PRESSURE VESSELS
JACKET SELECTION AND SURFACE ENHANCEMENT

R-V INDUSTRIES INC.

INDUSTRIAL DESIGN AND MANUFACTURING

"To Supply Superior Products and Services at a Competitive Price With Integrity"

For over 40 years, R-V Industries has partnered our engineering and manufacturing expertise with customer ideas to produce quality products. Our experienced and dedicated sales staff is prepared to offer you:

- Complete and Total Confidentiality
- Prompt, Professional RFQ Response
- On-time Delivery "Guaranteed"
- Competitive Pricing
- Will Not Cut Corners in "Service To Our Customers"

Production Information

- 180,000 sq. feet of Fabrication Facilities
- 26,000 sq. foot Expansion Completed
- 265 Dedicated and Skilled Employees
- 300,000+ Annual Production Hours
- Design, Engineering, Machining, Fabrication, Finishing, Assembly, and Testing All In-House
- R-V Project Management Team to Ensure Compliance and Delivery

R-V Industries offers a unique combination of small company attention to ***customer service*** and big company capabilities, processes, and technologies.

Selecting the Best Vessel Jacket

Jacketing provides the optimum method of heating and cooling process vessels in terms of control, efficiency and product quality.

Using a jacket as a means of heat transfer offers many advantages.

• All liquids can be used, as well as steam and other high-temperature vapors.

• Circulation, temperature and velocity of heat-transfer media can be accurately controlled.

• Jackets may often be fabricated from a less expensive metal than the vessel itself.

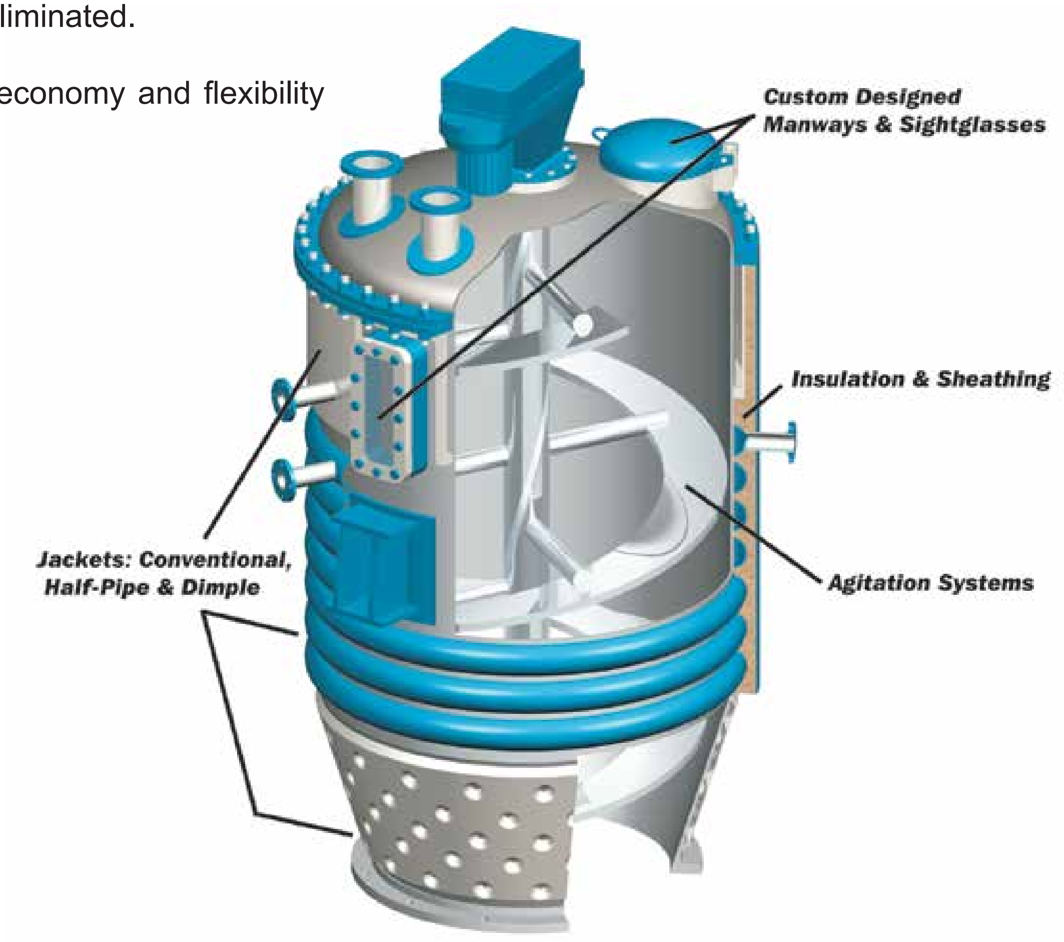
• Contamination, cleaning and maintenance problems are virtually eliminated.

• Maximum efficiency, economy and flexibility is achieved.

Types of Jackets: Jacketing of process vessels is usually accomplished by using one of the three main available types.

1. Conventional or Open Jackets
2. Dimple Jackets
3. Half Pipe Coil Jackets

In designing reactors for specific processes, this variety of jacket type provides the engineer with a great deal of flexibility in the choice of heat-transfer medium.



Conventional Jackets

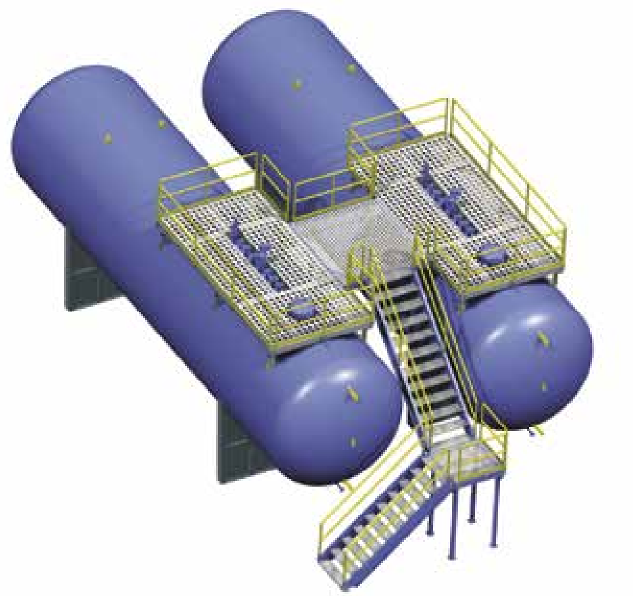
Conventional Jackets or Open Jackets are best applied on small volume vessels (less than 300 gallons) and in high-pressure applications where the internal pressure is more than twice the jacket pressure.

The Conventional Jacket, simply described, is an extra covering around all or part of a vessel, with an angular space (generally concentric) between the outer vessel wall and the inner wall of the jacket. Baffles are provided as required to control the heat-transfer medium.

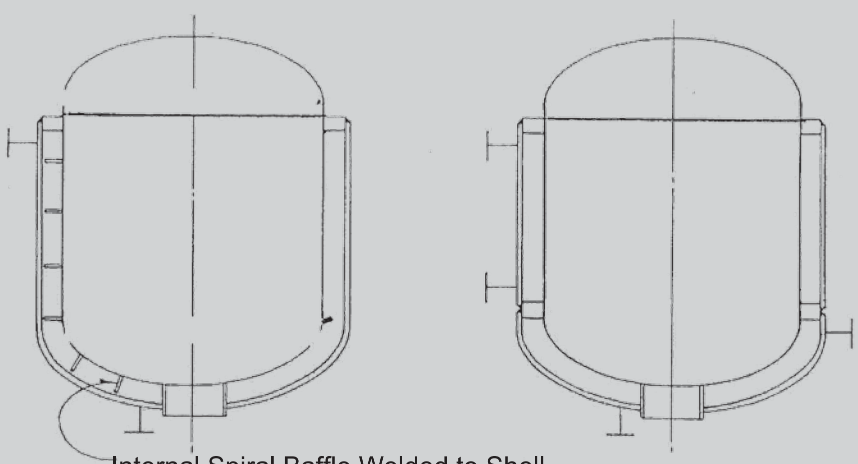
While the Conventional Jacket has been a popular type, it is not as widely used as in the past. This is especially true in the jacketing of vessels made from various alloys. The normal configuration of the Conventional Jacket is shown below. This assures the most efficient heat-transfer to the maximum surface area of the vessel. A cross-section is also shown in this figure. Note that the heat-transfer surface available inside the jacket extends up to the top of the upper jacket-closure bar.

An often-used variation of the configuration is made (Fig. 6b) by dividing the straight side into two or more separate jackets.

If desired, the vessel can be jacketed on the straight side only varying from complete to partial vertical coverage. A jacket can also be fabricated to cover the bottom head only.



Conventional Jackets



Dimple Jacket

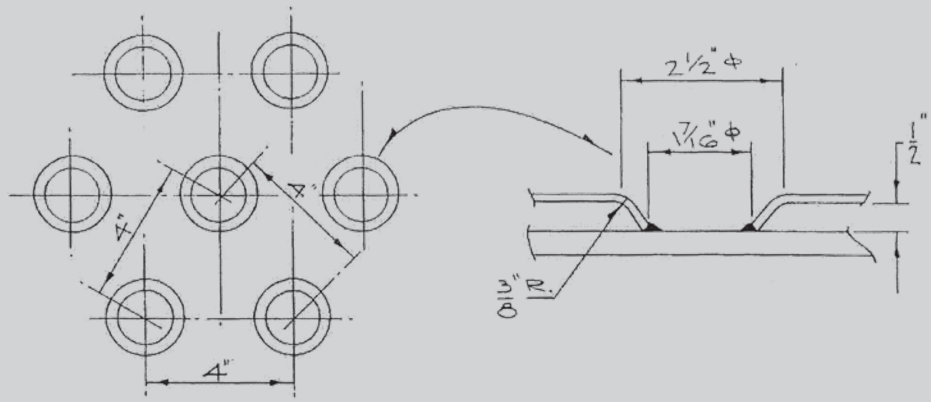
The design of the Dimple Jacket permits construction from light-gauge metals without sacrificing the strength required to with-stand specified pressures. This results in considerable cost saving over Conventional Jackets. Savings increase when higher jacket pressures and larger reactors are produced.

The Dimple Jacket design is approved by the National Board of Boiler and Pressure Vessel Inspectors and can be stamped in accordance with the ASME Unfired Pressure Vessel Code up to pressures of 300 psi. Metal thicknesses are calculated to with-stand the required pressure.

Dimple Jackets can be manufactured from a number of materials, including Type 304, 304L, 316, and 316L stainless steel, as well as Incoloy and Inconel Alloys.

The Dimple Jacket design has fallen into disfavor due to the high frequency of pin-hole cracking in the multitude of dimple welds, lack of positive drainage and flow for liquid medium. The pin-hole cracking is a result of the buildup of cold forming stress in making the Dimple Jacket further stressed by the high heat of welding each dimple.

Dimple Jackets

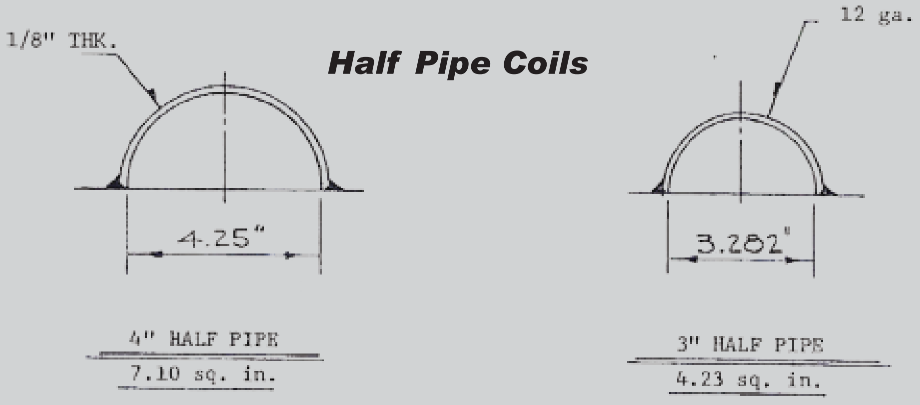


Half Pipe Heating or Cooling Coils

R-V Industries has the capability to manufacture virtually any specially engineered thermal transfer component. With our continuous strip-shaping systems, we can provide Half-Pipe in multiple revolutions, minimizing waste material and section welds at your facility. Throat in or throat out, we produce units as small as 12” in diameter to the largest sizes needed.

We routinely manufacture 2”-, 3”-, and 4”- diameter Sch 10 and Sch 40, with larger-size pipe upon request. Common materials include: Carbon Steel, 300 Series Stainless and Inconel, as well as customer-specific special-materials requirements.

Half Pipe Coils



Half Pipe Coil Jackets

The design of the Half Pipe Coil Jacket also permits construction from light-gauge metals without sacrificing the strength required to withstand specified pressures. The Half Pipe Coil Jacket design is approved by the National Board of Boiler and Pressure Vessel Inspectors and can be stamped in accordance with the ASME Code up to pressures of 750 psig.

Half Pipe Coil Jackets can be manufactured from a number of materials, including Type 304, 304L, 316, and 316L stainless steel, as well as Inconel and Incoloy Alloys.

The Half Pipe design provides high velocity and turbulence and circulation can be closely controlled to effect an unusually high film coefficient. This, plus the built-in structural rigidity, makes the Half Pipe design particularly well suited to a wide range of processing services.

The Half Pipe Coil Jacket is especially recommended for high-temperature services and for use with all liquid heat-transfer services. The design is ideal for hot-oil applications because of the equipment's high structural strength. It can be used effectively with water and in most cases is better than either conventional or Dimple Jackets because of positive channeling and because pressure drop can be calculated simply. For steam, additional connections should be provided to carry away condensate and avoid two-phase flow. In addition to the other heat-transfer media, glycols can be used for cooling.

Because there are no limitations to the number and location of inlet and outlet connections, the Half Pipe Coil Jacket can be divided into multiple zones for maximum flexibility and efficiency. Thus, either the entire jacket may be used, or only as much as needed, so that various-size batches can be processed economically in the same vessel. (This is not feasible with either Conventional or Dimple Jackets, since the cost of zoning is considerably higher for these designs.) Multiple zoning reduces the pressure drop of the heat-transfer medium in the jacket.

In addition to zoning, other economies can be realized through the use of a Half Pipe Coil Jacket. Most important, it usually allows reductions in the thickness of the inner wall of the vessel. In the fabrication of high-strength-alloy vessels, significant savings can be affected.

R-V Industries, Inc. standard sizes for the Half Pipe Coil Jacket are 2”, 2 ½”, 3”, and 4”. Jackets are fabricated from the same or similar material as the vessel for welding compatibility and to minimize differential thermal expansion. The various stainless steels, as well as Inconel, Incoloy and Monel are among the materials that can be used.

Half Pipe Coil Jackets should be utilized for all liquid heat-transfer medium, as well as all situations where the jacket pressure is the controlling factor in determining the vessel wall thickness.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Matching the Jacket with the Medium

Steam Service: The Half Pipe Coil Jacket and Dimple Jacket offer great economical advantages over the Conventional Jacket in the use of steam. The Dimple Jacket is limited to 300 psig while the Half Pipe Coil Jacket is approved for pressures of up to 650-700 psig. The higher the steam pressure, the greater the economies affected by Half Pipe Coil Jacket and Dimple Jacket.

For Half Pipe Jackets the higher flux rates may require multiple sections of jacket to avoid condensate covering too much of the heat-transfer area. If the inside film coefficient is rather low (in the 10-25 range), economic advantages can be realized by reducing the number of turns of the Half Pipe Jacket on the shell and head, and taking advantage of the "fin" efficiency of the Half Pipe Jacket.

Negatives with Dimple Jacket include the build-up of scale and other foreign matter in the lower sections of the jacket due to the inherent problem of not achieving complete positive drainage of the condensate. Over a period of time "dead spots" develop.

Pin-hole cracking, as discussed earlier in this report, tends to surface after the wear and tear of years in service.

Hot Oil, Dowtherm, Therminol:
Although pressures are low when using these liquids, the temperatures are high, with resulting low allowable stress values for the inner vessel material. Besides requiring a greater shell thickness than the other two designs, the Conventional Jacket requires expansion joints to eliminate the stresses induced by the difference in metal temperature between the jacket and shell, or by the difference in thermal expansion when the jacket is not the same material as the shell (e.g. a stainless steel shell and a carbon steel jacket).
The Half Pipe Coil Jacket is superior to the Dimple Jacket because of it's greater structural strength, positive channeling, multiple zone capabilities and because pressure drop can be simply calculated. Please remember that multiple zoning reduces pressure drop in the jacket. For Dimple Jackets, due to the turbulence created by the dimples, calculations of pressure drop become very complex and there are reservations as to their accuracy.

We recommend that if Dimple Jackets are utilized for high temperature hot oil medium that the following precautionary steps be taken:

1. A process be developed for proper testing for pinholes in all of the small fillet welds.

2. Take care to design nozzle manifolds to avoid stress concentrations.

In both the Conventional and Dimple Jackets, the flow path and jacket fluid velocity are controlled by directional baffles that have positive attachment to the inner shell only. There is a tendency for the fluid to bypass these directional baffles. The Half Pipe Coil jacket is so constructed that any bypassing is automatically precluded. This is important in maintaining a certain desired jacket-side heat-transfer coefficient under all conditions.

Water: Many of the conditions set forth in the hot oil medium section are applicable with water. The Half Pipe Coil Jacket design allows the only solution for 100% drainage due to the downward spiral pitch of the jacket. Both Dimple Jackets and Conventional Jackets are designed in ways that positive drainage is never completely achieved.

Chloridic Stress Cracking is a condition that develops when untreated water high in chlorides is utilized in dual service with a steam cycle on a repeated basis. This condition creates a maintenance nightmare and can be avoided by incorporating one or more of the following:

1.Treat water to minimize or eliminate chlorides.

2.Fabricate Half Pipe Coil jacket from Inconel 600 which is an alloy non-susceptible to the chloride problem.

3.Utilize parallel circuits with circuit A for steam service and circuit B for water service or any other combination of passes and/or zones.

Surface Area Available for Heat Transfer

With Conventional Jackets there are no questions regarding surface that is available. It is always that area covered by the jacket.

On Half Pipe Coil Jackets some engineers believe that the space between the half pipes is not useful for heat transfer. This is not accurate because the space between the coils acts like the fin on a finned tube.

With the Dimple Jacket some engineers are also concerned that the Dimple holes are not available for heat-transfer. The same basic analogy for heat conduction is applicable to Dimple Jackets as for the Half Pipe Coil design. The temperature of the jacket fluid is transferred by conduction to the inner shell.

Plate Coil Jackets

Plate Coil Jackets have not been discussed in this report because they are not considered as a viable alternative to the (3) major jacket types just presented when fabricating new equipment.

Plate Coil Jackets are integral units with small cross-sectional flow areas that are then attached externally to the vessel utilizing clips and mastic material. The result is a low film coefficient and resulting poor performance in comparison to the Half Pipe Coil Jacket, Dimple Jacket and Conventional Jacket.

Plate Coil Jackets are utilized on new equipment with low heat requirements and for the attachment to vessels that are in service in the field.

Law of Reflection

In our industry there is much confusion, misunderstanding and a wide variety of positions regarding the subject of "Surface Finishes" as it relates to vessel fabrication and performance after delivery and installation.

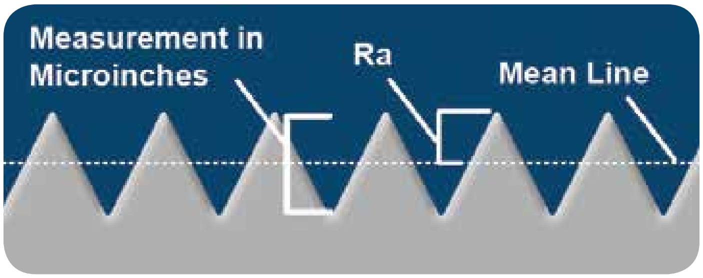
Basic Law of Reflection

All metal surfaces have a profile consisting of peaks and valleys. If the peaks and valleys have a large vertical distance between them, light will enter the valley and not bounce or reflect back. This set of circumstances produces a relative "dull" surface.

Surface finish enhancement by means of metal removal generally accomplished by utilizing abrasives on belts, grinding wheels and other media, changes the profile of the surface finish.

During the surface enhancement process, the vertical distance between the peaks and valleys is minimized and/or reduced allowing for degrees of greater bounce back or reflection producing a brighter surface finish. The closer the peak distance is to the valley and the greater uniformity of the finite scratches, the higher the reflectance resulting in a brighter surface.

Surface profile or finish is measured in microinches. A microinch is 1/1,000,000 of one inch. Surface profile is measured by evaluating the distance above and below an established "mean line". Historically, microinch measuring has utilized (2) processes:



Ra - Roughness Average is an absolute average height whereby you establish a mean line and a number of height samples i.e. H1, H2, H3 etc. above and below the line:

H1 +H2 + H3etc. = Ra N (number of samples)
RMS - Is a value calculated from taking the square root of all (H) samples divided by the number of samples.

RMS numbers usually run 11% to 25% higher than the Ra numbers for the same surface profile. Ra has become the industry standard and should be measured in microinches rather than microns.

Surface profile can only be measured by a PROFILOMETER. It has a stylus probe that when calibrated properly, runs across the grain of the surface and provides a digital readout of the surface profile or finish.

Grit is sand like particles utilized as an abrasive in the metal industry for surface enhancement. The most commonly used grit is an artificial aluminum oxide which is a sharp, hard and fast cutting product.

Grits are given grades or numbers relative to their roughness. Standard grades are:

- 80 Grit	- 120 Grit	- 150 Grit
- 180 Grit	- 240 Grit	- 320 Grit

People in our industry regularly spell out surface finish requirements as standard grit grades i.e. 120 Grit, 180 Grit, etc. This is not the proper way to identify an end result because a.) grit is a product or tool utilized in removing metal, results will vary relative to a variety of variables, b.) grit cannot be measured. How would you know if a fabricator polished your vessel to a 180 grit finish?

Surface finish requirements must be specified to an Ra or RMS which is a profile that can be measured utilizing the profilometer. I recommend to our customers that you establish a range such as 20 to 30 Ra or a "not to exceed" such as not to exceed 20 Ra to pinpoint your measurable requirements.

Electropolishing

Electropolishing is a surface enhancement procedure that produces a smooth, bright finish by leveling or rounding off both the peaks and the valleys in a process similar to electroplating except material is removed rather than deposited.

Utilizing an electrolyte subjected to a low voltage electric current, surface roughness is removed by anodic dissolution resulting in an extremely smooth finish.

Vessel surfaces are usually mechanically polished to a 20 to 30 Ra followed by Electropolishing which greatly improves anti-cling and sterility characteristics.

In closing, the surface enhancement of Nickel Alloy Fermenters, Reactors, Tanks and Vessels is accomplished by utilizing grit abrasives on belts, grinding wheels and other media in an effort to smooth out the surface profile, minimizing scratches, pits and other defects.

End users of our process equipment specify surface enhancement most usually for the following four reasons:

1. Improvement of anti-cling characteristics.

2. Improvement of sanitary characteristics.

3. Improvement of resistance to corrosion characteristics.

4. Improved appearance.

All of these “value added” options increase front end costs but produce a return on investment over the life time of the vessel.

R-V Industries looks forward to working with you in identifying solutions to satisfy your vessel surface enhancement requirements. Please feel free to contact us with any of your vessel questions and/or concerns.

Surface Measurement Comparison

Explanation of Measurements

Grit Size	RA (Micro-Inch)	RA Micron	RMS (Micro-Inch)	RMS (Micron)	Finish
36	142	3.61	160	4.06	
80	71	1.80	80	2.03	
120	52	1.32	58	1.47	
150	42	1.06	47	1.20	
180	20-30	0.76	24-34	0.86	#4 Finish
240	15	0.38	17	0.43	#6 Finish
320	8-12	0.30	10-14	0.36	#7 Finish

A Diversified Company

R-V is a uniquely diversified engineering and manufacturing company. Since it's founding in 1974, by Ronald L. Putt and Victor D. Dodd, the company has been committed to providing a quality product at a competitive price with integrity.

Corporate Headquarters • Honey Brook, PA

R-V recognizes (8) different markets that form its core group of products. These markets include:

- Biomedical, Pharmaceutical and Scientific Research
- Chemical
- Engineering Services
- Food and Beverage
- Fossil Power
- Nuclear
- Oil and Gas
- Paper Mill Machinery

As part of continuing efforts for employee safety and product quality, R-V maintains certification with SHARP (Safety & Health Achievement Recognition Program) through OSHA. This rating has been achieved by only 45 companies in Pennsylvania.

SHARP
Safety & Health Achievement Recognition Program
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Steam Sterilizer for the Sciences

Paper Press Assembly

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584 POPLAR ROAD
HONEY BROOK, PA 19344
RVII.COM • 610.273.2457