Stirred Reactors and Pressure Vessels

Designing and Building Quality Pressure Apparatus for Over 100 Years



Chapter 1

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This pdf is chapter one of our Catalog 4500. Please refer to all five chapters to make the proper equipment choice for your needs.

Catalog Organization

We have arranged this catalog in a manner which will lead you to descriptions and specifications for a wide range of Parr Laboratory Reactors and Pressure Vessels, all offered with many optional fittings and attachments. There are many choices to be made. For example, when selecting a stirred reactor, we offer:

Twenty-five different Vessel Sizes
Three different Working Pressure Ranges
Two different Head Sealing Systems
Two different Vessel Mounting Styles
Eleven different Materials of Construction
Seven different Stirrer Drive Motors
Six different Magnetic Couplings
Various heaters, cooling coils, stirrers, options and accessories.

We hope that from these choices you will be able to select a system that is ideally matched to your reaction and installation requirements.

The catalog itself is divided into five color-coded sections:

The **Blue Section** of the catalog contains descriptive information on some of the major design features, components, and options for Parr reactors and vessels.

The **Green Section** contains detailed specifications and ordering information on all Parr stirred reactors. Additional tables in this section will help you compare different models and options.

The **Brown Section** describes various optional fittings and custom modifications available for Parr stirred reactors. Many of these options are also applicable to non-stirred vessels as well. Also included in this section is information on complete reactor systems which can be assembled to your specifications.

The **Red Section** describes the Parr Series 4830 and 4840 Temperature Controllers with various options, and the new Parr 4870 Process Controller, all of which can be used in both stirred and non-stirred systems.

The **Orange Section** describes an extensive list of non-stirred, general purpose pressure vessels together with appropriate heaters and fittings.

Table of Contents

The Catalog is Only the Beginning

What we have not included in this catalog is as important to you as what we have shown. We refer here to the long-established practices and policies of Parr Instrument Company that have helped to build our reputation as a reliable supplier in our specialized field, such as:

Delivery

A commitment to prompt and dependable delivery schedules for not only catalog items, but also for custom equipment as well. Typical delivery time for catalog reactors constructed of stainless steel is two to four weeks. For special alloys and custom modifications, plan for 4 to 8 week delivery. For systems or orders requiring extensive custom design work allow 8 to 12 weeks. Of equal importance over the life of your reactor is our commitment to maintain commonly used replacement and service parts in stock for same day shipment.

Communication

A commitment to listen to our customers and a willingness to make the additions or changes in a reactor or pressure vessel that the customer may want or need. Approximately 40 percent of all the reactors and vessels we ship are modified in some way over-and-above the options listed in this catalog. Special valves, special head layouts, electrical leads, special stands, additional openings, unique motors, and non-standard materials of construction are just a few of the modifications we work with every day.

Investment

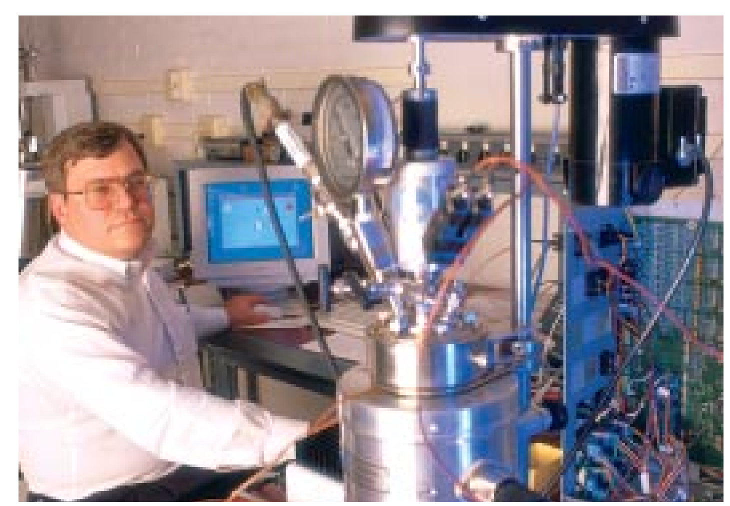
An investment in modern machine tools and superior production management methods enables us to make available not only all of the options listed on the following pages, but also to handle custom orders for one-of-a-kind designs along with regular production orders on a routine basis.

Service

A commitment to maintain commonly used replacement and service parts in stock for same day shipment.

Support

A technical sales and support staff with an average of over 20 years of experience in this specialized field. We have “been there and done that” and we are looking forward to helping you solve your unique requirements.

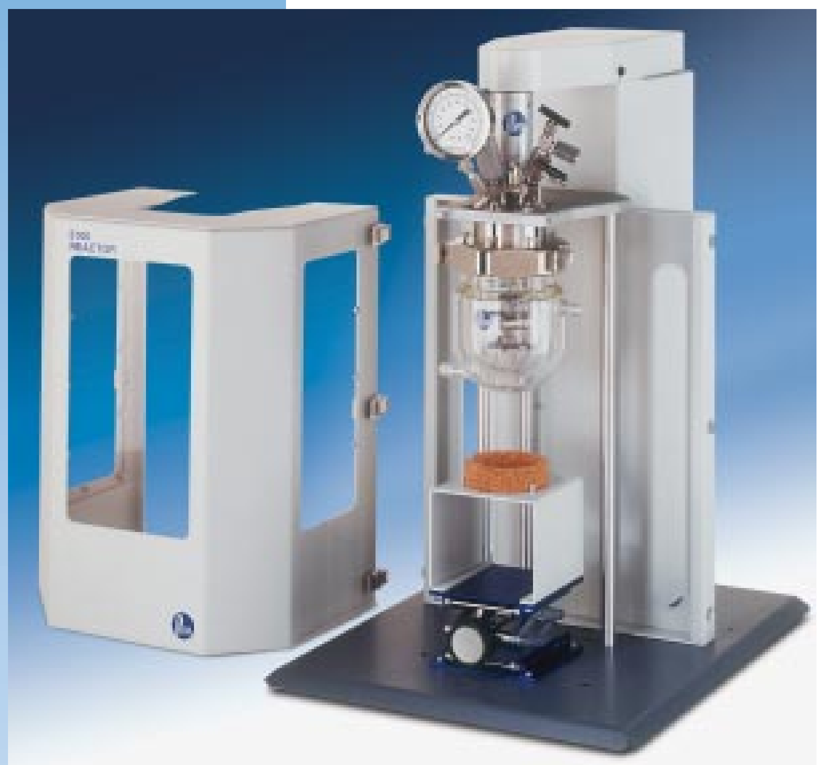


Research

A commitment to new materials, manufacturing methods, research disciplines, and computer advances to continue our leadership position.

New Products and Designs

We call your attention particularly to:



Pg. 70 **New Low Pressure Glass Reactors** with volumes from 160 mL to 1.5 liters. Jacketed glass vessels rated for pressures up to 10 atmospheres and temperatures to 225 °C. Vigorous internal stirring, with full reaction controls. Interchangeable metal vessels provide for operating pressures up to 65 atmospheres. A wide variety of options are available for heating, explosion proof operation and control.

Pg. 9 Parr Instrument Company's Quality Assurance, Quality Control, and Compliance Management System has been certified to **ISO 9001 – 2000**.

Pg. 10 Parr Instrument Company is authorized to design, manufacture, test, and certify pressure vessels for compliance to the **European Community Pressure Equipment Directive.**

Pg. 62 This **New Multiple Reactor System** provides six – 45 or 75 mL stirred reactors with individual temperature control, continuous pressure monitoring, computer control and data logging of all relevant information. This system provides operating pressures to 3000 psi (200 bar) and operating temperatures to 300 °C. This system has been developed for high throughput testing and combinatorial investigations. Either simple or elaborate gas handling and measurement systems are available.

Pg. 66 **New Compact Laboratory Reactors** include a High Pressure Reactor, an aluminum block heater, a stirrer drive motor, and an automatic PID temperature controller designed for operating pressures to 3000 psi at temperatures to 350 °C. This compact reactor package takes up less than one square foot (900 cm^2) of bench top space. Reactors are available with volumes 25 to 600 mL. These reactors feature a new compact magnetic drive with an integral variable speed motor.

Pg. 87 New **Gas Dosing System**: an automatic device for measuring total gas consumption in a high pressure reaction. Precision is not dependent upon reaction or flow rates in this PC-based system.

Pg. 110 **A new computer-controlled process controller** is offered which can provide an integrated control system for either a single reactor with multiple feed and product controls and/or multiple reactors operating either in parallel or independently. Provisions are made for up to 96 digital and/or analog inputs and outputs. Up to 8 reactors can be controlled by a single controller. Easily configurable SCADA and GUI software packages are included.

The User's Responsibility

All Parr reactors and pressure vessels are designed and manufactured with great care to ensure safe operation when used within their prescribed temperature and pressure limits. But… the basic responsibility for safety when using this equipment rests entirely with the user; who must:

1. Select a reactor or pressure vessel which has the capability, pressure rating, corrosion resistance and design features that are suitable for its intended use. Parr engineers will be glad to discuss available equipment and material options with prospective users, but the final responsibility for selecting a reactor or pressure vessel that will perform to the user's satisfaction in any particular reaction or test must rest with the user - not with Parr.

   In exercising the responsibility for the selection of pressure equipment, the prospective user is often faced with a choice between over or under-designed equipment. The hazards introduced by under-designed pressure vessels are readily apparent, but the penalties that must be paid for over-designed apparatus are often overlooked. Recognizing these criteria, Parr reactors and pressure vessels are offered in several different styles, each designed for convenient use in daily operation within certain temperature and pressure limits, using gaskets, closures and other elements carefully selected for safe operation within the limits specified for that design. But in order to preserve the validity of these designs, all temperature and pressure limits must be observed, and no attempt should be made to increase these limits by making alterations or by substituting components which are not recommended by the manufacturer.

2. Install and operate the equipment within a suitable barricade, if required, with appropriate safety accessories and in full compliance with local safety codes and rules.

3. Establish training procedures to ensure that any person handling the equipment knows how to use it properly.

4. Maintain the equipment in good condition and establish procedures for periodic testing to be sure the vessel remains structurally sound.

Design Features

Design Codes and Certification

Design criteria specified in the ASME Code for Unfired Pressure vessels are closely observed in the manufacture and testing of all Parr pressure equipment. Cylinders for each reactor and pressure vessel of standard design are machined from solid, hot-rolled or forged bars of selected corrosion resistant alloys with no seams or welds in the vessel as potential sources of weakness or localized corrosion. Each individual cylinder is tested hydrostatically to at least 1.3 times its maximum rating, and each complete reactor and vessel is tested with nitrogen to be sure that it is leak-free and operating properly.

Protection against equipment damage and possible personal injury in case of an accidental over-pressurization is provided by a safety rupture disc installed in the head of each reactor and in each gage block assembly. A description of these safety discs and rules to be observed in their selection and use are given on page 84.

Quality Assurance

Parr Instrument Company has designed, installed and operates under a Quality Assurance Program which ensures that all aspects of the design, materials selection and procurement, manufacture, testing and certification of its pressure vessels are performed in accordance with accepted codes and practices. Currently this Quality Assurance Program has been certified to be in compliance with ISO 9001-2000 for Total Quality Procedures, ASME and European Community Pressure Equipment Directive (CE-PED) for pressure vessel design and testing, CSA for electrical safety and CE where appropriate.

ISO 9001-2000 Certification

Parr Instrument Company's overall Quality Assurance System has been certified to be in compliance with ISO 9001-2000 by TÜV. ISO 9001-2000 covers the overall quality assurance and management compliance aspects of Parr's activities as opposed to the certification of an individual product.

A Commitment to a Worldwide Market

In 1973, Parr Instrument Company made a commitment to serve customers on a worldwide basis in a reliable and continuing manner. Parr products were exhibited for the first time at Achema in Frankfurt, Germany that year. An extensive effort was initiated to select and train a network of local agents to provide technical sales and service support as well as import services in each of the countries where modern chemical research and development is conducted.

In 1982, Parr Instrument Company was awarded the *President's E Award for Excellence in Exporting* in recognition of our successful efforts in this area. In 1988, Parr was awarded the U.S. Department of Commerce's highest level award the *President's E Star Award for Excellence in Exporting* in recognition of our continuing and accelerating success in servicing the world market.

Today, Parr pressure reaction equipment is in use in over 80 countries and active exclusive agents are operating in 28 of these. Today, nearly half of all Parr pressure reaction equipment is exported from the USA. As a part of this expansion in the world market, international considerations are designed into, not added onto, all Parr equipment.

ASME Certification

The Parr Instrument Company holds a Certificate of Authorization issued by the Boiler and Pressure Vessel Committee of the American Society of Mechanical Engineers as an approved facility for manufacturing unfired pressure vessels. If required, any Parr reactor or pressure vessel can be Certified to the ASME Code, Section VIII, Division 1, which involves:

1. Vessel inspection and tests by an Authorized Inspector of the National Board of Boiler and Pressure Vessel Inspectors.
2. Issuance of Form U-1A, "Manufacturer's Data Report for Pressure Vessels", which provides certification of the chemical analysis and physical properties of materials used in the vessel.
3. Application of the ASME "U" Stamp to the vessel by the Inspector.
4. Registration of the vessel with the National Board.

There is an added charge for this special certification.

Parr is also certified under Section IX of the ASME Code for welding. Normally welding is done only to attach jackets or fittings to the primary vessel.

CE-PED Certification

The Parr Instrument Company is authorized to design, manufacture, test and certify vessels to European Community Pressure Equipment Directive (CE-PED) under authorization issued by TÜV Süddeutschland Bau und Betrieb GmbH. The additional charge for this certification will depend upon the special testing required.

Parr Certification

If requested, Parr will furnish a signed certificate listing the materials of construction used in the manufacture of an individual reactor or pressure vessel, the pressure tests applied to that reactor, material certificates and dimensional drawings. There is an added charge for this certification.

CSA Certification

Where appropriate, Parr reactors are manufactured and certified to the electrical code established by the Canadian Standards Association. Identification of those units for which CSA Certification has been received will be provided upon request. The CSA logo is shown on the nameplate of each CSA certified unit.

CE Certification

Where appropriate, Parr reactors will carry the CE Mark certifying compliance with the European Community Directives 89/336/EEC for EMC Compliance, and EC Directive 73/23/EEC for low voltage electrical safety.

Other National or Local Codes

Parr regularly works with other national, state or international authorities to obtain individual approval for specific vessels. The internationally recognized Quality Assurance Program in place at Parr and the experience of the Parr engineering department in working with these authorities makes it possible to obtain these approvals with little difficulty. It is the user's responsibility to identify any such applicable code so that these requirements can be met before the vessel is fabricated and delivered. Parr's network of international distributors are familiar with the applicable codes for pressure vessels within their countries of responsibility.

Materials of Construction

Parr reactors are normally made of Type 316 stainless steel, but they can also be made of other alloys as well. The list of available construction materials includes:

- Type 316/316L Stainless Steel
- Alloy 20Cb-3
- C1018 Carbon Steel
- Alloy 400
- Alloy 600
- Titanium Grades 2, 4 & 7
- Nickel 200
- Alloy B-3
- Alloy C-276
- Alloy C-2000
- Zirconium

Alloy Designation

Parr now uses alloy designation numbers to identify the various corrosion resistant alloys available for use in Parr reactors and pressure vessels. These alloys can also be identified by trade names and by ASTM, ASME, DIN and other specification numbers. Many of the high nickel alloys were originally patented and sold under trade names, such as Monel[1], Inconel[1], Incoloy[1], Carpenter Alloy[2], Hastelloy[3], etc. Most of the original patents have expired and these alloys are now materials of construction available from other reputable suppliers, as well as from the owners of the original trade names.

Among the many corrosion resistant alloys now available, there may be two or three with very similar compositions and intended for use in the same corrosive environment. In these cases, Parr will select and offer the most widely used alloy in each of the basic corrosion resistance categories, rather than catalog and stock all three.

Each of these alloys has its own physical strength and temperature characteristics as well as its own unique resistance to certain corrosive materials. All of these factors must be considered when making a selection, with cost and availability also becoming factors in the final choice.

The basic composition of these alloys is listed in Table I, and a procedure for estimating the maximum temperature and pressure limits for reactors made from these alloys is described in conjunction with Table II.

Corrosion resistance information can be obtained from various corrosion handbooks and metallurgical publications. Helpful information can also be obtained from the individual alloy manufacturers.

The Parr Instrument Company will attempt to answer questions regarding corrosion resistance and will suggest materials that might be suitable for specific applications, but no guarantee can be made that any particular alloy will be fully resistant to a prescribed set of corrosive conditions.

Any abridged listing of corrosion resistance of various metals and alloys can be potentially misleading since it can not possibly deal with all of the effects of concentration, temperature, pressure and the presence of additional ions, all of which have a significant effect upon the ability of a reactor to withstand corrosion. In addition, the vulnerability of any material to stress corrosion cracking, intergranular corrosion and pitting must also be considered when judging the suitability of a material for a particular application.

The principal characteristics of the several construction materials offered by Parr are summarized on the next page. These listings are intended to serve only as a starting point for any study of comparative corrosion resistance and physical properties. Material manufacturers booklets on each alloy are available on our website at www.parrinst.com. Additional details may also be obtained from other sources.

All Parr raw materials are carefully identified throughout the manufacturing process for traceability — as required by ASME and other codes.

[1] MONEL, INCONEL and INCOLOY are Registered Trademarks of Special Metals Corp.
[2] CARPENTER 20Cb-3 is a Registered Trademark of Carpenter Technology Corporation.
[3] HASTELLOY is a Registered Trademark of Haynes International, Inc.

Type 316/316L Stainless Steel

Type 316 Stainless Steel is an excellent material for use with most organic systems. A few organic acids and organic halides can, under certain conditions, hydrolyze to form inorganic halogen acids which will attack T316SS. Acetic, formic and other organic acids are routinely handled in T316SS. T316SS is not normally the material of choice for inorganic acid systems. At ambient temperatures it does offer useful resistance to dilute sulfuric, sulfurous, phosphoric and nitric acids, but sulfuric, phosphoric and nitric acids readily attack T316SS at elevated temperatures and pressures. Halogen acids attack all forms of stainless steel rapidly, even at low temperatures and in dilute solutions.

Although T316SS offers excellent resistance to surface corrosion by caustics, they can cause stress corrosion cracking in stainless pressure vessels. This phenomenon begins to appear at temperatures just above 100 °C and has been the most common cause of corrosion failure in stainless laboratory vessels. T316SS does offer good resistance to ammonia and to most ammonia compounds.

Halogen salts can cause severe pitting in all stainless steels. Chlorides can cause stress corrosion cracking, but many other salt solutions can be handled in stainless vessels, particularly neutral or alkaline salts.

At moderate temperatures and pressures, T316SS can be used with most commercial gases. In scrupulously anhydrous systems even hydrogen chloride, hydrogen fluoride and chlorine can be used in stainless steel.

Essentially all of the T316SS produced today also meets the specifications for T316L, low carbon stainless steel.

Alloy 20Cb-3

Alloy 20Cb-3 is an enriched grade of stainless steel, designed specifically for use with dilute (up to 30 percent by weight) sulfuric acid at elevated temperatures. It can also be used for nitric and phosphoric acid systems as well as for all systems for which T316SS is suitable.

Alloy 400

Alloy 400 is an alloy comprised essentially of two-thirds nickel and one-third copper. For many applications it offers about the same corrosion resistance as nickel, but with higher maximum working pressures and temperatures and at a lower cost because of its greatly improved machinability.

Table I

Nominal Chemical Composition of Pressure Vessel Materials

		Major Elements (Percent)					
Material	*Typical Trade Name*	*Fe*	*Ni*	*Cr*	*Mo*	*Mn*	*Other*
T316 Stainless Steel		65	12	17	2.5	2.0	Si 1.0
Alloy 20Cb-3	Carpenter 20	35	34	20	2.5	2.0	Cu 3.5, Cb 1.0 max
Alloy 400	Monel 400	1.2	66				Cu 31.5
Alloy 600	Inconel 600	8	76	15.5			
Alloy B-3	Hastelloy B-3	2	66	1	28	1	Co 1.0
Alloy C-276	Hastelloy C-276	6.5	53	15.5	16	1	W4.0, Co 2.5
Alloy C-2000	Hastelloy C-2000	3.0	54	23	16	0.5	Co 2.0, Cu 1.6
Nickel 200			99				
Titanium Grade 2			Commercially pure titanium			Ti 99 min	
Titanium Grade 4			Commercially pure titanium			Ti 99 min	
Titanium Grade 7				99			0.15 Pd
Zirconium 702			Zr + Hf 99.2 min Hf 4.5 max				
Zirconium Grade 705			Zr 95.5 min, Hf 4.5 max, Co 2.5				

Alloy 400 is widely used for caustic solutions because it is not subject to stress corrosion cracking in most applications. Chloride salts do not cause stress corrosion cracking in Alloy 400. It is also an excellent material for fluorine, hydrogen fluoride and hydrofluoric acid systems. Alloy 400 offers some resistance to hydrochloric and sulfuric acids at modest temperatures and concentrations, but it is seldom the material of choice for these acids. As would be expected from its high copper content, Alloy 400 is rapidly attacked by nitric acid and ammonia systems.

Alloy 600

Alloy 600 is a high nickel alloy offering excellent resistance to caustics and chlorides at high temperatures and high pressures when sulfur compounds are present. In caustic environments, Alloy 600 is unexcelled. It also is often chosen for its high strength at elevated temperatures. Although it can be recommended for a broad range of corrosive conditions, its cost often limits its use to only those applications where its exceptional characteristics are required.

Alloy B-3

Alloy B-3 is an alloy, rich in nickel and molybdenum, which has been developed primarily for resistance to reducing acid environments, particularly hydrochloric, sulfuric and phosphoric. Its resistance to these acids in pure forms is unsurpassed, but the presence of ferric and other oxidizing ions in quantities as low as 50 ppm can dramatically degrade the resistance of this alloy.

Alloy C-276

Alloy C-276 is a nickel chromium-molybdenum alloy having perhaps the broadest general corrosion resistance of all commonly used alloys. It was developed initially for use with wet chlorine, but it also offers excellent resistance to strong oxidizers such as cupric and ferric chlorides, and to a variety of chlorine compounds and chlorine contaminated materials. Because of its broad chemical resistance, Alloy C-276 is the second most popular alloy, following T316SS, for vessels used in research and development work.

Alloy C-2000

Alloy C-2000 is a new nickel chromium-molybdenum alloy from Haynes International. It was approved for coded pressure vessels in 1997. While there is a wealth of information that is available for the earlier members of the Alloy C family, extensive data does not yet exist for Alloy C-2000. Initial reports suggest that this alloy will extend the already broad applications covered by the Alloy C family. In general, this alloy should provide resistance similar to Alloy C-276. Its high chromium content is intended to extend its resistance to oxidizing media and its high molybdenum content is intended to extend its resistance to reducing media. Alloy C-2000 is also reported to have superior resistance to pitting and crevice corrosion when compared to Alloy C-276.

Nickel 200

Nickel 200 is one of the designations of commercially pure nickel. It offers the ultimate in corrosion resistance to hot caustic environments, but its applications are severely restricted because of its poor machinability and resultant high fabrication costs.

Tantalum

offers outstanding resistance to a wide variety of corrosive media including hydrochloric, nitric, sulfuric and phosphoric acids. It is not, however, available in the solid billets required to manufacture these pressure vessels. Parr has furnished a number of vessels where tantalum internal fittings are used in conjunction with a head made of one of the other corrosion resistant alloys (for example Hastelloy C-276 or Zirconium) to meet unique corrosion requirements. The Parr Technical Service Department will be pleased to answer your questions about the possibility and practicality of lined vessels.

Titanium

Titanium is an excellent material for use with oxidizing agents, such as nitric acid, aqua regia and other mixed acids. It also offers very good resistance to chloride ions. Reducing acids, such as sulfuric and hydrochloric, which have unacceptably high corrosion rates in their pure form can have their corrosion rates in titanium reduced to acceptable levels if relatively small quantities of oxidizing ions, such as cupric, ferric, nickel or even nitric acid are present to act as corrosion inhibitors.

This phenomenon leads to many successful applications for titanium in the hydrometallurgy field where acids, particularly sulfuric acid, are used to leach ores. In these operations the extracted ions act as corrosion inhibitors.

Prospective users must remember that titanium will burn vigorously in the presence of oxygen at elevated temperatures and pressures. While there have been many successful applications in hydrometallurgy where oxygen and sulfuric acid are handled in titanium equipment, the danger of ignition is always present and must be protected against whenever titanium and oxygen are used together.

Commercially pure titanium is available in several grades. Grade 2 is the material most commonly used for industrial equipment since it can be fabricated by welding and is approved by the ASME Code for Unfired Pressure Vessels. Grade 4, which has slightly higher trace levels of iron and oxygen, has higher strength than Grade 2 but it is not suitable for welding and it is not covered by the ASME Code.

Since most Parr vessels are not welded, they usually are made of Grade 4 to obtain higher working pressures than can be obtained with Grade 2. Grade 7, containing small amounts of palladium, and Grade 12 containing small amounts of nickel and molybdenum, offer enhanced resistance to certain environments and can be used for Parr reactors and pressure vessels if suitable billets can be obtained.

Zirconium

Zirconium offers excellent resistance to hydrochloric and sulfuric acids, however, as with Alloy B-3, oxidizing ions such as ferric, cupric and fluorides must be avoided. Zirconium also offers good resistance to phosphoric and nitric acids, and to alkaline solutions as well. Two different grades are available: Grade 702 which contains hafnium is the standard commercial grade offering the best resistance to most corrosive agents, Grade 705 contains small amounts of both hafnium and columbium which increases the strength characteristics and allows for higher maximum working pressures for a vessel. Grade 702 typically offers better corrosion resistance than Grade 705. Grade 702 is also more widely available from commercial stocks of raw materials.

Carbon Steel

Carbon Steel is usually used for laboratory reactors only when it is desired to duplicate construction material used in plant equipment. Because it rusts easily, carbon steel vessels are not carried in stock and must be made to order, often resulting in costs higher than stainless steel equipment despite the lower material cost for carbon steel.

WHEN SPECIAL ALLOY CONSTRUCTION IS SPECIFIED FOR A PARR REACTOR, THE HEAD, CYLINDER AND ALL INTERNAL WETTED PARTS OF THE VESSEL WILL BE MADE OF THE PRESCRIBED MATERIAL, WITH THE EXTERNAL VALVES AND FITTINGS CONSTRUCTED OF STAINLESS STEEL. USUALLY THE EXTERNAL PARTS ARE NOT SUBJECT TO THE SAME CORROSIVE CONDITIONS WHICH EXIST INSIDE THE VESSEL, THEREFORE, THE HIGHER COST OF EXTERNAL PARTS MADE OF SPECIAL ALLOYS IS SELDOM JUSTIFIED. IF EXTERNAL PARTS MADE OF SPECIAL ALLOYS ARE REQUIRED, PARR WILL ATTEMPT TO MEET THIS REQUIREMENT, ALTHOUGH THERE MAY BE EXCEPTIONS WHERE SUCH PARTS CANNOT BE MADE.

Design Features 1

Pressure and Temperature Limits

The maximum pressure and temperature at which any reactor or pressure vessel can be used will depend upon the design of the vessel and the materials used in its construction. Since all materials lose strength at elevated temperatures, any pressure rating must be stated in terms of the temperature at which it applies. All Parr listings show the maximum allowable working pressure for each reactor and pressure vessel in pounds per square inch (psi) or bar at 350 °C for vessels constructed of Type 316 Stainless Steel. Table II provides a set of multipliers which can be used to convert 350 °C pressure ratings for any T316SS vessel to higher or lower temperatures. It can also be used to determine the corresponding ratings for vessels of the same design made of other materials.

These conversions are only rough approximations. Actual ratings of other materials and ratings for other temperatures will be computed and assigned by the Parr Engineering Department.

Although lower operating temperatures sometimes permit higher working pressures, the pressure rating for a vessel should never be increased to more than 20 percent above its rating at 350 °C. Some vessels can not be raised at all since closures, magnetic drives or other components, not the strength of the vessel material, establish the maximum allowable working pressure.

Although pressure rating factors for temperatures as high as 600 °C are included in Table II, many Parr vessels cannot be used at these higher temperatures because of gasket material restrictions or other design limitations. The maximum allowable working temperature for which allowable stress values are published in the ASME Pressure Vessel Code are included in Table II. No reactor or pressure vessel should be operated above these maximum temperature limits.

Examples:

What is the maximum pressure rating at 450 °C for a T316SS vessel rated at 1900 psig at 350 °C?

(1900)(0.95) = 1805 psi

What is the maximum pressure rating at 450 °C for an Alloy 400 (Monel) vessel when the same vessel made of T316SS is rated at 1900 psig at 350 °C?

(1900)(0.54) = 1026 psi

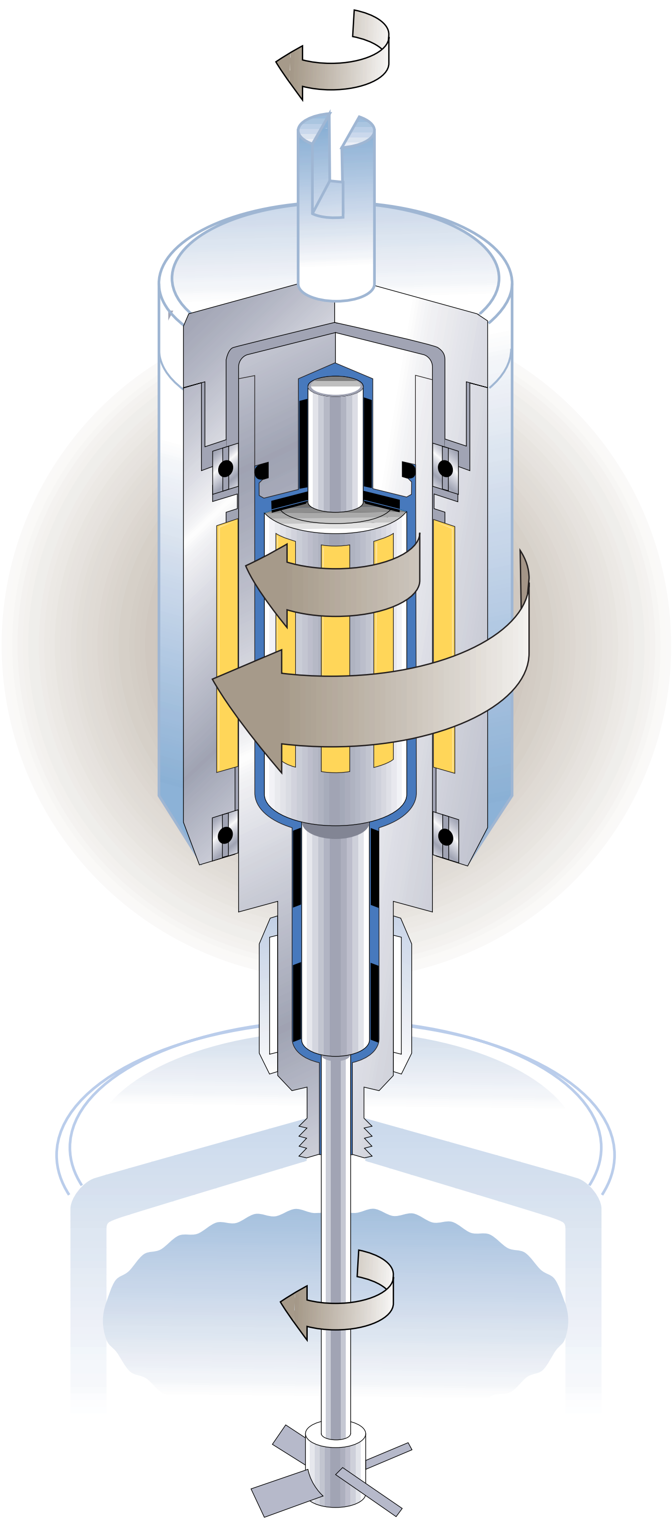
Table II

Pressure Rating Factors

Material	Temperature (°C) 25	100	200	300	350	400	450	500	550	600
T316 Stainless Steel	1.13	1.13	1.09	1.04	1.00	0.97	0.95	0.93	0.90	0.75
Alloy 400	1.20*	1.20*	1.20*	1.20*	1.19	1.11	0.54	0.24 at 472 °C Maximum		
Alloy 600	1.20*	1.20*	1.20*	1.20*	1.20*	1.20*	1.20*	1.20*	0.75	0.42
Alloy B-2	1.20*	1.20*	1.20*	1.20*	1.20*	1.20*	1.20* at 427 °C Maximum			
Alloy C-276	1.20*	1.20*	1.20*	1.20*	1.20*	1.20*	1.20*	1.20*	1.20	0.88
Alloy C-2000	1.20*	1.20*	1.20*	1.12	1.07	1.03	1.02 at 427 °C Maximum			
Nickel 200	0.60	0.60	0.60	0.60	0.60 at 316 °C Maximum					
Alloy 20Cb-3	1.20	1.20	1.17	1.16	1.16	1.16	1.15 at 427 °C Maximum			
Titanium Grade 2	0.75	0.64	0.47	0.36	0.34 at 316 °C Maximum					
Titanium Grade 4	1.20	1.02	0.65	0.47	0.47 at 316 °C Maximum					
Zirconium Grade 702	0.78	0.66	0.44	0.36	0.34	0.29 at 371 °C Maximum				
Zirconium Grade 705	1.20	0.98	0.65	0.65	0.61	0.60 at 371 °C Maximum				

** Some standard designs cannot be rated higher than 1.00 without checking all aspects of the design.*

High Torque Magnetic Drives



All Parr stirred reactors are equipped with a magnetic drive to provide a trouble-free linkage to an internal stirrer, thereby avoiding the leakage problems which can arise with a packed gland stirrer drive. With a Parr magnetic drive there are no rotating seals. The drive turns freely and the system remains gas-tight, permitting long, continuous runs at pressures up to 5000 psi (345 bar) with little or no attention to the seal and drive.

Parr drives are assembled with specially designed permanent magnets which have excellent temperature stability and can be depended upon to operate for long periods with little or no flux degradation. Magnets for the inner rotor to which the stirrer shaft is attached are enclosed in a stainless steel (or other alloy) housing, permanently sealed by laser welding and supported by graphite-filled, PTFE bushings to provide a long life, chemically inert stirring system. Magnets for the outer drive are also fully enclosed and supported by twin, high quality sealed ball bearings for smooth operation and long life. A water cooling sleeve attached to each drive protects the components from excessive heat arising from the reactor.

Four Sizes

Parr magnetic drives are made in four sizes, designed to match the full range of Parr reactor sizes and to provide alternate drives for high viscosity loads, higher stirring speeds and other special requirements. Each drive is assembled in a sealed housing which threads directly into the reactor head.

The A1120HC and A1180HC models are the standard units normally furnished with the reactor sizes listed in the adjoining table. The A1750HC2 model is a special high torque drive intended primarily for heavy loads and high viscosity applications. When it is used to replace a standard drive, the standard motor and drive system may have to be modified to provide the higher torque which the A1750HC2 drive is capable of transmitting.

The new 5500 Series Compact Reactors have a smaller magnetic drive with a self-contained 1/50 hp motor. It is intended for low viscosity applications and has a torque rating of 8 oz.-in. (5.5 Ncm)

Significant progress was made in recent years in both magnetic materials and magnetic coupling design. Parr uses neodymium-iron-boron magnets with 25% more coupling force than samarium-cobalt magnets. With very few exceptions involving gear reduction drives, the magnetic stirrers fitted to reactors have higher coupling torques than the stall conditions of standard motors. Today magnetic drives are used with confidence for high viscosity polymerization reactions.

Parr magnetic drives are supported with three Graphite filled PTFE bushings and quality internal ball bearings. They routinely deliver 2000 hours of operation without service.

Two Styles Available

Parr offers a choice of two styles of magnetic drive shafts. The general purpose A1120HC, A1180HC and A1750HC2 operate with small diameter stirrer shafts which require a lower guide or "foot" bearing to stabilize the stirrer shaft. These drives are intended for high speed stirring for applications involving liquid-liquid or gas-liquid mixing. The A2140HC, A2160HC and A2170HC footless magnetic drives employ a larger diameter stirrer shaft designed to operate without this lower guide or "foot" bearing. They were originally designed for digesting ores where the abrasive solids would get caught in the PTFE foot bearing and wear away the stirrer shaft. They are also recommended for slower speed mixers such as the anchor, paddle, or spiral stirrers. Footless drives can be used for stirrer speeds up to 2000 rpm. It is also important to select the appropriate motor which can handle the increased drag associated with the larger diameter shafts.

Alternate Packed Gland Drive

For rare circumstances where a direct mechanical drive is preferable to a magnetically coupled system, Parr can furnish a self-sealing packed gland which will maintain a reliable seal on the stirrer shaft at working pressures up to 2000 psig (138 bar). These glands are made to a Parr design which uses a combination of cones and O-rings in conjunction with pressure from within the vessel to maintain a positive seal on the rotating shaft.

Today, with the variety of magnetic drive styles and high coupling torques, virtually all reactors except special application systems are equipped with magnetic drives.

Parr Magnetic Drive Series

Magnetic Drive No.	*Style*	*Designation*	*Coupling Poles*	*Coupling Torque in-lb**	*Installed as Standard Drive on*	*Available as Optional Drive on*
A1120HC	Gen. Purpose	General Purpose	4	16	All 25 mL thru 2000 mL Reactors	None
A1180HC	Gen. Purpose	Heavy Duty	6	60	All 1 G thru 5 G Reactors	1000 mL and 2000 mL Reactors
A1750HC2	Gen. Purpose	Extra Heavy Duty	12	120	None	1000 mL thru 5 G Reactors
A2140HC	Footless	General Purpose	4	16	None	300 mL thru 2000 mL Reactors
A2160HC	Footless	Heavy Duty	6	60	None	1000 mL thru 5 G Reactors
A2170HC	Footless	Extra Heavy Duty	12	60	None	1000 mL thru 5 G Reactors
A2160HC2	Footless	Heavy Duty	6	120	None	1000 mL thru 5 G Reactors
A2170HC2	Footless	Extra Heavy Duty	12	120	None	1000 mL thru 5 G Reactors
A2720HC	Compact		6	8 oz-in (5.5 Ncm)	All 5500 Series Compact Reactors	None

** in-lb = 0.11 Newton Meter*

Split-Ring Closures


Split-Ring with Cap Screws for Moveable Vessels


Split-Ring with Cap Screws for Fixed Head Vessels


Split-Ring for Self Sealing O-ring Closures

We have all heard the story of the man who resigned from the Patent Office around 1900 because he believed that everything that could be invented already had been. That is not the philosophy that has driven Parr Instrument Company over its more than a century of service to the chemical industry. The following prediction first appeared in February 1930 in the "Forward" of our bulletin describing our catalytic hydrogenation apparatus.

"The greatest chemical discoveries are yet to be made, untold numbers of which will result from the new studies in catalysis and catalytic reactors. These studies have already unearthed a mine of information, but with a more exact knowledge of catalytic processes, much more will be learned in the future."

We are delighted with the foresight of our predecessors here at Parr and are dedicated to continuing this outlook for the future as we enter our second century of service to our friends and customers in this critical industry.

[1]Split-Ring U.S. Patent No. 2625296

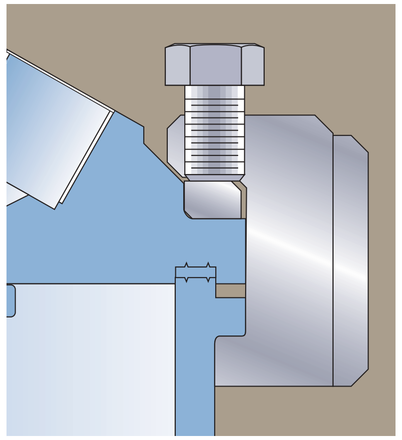
Easy Access to Pressure Vessels

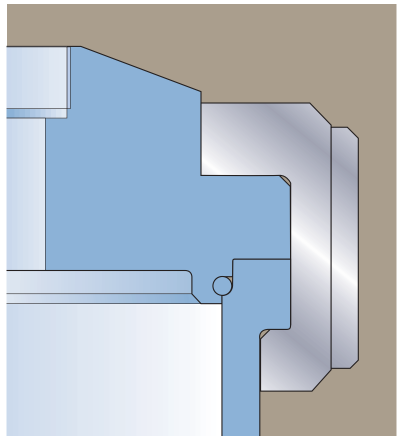
Parr reactors and pressure vessels are equipped with a unique split-ring cover clamp which adds greatly to the convenience of the equipment and the ease with which it can be handled. This is an exclusive Parr design[1] which allows easy access to a pressure vessel without using a heavy screw cap, cumbersome cover clamps, or a wide flange for moveable bolts. Instead, the head is clamped to the cylinder by a Type 4140 Stainless Steel ring which has been split into two sections. These sections slide into place from the sides without interfering with any fittings attached to the head.

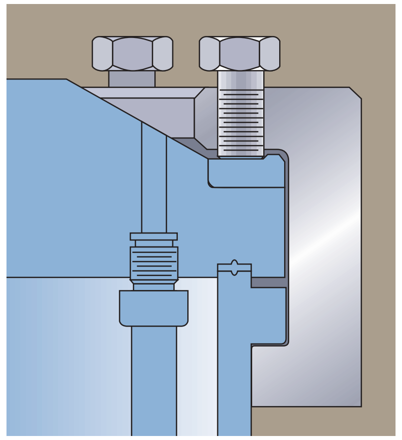
Self-Sealing and Cap Screw Designs

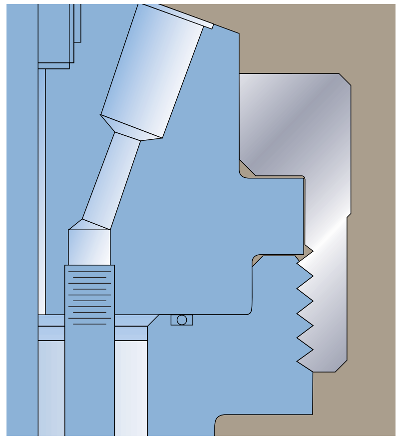
Parr split-ring cover clamps are made in two styles. For reactors and vessels in which a self-sealing O-ring is used as the main head seal, there are no cap screws in the split-ring sections. The vessel is closed by simply sliding the two ring sections into place and locking them with either an encircling drop band or with attached, quick-opening latches. This convenient closure can be used on most small and mid-sized stirred reactors and pressure vessels, provided the intended operating temperature does not exceed the allowable working temperature limit for the O-ring seal.

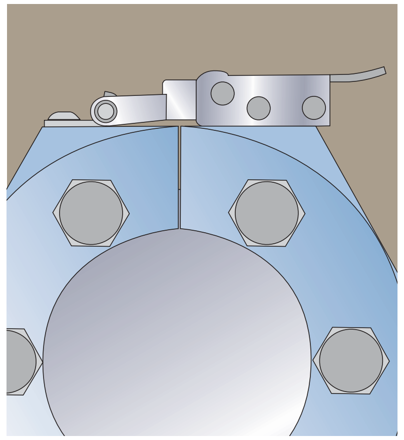
Split ring closures for reactors with PTFE, flexible graphite, metal or other contained, flat gaskets have a set of cap screws in the rings which must be tightened to develop the compressive force required to seal the gasket. These split rings are locked together with either a drop band, special compression ring with a retaining lip, or quick opening latches.


Split-Ring with Cap Screws and Drop Band


Split-Ring with No Cap Screws


Split-Ring with Cap Screws and No Drop Band


Screw Cap Closure


Split-Ring with Latches and No Drop Band

With either style, the closure parts come completely away from the vessel so that the head with all of its fittings can be lifted from the cylinder or the cylinder can be dropped away without disrupting any attached fittings. When cap screws are used, they are simply tightened or loosened, they are never completely removed from the split ring or drop band. This saves time both in opening and closing the vessel and in looking for lost parts.

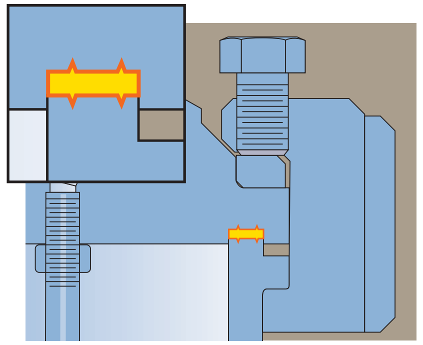
Split-ring closures add many attractive features to Parr reactors and pressure vessels.

- The reactor or vessel can be opened and closed without disturbing any connections or fittings attached to the head.
- The full inside diameter of the vessel is exposed when the head is removed.
- A maximum area is exposed on the head for attaching valves and fittings.
- There are no cumbersome bolt flanges or threaded studs to interfere with operations, and
- No delicate threads on the cylinder to gall or to be damaged in handling.

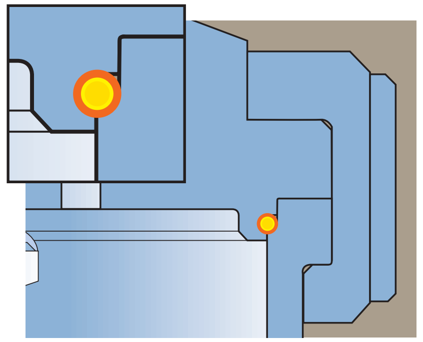
Screw Cap Closures

Parr uses screw cap closures on small vessels where enough sealing force can be developed by simply tightening the main screw cap. This design can be made more compact than the split ring closure and is used primarily on general purpose vessels with volumes of less than 100 mL.

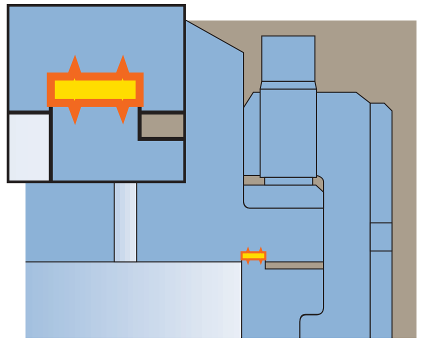
Gasket and Seals



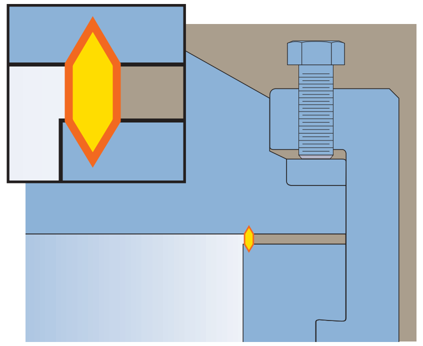
Flat PTFE Gasket



O-ring FKM Seal



Contained Graphoil Flat Gasket



High Pressure Metal Gasket

There are four different types of gasketing material for the main head seal in Parr reactors and pressure vessels, each with its own advantages and limitations. Some of these are recent additions which have significantly expanded the choices a user can consider when selecting a closure and gasket material for the intended operating conditions.

Confined and Contained Flat PTFE Gaskets for Temperatures to 350 °C

The traditional and most popular main head gasket for Parr vessels is a flat gasket made of a PTFE fluoropolymer. In Parr flat gasket closures the gasket is held in a recess in the vessel cover. A matching pilot on the cylinder closes the recess, leaving the gasket completely confined with only a small inside edge exposed to the reactants within the vessel. This combination of complete gasket containment and the exceptional properties of PTFE materials produces a reliable closure for working temperatures up to 350 °C.

Flat contained gaskets require an initial loading pressure in order to develop and to maintain a tight seal. In Parr designs this is produced by tightening a ring of cap screws in a split-ring cover clamp. Fortunately PTFE is slightly "plastic" and will flow under pressure, producing a seal that improves with each use as the gasket is forced into the faces on the head and cylinder. It also is a very forgiving seal which does not require the special care needed to achieve a uniform loading, which is essential when working with a metal or other non-plastic gasket material.

An equally important advantage of the PTFE gaskets is their essentially universal chemical resistance.

Self-Sealing O-rings

Parr has greatly expanded its offerings of reactors and vessels which feature self-sealing O-ring closures. In these designs the sealing force on the gasket is developed from pressure within the vessel itself, eliminating the need for cap screws in the split ring to pre-load the seal. In these self-sealing closures the split ring sections simply lock the head and cylinder together.

Users who select the self sealing O-ring design must consider two important characteristics of elastometric materials. First, they will not withstand operating temperatures as high as the PTFE gaskets. Secondly, none of these materials offers the universal chemical resistance of PTFE polymers. The chemical resistance is especially important since the O-ring is directly exposed to the contents of the vessel.

Although there are a number of available O-ring materials, the real choice comes down to two: Fluoroelastomer (FKM) O-rings, such as Viton, are a first choice for Parr self-sealing closures. They have good chemical resistance and a working temperature up to 225 °C Perfluoroelastomer (FFKM) O-rings, such as Kalrez, have extremely broad chemical resistance and can be used at working temperatures up to 275 °C. Unfortunately, this

O-ring Main Head Seal with Retaining Lip

material should probably be considered an "exotic" because it costs approximately 80 times as much as an FKM O-ring. And while it will raise the allowable working temperature to 275 °C, as a practical matter, most users intending to work at this temperature level would be well advised to choose a closure with a flat PTFE gasket and a 350 °C temperature limit.

Other exotic O-ring materials are available, and there are economically priced materials such as ethylene-propylene that will resist some materials that cause FKM to fail, with only slight sacrifices in operating temperatures.

Contained Flat Flexible Graphite Gaskets for Temperatures to 600 °C

For operating temperatures above 350 °C, Parr uses a recently developed flexible form of graphite, called Grafoil, which has proven to be an excellent high temperature sealing material. It consists of flexible layers of graphite bonded together to produce a gasket that is almost as easy to seal as a flat, PTFE gasket, but with an almost unlimited temperature range and excellent chemical resistance.

Parr has converted all of its standard designs to accept a flat, Grafoil gasket whenever operating temperatures above 350 °C are required, replacing the metal gaskets formerly used for high temperatures. These flexible graphite gaskets are held in grooves identical to the ones used for PTFE gaskets and sealed with the same split-ring closures. This makes it possible to substitute a PTFE gasket whenever the vessel is to be used at temperatures below 350 °C. Grafoil gaskets are reusable, but their service life is shorter than can be obtained with a PTFE gasket.

Metal Gaskets

Metal gaskets have traditionally been the only gaskets available for use at temperatures above 350 °C. Parr has designs for diamond cross-section metal gaskets which can be furnished for special applications, but we would recommend the flexible graphite gaskets described above for most applications.

Trademarks of Sealing Materials

A number of gasketing materials have so dominated their product categories that their Trade Names have become more common than the actual material designation itself. In an attempt to respect the value of these Trade Names and their proper usage and to minimize the disruptions in our descriptions, we have adopted the following generic material descriptions and designations for use in this catalog. Where available we have selected the ASTM material designation.

Common or Trade Name	Material	Designation
Viton®	fluoroelastomer	FKM
Kalrez®	perfluoroelastomer	FFKM
Teflon®	tetrafluoroethylene polymer	PTFE
Grafoil®	flexible graphite	FG

Viton®, Kalrez®, Teflon® are Registered Trademarks of DuPont.
Grafoil® is a Registered Trademark of UCAR Carbon Co. Inc.

Two Mounting Styles

Fixed Head Reactors

Parr now offers all of its laboratory reactors in a fixed head design. This includes all reactors with volumes from 25 mL to 7.5 liters. In these reactors the head of the vessel may remain fixed in the reactor support stand. All attachments to the head: gas and liquid feed and discharge lines, cooling water, vapor take-off and condenser, thermocouple and any electrical leads can remain permanently in place. The reactor is opened by simply removing the cover clamp sections and lowering the cylinder away from the head, leaving all of the attachments undisturbed. If desired the complete vessel assembly can be removed from the head support plate.

Close up view of a fixed head reactor with the cylinder and heater lowered.

Model 4523 Reactor, Fixed Head, 1 Liter.

In the Series 4560 and 4590 reactors, the operator lowers the heater and removes the cylinder by hand. In the 1 and 2 liter Series 4520 and 4530 reactors, and in the 600 mL and 1200 mL Series 4540 high pressure models, a manual lift and support mechanism is provided for raising and lowering the cylinder. In the 4550 and 4580 Series 1 and 2 gallon units, as well as the 4570 Series 1 and 1.8 Liter sizes, the cylinder is raised and lowered by either a manual or a pneumatic lift mechanism.

Moveable Vessel Reactors

As an alternate to the fixed head designs described on the previous page, all Parr reactors can be furnished in designs which allow the entire vessel to be removed as a complete assembly from the support stand allowing for charging, product recovery, and cleaning. In the smaller and mid-sized models the entire vessel is simply lifted out of the heater by hand. In the larger 1, 2 and 5 gallon models the vessel can be opened and closed with the cylinder remaining in the heater, but the head must be lifted out by hand. In the larger 5 gallon model a chain hoist is provided for lifting the heavier head and cylinder.

600 mL Moveable Vessel

Model 4544 High Pressure Reactor, Moveable Vessel, 600 mL.

These moveable reactors will be attractive to users that intend to operate fairly simple batch systems rather than continuous flow arrangements, and that want to be able to remove the vessel for product recovery, charging or cleaning. They will also appeal to those that need to prepare the vessel in a special atmosphere, or want to clean the cylinder and stirrer at a site away from the reactor stand and heater. There is also the added advantage of being less expensive than the fixed head models since they do not require the more elaborate head or the cylinder and heater lift mechanism.

Parr Instrument Company Warranty

Parr Instrument Company (Parr) combustion vessels, calorimeters, reactors, pressure vessels and associated products are designed and manufactured only for use by or under the direct supervision of trained professionals in accordance with specifications and instructions for use supplied with the products. For that reason, Parr sells only to professional users or through distributors to such users. Parr produces precision equipment and associated products which are not intended for general commercial use.

Exclusive Warranty. To the extent allowed by law, the express and limited warranties herein are the sole warranties. Any implied warranties are expressly excluded, including but not limited to implied warranties of merchantability or fitness for a particular purpose.

Warranty Conditions:

1. Non-assignable. The warranties herein extend only to the original purchaser-user and to the distributors to such users. These warranties or any action or claims based thereon are not assignable or transferable.

2. Use of product. The warranties herein are applicable and enforceable only when the Parr product: (a) is installed and operated in strict accordance with the written instructions for its use provided by Parr, (b) is being used in a lawful manner, and (c) has been stored or maintained in accordance with written instructions provided by Parr, or if none were provided, has been stored and maintained in a professionally reasonable manner.

3. The user's responsibility. Parr engineers and sales personnel will gladly discuss available equipment and material options with prospective users, but the final responsibility for selecting a reactor, pressure vessel or combustion vessel which has the capacity, pressure rating, chemical compatibility, corrosion resistance and design features required to perform safely and to the user's satisfaction in any particular application or test must rest entirely with the user - not with Parr. It is also the user's responsibility to install the equipment in a safe operating environment and to train all operating personnel in appropriate safety, operational and maintenance procedures.

4. Warranty period. Unless otherwise provided in writing by Parr, the warranties herein are applicable for a period of one year from date of delivery of the product to the original purchaser/user. Note, however, that there is no guarantee of a service life of one year after delivery.

5. Notification. To enforce any express warranty created herein, the purchaser/user must notify Parr in writing within thirty (30) days of the date any defect is detected. Upon request of Parr, the part or product involved must be returned to Parr in the manner specified by Parr for analysis and non-destructive testing.

Express Warranties.

Subject to the above conditions, Parr expressly warrants that its products:

1. Are as described in the applicable Parr sales literature, or as specified in Parr shipping documents.
2. Will function as described in corresponding Parr sales bulletins or, for specially engineered assemblies, as stated in the sales proposal and purchase agreement.
3. Will remain free from defects in materials and workmanship for the Warranty Period.

Limitations on the Parr Warranty.

As to the original purchaser/user and to the distributors to such users, Parr limits its liability for claims other than personal injury as follows:

1. Replacement or repair. With respect to express warranties herein, Parr's only obligation is to replace or repair any parts, assemblies or products not conforming to the warranties provided herein.
2. Disclaimer of consequential damages. In no event shall Parr be liable for consequential commercial damages, including but not limited to: damages for loss of use, damages for lost profits, and damages for resulting harm to property other than the Parr product and its component parts.

Indemnity and Hold Harmless.

Original purchaser-user agrees to indemnify and hold Parr harmless for any personal injuries to original purchaser-user, its employees and all third parties where said injuries arise from misuse of Parr products or use not in accordance with specifications and instructions for use supplied with the Parr products.

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