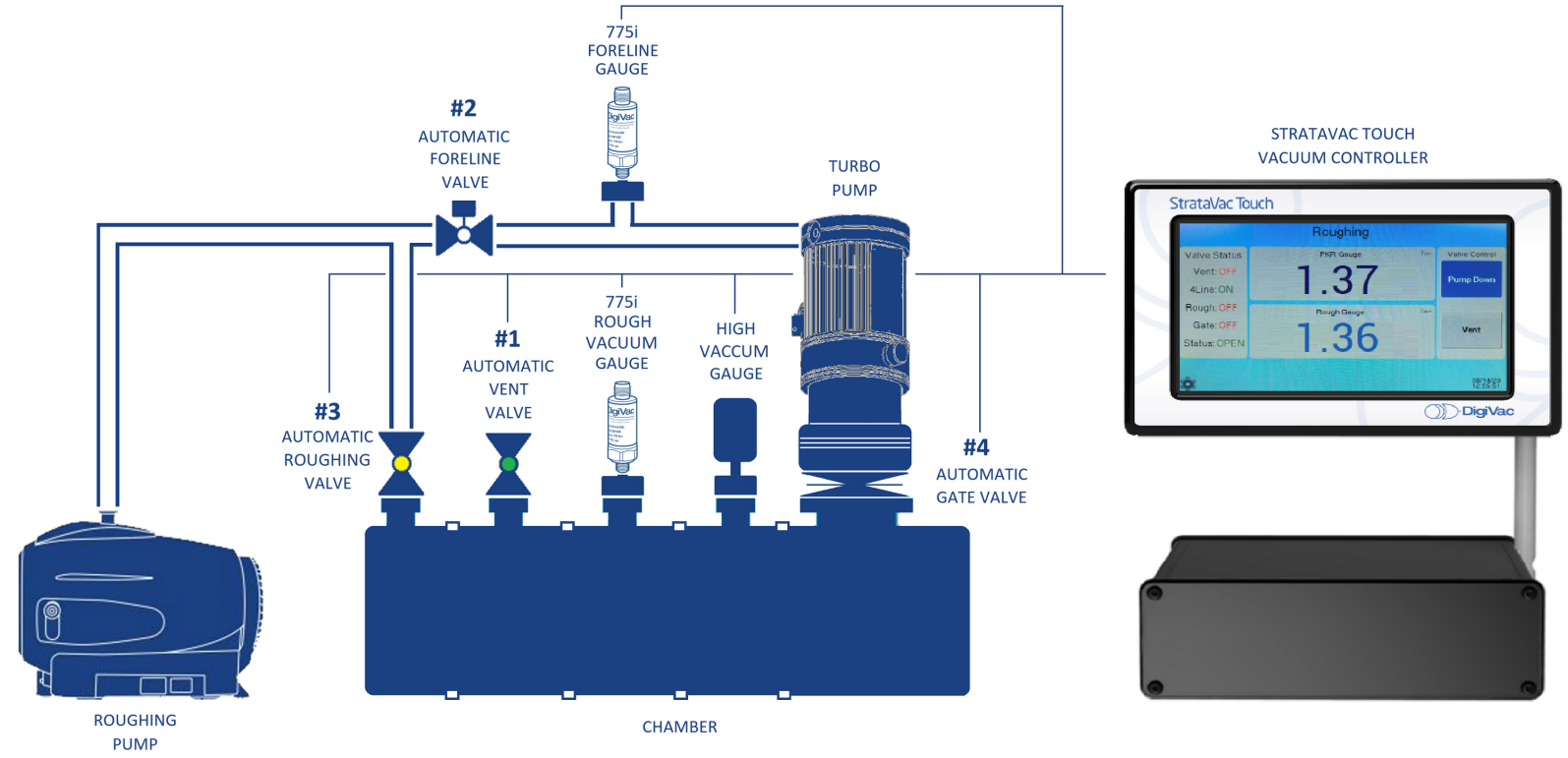
DIGIVAC CASE STUDY

AUTOMATED VACUUM CONTROL SYSTEM



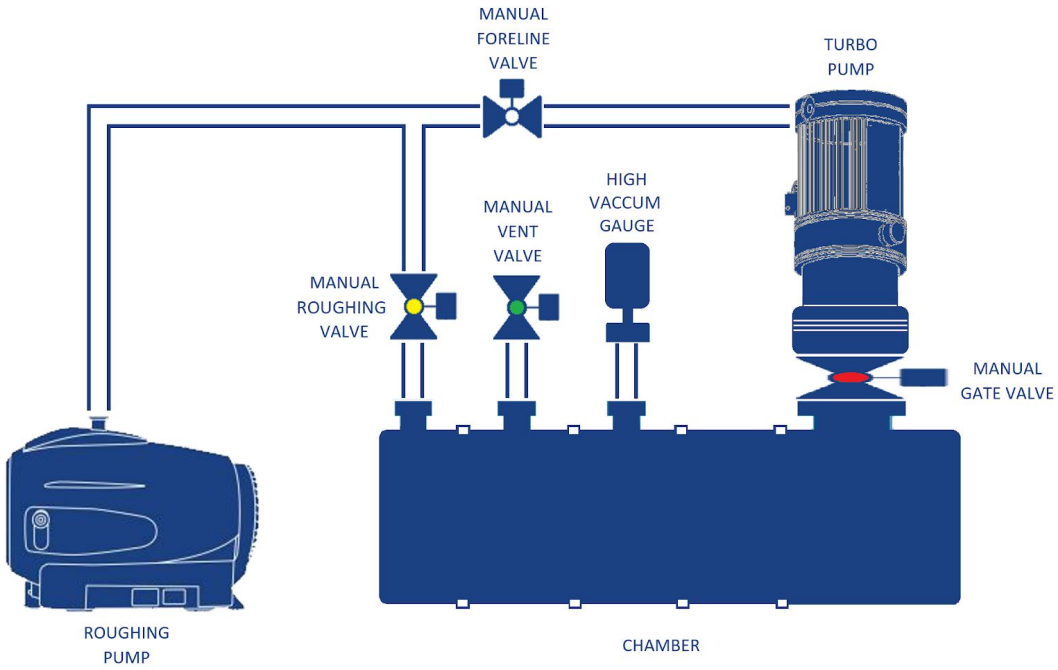
DigiVac

Scientific Measurement & Control

Case Study on Software Innovation

AUTOMATED VACUUM CONTROL SYSTEM

PROBLEM STATEMENT: A large research laboratory reached out to DigiVac to help them automate their Vacuum Stations. They wanted to move from their current process that included manually-actuated electronic valves to an automated vacuum control system.



Their Objectives Were To:

- Streamline the process and save time
- Help eliminate downtime
- Increase process repeatability
- Eliminate operator error

ENGINEERING APPROACH:

Understand Current Application and Customer Needs: The customer's setup consisted of multiple vacuum systems, each having a number of electrically-powered pneumatic valves which required a technician to manually operate. This manual process was time consuming and had the risk of human error,

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more so as one operator could be monitoring several systems at the same time. The vacuum station consisted of two rough pumps sharing roughing/backing duties and a turbomolecular pump evacuating a large process chamber. The operator was to follow a predefined pump-down sequence. If the wrong valve was opened or closed out of sequence, valuable process time would be lost while the system was corrected to the desired pressure, or system components could be damaged. Our customer thought the best approach would be to automate the system to increase process efficiency and decrease the risk of operator error. **The timeframe for this step (1 month):** from initial discussion, iterative solution discussion and quoting.

Research, Design, and Testing: DigiVac used the existing platform of our modular StrataVac Touch Vacuum Controller with the addition of custom software designed by our engineering team. This custom software profile within the StrataVac Touch allows for automatic pump down on our customer's vacuum station, but the Pumpdown Profile can be easily configured to support a number of applications.

In initial testing, potential pitfalls were found in the initial requested process sequence. Some pitfalls were non-issues (the customer would never replicate the conditions that were discovered), and some made sense to address. This iterative testing approach allowed us to strike a balance between a safe system, but one that wasn't too complex.

Speed to implementation (Timeframe 6 weeks): Since the hardware for the project already existed, DigiVac created a customized software profile within the StrataVac Touch to measure and control through a logic sequence supplied by the customer.

NEW PROCESS DESIGN | ROAD TO SIMPLE AUTOMATION

Digivac devised a solution that would incorporate the customers' existing solenoid piloted valves to deliver automatic control for that system. A mock up of the customer's system was made, using simple solenoid valves that could be automated, and were actuated in the same way as the customer's existing valves.

Operator valve control was implemented with smart software engineering utilizing a state machine such that all valves are controlled by the touch of two buttons: "**Pump Down**" and "**Vent**". Proper sequencing, safety interlocking and valve interaction are all handled automatically by the StrataVac controller.

With this implementation, a technician at the laboratory can safely operate a turbo pump while the StrataVac Touch controller handles all the fine details. In addition, at the customer's request, a remote control was incorporated so *a technician miles away from the facility can issue a "PUMP!"* command to the unit using DVCUP (DigiVac Communication User Protocol) and the pump down procedure

initiates. The user can issue a "VENT!" command which then initiates the venting procedure. **See a Video of the Process here.**

The test system that was created included:

- StrataVac Touch Controller with custom Pump-down Profile
- 30-gallon vacuum chamber/tank. The customer's process tank was larger but replicating the system with a smaller volume allowed faster software development cycles.
- Agilent IDP-10 dry scroll pump
- Varian V-250 Turbo pump
- 4x electromagnetic vacuum valves
- 2x vacuum gauges for monitoring pressure at the main chamber. One gauge was the exact instrument the customer already owned, the second was a much more accurate isolated sensor of our own design.

Pump-Down Profile: The StrataVac Touch Vacuum Pump-down profile allows the user's pumps to operate with virtually zero interaction and allows for Pump-down activation or venting of the system with a simple touch of a button.

This High Vacuum Pump-down StrataVac Touch Profile pulls vacuum in three stages:

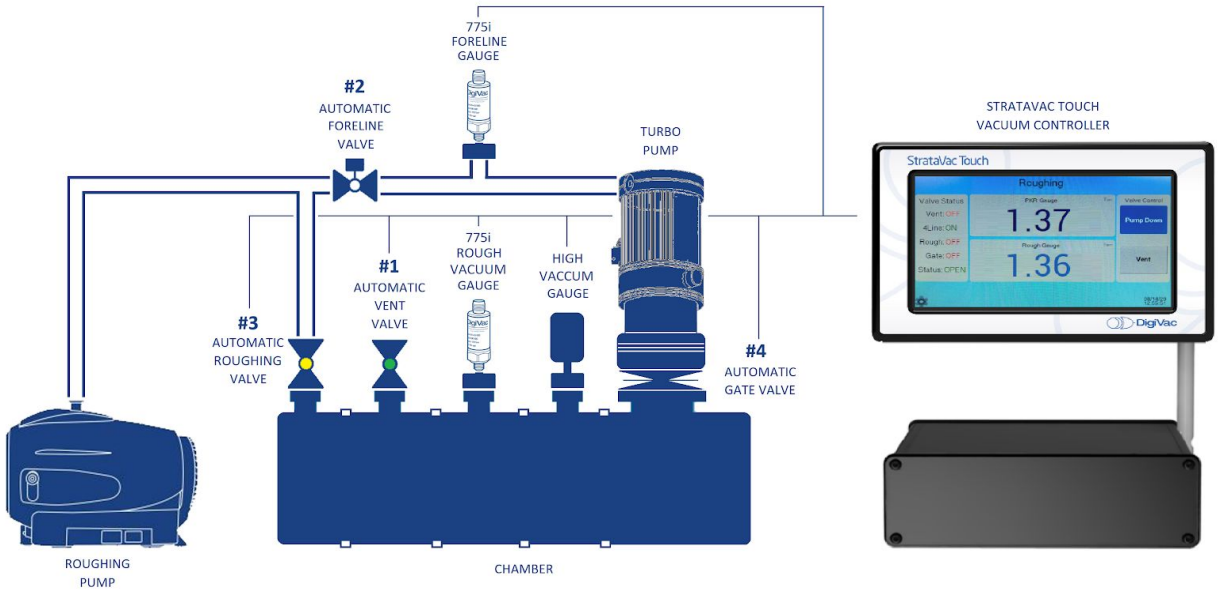
1. **Roughing Stage**: Turbo is isolated, Automatic Foreline Valve closes, Automatic Rough/Bypass Valve opens, and the chamber is evacuated to a safe turbo pump cross-over pressure.
2. **Turbo Pumping Stage**: Once chamber pressure reaches a programmed setpoint, the Automatic High Vacuum Valve opens, the Automatic Rough/Bypass Valve closes, and the Automatic Foreline Valve opens, allowing the Turbo Pump to evacuate the Chamber to high vacuum levels.
3. **Vent Stage**: Automatic High Vacuum Valve is closed, and the Chamber is vented to atmospheric pressure.

How was DigiVac quickly able to pivot and provide a custom vacuum control package that fully aligns with the customer's needs?

1. Expertise based on almost 40 years of experience in scientific measurement and control
2. Flexibility of the **StrataVac Touch**
3. R&D laboratory stocked with sufficient resources to replicate virtually any vacuum system in use. Development team was able to leverage in-house equipment to build a system comparable to what the customer was running.

The **StrataVac Touch** is a premium, touchscreen vacuum controller that can be used to monitor and/or control all pressures in any vacuum system. It can be configured to cover a range of vacuum pressures from rough to high vacuum. A user can:

- Easily see a snapshot of up to 4 vacuum gauges and the status of 4 valves across your vacuum system. Numeric readings or graphical representation of system status can be observed at any time.
- Control vacuum through a wide pressure range (rough through high vacuum) using bleed and/or throttle valves



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Pump down with roughing & turbopump running	**Venting**
• Process begins with Foreline Valve open, all other valves closed • Close or verify Vent Valve (#1) is closed • Close Foreline Valve (#2) • Open Rough/Bypass Valve valve (#3) • Verify when chamber pressure reaches the programmed pressure setpoint • Close the Rough/Bypass Valve valve (#3) • Open the Foreline Valve (#2) • Open the High Vacuum Valve (#4)	• Close the High Vacuum Valve (#4) • Open the Vent Valve (#1) *Vent duration and pressure ramp up controlled by StrataVac*

DESCRIPTION OF DIAGRAM *(refer to diagram p. 4)*

- Valve 1 (Vent Valve) opens to ambient air, or a dry gas supply, to allow the chamber to equalize to atmospheric pressure. This valve must be closed before initiating pumpdown.
- Valve 2 (Foreline Valve) opens to allow the Roughing/Forepump to serve as a backing pump for the turbomolecular pump.
- Valve 3 (Rough/Bypass Valve) opens to allow the Roughing Pump to evacuate the chamber from atmospheric pressure to the programmed setpoint, where the turbo pump will take over (the cross-over point).
- Valve 4 (High Vacuum Valve) controls the path between the Turbo Pump and the chamber. It opens to allow the turbo to evacuate high vacuum (low pressure), and automatically closes to protect the turbo from high pressures that may damage it.

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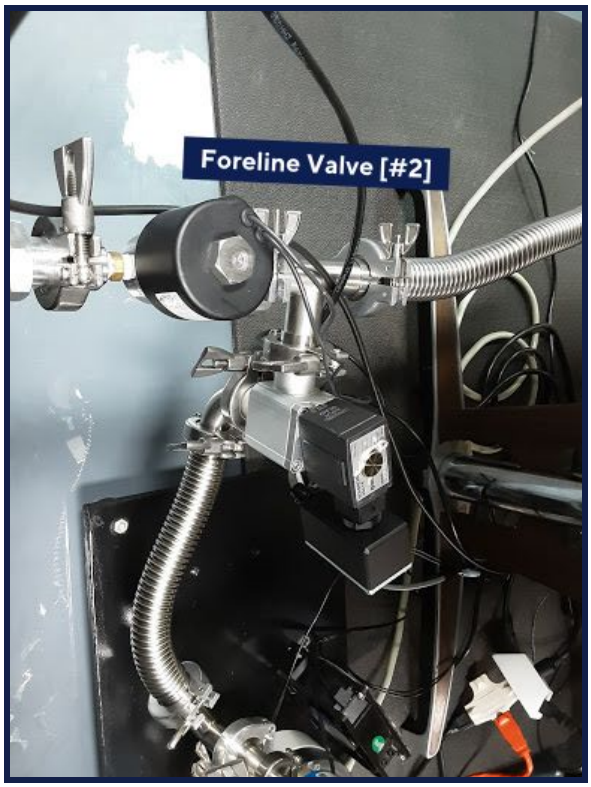

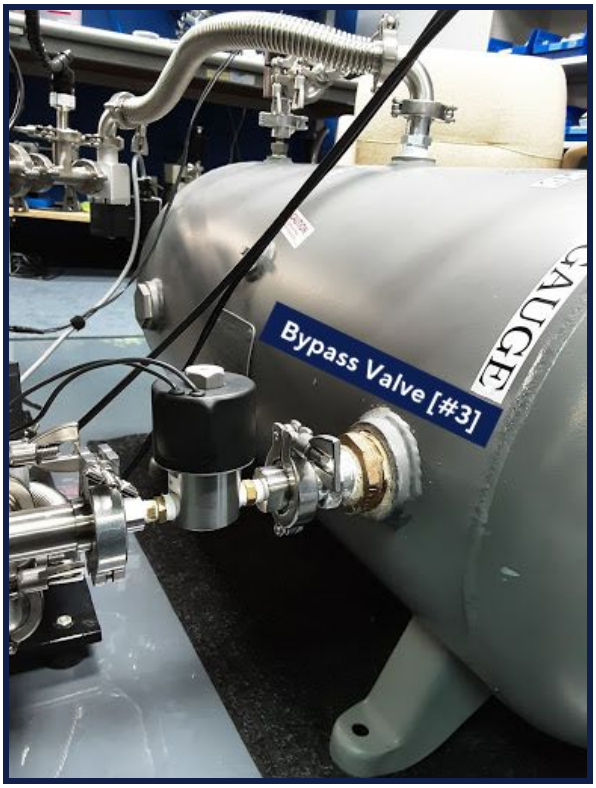

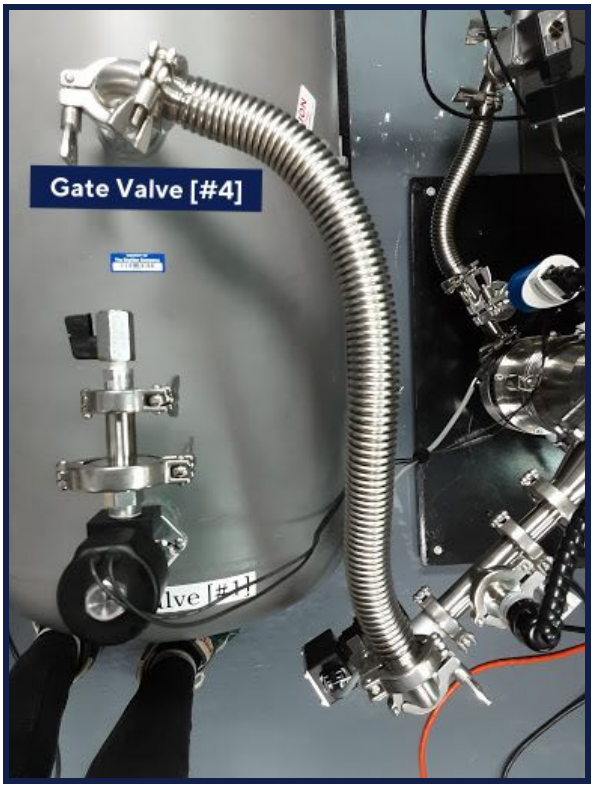

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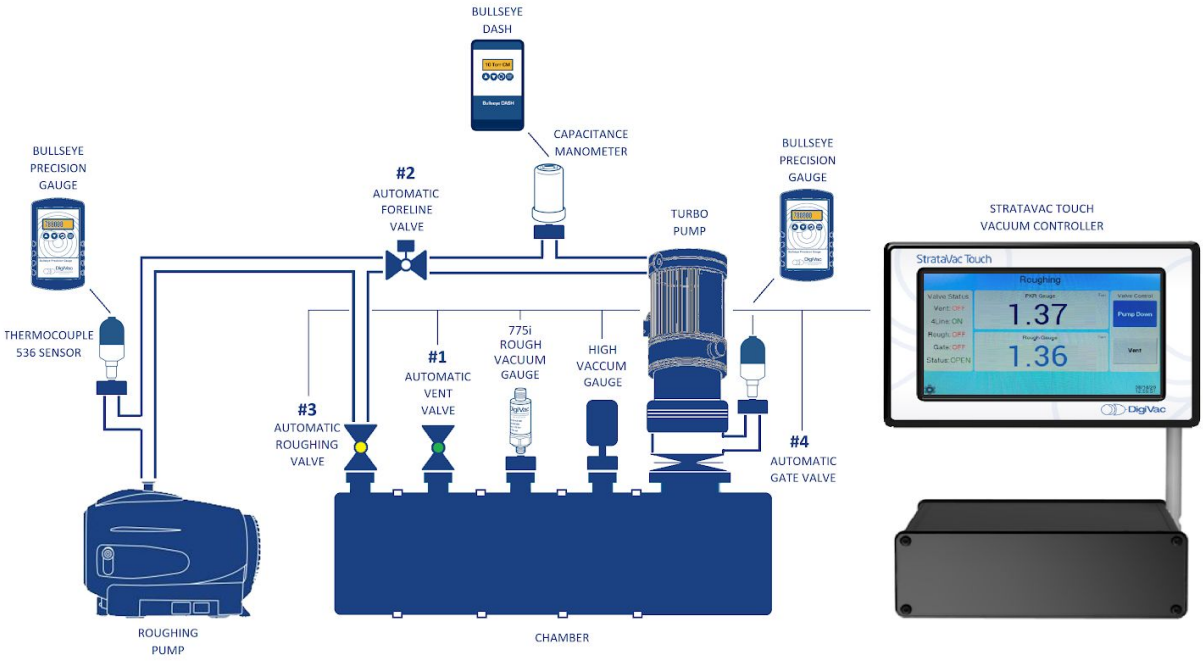
VALIDATION

While in the testing phase, it was important to verify the pressures throughout the system, even in nodes that might at first appear to be beyond the scope of the project specification.

Additionally, the DigiVac **StrataCapture** software was used in order to collect and visualize run data, and our **vacuumnetwork.org** facility so our engineers could remotely access real time run data during overnight runs to make sure everything was performing as anticipated.



As part of the interactive process to make absolutely sure that this system was doing what the customer wanted, this configuration was instrumented so it would be possible to double check all of the important pressures, and how they changed at different points in the pumpdown. For this system, it was decided to utilize (2) **Bullseye Precision Gauges**® to monitor the pressure at the Roughing Pump and the inlet of the turbo pump. The **Bullseye DASH** with a 10 Torr capacitance manometer was used to monitor the foreline pressure on the Turbo. All vacuum pumps were running continuously. The valves alternately open and block the pathways between them to allow for the flow of air to control the pressure in the chamber.

Foreline pressure should be monitored during the roughing stage. If the pressure exceeds maximum foreline tolerance of turbo, Rough/Bypass Valve (#3) must be closed and Foreline Valve (#2) must be opened to protect turbo.

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RESULTS

The DigiVac engineering team used an iterative approach to design and develop a product that met the specific needs of the client to automate a Vacuum Station moving from manually operated valves to an automated vacuum control system that helped minimize downtime, and normalize the process. Ultimately, this saves them time, increases process repeatability, and eliminates operator error that can damage high cost components or the customer's product.

STUDY LIMITATIONS

This section serves to point out some things we might change with the approach or the solution for our next customer:

1. We should have a formal specification template for the customer that enumerates different options, safety features and other options.
2. While not typically necessary, if we are to measure the inlet pressure of the Turbo, we should use a high vacuum gauge, not just a TC gauge.
3. The turbo pump inlet was restricted due to the chamber inlet flange size. To maximize turbo pumping speed, and not create a conductance limitation, the turbo pump should be installed directly to the chamber.
4. We feel an extra **775i sensor** in the foreline would allow the system to have a very simple safety to ensure the foreline pressure never exceeds turbo pump foreline tolerance pressure.
5. The screen may benefit from more intuitive UI features, such as more industry standard terminology, and visual clarification of the different modes of operation.

SUMMARY

DigiVac has a rich history of innovation in Automated vacuum control applications. DigiVac utilizes vacuum standards set-up on robust vacuum manifolds to allow us to test under real vacuum conditions. DigiVac runs a busy calibration lab, and having these onsite capabilities allows us to provide high quality technical support and supports our R&D product development activities.

DigiVac designed and created a sophisticated automated vacuum control system requiring minimal supervision or operation, using advanced software-controlled processes to pump and vent a chamber in accordance with the customer's vacuum process needs.

Our StrataVac Touch Controller is the brains behind the operation – the user only needs to program in the setpoints that they choose to actuate the valves, and the controller does the rest. The valve function can be controlled using the

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touchscreen or using DVCUP (DigiVac Communication User Protocol) where the user sends commands remotely, enabling a technician to operate and monitor the vacuum system remotely.

DigVac was able to quickly develop a custom software solution that delivered a super simple way to automate a complex high vacuum pumpdown station, which doesn't require a separate PLC and avoids manual operation errors. **DigiVac created a simple solution that automatically Pumps Down and Vents a system with the touch of a button! See the application in process in this video.**

Looking to automate your vacuum system? Give DigiVac a call at (732) 765-0900. Or, **contact us** and let us help you develop the best solution to meet your needs.

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