Stirred Reactors and Pressure Vessels

Chapter One

This pdf is just one chapter from our Catalog 4500. Please refer to all eight chapters to make the proper equipment choice for your needs.
Welcome to the Fourteenth Edition of the Parr Stirred Reactor and Pressure Vessel Catalog. We proudly present here our latest catalog describing the continued expansion of this product line. New products, new designs, and expanded options are offered; all backed by Parr’s continuing dedication to product quality, safety, and customer satisfaction. We hope you will find this new catalog to be a useful tool.
Table of Contents

New Products and Design .......................... 4
The User’s Responsibility ........................ 6

Chapter One: Design Features ........................ 7
Design Features .............................. 7
Design Codes and Certification ........................ 9
Materials of Construction ......................... 10
Pressure and Temperature Limits ......................... 13
High Torque Magnetic Drives ....................... 14
Split Ring Closures ...................... 16
Gaskets and Seals ..................... 18
Mounting Styles ..................... 20
Warranty .................................... 22

Chapter Two: Stirred Reactors ........................ 23
Reactor Selection Guide ......................... 24
How to use Ordering Guide .................. 27
Series 4520 1-2 L Bench Top Reactors ...... 28
Series 4530 1-2 L Floor Stand Reactors ...... 32
Series 4540 600-1200 mL HP Reactors ....... 36
Series 4550 1-2 Gallon Reactors .............. 40
Series 4555 2.6-5 Gallon Floor Stand Reactors 44
Series 4560 Mini Reactors ..................... 48
Series 4570-4580 HT/HP Reactors ............ 52
Series 4590 Micro Reactors ................... 56
Series 5100 Glass Reactors .................... 60
Series 5500 HP Compact Reactors ............ 64

Chapter Three: Multiple Reactors .................... 67
Series 5000 Multiple Reactor System (MRS) .................. 68
Combinatorial Chemistry and High-Throughput Screening .................. 72

Chapter Four: Tubular Reactors .................. 75
Series 5400 Continuous Flow Tubular Reactors ........ 76
Fluidized Bed Reactors .................... 82

Chapter Five: Specialty and Custom Reactor Systems 85
Introduction to Specialty Custom Reactors .................. 86
Biofuels and Alternative Fuels Research Systems .... 87
Horizontal Reactors ........................... 88
Supercritical Fluids ...................... 90
GTO (Gas-To-Oil) System .................. 91
Apparatus for Vapor Pressure Determination ........ 92
Disbonding Apparatus for ASTM G146 ............. 92
Apparatus for Corrosion Studies ................. 92

Chapter Six: Controllers .......................... 93
Controller Overview ........................... 94
Series 4848 Reactor Controllers ................ 96
Series 4838 Temperature Controller ............. 99
SpecView Software for 4848 & 4838 Controllers .......... 100
Series 4871 Process Controllers ................ 101
Series 4875 Power Controller ................ 105
Series 4876 Power Controllers ................ 105
4877 Valve Controller ..................... 106
A2110E Motor Controller .................... 106
A2200E Mass Flow Controller ................ 106

Chapter Seven: Optional Fittings .................. 107
Heaters .................................. 108
Stirring Motors and Drives ................. 110
Stirrer Options ............................ 112
Gas Entrainment ........................... 113
Catalyst Baskets ............................. 114
Condensers ................................ 115
Safety Rupture Discs ....................... 116
Pressure Relief Valves and Gages .......... 117
Gas Measurement Systems .............. 118

Liquid Charging Systems .................. 119
Solid Charging Systems .................. 120
Cooling Coils ............................ 121
Cylinder Liners ............................ 121
Sample Collection Vessels .................. 122
Bottom Drain Valves ..................... 122
Valves and Fittings ..................... 123
Thermocouples ............................. 124
Pressure Hoses ............................ 124
Equipment for Use in Potentially Ignitable Atmospheres .......... 126
Windows ............................. 127
Insulated Electrical Glands .................. 128
Temperature Limits ...................... 128
Spare Parts Kits ............................. 128
External Valves and Fittings ............. 129

Chapter Eight: Non-Stirred Vessels ................. 131
Introduction ................................ 132
Series 4703-4714 22-45 mL Vessels ......... 134
Series 4740 25-75 mL HP/HT Vessels ......... 136
Series 4750 125-200 mL Vessels .............. 138
Series 4790 25-100 mL HP/HT Vessels ........ 140
Series 4760-4777 100-600 mL Vessels ........ 144
Series 4760-4768 300-600 mL HT Vessels ...... 144
Series 4600-4620 1-2 L GP & HP Vessels ...... 148
Series 4605-4626 600-1200 mL HP Vessels .... 152
Series 4650 250-1000 mL HP Vessels ........ 154
Series 4660 1-2 Gallon Vessels ............... 156
Series 4680 1-1.8 L HP/HT Vessels ............. 158
Series 4670 1-1.5 Gal. HP/HT Vessels ......... 160
Series 4676-4679 2.6-5 Gal. Vessels ........ 162
Gage Block Assemblies ..................... 165
Coned Pressure Fittings ..................... 165
What we cannot easily show 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:

**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.

**www.parrinst.com** is continually updated to provide you with 24 hours access to a more extensive discussion of our products and capabilities. Look for our online resources to expand as we strive to continue to provide you with the world class experience you have come to expect from Parr Instrument Company.

**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.
**Introduction**

**Service**

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

**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.

**Research**

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

**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 five to seven weeks. For special alloys and custom modifications, plan for seven to nine weeks for delivery. For systems or orders requiring extensive custom design work allow at least eight to twelve 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.
At Parr Instrument Company, we never rest on our past successes. We are constantly working to further improve our products and to streamline our processes. We continue to lead the industry in innovation, safety, and reliability. Researchers from around the world rely on Parr’s scientific and engineering design expertise.

**Hinged Split Rings.** Available on many of our larger Reactor Systems throughout this catalog.

**New Floor Stand System** with 10 liter Reactor and Flexible Mantle Heater. [See page 44.](#)

**High Pressure / High Temperature Micro Pressure Vessels.** [See page 142.](#)

**4848 Reactor Controller** with multiple expansion options. [See page 96.](#)
We are continually expanding our expertise for designing and developing custom systems. From single units to complex multi reactor systems, we can help find a solution for your research needs.
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 Parr Instrument Company.

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.

   All standard Parr pressure vessels are provided with either a suitable relief device or a means to attach one (typically in the form of a plugged opening). When a pressure vessel is delivered without a pressure venting device, it is the customer’s responsibility to provide pressure relief in order to protect the operator and the equipment from destructive high pressures. If you need more information or need help in selecting a proper relief device, please contact Parr Instrument Company.

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.
Chapter 1
Design Features

Inside this chapter you will find:
- DESIGN CODES
- CERTIFICATION
- QUALITY ASSURANCE:
  - ISO 9001:2008
  - ASME
  - PED
  - PARR
  - CSA
  - CE
  - CHINA
- MATERIALS OF CONSTRUCTION
- ALLOY DESIGNATIONS
- PRESSURE AND TEMPERATURE LIMITS
- MAGNETIC DRIVES
- SPLIT-RING CLOSURES
- GASKETS & SEALS
- MOUNTING STYLES
- WARRANTY
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 corro-sion. Each individual cylinder is tested hydrostatically. For vessels bearing ASME Certification Mark with “U” Certification designator, the minimum hydrostatic test pressure is 1.3 times the rated working pressure corrected for temperature. For CE marked pressure vessels the minimum hydrostatic test pressure is the higher of 1.43 times the rated working pressure or 1.25 times the rated working pressure corrected for temperature. 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 typically 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 116.

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: 2008 for Total Quality Procedures, ASME, CSA (Canadian Standards Association), and all applicable European Directives (CE) which include but are not limited to PED (Pressure Equipment Directive), LVD (Low Voltage Directive), EMC (Electromagnetic compatibility), and Machinery Safety.

ISO 9001: 2008 Certification

Parr Instrument Company’s overall Quality Assurance System has been certified to be in compliance with ISO 9001: 2008 by TÜV SÜD. ISO 9001: 2008 covers the overall quality assurance and management compliance aspects of Parr’s activities as opposed to the certification of an individual product.

ASME Certification

Parr Instrument Company holds a Certificate of Authorization issued by the Boiler and Pressure Vessel Committee of the American Society of Mechanical Engineers (ASME) and the National Board of Boiler & Pressure Vessel Inspections (NBBI) as an approved facility for manufacturing unfired pressure vessels. If required, any Parr reactor or pressure vessel can be certified to the ASME BPVC, 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-1 or U-1A, “Manufacturer’s Data Report for Pressure Vessels”, which provides all relevant documentation of the finished vessel including certification of the chemical analysis and physical properties of materials used in the vessel.
3. Application of the ASME Certification Mark with “U” Certification Designator to the vessel by the Inspector.
4. Registration of the vessel with the National Board. There is an added charge for this special certification. It should be noted that unless specifically requested, ASME certification provided by Parr will cover the vessel only and not the relief device. Parr can furnish certain relief devices with ASME certification upon request – see page 116 for further details.

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.

PED Certification

Parr Instrument Company has implemented, operates and maintains a quality assurance system as described in the Pressure Equipment Directive Annex III, Module H/H1 for the scope of Design and Manufacture of Pressure Reactors and Assemblies for Laboratory Applications.

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, over 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.
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 all applicable European Community Directives.

China Special Equipment Manufacture License

Where appropriate, Parr reactors will bear the China Special Equipment Manufacture License number issued by AQSIQ of the People’s Republic of China for manufacture of its pressure vessels.

Other National or Local Codes

Parr regularly works with other national, state or international authorities to obtain individual approval for specific vessels. Parr has obtained Pattern Approval for pressure vessels in China and CRN Approval for pressure vessels in all Canadian provinces. 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.

Alloy Designation

Parr 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®, Inconel®, Incoloy®, Carpenter Alloy 20®, Hastelloy®, 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. Corrosion resistance information can be obtained from various corrosion handbooks and metallurgical publications. Helpful information can also be obtained from the individual alloy manufacturers.

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 construction materials offered by Parr are summarized on the following pages. 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.

1 MONEL, INCONEL and INCOLOY are Registered Trademarks of Special Metals Corp.
2 CARPENTER 20 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 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 fluoride, 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-2/B-3
Alloy B-2/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.

Table I Nominal Chemical Composition of Pressure Vessel Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Typical Trade Name</th>
<th>Fe</th>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
<th>Mn</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>T316 Stainless Steel</td>
<td></td>
<td>65</td>
<td>12</td>
<td>17</td>
<td>2.5</td>
<td>2.0</td>
<td>Si 1.0</td>
</tr>
<tr>
<td>Alloy 20</td>
<td>Carpenter 20</td>
<td>35</td>
<td>34</td>
<td>20</td>
<td>2.5</td>
<td>2.0</td>
<td>Cu 3.5, Cb 1.0 max</td>
</tr>
<tr>
<td>Alloy 230</td>
<td>Haynes 230</td>
<td>3</td>
<td>52</td>
<td>22</td>
<td>2</td>
<td>0.7</td>
<td>Co-5, W-14, Si-0.5</td>
</tr>
<tr>
<td>Alloy 600</td>
<td>Inconel 600</td>
<td>8</td>
<td>76</td>
<td>15.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alloy 625 Gr1</td>
<td>Inconel 625 Gr1</td>
<td>5</td>
<td>58</td>
<td>22</td>
<td>9</td>
<td>0.5</td>
<td>Nb+Ta 3.7</td>
</tr>
<tr>
<td>A-286</td>
<td>Alloy 286</td>
<td>53</td>
<td>25</td>
<td>15</td>
<td>1.2</td>
<td>2</td>
<td>Si-1, Ti-2, Al-0.35</td>
</tr>
<tr>
<td>Alloy B-2/B-3</td>
<td>Hastelloy B-2/B-3</td>
<td>2</td>
<td>66</td>
<td>1</td>
<td>28</td>
<td>1</td>
<td>Co 1.0</td>
</tr>
<tr>
<td>Alloy C-276</td>
<td>Hastelloy C-276</td>
<td>6.5</td>
<td>53</td>
<td>15.5</td>
<td>16</td>
<td>1</td>
<td>W4.0, Co 2.5</td>
</tr>
<tr>
<td>Nickel 200</td>
<td></td>
<td>99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Titanium Grade 2, 3, 4</td>
<td>Commerically pure titanium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ti 99 min</td>
</tr>
<tr>
<td>Titanium Grade 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ti 98.8 min, 0.15 Pd</td>
</tr>
<tr>
<td>Zirconium Grade 702</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Zr + Hf 99.2 min, Hf 4.5 max</td>
</tr>
<tr>
<td>Zirconium Grade 705</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Zr + Hf 95.5 min, Hf 4.5 max, Nb 2.5</td>
</tr>
</tbody>
</table>
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.

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.

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 can be used to make vessels compliant to the PED and ASME codes. 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 PED or ASME Codes.

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-2/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 niobium which increases the strength characteristics and allows for higher maximum working pressures for a vessel. Grade 702 typically offers better corrosion resistance than Grade 706. Grade 702 is also more widely available from commercial stocks of raw materials.

High Temperature / High Strength Alloys
In addition to the metals chosen for their corrosion resistance Parr also offers some alloys that are selected for their outstanding strength values, their high temperature strengths, or both.

Alloy 625
Alloy 625 is an alloy with chemical resistance similar to Alloy C-276, but with much greater strength. We use this alloy to obtain additional pressure ratings for high temperature applications.

Alloy 230
Alloy 230 is an alloy approved for ASME pressure vessel design for temperatures up to 980 °C. It is an alloy high in nickel, chromium, tungsten, and cobalt. While it has resistance similar to Alloy 600, it is normally selected for its high strengths at very high temperatures. It is sometime selected as a bolting material.

Alloy A-286
Alloy A-286 is an alloy of the Stainless Steel family with very high strengths up to 371 °C it is commonly used as a bolting material.

Tantalum
For hot concentrated acid applications including hydrochloric acid (HCl), sulfuric acid (H2SO4), acetic acid, sour gas (H2S), and nitric acid, tantalum offers excellent corrosion resistance but at a very high price. A more cost effective solution can be found in the treatment of the reactor with vaporized tantalum, which results in a surface layer with characteristics of pure tantalum metal. Parr Instrument Company’s preferred vendor for tantalum treatment is TANTALINE®. We can arrange to have your reactor treated by this leading producer of tantalum surface alloys.
The maximum pressure and temperature at which any reactor or pressure vessel can be used will depend upon the design of the vessel, its material of construction, and other components integral to its design. Since all materials lose strength at elevated temperatures, any pressure rating must be stated in terms of the temperature at which it applies. The listings shown in this catalog show the maximum allowable working pressure (MAWP) for each vessel in pounds per square inch (psi) and in bar at the maximum rated temperature for that particular design when that vessel is constructed of Type 316 Stainless Steel. Maximum pressure and temperature limits for vessels constructed of other alloys are computed and assigned by the Parr Engineering Department in accordance with all applicable regulations.

Lower operating temperatures sometimes permit higher working pressures. For example, the 4560HT High Temperature reactors are rated at 2000 psi (138 bar) maximum pressure and 500 °C maximum temperature. Standard 4560 reactors are rated at 3000 psi (200 bar) maximum pressure at 350 °C maximum temperature.

One should not assume that any vessel being operated at a lower temperature can be used at pressures exceeding the rated MAWP. Factors other than the material strength of the vessel wall may well be the constraint controlling the rating. Other factors that can limit the pressure and temperature ratings are the closures design, the magnetic drive, the type of seal, the choice of other components used, as well as the material of construction. The maximum operational temperature of some materials is much lower than what is permissible with stainless steel as shown in Table II. Users are encouraged to contact the Parr Customer Service Department with any questions.

### Table II

<table>
<thead>
<tr>
<th>Materials of Construction</th>
<th>Maximum Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>T316/316L Stainless Steel</td>
<td>800 °C</td>
</tr>
<tr>
<td>A-286</td>
<td>371 °C</td>
</tr>
<tr>
<td>Alloy 20</td>
<td>426 °C</td>
</tr>
<tr>
<td>Alloy 230</td>
<td>980 °C</td>
</tr>
<tr>
<td>Alloy 400</td>
<td>482 °C</td>
</tr>
<tr>
<td>Alloy 600</td>
<td>625 °C</td>
</tr>
<tr>
<td>Alloy 625 Gr 1</td>
<td>648 °C</td>
</tr>
<tr>
<td>Alloy B-2/B-3</td>
<td>426 °C</td>
</tr>
<tr>
<td>Alloy C-276</td>
<td>625 °C</td>
</tr>
<tr>
<td>Nickel 200</td>
<td>315 °C</td>
</tr>
<tr>
<td>Titanium Grade 2, 3, 4, 7</td>
<td>315 °C</td>
</tr>
<tr>
<td>Zirconium Grade 702, 705</td>
<td>371 °C</td>
</tr>
</tbody>
</table>

Multiple factors are involved in safely calculating the maximum working pressures and temperatures of Parr Pressure Vessels and Reactors. Please contact Parr Customer Service Department for more information and to assist you in making the correct purchase decision.
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.

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.

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 5500 Series Compact Reactors have a smaller magnetic drive that is used with a 1/17 hp motor. It is intended for low viscosity applications and has a torque rating of 2.5 in-lb.

### Two Styles Available

Parr offers a choice of two styles of magnetic drives. 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. 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**

<table>
<thead>
<tr>
<th>Magnetic Drive</th>
<th>Coupling Torque (in-lbs)*</th>
<th>Shaft Diameter (inches)</th>
<th>Foot Bushing Required? (see text above)</th>
<th>Ordering Guide Abbreviation</th>
<th>Supplied as Standard Mag Drive on Reactors with these Volumes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Purpose</td>
<td>16</td>
<td>3/16&quot;</td>
<td>Yes</td>
<td>M</td>
<td>25 mL to 2 L</td>
</tr>
<tr>
<td>Heavy Duty</td>
<td>60</td>
<td>3/8&quot;</td>
<td>No (Footless)</td>
<td>HD</td>
<td>1- to 5-Gallon</td>
</tr>
<tr>
<td>Extra Heavy Duty</td>
<td>120</td>
<td>3/8&quot;</td>
<td>Yes</td>
<td>XHD</td>
<td>1- to 5-Gallon</td>
</tr>
<tr>
<td>Compact</td>
<td>2.5</td>
<td>3/16&quot;</td>
<td>Yes</td>
<td>N/A</td>
<td>5500 Compact Reactor</td>
</tr>
</tbody>
</table>

* in-lb = 0.11 Newton Meter

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 (see sidebar) 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 either a Type 4140 steel or a Type 316 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 Compression Bolt 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 compression bolts 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 compression bolts 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 or quick opening latches.

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 compression bolts 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.
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. The mating lip 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 maintain a tight seal. In Parr designs this is produced by tightening a ring of compression bolts 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 compression bolts 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 offer 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 300 °C. Unfortunately, this
material should probably be considered an “exotic” because it costs approximately 80 times as much as an FKM O-ring. While it will raise the allowable working temperature to 300 °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 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.

<table>
<thead>
<tr>
<th>Common or Trade Name</th>
<th>Material</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viton®</td>
<td>fluoroelastomer</td>
<td>FKM</td>
</tr>
<tr>
<td>Kalrez®</td>
<td>perfluoroelastomer</td>
<td>FFKM</td>
</tr>
<tr>
<td>Teflon®</td>
<td>tetrafluoroethylene polymer</td>
<td>PTFE</td>
</tr>
<tr>
<td>Grafoil®</td>
<td>flexible graphite</td>
<td>FG</td>
</tr>
</tbody>
</table>

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

Parr offers most of its laboratory reactors in a fixed head design. This includes all reactors with volumes from 25 mL to 20 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 split ring 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.

The support frames for fixed head reactors vary based on the sizes and weights of the vessels:

- For vessels with volumes of 25 mL to 600 mL, the cylinder may be lowered and removed manually by the operator.
- Vessels with volumes of 1 to 2 liters include a manual lift mechanism to raise or lower the cylinder.
- Vessels with volumes greater than two liters or where weight dictates include a pneumatic cylinder lift mechanism.

Model 4523 Reactor, Fixed Head, 1 liter.

Close up view of a fixed head reactor with the cylinder and heater lowered.
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 stand by hand. In the larger 1, 2, 5 gallon, and 10 liter models the vessel can be opened and closed with the cylinder remaining in the heater, but the head must be lifted off by hand. In the larger 5 gallon and 10 liter models a chain hoist is provided for lifting the heavier head and cylinder.

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.

4544 Reactor, 600 mL, Moveable Vessel, Split Ring with Compression Bolts, and a 4848 Controller shown with optional Expansion Modules.

600 mL High Pressure Moveable Vessel for use to 5000 psi.
Parr Instrument Company (Parr) combustion bombs, 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 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.
   (c) Has not been modified by any entity other than Parr Instrument Company.
   (d) 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 bomb 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.