

An Overview of Radius' RTM / SQRTM Injection Equipment Offerings

- ▶ Design Focus & Key Features
- ▶ Product Offering
- ▶ Injection Systems Comparison
- ▶ Radius Engineering Advantage

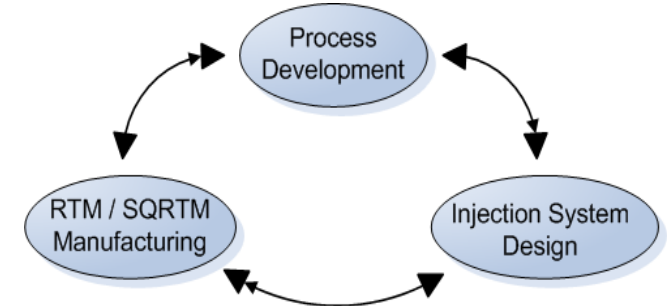


10,000cc Injection System

Radius Injection Systems are built with a unique design focus and proven feature set

▶ Design Focus

- Provide consistent and total process control for RTM and SQRTM resins.
- Offer a robust design and feature set driven by Radius' unique ability to integrate:
 - 22-years of composite process knowledge
 - RTM / SQRTM manufacturing expertise
 - Injection system design knowledge



▶ Key Features

- Currently the **only** production proven & capable **SQRTM** injection system on the market
- Positive Displacement Design & Control System
 - Precision Flow Rate Control
 - 'PID' Pressure Control up to 27 bar
 - Safety
- High Vacuum Level Sealing & Degassing
- Complete Process Monitoring & Acquisition



Injection Cylinder
Cutaway View

Standard Injection Systems provide precise control and monitoring

- ▶ Capacities
 - 2100cc, 5000cc, 10,000cc
- ▶ Resin Flow Rate & Pressure Control
 - Injection pressure up to 27 Bar
 - Flow rate up to 1500 cc/min
- ▶ High Vacuum Capable Cylinder
 - Vacuum sealing to < 0.1 mbar
- ▶ 'PID' Heated Resin Cylinder & Line Heater
 - Temperature control and monitoring up to 180°C
- ▶ PLC Based Control System
 - 15 cm color touch screen interface
 - Complete data acquisition
 - Real-time trending of injection parameters
 - Auxiliary temperature monitoring of up to 8 inputs
 - Auxiliary tool pressure monitoring
 - Floware™ software



5,000cc Electric RTM Injector



Real Time Process Trending

Options provide versatility for processing and cost

▶ In-Cylinder Degassing

- Agitating degassing head for in-cylinder heating and degassing of resin.
- Includes a dual stage rotary vane vacuum pump capable of 0.007 mbar.
- Vacuum monitoring capability along with leak rate calculator software.
- Available for 5000cc & 10000cc versions.

▶ Pneumatic Actuation

- A lower priced option which includes all of the standard injection system features with the exception of flow control.
- Available in 2100cc & 5000cc versions.

▶ High Temperature Series Injectors

- Offers an extended temperature processing range up to 280°C
- Available in 2100cc and 5000cc versions.

▶ Heated End-Plug

- Provides temperature control of the cylinder end plug.
- Commonly used when processing high viscosity resins.

▶ Vacuum Monitoring and Recording

- Provides vacuum level monitoring & acquisition capabilities.
- High resolution vacuum transducer (26 – 0.02 mbar) absolute pressure.
- Software features such as tool leak rate calculator and real time plotting.



In-Cylinder Degasser



2100cc Pneumatic Injector

Radius custom injection and auxiliary equipment address special needs

▶ RTM Degassing and Transfer Carts

- High Vacuum Level Degas (<0.1 mbar)
- 'PID' Temperature Controlled Resin Heating
- Dual Stage Rotary Vane Pump
- Available in 3.5 Liter and 10 Liter Capacities



3.5 Liter - Resin Degassing Cart



20 Liter – Pail Injection System

▶ Radius RTM Pail Injectors

- Inject pre-degassed resin directly from shipping pail
- 'PID' Pressure Control and Platen Heating
- Gerotor pump for high volume & high pressure capability

▶ Custom Injection Equipment

- Radius can offer completely customizable resin injection solutions based on project requirements
- Developments Include:
 - Custom 1900 Liter Injection System
 - 24 Liter Injection System
 - 25 Liter Resin Degas & Transfer Cart



Custom 1900 Liter Injection System

Radius Injection Systems provide superior operating and safety features compared to alternatives

Legend

○	Good
-	Moderate
✗	Poor
N/A	Not Applicable

Radius RTM / SQRTM Injection Systems
Competitors' RTM Injectors
Pressure Pot Systems
Meter Mix Systems

	Features					Description
Technical Specifications	Injection pressures up to 27 Bar	○	-	✗	○	<ul style="list-style-type: none"> High tolerance precision honed components and unique dual polyseal design provides pressure (27 Bar) and vacuum (<0.1 Torr) sealing that is critical to the SQRTM/RTM processes and unmatched by competitors Radius is the only production proven SQRTM injection system available on the market.
	Precise flow rate control (5cc/min up to 1500cc/min)	○	✗	✗	✗	
	Flow rate resolution (1cc/min)	○	✗	✗	✗	
	Standard temperature range (180 C)	○	○	-	-	
	High temperature option (280 C)	○	✗	✗	✗	
	Vacuum Sealing (<0.1 mbar)	○	✗	✗	N/A	
	SQRTM processing capability	○	✗	✗	✗	
	High viscosity resin processing	○	-	✗	○	
Safety	Low Exothermic Risk	○	-	✗	○	<ul style="list-style-type: none"> Radius' control system constantly monitors process values for exotherm identification and mitigation
	Low Burst Risk (Potential Energy Storage)	○	○	✗	○	
	Automated Process Monitoring	○	✗	-	-	
	Direct In-cylinder Pressure Monitoring	○	-	○	N/A	

Radius Injection Systems offer full integration with Radius work cells and offer extensive design features

Legend

○	Good
-	Moderate
✗	Poor
N/A	Not Applicable

*Radius RTM / SQR™ Injection Systems
Competitors' RTM Injectors
Pressure Pot Systems
Meter Mix Systems*

	Features					Description
Work cell Integration	Single PC control of entire workcell operation	○	✗	✗	✗	<ul style="list-style-type: none"> Only Radius can offer fully integrated <u>production proven</u> SQR™ work cells. Single source data acquisition and equipment control
	Full integration with RTM press software	○	-	✗	✗	
	Complete workcell data-acquisition	○	✗	✗	✗	
	Similar controls components for easy maintenance	○	✗	✗	✗	
Design Features	In-cylinder degassing option	○	✗	-	N/A	<ul style="list-style-type: none"> Radius injectors are fully customizable with auxiliary process options. Unique Radius injector seal design allows for quick cleaning and injector turn around. Eliminates the need for large volumes of solvent for cleaning Mechanical design is optimized to provide the lowest possible level of maintenance. Radius offers full 1 year warranty on all equipment
	Auxiliary heating control option	○	-	✗	-	
	Auxiliary sensors for Tool temperature & vacuum	○	-	✗	-	
	Touchscreen controls interface	○	-	✗	✗	
	Compact size, easy to move	○	-	○	-	
	Fast cleaning time (< 15 minutes)	○	-	○	-	
	Easy seal replacement / cleaning	○	-	N/A	N/A	
	No large quantities of solvent for cleaning	○	○	✗	✗	
	Low maintenance mechanical design	○	-	○	-	

Advantages of Radius Injection Systems come from 22-years of composite processing experience and equipment knowledge

- ▶ Experts in Injection Systems, Workstation Equipment & Tool Design
- ▶ All equipment can be specifically tailored to the project requirements.
- ▶ Complete systems integration between Radius Tooling, Workstation, and Injection Equipment.

