels of two gallons or less. These heaters are machined from solid blocks of aluminum with heater wells machined into the walls of the block. Optional cooling channels are also available.

Aluminum block heaters have distinct features that make them desirable for certain applications. When compared to a circulating jacket, they offer the convenience of direct electric heat control as well as no plumbing requirements for hot oil. The heating elements, cooling channels, and associated wiring are embedded within the machined aluminum enclosure. This allows for even heat distribution, physical isolation of the electrical connections, and rapid cooling when needed. These attributes, in combination with a surface temperature

limiting device and proper external wiring, have allowed these heaters to be used in some potentially ignitable atmospheres (Hazardous Locations). Having integral machined cooling channels, aluminum block heaters have also been used for control of some exothermic reactions when internal cooling is not available.

Flexible Heating Mantles
These can be furnished for many different applications. These are similar to our rigid type heating mantles except they are not held in an aluminum housing. They have a flexible fabric outer case for electrical and thermal insulation. This type of mantle is particularly useful for heating vessels with irregular shapes, such as those with windows in the cylinder wall, since they are flexible and can be split and laced onto a vessel around any external protrusion. As with rigid mantles, they will produce temperatures up to 350 °C, but they are limited to watt densities of 10 watts per square inch. This type of heater can be made to cover any of the vessels offered by Parr, and they are sometimes preferred when only moderate temperatures are required. Since they are constructed of cloth, an electrical ground wire cannot be provided.

Circulation Jackets
A jacket can be welded to the outer wall of most Parr pressure vessels to provide a means for heating or cooling the vessel with a hot or cold liquid or steam. This type of heating is ideal for users who want to duplicate plant operating conditions, using a jacketed reactor comparable to jacketed equipment used in their plant. Since there are no electrical components in a jacket, and since the maximum temperature can be controlled by controlling the temperature of the heating medium, a jacketed vessel may be a good option for use in hazardous atmospheres.

Rapid and uniform heating can be attained with a jacketed vessel since the heating medium is in direct contact with the vessel. By controlling the temperature of the heating medium, temperature overshoots can be avoided when working with sensitive materials. Standard jackets are designed for operating pressures up to 100 psig (7 bar) within the jacket. Higher pressure jackets can be provided if required.

Stirrer Motors and Drives

Torque vs. Stirring Speed

The standard, open-type, variable speed motor installed on each Parr reactor will produce stirring speeds from zero to between 600 and 800 rpm with a torque adequate to drive the installed impellers in average viscosity mixtures. Higher horsepower motors and special stirrers can be provided for higher viscosities. Alternate drive pulleys are available to produce higher stirring speeds, but several basic rules must be considered when changing any of these components.

The highest torque from any motor is obtained at lower stirring speeds. Increasing the stirring speed reduces the torque in inverse proportion to the speed. For operations involving high viscosity mixtures, the motor size, the type of impeller and the stirring speed must be matched to provide an effective mixing system.

As a general rule, the magnetic coupling installed on each Parr reactor will have a torque rating considerably higher than the torque obtainable from the motors offered for use with that apparatus. The goal is to make the motor the weak link so that the magnetic stirrer will be protected. Reference torque rating for applicable magnetic drive.

Explosion-proof Motors

Explosion-proof motors designed for Class I, Groups C and D and Class II, Groups F and G with variable speed control can be furnished for most Parr reactors.

Flameproof "d" Motors

ATEX certified AC Flameproof Motors designed for use with group IIC gases are available for all of Parr's stirred reactors. These inverter duty motors are available with simple variable frequency drives for control of the stirring speed. Please consult Parr for any specific ATEX certification related requirements.

Air Motors

Air-driven motors can be installed on most reactors. The horsepower rating, torque, and available speed are all dependent upon the pressure and available volume of the driving air source. Maximum torques are delivered at relatively slow speeds and maximum horsepower is delivered at high speed.

Stirrer Drive Motors

					Standard Pulley		Optional Pulley	
Motor Designation	**HP (kW) Rating**	**Hazardous Location***	**Variable Speed**	**Type**	**Max Speed, RPM****	**Max Torque, in-lb**	**Max Speed, RPM****	**Max Torque, in-lb**
-VS.12	1/16 (0.05)	No	Yes	PMDC	600	6.75	1700	2.25
-VS.25	1/4 (0.18)	No	Yes	PMDC	600	27	1700	9
-XP.25	1/4 (0.18)	Class I, Div. 1 & 2 Groups C & D, E & F	Yes	PMDC	600	27	1700	9
-XP.25X	1/4 (0.18)	Ex 2G de IIC T4	Yes	Inverter Duty Constant Torque AC	450	33	1350	11
-AM.25**	1/4 (0.18)***	Ex II 2 GD c T4	Yes	Air	1000***	30	—	—
-VS.50	1/2 (0.37)	No	Yes	PMDC	600	54	1700	18
-XP.50	1/2 (0.37)	Class I, Div. 1 & 2 Groups C & D, E & F	Yes	PMDC	600	54	1700	18
-XP.50X	1/2 (0.37)	Ex 2G Ex de IIC T4	Yes	Inverter Duty Constant Torque AC	450	66	1350	22
-AM.50**	1/2 (0.37)***	Ex II 2 GD c T4	Yes	Air	1000***	66***	—	—
-VS.75	3/4 (0.55)	No	Yes	PMDC	600	81	1700	27
-XP.75	3/4 (0.55)	Class I, Div. 1 & 2 Groups C & D, E & F	Yes	Yes	600	81	1700	27

Values represented are nominal.

*For more information on Hazardous Locations information see Tech Note 230.

**Maximum speed values based on "no load"

***HP, RPM, and torque values for air motors are based on a 40 psi supply capable of 34 cfm for the AM.50 and 10 cfm for the AM.25.

Gear Box Torques						
	3:1 Gear Box		*5:1 Gear Box*		*10:1 Gear Box*	
Motor HP Rating	**Max Speed, RPM**	**Max Torque, in-lb**	**Max Speed, RPM**	**Max Torque, in-lb**	**Max Speed, RPM**	**Max Torque, in-lb**
1/4	600	27	360	45	180	90
1/2	600	54	360	90	180	180
3/4	600	81	360	135	Not Recommended	

Contact Parr for ATEX Gear Box.

Geared, Direct Drive Motors

A geared, direct drive motor can be installed on most fixed head floor stand reactors. This is an attractive arrangement for handling heavy stirring loads.

Any 1/4 hp or larger, variable-speed standard or explosion-proof motor can be used. Gear box drives are available with ratios of 3:1, 5:1 and 10:1. The 1700 rpm maximum speed will be reduced in an amount determined by the reduction ratio of the gear box, and the associated torque values from the table will be increased in the same ratio.

Magnetic Drive	
Description	**Maximum Torque, in-lb**
General Purpose	16
Footless General Purpose	16
Heavy Duty	60
Footless Heavy Duty	60
Extra Heavy Duty	120
Footless Extra Heavy Duty	120

Parr Geared Drive Motor mounted on a Series 4553 Stirred Reactor System.

Stirrer Options

(1) Turbine Type Impeller

(2) Stamped Spiral Stirrer

(3) Machined Spiral Stirrer

(4) Anchor Stirrer

(5) Paddle Type Anchor

(6) Anchor Stirrer with Wiper Blades

Turbine Type Impellers (1)
Parr reactors are usually equipped with turbine type impellers which produce an excellent mixing action over the range of stirring speeds at which these reactors typically operate. These impellers are made in four-blade and six-blade styles, with the smaller four-blade impellers used only on Micro and Mini Reactors. These impellers, for reactors with 300 mL volume or greater, may be positioned anywhere on the stirring shaft, with one impeller usually located near the bottom of the vessel to keep solids up in suspension and a second impeller positioned near the base of the vortex to pull reactant gases down into the liquid phase. These impellers generally provide excellent mixing for systems with effective viscosities up to approximately 25,000 centipoise (cP) with a 16 in-lb magnetic drive or up to 50,000 cP with 60 in-lb magnetic drive.

Spiral Stirrers (2,3)
Spiral stirrers are offered in two styles: stamped and machined. The standard spiral stirrer includes blades constructed of stamped sheet metal and provides a cost-effective option. The more robust machined spiral stirrer is manufactured from a solid piece of bar stock which results in added strength and facilitates cleaning. Either of these spiral stirrers can be installed in any 1 liter, 2 liter or 1 gallon reactor to produce a positive downward thrust or upward thrust action when working with viscous polymers or other high viscosity mixtures. They work best in floor stand reactors with adjustable speed and heavy duty drive systems. Either left-hand (downward thrust) or right hand (upward thrust) spirals are available. The downward thrust spiral is generally preferred for heavy suspensions.

Note: All stirrer options may not be appropriate or available for each reactor size. Additional internal fittings may be required to adapt some stirrer styles to existing reactors in the field. Please contact the Parr Technical Service Department for assistance in selecting a stirrer suitable for the intended operating volume and viscosities.

Anchor Stirrers (4-6)
Anchor stirrers are available in several configurations for use with moderate to high viscosity materials. This type of stirrer usually works best in vessels with an inside depth to diameter ratio of 1.5 to 1 or less. They are intended to operate at relatively slow speeds and generally require a heavy duty drive system capable of generating and delivering sufficient torque to the agitator. Footless magnetic drives work well with anchor or spiral stirrers.

Three basic types are offered:

- A U-shaped, flat bar anchor.
- A flat blade, paddle type anchor.
- A two-arm or three-arm, self centering anchor with PTFE wiper blades.

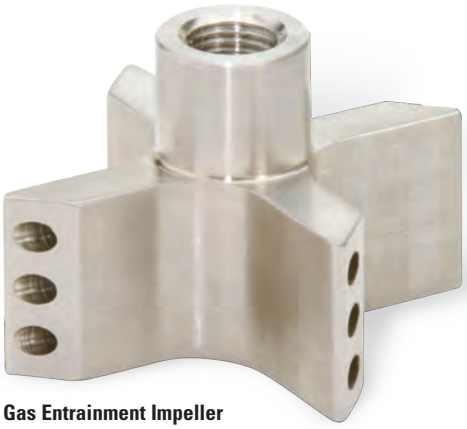
Gas Entrainment Impellers

Parr offers a series of gas entrainment impellers for users who want to obtain maximum gas dispersion into a liquid system. This is obtained with a unique impeller attached to a hollow stirring shaft through which gases are continuously recirculated from the head space above the liquid through the impeller into the liquid phase. As with all impellers, the speed of the stirrer creates a vacuum at the tip of the impeller. Gas enters openings near the top of the shaft and is pulled through dispersion ports located at the tips of the impellers. In the Parr system with dispersion ports located at the very tips of the impellers, the higher the stirring speed — the higher the vacuum — and the higher the driving force for this very effective gas dispersion system.

When ordered with a new reactor, these impellers are offered as a complete package which includes the impeller, the hollow shaft with coupling, and any required foot bearings and brackets for the intended reaction. The baffles are a separate option which must be ordered individually.

The gas entrainment stirrers may be ordered as an optional stirrer when purchasing a new reactor system or easily installed in an existing system in the field. With the wide variety of reactor head styles and magnetic stirrers furnished on Parr reactors it is best to contact us with the numbers stamped on the head of your vessel so that we will be able to furnish the correct gas entrainment assembly for a particular reactor system.

Since these gas entrainment impellers operate best in the 1000-1200 rpm range, users will want to ensure that their stirrer drive system is set up to deliver these operating speeds; alternate pulleys and belts are available to convert existing reactor systems.



Gas Entrainment Impeller

Gas Entrainment Impeller with Hollow Shaft

Baffles

Because it is the relative speed of the tip of the impeller to the liquid phase that governs the mass transfer, baffles, which impede the rotation of the liquid with the impeller, can greatly enhance the operation of these gas entrainment impellers. While some natural baffling is provided by the internal thermowell, dip tube and cooling coils, the removable baffles are recommended for use with these gas entrainment impellers. These baffles may also be beneficial with the more traditional turbine type impellers for certain applications.

Removable Baffle

Catalyst Baskets

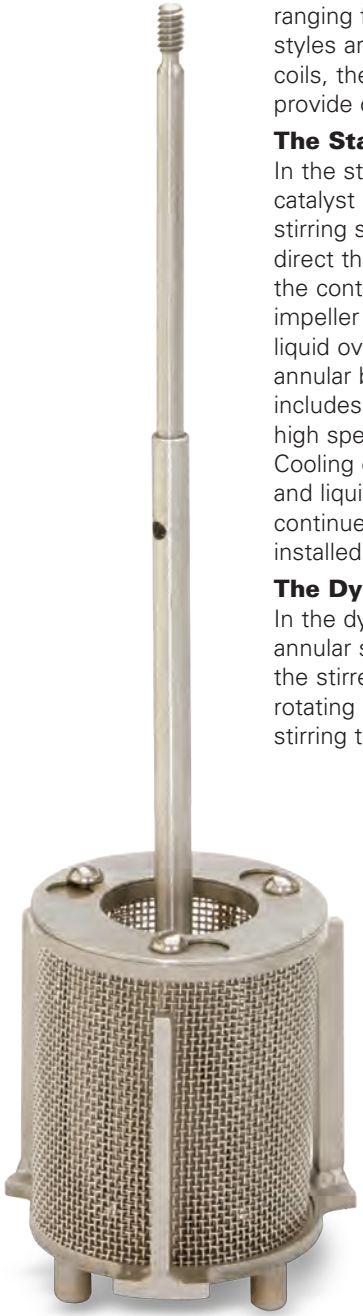
Catalyst baskets can be provided for holding a supported catalyst so that it will not be destroyed or changed by the stirring action of the impeller. These can be installed in reactors with volumes ranging from 300 to 2000 mL. Two interchangeable styles are available. Special heads, internal cooling coils, thermowells and dip tubes are required to provide clear space in the vessel for these baskets.

The Static Design

In the static design the mesh basket holding the catalyst remains stationary while impellers on the stirring shaft and baffles outside of the basket direct the flow of reactants over the surface of the contained catalyst. A unique gas entrainment impeller provides a uniform flow of both gas and liquid over the fixed catalyst bed held within the annular basket. The Parr design for these baskets includes a rigid bottom support which permits high speed stirring without excessive vibration. Cooling coils, internal temperature measurements, and liquid and gas sampling operations can be continued as usual without interference from the installed catalyst basket.

The Dynamic Design

In the dynamic design the catalyst is held in an annular shaped, mesh basket which is attached to the stirrer drive in place of the stirring shaft. The rotating basket then serves as an impeller for stirring the reactants. Fixed baffles and coaxial impellers ensure good circulation over the surface of the contained catalyst. The dynamic baskets are available for reactors with volumes of 1000, 1800, and 2000 mL. Dynamic baskets must be installed in reactors equipped with at least 1/4 hp motors to ensure that sufficient stirrer torque and speeds are available for proper operation. Dynamic baskets are interchangeable with static baskets in 1 liter and larger vessels.



Catalyst Basket Static Design

Catalyst Basket Dynamic Design

Catalyst Basket Static Design with Uniflow Stirrer

Condensers

Parr offers two styles of condensers for attachment to the head of a stirred reactor or pressure vessel. These can be made in various sizes to match the size of the reactor.

Reflux Condenser
The reflux condenser consists of a length of tubing connected directly to the head of a vessel and equipped with a water cooling jacket. Condensed vapors are returned directly to the vessel and any non-condensable gases can be released through a needle valve at the top of the condenser. A helical insert in the condenser ensures maximum effectiveness in a rather short length.

Reflux/Take-Off Condenser
The reflux/take-off condenser consists of the same water jacketed tube described above, assembled with a receiving vessel attached to the lower end of the condenser. Any vapor, such as water from a polymerization reaction, can be condensed and collected in the receiver, from which it can be withdrawn through a bottom valve. Any non-condensable gases can be released through a needle valve at the top of the condenser. If condensate collection is not required, the receiver can be removed and the condenser can be mounted directly above the reactor for direct reflux into the vessel.

Modifications
Many users opt to install a ball valve at the head of the reactor below the condenser to use as a shut-off to the condenser. Alternate collection vessel volumes are available upon request.

The installation of a condenser on any of the Parr reactors requires a larger port in the head of the vessel, the size of which will vary with the volume of the reactor system. Due to the limited space on the 4560 mini reactors, either the gage opening or one of the cooling coil ports can be enlarged to 1/4" NPT for use with a condenser. This modification would then either combine the gage and condenser functions or eliminate the internal cooling loop to accommodate the condenser. Reactors with volumes of 1 liter and greater would be modified with a 3/8" NPT opening or larger depending on the reactor volume. The standard head fittings would be rearranged to accommodate this port.

Reflux Condenser

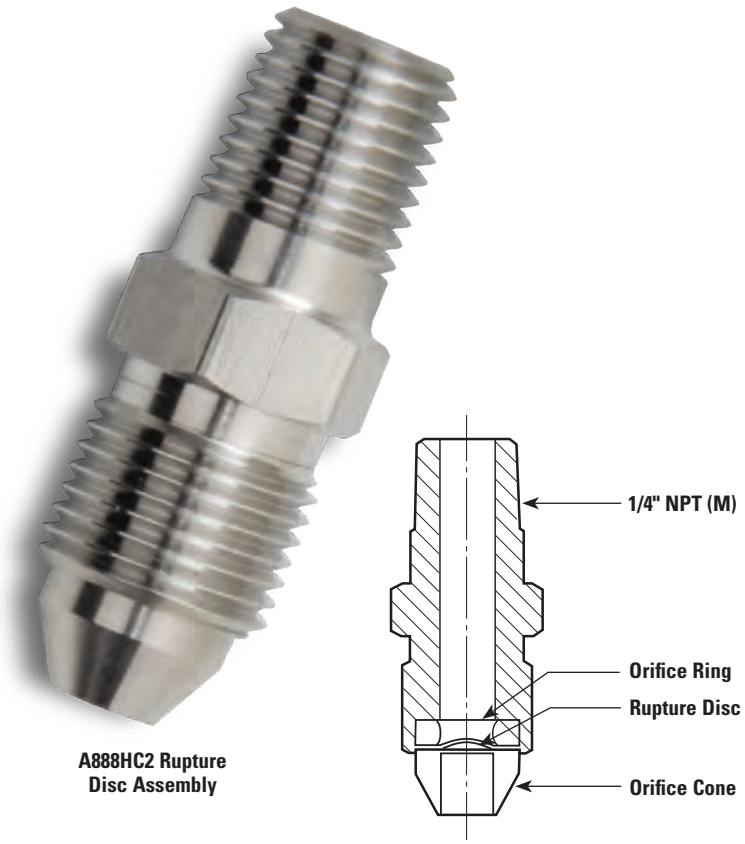
Reflux Take-Off Condenser

Condensers

Reactor	Style	Note	Inner Tube O.D. Diameter, in.	Standard Receiver, mL	Part No.
4560 / 4590	Reflux/Take-off	Mod. Gage Opening 1/4" NPT	3/8	150	A2011HC
4560 / 4590	Reflux	Mod. Gage Opening 1/4" NPT	3/8		A2012HC
4560	Reflux/Take-off	Mod. Cool Coil Opening 1/4" NPT	3/8	150	A2013HC
4560	Reflux	Mod. Cool Coil Opening 1/4" NPT	3/8		A2014HC
4520 / 4530 / 4550	Reflux/Take-off	3/8" NPT	1/2	300	A2001HC
4520 / 4530 / 4550	Reflux	3/8" NPT	1/2		A2002HC
4530 HD*	Reflux/Take-Off	3/8" NPT	1/2	300	A2003HC
4530 HD*	Reflux	3/8" NPT	1/2		A2004HC
4540 / 4570 / 4580	Reflux/Take-off	3/8" NPT	3/8	300	A2016HC
4540 / 4570 / 4580	Reflux	3/8" NPT	3/8		A2017HC
4555	Reflux/Take-off	1/2" NPT	3/4	1000	A2018HC
4555	Reflux	1/2" NPT	3/4		A2019HC

*with HD Magnetic Drive

Safety Rupture Discs



A888HC2 Rupture Disc Assembly

Parr Pressure Vessels are protected by custom built rupture discs. Examination of these discs will show that each of these discs is domed. This dome was produced at the factory by taking the individual disc to 70% of its burst pressure.

ASME as well as other pressure vessel codes dictate that pressure vessels must be equipped with a rupture disc designed to burst no higher than the design pressure of the vessel. For pressure loads that do not cycle rapidly such as in our vessels, we suggest limiting the actual operating pressure to no more than 90% of the disc burst pressure. This combination will limit operating pressures to no more than 90% of the design pressure of the vessel in most cases.

We have selected Alloy 600 as the standard material for these rupture discs. It provides excellent corrosion resistance while retaining over 90% of its room temperature rating at temperatures up to 450 °C. For added corrosion resistance we can furnish these discs with gold facing or replace them with discs made of Alloy C-276. Discs can be produced to match any operating pressure and temperature above the stated minimums.

Parr reactors and pressure vessels from 25 mL to 2000 mL use the 526HC Series Alloy 600 disc or 581HC Series Alloy 600 with gold facing. The 1 gallon and larger use the 708HC series discs. The 4580 reactor systems use the 1415HC series discs.

In general, the 1000 psi disc in the 526HC/581HC series discs and the 800 psi in the 708HC are the lowest available ranges in the Alloy 600 material. Alternate disc materials are available but they do not offer the same corrosion resistant properties and temperature capabilities.

For applications where users prefer a lower range pressure gage, we would add a spring loaded relief valve set to protect the gage and a 1000 psi rupture disc as the fail safe protection.

Safety Rupture Discs

Most rupture discs furnished by Parr come with CE certification. Upon request, Parr can furnish ½" discs with flat seat (both holder and rupture disc) with ASME certification markings and documentation (with UD certification designator).

Users are invited to contact the Parr Technical Support Staff with requirements for your rupture disc needs.

Typical Rupture Discs for 1/4" Orifice

Burst Rating, psig	Inconel Disc	Gold-Faced Inconel Disc
1000	526HCPD	581HCPD
2000	526HCPF	581HCPF
3000	526HCPG	581HCPG
4000	526HCP40CT	581HCP40CT
5000	526HCPH	581HCPH
8000	526HCPJ	581HCPJ
10000	526HCP100CT	

Typical Rupture Discs for 1/2" Orifice

Burst Rating, psig	Inconel Disc
1000	708HCP10CT
1500	708HCP15CT
2000	708HCP20CT
3000	708HCP30CT
3000	1415HCP30CT
4500	1415HCP45CT

Note: For a complete list of rupture disc part numbers, burst ranges, materials, and temperature ratings, see manual 231M.

Pressure Relief Valves

Spring-loaded relief valves should be viewed as a supplement to and not a substitute for a safety rupture disc. The rupture disc is the primary means for protection of the operator and the vessel in case of accidental over-pressure. Spring-loaded relief valves can be added to a reactor or vessel to:

- Relieve pressures near the maximum operating pressure.
- Reseal once excess pressure has been relieved.
- Protect low pressure components at pressures below available rupture disc ranges.

The relief valves listed below can be installed on any Parr vessel. The relief valves are constructed of stainless steel and have FKM O-rings. Other valve and O-ring materials are available on special order. Relief valves with CE Certification are also available.

A175VB Relief Valve

A140VB2 Relief Valve

Pressure Relief Valves for Low Pressures

Part No.	Preset psi	Adjustable psi	Bar	Discharge Connection
A140VB2PA	100	50-150	3.45-10.3	1/4" NPT (M)
A140VB2P1	150	50-150	3.45-10.3	1/4" NPT (M)
A140VB2P2	145	50-150	3.45-10.3	1/4" NPT (M)
A140VB2PB	200	150-350	10.3-24.1	1/4" NPT (M)
A140VB2PC	600	350-600	24.1-41.4	1/4" NPT (M)
A140VB2PD	300	150-350	10.3-24.1	1/4" NPT (M)

Pressure Relief Valves for High Pressures

Part No.	Pressure Relief Range, psi	Bar	Discharge Connection
A175VB	750-1500	52-103	1/4" NPT (F)
A175VB2	1500-2250	103-155	1/4" NPT (F)
A175VB3	2250-3000	155-207	1/4" NPT (F)
A175VB4	3000-4000	207-276	1/4" NPT (F)
A175VB5	4000-5000	276-345	1/4" NPT (F)
A175VB7	350-750	24-52	1/4" NPT (F)
A175VB8	50-350	3.4-24.1	1/4" NPT (F)

** Note: When ordering any of the above relief valves, the user may specify a desired set pressure.*

Gages

593HCPF Gage 3-1/2" Dia.

56HCPF Gage 4-1/2" Dia.

2633HCP10AD 3-1/2" Back Mount Gage

Gages for Parr pressure vessels can be furnished with either 3-1/2" or 4-1/2" dials in any of the ranges shown in the table below. All have stainless steel Bourdon tubes and 1/4" NPT male connections.

Alloy 400 gages are available on special order. Accuracy is 1.0 percent of full scale for the 4-1/2" size and 1 percent for the 3-1/2" gages. All standard gages include dual scales, with graduations in both pounds per square inch (psi) and bar. Gages in Pascal units are available on special order. Compound gages which show vacuum to 30 inches of Mercury and positive pressures to 300 psi (20 bar) are also available.

When ordering a special gage, specify the gage diameter, the desired range and scale units.

The gage on a pressure vessel should be 150 percent of the maximum operating pressure. This allows the gage to operate in the most accurate pressure range and prevents the gage from being stressed repeatedly to its full range, which will effect the calibration.

Gages

Pressure, psi	Range, bar	4-1/2" Dia. Gage No.	3-1/2" Dia. Gage No.	3-1/2" Dia. Back Mount Gage No.
0-100	0-7	56HCPA	593HCP1AD	2633HCP1AD
0-200	0-14	56HCPB	593HCP2AD	2633HCP2AD
0-600	0-40	56HCPC	593HCP6AD	2633HCP6AD
0-1000	0-69	56HCPD	593HCPD	2633HCP10AD
0-2000	0-138	56HCPF	593HCPF	2633HCP20AD
0-3000	0-207	56HCG	593HCPG	2633HCP30AD
0-4000	0-275	N/A	593HCP40AD	N/A
0-5000	0-345	56HCPH	593HCP50AD	2633HCP50AD
0-7500	0-517	56HCP75AD	N/A	2633HCP75AD
0-10000	0-690	56HCPK	593HCPK	N/A
30" Hg Vac/300 psi		56HCP3YB	593HCP3YB	2633HCP3YB

Parr's standard stainless steel reactor gages are typically manufactured to meet ASME/ANSI B40.1 Grade A accuracy specifications.

Gas Measurement Systems

Parr offers a variety of accessories for its line of pressure reaction vessels to enable the investigator to accurately determine the amount of gas consumed in a reaction conducted at elevated pressures and temperatures. There are essentially two methods used to measure the amount of gas delivered to a reaction vessel. These are:

1. The measurement of the pressure drop in an auxiliary supply vessel of known volume.
2. The measurement and integration of the flow rates using an electronic mass flow meter.

Each of these methods has its advantages and limitations as discussed below.

Intermediate Supply Tanks

Certainly the simplest method to measure the amount of gas consumed in a reaction is to feed the gas from a vessel of known volume and to measure the pressure drop in this vessel during the course of the reaction. The consideration in this method is to select a supply vessel with a volume matched to the amount of gas that will be consumed in the reaction. It needs to be large enough to contain enough gas to complete the reaction and small enough that the pressure drop will be significant and measurable. This basic technique can be applied in a number of ways:

1. The supply tank can be connected directly to the reaction vessel. This is the simplest and least expensive. The principal limitation of this approach is that the reaction pressure will fall as gas is consumed and the reaction will not be conducted at a constant pressure.
2. The supply tank can be fitted with a constant pressure regulator. The regulator must be selected to match the planned operating pressure. This regulator will deliver gas to the reaction vessel at constant pressure overcoming the limitation described in (1) above.
3. Initial and final pressures in the supply tank can be measured with analog gages, or continuous pressure readings can be made and recorded using pressure transducers. While the transducers add cost, they also add increased resolution and the opportunity to follow the rate of the pressure drop and hence the rate of reaction.
4. Enhanced precision can be achieved by measuring the temperature in the supply tank and applying corrections as appropriate.

Parr offers a series of high pressure burettes in complete packages for direct connection to our reactors. The basic ones are listed on the following page.

These burettes can also be equipped with digital pressure transducers, internal thermocouples and data acquisition and reduction support. Please contact our customer support group for information on these possibilities.

Mass Flow

Parr Instrument Company can provide mass flow meters or controllers for quantitative mass flow based analysis. Mass flow controllers are mass flow meters that incorporate an integral control valve, external valve, or feed pump to control the fluid flow. Mass flow controllers are typically used in automated or semi-automated systems. Due to many application and calibration specific requirements, please contact Parr Instrument Company for technical assistance with mass flow meters or controllers.

Parr offers multiple, price driven, electronic interface devices for mass flow meters and controllers. The Parr A2200E Mass Flow Meter/Controller interface system offers a manually operated readout and/or set point module for up to four mass flow meters/controllers. When the A2200E is used with a mass flow controller, a manually operated back pressure regulator is required. The Parr 4871 Process Controller offers remote set point, readout, data logging, totalizing, gas mixing, and process related interfaces with these mass flow devices. Other intermediate interfaces can be provided.

High Pressure Gas Burettes

Parr offers a series of high pressure burettes intended to introduce gas (commonly hydrogen) to a reactor at a constant pressure. The burettes consist of a high pressure reservoir equipped with an inlet valve, a pressure gage and a relief valve. A constant pressure regulator with a check valve, a connecting hose and a support stand are included with each pipette.

The amount of gas consumed in a reaction can be determined by knowing the volume of the high pressure reservoir and observing the pressure drop in the reservoir during a reaction.

Series 2280 High Pressure Gas Burette

Parr high pressure burettes can be furnished in various sizes as shown in the adjoining table, each with a regulator to deliver gas to the reactor over the designated pressure range. The moles of gas shown in the table represent the amount of hydrogen that will be held in the burette at the maximum pressure. The deliverable volume will be a function of the difference in pressure between the pipette and the reactor. The size of the burette selected should be large enough to provide sufficient gas to complete the reaction while still maintaining sufficient pressure in the burette to force gas into the reactor.

Reservoirs with larger volumes are available as are regulators with different delivery ranges. Modifications can be made to these basic systems to add an internal thermocouple to the reservoir and/or a pressure transducer for digital readout and/or recording.

Gas Burettes Sizing

Sample Cylinder Volume, mL	Maximum Pressure, psi	Moles of H_2	Maximum Pressure (bar) For CE (TPED) Applications	Moles of H_2 For CE (TPED) Applications
150	1800	0.6	100	0.5
300		1.3		1.1
500		2.3		1.8
1000		4.6		3.7
2250		10.4		8.5
150	5000	1.7	300	1.5
300		3.4		3.0
500		5.7		5.0

Liquid Charging Systems

Liquid Metering Pumps

Liquid metering pumps are commonly used to introduce liquids into a reactor or vessel at elevated pressures on a continuous basis. A wide variety of pumps are available to meet various pressure, flow, and control requirements. The pumps listed here cover some of the more common pressure and flow requirements associated with Parr reactors and pressure vessels. The pumps described under these catalog numbers include an inlet filter, a reverse-flow check valve and the outlet tubing to the reactor. Special pumps can be furnished to meet requirements outside the range of these pumps. All pumps can be operated from their faceplates and all except the 2312E can also be remotely controlled with a 0-10VDC analog signal, such as from the Model 4871 Process Controller.

Liquid Metering Pumps

Part No.	Flow Rate, mL/min	Pressure, Max. psi	Wetted Material	Digital Pressure Alarm / Shut-off
2312E	0.01-10	2000	PEEK	No
2313E	0.01-10	5000	Stainless	No
2314E	0.04-40	1500	Stainless	No
2315E	0.01-10	5000	Stainless	Yes
2316E	0.04-40	1500	Stainless	Yes

Liquid Charging Pipettes

To introduce liquids into reactors or vessels at elevated pressures, the most economical way is to use a pressure pipette as a secondary vessel. These are often used for liquid addition to a batch process. Liquid is forced into the reactor from the pipette by applying gas pressure to the pipette greater than the pressure within the vessel. If the passages in the connecting line are large enough, slurries or catalyst suspensions can also be charged into the reactor in this manner.

The pipettes listed below offer a choice of volumes and are rated for pressures to 1800 psi. They include a nitrogen filling connection for attachment to a nitrogen tank. More elaborate pipette systems can be assembled to special order to include additional fittings, such as a pressure gage for the pipette, a pressure relief valve or a large opening ball valve. Special pipettes can also be furnished for higher pressures to 5000 psi.

A2113HC Liquid Charging Pipette

Liquid Charging Pipettes

Part No.	Pipette Volume, mL	Pressure Rating, psi
A2113HC3	50	1800
A2113HC4	150	1800
A2113HC	300	1800
A2113HC2	1000	1800

Solids/Slurry Addition Devices

One of the modifications most frequently requested is a port or other means to feed liquids, solids, or slurries into the vessel without removing the head. This can be done in various ways.

Solids Charging Port with Ball Valve

A ball valve with a 3/8" diameter opening can be installed on any one liter or larger vessel and used in conjunction with a high pressure pipette for injecting slurries under pressure. These are opened or closed with a quarter turn of the handle. Larger diameter valves are available for 1 gallon and larger vessels. These ball valves will withstand the full pressure developed in a reactor at moderate temperatures, but their pressure rating falls off rapidly at temperatures above 100 °C.

A143VB Ball Valve

Solids Charging Ports

Part No.	Nominal Size	Orifice Diameter, in.
A143VB	1/4" NPT (F)	0.250
A132VB	3/8" NPT (F)	0.375
396VBAD	1/2" NPT (F)	0.406

Internal Catalyst Addition Device (ICAD)

Parr has developed a unique device for adding small amounts of solids (or liquids) from a sealed container held within a reactor. The ICAD is of particular interest to users performing kinetic studies of catalytic reactions. This device consists of a small cylindrical chamber with a cap that is sealed to the body with an O-ring. It attaches to the underside of the vessel head with a 1/8" NPT connection. To discharge the contents of the holder, gas pressure is applied through a valve installed on the top of the head. When the applied pressure is greater than the pressure within the reactor, the cap is forced open and the catalyst or other contents of the holder will be released into the reactor. This device works best in the taller, 450 mL and 600 mL Mini Reactors, and in the 1 liter and larger Parr Reactors.

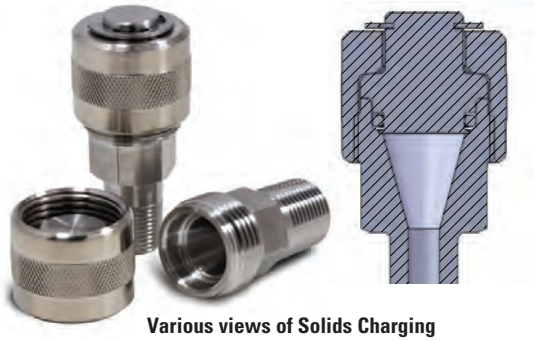
A550HC Catalyst Addition Device

Internal Catalyst Addition Devices

Complete Reactor	Mounting Size, cc	Assembly No.	Thread
Mini	6	A550HC3	1/8" NPT
One Liter	8	A550HC	1/8" NPT
Larger	20	A550HC2	1/8" NPT

Solids Charging Device

A solids charging device in the head of a reactor can serve as a convenient solids charging port at atmospheric pressure. The body of this device is machined with an internal taper to aid in the delivery of the solids into the vessel. It has a convenient screw cap closure with an FKM O-ring seal for use up to 225 °C. Other O-ring materials are available upon request, either for higher temperature operation or material compatibility.



Various views of Solids Charging Device with internal taper

Solids Charging Devices & External Catalyst Addition Device (XCAD)

Reactor	Available Fitting Sizes
Mini	1/4" NPT (M)
1 & 2 Liter	3/8" NPT (M)
Gallon & up	1/2", 3/4", & 1" NPT (M)

External Catalyst Addition Device (XCAD)

The addition of a specialized 5 mL or 10 mL chamber with a tools-free closure and two valves to the above solids charging device adds two important capabilities:

1. The chamber/valves assembly can be removed from the reactor without tools and filled in a glove box, for example, if an atmosphere-sensitive catalyst is being used.
2. Upon reattachment of the chamber/valves assembly to the reactor, a high pressure gas source can be connected to the top of the device to allow addition of catalyst to the reactor at elevated temperature and pressure.

Similar to the Internal Catalyst Addition Device (ICAD) shown above, the XCAD is ideal for kinetic studies, and is often paired with a gas burette (page 126) for constant pressure hydrogenation catalyst screening/characterization studies.

Solids Charging Device | **5 mL or 10 mL vessel with two valves**

XCAD

Cooling Coils

Serpentine Cooling Coil 1000 mL

Spiral Cooling Coil 1000 mL

Internal cooling coils are available for all but the smallest Parr reactors. These coils provide an extremely effective means of removing heat from the vessel to control an exothermic reaction or for cooling the reactor at the end of a test. Since heat is transferred through the relatively thin wall of the coil instead of the thick wall of the vessel, cooling rates are generally much faster than heating rates; particularly at temperatures above 80 °C. Water is normally used as the cooling medium although compressed air can be used for modest cooling loads. Cooling coils are offered in three standard configurations:

Single Loop - Single loop coils consist of a vertical run of tubing formed into a "hairpin" shape. These are normally installed on small reactors where there is minimum space available.

Serpentine Coils - Serpentine coils consist of six to eight vertical runs of tubing uniformly spaced around the circumference of the vessel. These coils provide reasonable surface area, minimum interference with stirring patterns, a reasonable amount of baffling, and ease of cleaning and maintenance.

Spiral Coils - Spiral coils consist of multiple loops wound just inside the inside diameter of the vessel. They are normally available only for the 4" and 6" ID vessels although other sizes have been built on special order. They do maximize the cooling area available, but sometimes at the expense of uniform stirring and ease of cleaning. The individual reactor specifications will dictate the style of coil or coils available for each reactor.

Cooling coils are available in the same choice of materials as the reactor bodies themselves. All cooling coils are removable. Plugs are available to close the openings in the head and in most cases these openings can be converted to alternate inlets/outlets if cooling is not required.

Liners

Removable, open top, cylindrical liners made either of borosilicate glass or PTFE can be furnished to fit most Parr reactors and general purpose vessels. These liners slide into the cylinder and require no additional fittings, but they may not coordinate with some alternate accessories and stirrers. Although they will not keep corrosive vapors from reaching the surfaces of the cylinder and head, they make it much easier to add and remove liquid reactants, and they give some protection to the cylinder when working with corrosive solutions. It must be noted, however, that adding a PTFE liner will slow the heat transfer rate into and out of the vessel, and it may be necessary to adjust the temperature control method to prevent overheating.

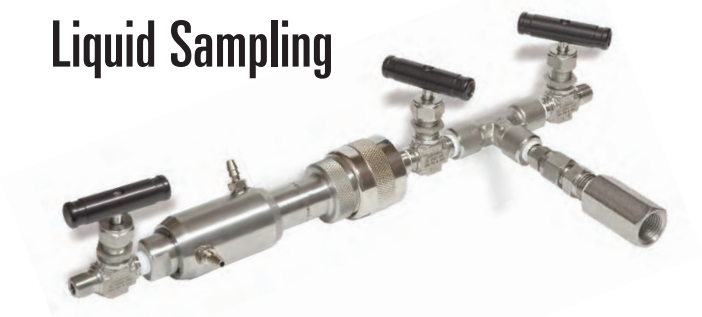
Liners

Fits ID, in.	Fits Cylinder Size, mL	Glass Liner Part No.	PTFE Liner Part No.
1.3	50	1431HC	1431HCHA
1.3	100	1431HC2	1431HC2HA
1.5	125	2920HC2	2920HC4HA
1.5	200	2920HC3	2920HC3HA
1.5	75	2920HC	2920HC2HA
2-1/2	250	762HC10	N/A
2-1/2	500	762HC2	762HCHHA
2-1/2	300	762HC	762HC4HA
2-1/2	450	762HC2	762HC5HA
2-1/2	600	762HC3	762HC6HA
2	100	762HC7	762HC7HA
2-1/2	160	762HC8	762HC8HA
3-1/4	600	2312HC	2312HC3HA
3-1/4	1200	2312HC2	2312HC4HA
3-3/4	1000	1441HC	1441HCHA
3-3/4	1800	1442HC	1442HCHA
4	1000	398HC	398HCHA
4	2000	399HC	399HCHA
6	1 Gallon	894HC	894HC4HA
6	2 Gallon	894HC2	894HC5HA

Glass Liners 2000 and 1000 mL Sizes
Temperature Limit: 565 ˚C

PTFE Liners 2000 and 1000 mL Sizes
Temperature Limit: 225–250 ˚C

Liquid Sampling



Sample Collection Vessel

A sample collection vessel can be added to most reactor systems. Designed to efficiently and safely allow for the withdrawal of liquid or vapor samples at elevated temperatures and pressures, this quick close, O-ring seal vessel has a volume of 5 mL or 10 mL and is designed for operating pressures to 3000 psi (200 bar).

The typical arrangement for this sample vessel includes a cooling sleeve, isolation and vent valves. A drain valve may also be added to the vessel.

The isolation valve is mounted at the head of this vessel and is used to seal the vessel once the sample is transferred. The vent valve is installed in a tee and is used to release any residual pressure in the line between the sample valve and the sample vessel. Samples can be removed either by opening the collection vessel and pouring it out or by use of the drain valve.

Standard material of construction is T316 Stainless Steel but it can be provided in any of the other alloys if required. A high pressure 25 mL or 75 mL sample collection vessel without a cooling sleeve for pressures to 5000 psi is available upon request.

Sample Collection Vessels

Part No.	Description
4351	Sample Collection vessel, 10 mL, with cooling sleeve, isolation & vent valves for connection to 1/8" NPT valves
4352	Sample Collection vessel, 10 mL, with cooling sleeve, isolation & vent valves for connection to 1/4" NPT valves
4353	Sample Collection vessel, 10 mL, with cooling sleeve, isolation & vent valves for connection to 3/8" NPT valves
-D	Optional Drain Valve

4878 Automated Liquid Sampler

A safe and reliable method for collecting multiple liquid samples from heated and pressurized reactors has been sought for many years. Parr Instrument Company is pleased to introduce the Parr 4878 Automated Liquid Sampler which can extract up to six liquid samples at a user-defined interval without the need for the continued presence of an operator. Controlled through a user-friendly touch screen, a series of precision switching valves allows collection and deposition of samples with consistent volumes into individual vials. The 4878 can operate up to the maximum working pressure of all standard Parr reactors and pressure vessels. A multi-step loop sequence ensures clearing of the reactor dip tube between samples to yield samples representative of the bulk reactor fluid.

Features include:

- Touch screen controller with easy-to-navigate graphical displays
- Compact footprint 14-in wide x 16-in deep (35cm x 40cm)
- Stand alone design compatible with any new or existing Parr reactors and pressure vessels
- User-definable parameters including time between samples, number of samples, and number of loop sequences
- Various sample loop volumes available to accommodate a wide variety of sampling scenarios
- Capability to connect with mobile devices on both iOS and Android platforms
- Possible customizations include: design for use in hazardous locations, increased number of samples, special alloy components. Contact Parr Technical Service for additional options to fit your requirements.

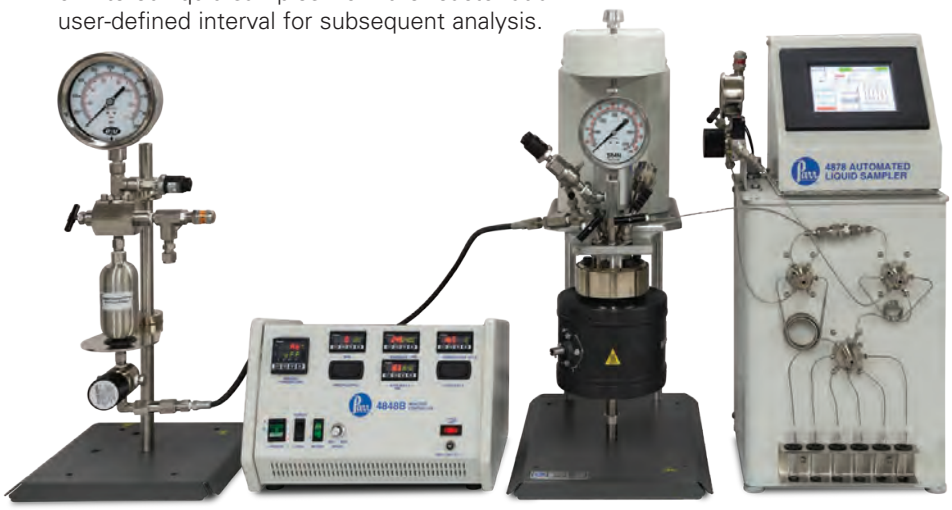
Filtered Dip Tubes

To assure you collect only liquid from a vessel, the solids must be removed. Parr recommends press-on filters, or in some instances screw-on filters, at the end of the dip tube to remove solids from the liquid sample. These sintered metal filters are available in a variety of materials, with a variety of nominal pore sizes, often from 0.5 microns to 40 microns. Most of these filters have a relatively small filtration area, so the user should consider how long it will take for a sample of desired volume, viscosity, and solids content to be collected in a sampling device. If clogging of a press-on filter is a possibility, Parr recommends purchasing a second easy-to-install complete filtered dip tube as the filters are factory-installed and not easily replaced in the field. Screw-on filters are field-replaceable and have a larger surface area, but due to their larger size usually only supplied for use with 1 Liter and larger vessels.

Catalyst Testing System

2280 Burette, 4566 Reactor with 4848 Controller, and 4878 Automated Liquid Sampler

The recent introduction of Parr's 4878 Automated Liquid Sampler has allowed the construction of a complete system for activity/kinetic testing of catalysts in a high pressure, high temperature environment. In the system shown, a Parr 2280 Gas Burette with 50 mL reservoir delivers H_2 at a user-settable, constant pressure to a 4566 300 mL stirred reactor. Operation at up to 180 bar at up to 350 °C is possible. A Parr XCAD (eXternal Catalyst Addition Device) allows introduction of solid/powder catalyst to the liquid contents of the reactor **at reaction pressure and temperature,** setting t=0 for kinetic experiments. An included gas entrainment impeller provides for high speed three phase mixing. A Parr 4878 Automated Liquid Sampler allows unattended collection of filtered liquid samples from the reactor at a user-defined interval for subsequent analysis.



Bottom Drain Valves

A465VB Bottom Drain Valve

Bottom drain valves can be added to most Parr reactors. These valves are particularly useful for those working with polymers or other material that must be discharged from the reactor while they are still hot and before they can solidify. These valves are also quite useful for the 1 gallon and larger vessels which are too large to conveniently lift from the heater for product recovery. Bottom valves are rarely installed on the micro and mini reactors with their small volumes and light vessel weights.

The standard bottom drain valve has a rising stem, that is flush with the inside cylinder bottom so that there is no dead space between the bottom of the vessel and the shut off point of the valve. In the fully open position the stem is retracted completely to open a clear passage for draining the vessel.

When the valve is reclosed, any material in this passage will be pushed back into the reactor by the rising stem. Valves with 3/8" diameter clear passage are recommended for vessels with volumes from 1000 mL to 2 gallons. A 1/4" valve is available for 600 mL and smaller vessels. High pressure and larger diameter valves are available where required.

These valves will withstand the full operating pressures and temperatures of the vessels in which they are installed in the closed position. They are available in all of the current Parr materials of construction. Users can also specify that a reactor ordered with a bottom valve shall have a tapered bottom so that it will drain easily through the valve opening.

Not all Parr reactors will accept a bottom drain valve. Since the valve extends approximately 8 inches below the bottom of the vessel, the entire vessel must be raised by this amount to accommodate the valve. This makes some models too tall for convenient bench top operation. The specification tables for each model will identify those reactors in which a bottom drain can be readily installed, and those which will not accept a bottom drain, or those which will require custom modification of the heater and support stand to accommodate a bottom valve.

Bottom Drain Valves

Part No.	Opening Dia., in.	Outlet Connection	Max. Press., psi	Max. Temp, °C	Seal
A485VB	0.20	1/4" NPT (F)	3000	225	PTFE
A485VB2	0.20	1/4" NPT (F)	3000	350	Silver
A485VB3	0.20	1/4" NPT (F)	3000	350	Silver
A465VB	0.34	3/8" NPT (F)	2000	350	Grafoil
A465VB2*	0.34	3/8" NPT (F)	2000	350	Grafoil
A465VB3	0.34	3/8" NPT (F)	2000	350	Silver
A177VB2	0.31	3/8" NPT (F)	5000	500	Silver
A296VB2	0.69	1" NPT (F)	1900	350	Silver

* Set up for a Band Heater.

Needle Valves and Ball Valves

Needle valves and ball valves can also be installed as bottom outlet valves. Needle valves are generally used on the smaller reactors. While ball valves can be used for large discharge passages, they are generally limited in their operating temperature/pressure capabilities and they leave a fairly large dead space between the bottom of the vessel and the seat of the valve.

Valves and Fittings

Parr stocks and can install a wide variety of valves and fittings for use with reactors and pressure vessels. These include:

- Needle Valves with NPT or tube connection.
- Regulating Valves with NPT or tube connection.
- Ball Valves with NPT or tube connection.
- High Pressure Valves
- Severe Service Valves
- Remote Operating Valves
- Tube Connectors
- Pipe Connectors
- Plugs
- Union Coupling Adapters

Please contact our customer service department for details.

Manual Control Valves for Compressed Gas Tanks

Tank valves with couplings to fit standard compressed gas cylinders are available in stainless steel for corrosive gases and in nickel plated brass for non-corrosive gases. The brass valves have a 2-1/2" diameter pressure gage which shows the tank pressure. Both styles have a 1/4" NPT female outlet which will accept any pressure hose or gas tube assembly. These valves do not regulate the delivery pressure of the gas. Pressure regulators are available on special order.

T303 Stainless Steel Valves-No Gage

Fits CGA Tank Valve No.	Outlet No.	Typical Usage
A120VBPN	510	Propane, butane, ethylene oxide
A120VBPP	660	Chlorine, sulfur dioxide, nitric oxide

Nickel-Plated Brass Valves with Cylinder Pressure Gage

Fits CGA Tank Valve No.	Outlet No.	Typical Usage
A120VBPQ	320	Carbon dioxide, methyl bromide
A120VBPR	350	Hydrogen, carbon monoxide, ethylene
A120VBPS	540	Oxygen
A120VBPT	580	Nitrogen, argon, helium
A120VBPU	590	Air

Note: Can be furnished with DIN/BSP connections on special order

Safety Check Valves

364VB Check Valve

Whenever gases or liquids are introduced into a vessel under pressure, the supply pressure must be greater than the pressure in the vessel to prevent reverse flow back into the supply system. Protection against reverse flow can be obtained by installing a check valve in the supply line. With a check valve in the line, the valve will snap shut if the supply pressure is lower than the pressure in the vessel. This protection is particularly important on stirred reactors where gas enters through a dip tube. With liquids in the vessel, any back pressure will force liquid back into the gas tank or into the gas supply system.

Parr stocks the poppet check valves for incorporation into the user's supply lines. These valves are typically constructed of T316SS with FKM O-rings with a 10 psi cracking pressure. Alternate O-ring materials and cracking pressures are available upon request.

Pressure Hoses

A506HC
Pressure Tube

A490HC
Pressure Hose

A495HC Pressure Hose

Three different pressure hose assembles are available for high pressure gas connections to both stirred and non-stirred vessels. The standard hose is a 6 foot length with a male "A" socket connector on one side and a 1/8" NPT (M) nipple with a 1/4" NPT (M) bushing on the other end. The "A" socket side of the hose attaches to couplings installed on the inlet valve of all stirred reactors and non-stirred vessels, as well as to a side port of the gage block assembly. The choice of either 1/8" NPT or 1/4" NPT on the opposite end of the hose allows for attachment to most gas tank valves, pressure regulators or other gas supply sources.

The A495HC Hose Assembly is made of nylon. It is rated for 2500 psi and is very flexible and easy to use with dry, non-corrosive gases (nitrogen, hydrogen and oxygen). Care must be taken to ensure that the nylon hose does not come in direct contact with any hot surfaces on the vessel or heater. One of these hoses is included with each complete Parr Series 4500, 5100, and 5500 Stirred Pressure Reaction Apparatus.

The A490HC Hose Assembly is a braided, stainless steel hose with a PTFE lining, rated for 2500 psi. It is reasonably flexible and recommended for use with corrosive gases and liquids, and for applications requiring additional abrasion resistance, but it is not intended for high temperature liquids or gases.

The A506HC Tube Assembly is a 6-foot length of 1/8" OD stainless steel tubing, rated for 7500 psi. This small diameter tubing is "bendable", but it is not as flexible as the other hoses. It is recommended for corrosive gases, high temperature transfers and other high pressure applications. Special versions of this assembly can be made of other corrosion resistant materials. Larger tubing can be used, but it is rigid rather than flexible.

Special hoses with different lengths or end fittings can be assembled for special orders.

Pressure Hose	
A495HC	Pressure Hose Assembly, 6-ft, reinforced Nylon
A495HC5	Pressure Hose Assembly, 6-ft, reinforced Nylon, with check valve
A495HC7	Pressure Hose Assembly, 10-ft, reinforced Nylon
A495HC8	Pressure Hose Assembly, 10-ft, reinforced Nylon, with check valve
A490HC	Pressure Hose Assembly, 6-ft, PTFE-lined, braided stainless steel
A490HC5	Pressure Hose Assembly, 6-ft, PTFE-lined, braided stainless steel, with check valve
A506HC	Pressure Tube Assembly, 6-ft, 1/8-in OD, T316SS
A506HC2	Pressure Tube Assembly, 6-ft, 1/8-in OD, T316SS, with check valve

Alternate lengths available upon request.

Thermocouples

Parr offers a variety of thermocouples for use in our reactors and pressure vessels. The standard thermocouple is a Type J (iron-constantan) which is compatible with the operating temperature range of these vessels.

The thermocouples are furnished with a sealed 1/8" OD stainless steel sheath and include a standard plug connection at the end of the probe. Our standard thermocouples are manufactured in accordance to ASTM E230.

Alternate thermocouple materials including Alloys C276 and 600 are readily available. Platinum resistance elements (3-wire RTD) are available as special orders as well as multiple point thermocouples.

Most commonly, in small volume vessels the thermocouple probe is installed directly into the vessel with a compression fitting and in larger vessels the probe sits inside a thermowell. The thermowell arrangement offers protection to the thermocouple from physical damage. We also furnish thermowells in vessels manufactured in materials other than stainless steel so the thermowell will be the alternate alloy and the thermocouple probe can be stainless steel.

Additionally, dual element thermocouples with two separate thermocouples in a single sheath are furnished in smaller volume vessels for use with accessory temperature meters. We also offer spring loaded thermocouples which are designed to be installed through the heater wall to the outside wall of the pressure vessel.

An extension wire is furnished to connect the thermocouple to the control device. The standard length is 5 feet but longer lengths are available if the control is to be mounted away from the reactor.

Type J Thermocouples with 1/8" Diameter		
Part Number	**Stem Length, in.**	**Sheath Material**
A472E	7.5	T316 Stainless Steel
A472E2	9.5	T316 Stainless Steel
A472E3	11.5	T316 Stainless Steel
A472E6	15.5	T316 Stainless Steel
A472E5	21.5	T316 Stainless Steel
A472E4	5.5	T316 Stainless Steel
A472E8	2.5	T316 Stainless Steel

Most of the above listed thermocouples are also available as Type K (Chromel-Alumel) or Type T (Copper-Constantan).

Equipment for Use in Potentially Ignitable Atmospheres

Parr reactors are typically equipped with totally enclosed variable speed motors, electric heaters, and controllers intended for use in non-hazardous environments. These standard units can be used in most laboratories without undue hazard, but there will be situations where the installed equipment must be considered for use in ignitable atmospheres. Parr offers various optional stirrer drives and heating solutions to meet these strict requirements.

USA and Canadian Codes (HAZLOC – Hazardous Locations)

Designing electrical equipment to be operated in hazardous locations is a complex subject, which is governed by extensive national electrical codes and supplemented by local regulations. These codes require all electrical equipment that is installed in a governed location must be approved for use with the specific gas, vapor, or dust that can be present in the defined location. USA and Canadian electrical codes classify hazardous locations according to the nature and concentration of specific hazardous or flammable materials. These are divided into three classes:

- **Class I –** Flammable liquids, gases or vapors.
- **Class II –** Combustible or electrically conductive dusts.
- **Class III –** Easily ignitable fibers/flyings.

There are two divisions within each of these classes.

- **Division 1 –** Where the flammable material exists in the atmosphere under normal operating conditions.
- **Division 2 –** Where the hazardous material is confined within a closed system from which it may be released only under abnormal conditions, such as a gas leak in the system.

Class I locations are further subdivided into four groups, A, B, C and D which identify specific explosive gases and vapors. Explosive dusts and fibers in Class II are subdivided into Groups E, F and G. Most hazardous applications for Parr apparatus will occur in atmospheres identified by Class I, Group B for hydrogen and Groups C and D for most other combustible gases and vapors. Class II, Group F covers coal dust. Most other combustible dusts, such as flour and grain, are in Group G. Minimum ignition temperatures and energy levels are established for specific materials in each group.

The European Community has corresponding classifications for "Explosive Atmospheres" referred to as ATEX (ATmospheriques EXplosives). Parr will work with all users to provide equipment compatible with their own local codes.

The components in Parr reactor systems that may be considered hazardous and the steps that can be taken to reduce or eliminate the hazards they represent are described below.

Motors

Because of sparking from brush contacts, permanent magnet DC electric motors clearly represent the principal ignition source introduced by a stirred reactor. Electric motors approved for Class I (Divisions 1 & 2), Groups C and D, and Class II (Divisions 1 & 2), Groups F and G atmospheres are readily available in most sizes and voltages. These totally enclosed motors are suitable for many hazardous applications, and they are sometimes used with hydrogen, though they are not approved for Group B atmospheres. Currently, there are no Division 1 motors available for Group A or B atmospheres. A special air purging system can be used to reduce the classification inside the motor. The motor is pressurized by building up a positive pressure of air, or inert gas, within the motor to prevent explosive gases or vapors from entering the motor housing.

Model 4524 Reactor, 2000 mL, Fixed Head Style with Aluminum Block Heater

Division 2 requirements are not as stringent. Other motor options are available. Please contact Parr for additional information for Class I, Division 2 requirements.

Parr can provide ATEX rated, IEC framed, AC motors when required. These constant torque motors have lower speed and torque characteristics than the DC motors Parr has used in the last several years.

An alternate method of dealing with the explosion hazard is to use an air driven motor. These are powered by compressed air and offer a convenient and satisfactory drive system for use in flammable atmospheres, including hydrogen. They are available in sizes suitable for most Parr reactors.

Heaters

The advisable way to heat a Parr reactor in a potentially ignitable atmosphere is to use a hot oil jacket and ensure that the highest temperature of the heat transfer media is below the minimum ignition temperature for the classified area in which it will be installed.

Purging Parr's aluminum block heaters with air, as well as limiting surfaces temperatures below the auto-ignition temperature, can make them suitable for use in classified areas, but it is likely that the air consumption in such heaters will be quite large. Please see our Heaters section on page 116 for additional information.

Wiring

Parr will provide ordinary location wiring for motors and heaters, which can be used for initial testing, setup, etc. Due to national and local requirements for installation of such equipment, it is the user's responsibility to install mains and motor wiring per code requirements.

Parr will provide wiring for intrinsic safety related sensors, transducers, etc. For application specific information on sensors for use in hazardous locations, please contact Parr Instrument Company.

Controllers

The most commonly used method for dealing with the ignition hazard introduced by a temperature or process controller is simply to locate the controller outside of the hazardous atmosphere. Another choice is to install the controller in an explosion-proof cabinet or a cabinet that can be purged using the purging system described above.

Air Motor

Windows

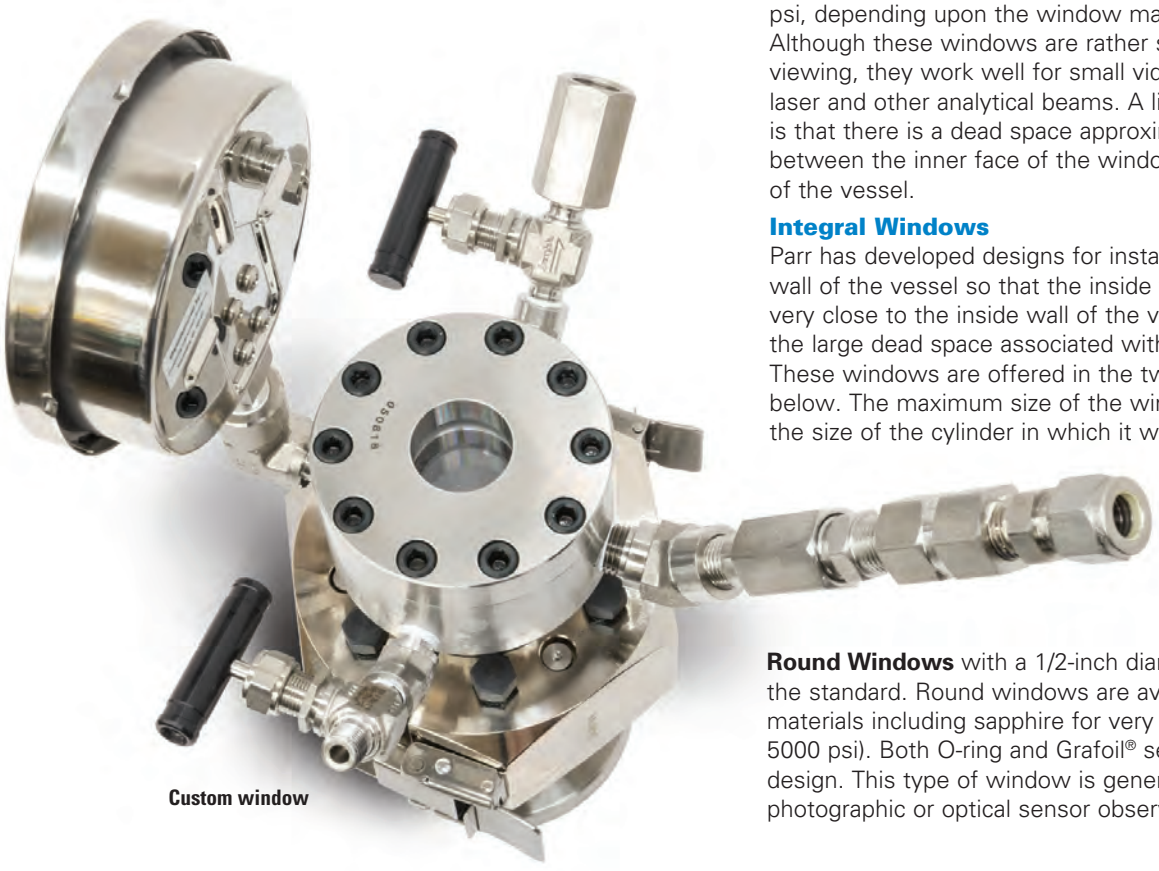
Round, screw-in window

Round, integral window

Custom window

Oblong window

Windows can be installed in Parr stirred reactors and pressure vessels for visual observations, light transmission and other purposes. They usually are installed in pairs so that light can be introduced through one window while the other is used for viewing. Our standard material for these windows is fused silica. Sapphire is also available for small diameter windows. Alternative window materials (with coatings, if requested) are available for specific transmission requirements. Windows can be mounted in several different ways.



Custom window

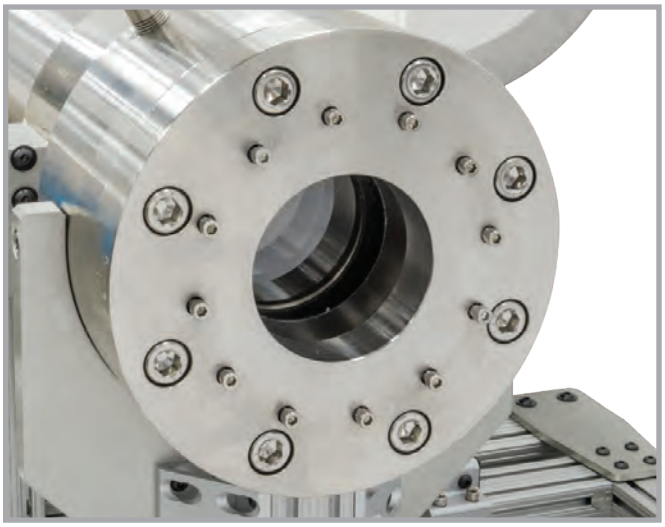
Screw-in Circular Windows

The simplest window is a screw-in type with a ½-inch diameter viewing area. The windows in these assemblies are sealed in a fitting which screws into the vessel using a standard ½ inch NPT male pipe thread. Obviously, the vessel wall must be thick enough to provide full engagement for this thread. O-ring seals restrict the maximum operating temperature to 225 °C or less, depending upon the O-ring material. Alternatively, a Grafoil® gasket seal option is available to increase temperature rating up to 350 °C. Pressure ratings range from 1900 to 5000 psi, depending upon the window material and its thickness. Although these windows are rather small for straight optical viewing, they work well for small video systems and for laser and other analytical beams. A limitation of this design is that there is a dead space approximately 1.25 inches long between the inner face of the window and the inside wall of the vessel.

Integral Windows

Parr has developed designs for installing windows in the wall of the vessel so that the inside face of the window is very close to the inside wall of the vessel. This eliminates the large dead space associated with screw-in windows. These windows are offered in the two styles described below. The maximum size of the window will depend on the size of the cylinder in which it will be installed.

Round Windows with a 1/2-inch diameter viewing area are the standard. Round windows are available in a variety of materials including sapphire for very high pressures (up to 5000 psi). Both O-ring and Grafoil® seals are available in this design. This type of window is generally used for visual, photographic or optical sensor observations.



Flange-mounted larger window

Oblong Windows with a viewing area 3.5-inch long and 0.62-inch wide are the standard size and can be installed on 4590/4790 vessels of 100 mL volume or 4560/4760 vessels of 450 mL volume and larger. Only O-ring seals are available in this design. Both Fused Silica and sapphire windows are available – maximum rating for these windows are limited to 1900 psi at 225 °C with FKM or FFKM seals. These windows are commonly used for visual observations of both the vapor and liquid phases or for observing the liquid level in the vessel. Multiple windows can be stacked or staggered on larger vessels.

The windows described above as standard are maintained in our inventory for readily available replacements. Custom windows in both the round and oblong styles can be furnished in larger sizes upon request. All reactors and pressure vessels equipped with windows require custom designed heaters and supports. Flexible heating mantles, integral cartridge heaters, and attached circulating jackets (600 mL mini and larger) are the most commonly used heaters for window vessels.

Externally Welded/Flange Mounted Larger Windows

Large round windows that are either externally welded or flange mounted to the vessel can be installed. These will provide a viewing area of 1-3/4-inch to 7-1/4-inch depending on the size of the window ordered and the size of the vessel. Externally welded windows greatly reduce the maximum working pressure of the vessel to 600 psi or less, although custom configurations rated higher are available.

Certification

The windows described above are considered "proprietary fittings" and as such are excluded from the scope of ASME Section VIII Division 1.

Most of the standard windows furnished by Parr can be installed on vessels bearing the CE mark. The windows furnished on these vessels are subjected to various tests on a per lot basis in order to satisfy requirements of 2014/68/EU (Pressure Equipment Directive). Please contact Parr Instrument Company for further information.

Insulated Electrical Glands

A variety of insulated electrical leads can be installed in most Parr reactors or pressure vessels for electrical connections required inside the vessel. Four commonly used examples are discussed below.

Transducer Glands

Transducer glands are available to allow up to 16 individual wires to be sealed and insulated through a single gland. These types of glands are typically used with low voltages and current.

Electrode Glands

Applications requiring a single electrical conductor having high current or very high voltage capacities can be handled with an electrode gland. These glands provide a seal for a single conductor or electrode with the ends of the conductor threaded so that internal and external lead wires can easily be attached.

Power Leads

Power leads can be provided with either single or multiple flexible wires. Current ratings range from 5 to 20 amperes at up to 600 volts. PTFE or ceramic insulating glands are commonly available. Ceramic glands can be used to the full temperature rating of most Parr vessels. Pressure ratings will vary depending upon the design of the gland, its size, and the type of insulation used.

Miscellaneous Sensors

Parr has installed a number of different sensors in its various reactors and pressure vessels, including single point and continuous liquid level sensors, pH electrodes, and dissolved oxygen electrodes. Each of these installations must be carefully developed in consultation with the user, the electrode or probe supplier, and Parr's Engineering Department. Glass electrodes with O-ring seals will obviously carry rather strict temperature and pressure restrictions. There are also space restrictions which generally dictate that accessories of this type can only be installed in 1000 mL or larger vessels.

Spare Parts Kits

Each stirred reactor is furnished with a set of spare parts and fittings including a 6-foot gas supply hose, head gaskets, rupture discs, and a set of replacement parts for the stirrer drive.

A reserve supply kit of spare parts can be ordered from Parr Technical Service to provide sufficient parts and tools to handle most normal replacements and emergency repairs during the first year of heavy usage. These kits include replacement gaskets, O-rings, rupture discs, drive belts, and seals. These kits are a convenient package of the small perishable items required for normal maintenance of the reactor.

When ordering any kit for an existing reactor please provide the serial number, specify the preferred gasket/seal material, the burst pressure of the rupture disc, material of the reactor, and the length of the drive belt.

Temperature Limits

There are a number of factors that determine the maximum temperature rating of a pressure vessel. For most applications it is the gasket material. Vessels with O-ring seals are limited to 225 °C and those with FKM or FFKM are limited to 300 °C. Parr's design for contained PTFE gaskets extends the operating temperature range to 350 °C. Flexible Graphite (FG) material essentially removes the gasket as the limiting factor. Maximum temperature limits for the metals used in these vessels are established by ASME code and other standards. Most metals have maximum temperature limits between 400 and 800 °C. The allowable strength for these metals falls off rapidly as they reach maximum operating temperature. Finally, the difficulties encountered with screw threads and other closure components operating at high temperatures establish a practical temperature limit for externally heated vessels. We have found 600 °C to be a reasonable limit.

Internally Heated Vessels

Exposed Heaters. Another approach that has proven useful in extending the maximum temperature limit is to place the heater inside the pressure vessel. The heater is surrounded by a layer of insulation. This creates a hot zone in the center of the vessel and prevents the walls from exceeding their allowable limit. As this system is very energy efficient, internal heaters can be less powerful than external heaters. Internally heated vessels are equipped with insulated electrical feed-throughs to power the heater. Multiple thermocouples are used to control or monitor the temperatures in the hot zone and on the vessel inner wall.

The reactions or studies carried out in internally heated vessels must be limited to those which will not destroy the exposed internal heaters and insulation. These are normally gas-solid reactions or controlled atmosphere heat treatment studies. The heating elements are normally ceramic. Some users have developed induction style heaters and insulators and have extended their investigations to above 2500 °C.

Although internal heaters can be installed in almost any non-stirred Parr pressure vessel, vessels with larger I.D.s are required in most applications.

Protected Heaters. Internally heated vessels have also been manufactured with cartridge type heating elements inserted in specially designed "heater wells". These wells protect the heater from the reactants and expand the applications that can be studied. Cartridge type heaters have a maximum temperature of 760 °C.

External Valves and Fittings

Materials of Construction

In the standard configuration, the valves, gage, magnetic drive, and other external parts on Parr reactors are furnished in stainless steel, even when a different material is specified for the head, cylinder, and internal wetted parts. The external stainless components are typically only exposed to the vapor of the reactants and are at much lower temperature than the cylinder and internal fittings. These conditions allow stainless steel external fittings to perform satisfactorily in most cases. If external parts made of a material other than stainless steel are required for safety or other reasons, Parr can accommodate this in most cases. Any request for external parts made of a specific material must be stated clearly when ordering.

Valves

Most reactor valves are also available in Alloy 400 at a reasonable cost premium. Valves made of Alloy C-276 are also available, but generally only on special designs and at a considerable cost premium. Soft materials such as titanium and zirconium generally make poor performing valves.

Gages

Pressure gages are available in stainless steel and Alloy 400. Other materials of construction are not available. The standard method for protecting the gage in a corrosive environment is to install a diaphragm gage protector. These have a flexible diaphragm which isolates the gage from the reactants and a sealed hydraulic connection for pressure transfer to the gage. These assemblies are too large to install on all but the largest Parr reactors. The diaphragm assemblies are large and may not be practical on small reactors.

As an alternative, Parr has designed an oil filled piston isolator gage protector to isolate the gage (and transducer, if required) on reactors and pressure vessels where space is limited. These isolators can be furnished in any of the current Parr materials of construction. A piston style isolator can limit the precision the pressure measuring device.

Pressure Transducers

Pressure transducers are commonly available in stainless steel and Alloy C-276 though other materials may be available. Parr provides a mounting adapter with a water cooling jacket on pressure transducers to protect them from excessive temperatures. These can be augmented with isolators similar to gage protectors when corrosion resistance is required. When a gage and a pressure transducer are installed, a single isolator can protect both.

Magnetic Drives

Magnetic drives can be furnished in all of the current Parr materials of construction except nickel, which is magnetic.

Rupture Discs

The standard materials of construction for rupture discs is Alloy 600, gold-faced Alloy 600, and Alloy C-276. Tantalum and other premium materials are available on special order.

Please see the Safety Rupture Disc Assemblies manual 231M for available rupture discs.