# The Sepro E100 Story

## Background

This story began in 2016 when Sepro Mineral Systems purchased a small manufacturer of agitators and peristaltic pumps called Canamix, primarily for its agitators. Sepro soon discovered that the market for peristaltic pumps was very large. Sepro also recognized that in order to succeed against well-established, large, global competitors in the peristaltic pump world, a serious differentiator would be required. A preliminary investigation into hose design quickly revealed that peristaltic hose or tubing must:

1. Be stiff enough to resist collapse in the presence of internal vacuum (or negative pressure).
2. Withstand the repeated folding that is required to seal against internal positive pressure.

These requirements necessitate a trade-off to be made when using conventional, circular peristaltic pump hose technology. Stiffness in peristaltic pump hose is achieved by making the walls thicker. Thicker walls significantly increase stresses when the hose is sufficiently squeezed to seal against internal pressure. It is possible to build a hose with relatively thin walls that can withstand high internal pressure, but it will collapse under even partial vacuum. The problem becomes exponentially more severe as internal diameter increases. (Bending moment in an evenly loaded beam is a function of the square of its length.)

Any review of commercially available peristaltic pumps will show that while there are a few pumps available with nominal internal diameter greater than 100 mm, the vast majority of the installed base is 100mm or less. For example, the largest diameter pump available from the world's largest manufacturer is 100mm. The conclusion is that while it is possible to build and operate a peristaltic pump with nominal ID greater than 100mm, hose life will be short and internal pressure will have to be kept very low, certainly below 10 Bar. The last major advance in hose design was made about 60 years ago when a patent was issued for fiber reinforcement of peristaltic pump hose. When using conventional hose design procedures, there is a natural 'barrier' when wall thickness exceeds ~22mm.

Another problem with peristaltic pumps larger than 100mm is that hose changing becomes very difficult. So, in addition to hose change frequency going up, hose change difficulty also goes up. The result has been a lack of widespread operator acceptance of hose pumps larger than 100mm.

In January 2021 the idea for a new hose shape was born. The idea was to create peristaltic pump hose that achieved the required stiffness against vacuum collapse by making the top and bottom walls sufficiently thick to prevent vacuum collapse while keeping the side walls thin enough for efficient bending. This approach significantly reduced the angle through which the side walls had to be folded. It also meant that the casing track and roller (or shoe) would have to be curved. It was hoped that this combination of features would reduce stresses sufficiently to allow much higher outputs from smaller pumps and allow construction of very much larger peristaltic pumps.

Fortunately, Finite Element Analysis (FEA) of reinforced rubber hose had also seen significant advancement by then. Sepro used the latest FEA software to investigate various geometries. The FEA results were sufficiently encouraging to warrant construction of prototype hose. An example of output from this early work is shown in Figure 1.

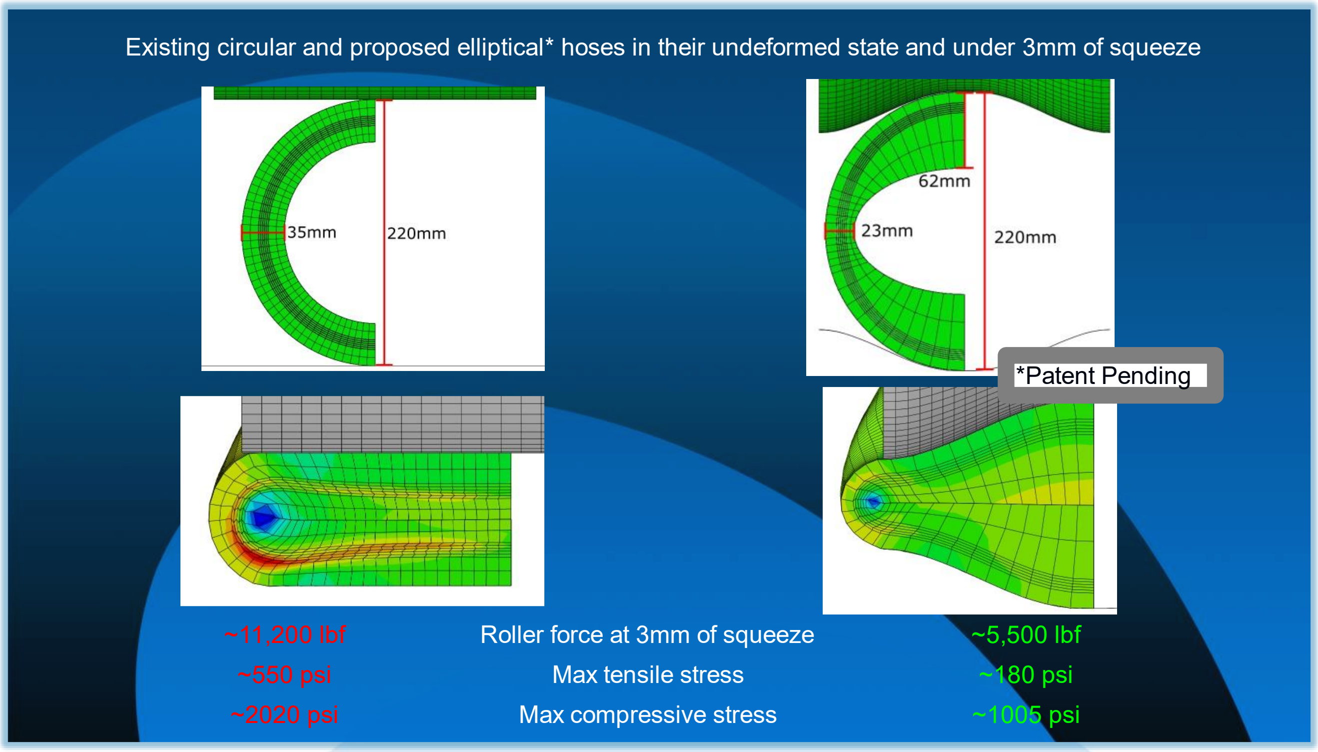



Figure 1: Early FEA outputs.

Although this early work was focused on nominal 150 mm hose, no good solution to the hose changing problem had emerged by that time, so efforts were diverted to 100 mm hose to ensure easier market acceptance of the new hose technology.

## FEED

Work began on the design of the E100 pump in 2022 with a Front End Engineering Design (FEED). The objective of this work was to enable Sepro's Engineering staff to design an extremely robust 100mm peristaltic pump with very high confidence.

Although FEA software can calculate loads on the casings and rotating elements of peristaltic pumps, Sepro elected to carefully measure these loads using actual hose and casings. Internal pressures ranged from zero to more than 20 Bar. There was a strong correlation between the FEA models and the field measurements. As expected, this work confirmed that the elliptical hose required much less force to form a seal than the circular hose. An unexpected and welcome result of this work was that the pressure gradient* of the elliptical hose was lower than for any circular hose tested by a very wide margin. This means that the elliptical hose is much more tolerant of under or over shimming than circular hoses. Figures 2 & 3 show the load measuring apparatus. Loads were applied using a hydraulic cylinder and internal pressure was applied using a manual water pump used for pressure testing of piping systems.

* Defined as the slope of a plotted line on a graph where pressure is ascending on the Y-axis and gap between the roller/shoe and the track is descending on X-axis.

Figure 2: Load Testing

Figure 3: Load testing

The data generated from this work was used to perform FEA analyses on all of the metal parts of the E100 pump including the gearbox, casing, rotor, roller carrier, rollers, and fittings.

Figure 4: Hose/Fitting Tests

Fittings and hose were pressure-tested in a separate apparatus shown in Figure 4.

Water pressure was applied using the manual test pump pictured.

Experiments were performed with both crimped and clamped fittings. Burst pressures above 40 bar were confirmed.

A design factor of safety was set at 2 according to the Association for Rubber Products Handbook of 2015.

## Detailed Design

### Hose

Data from the FEED was used to make a detailed design of a peristaltic pump including an elliptical hose with the same open area as a 100 mm circular pump, ~79 $cm^2$. The hose dimensions were finalized and subjected to FEA. A circular hose was also modeled for comparison purposes as shown in Figures 5 & 6 below. **Maximum stress in the E100 hose is approximately 50% of that in the circular hose.**

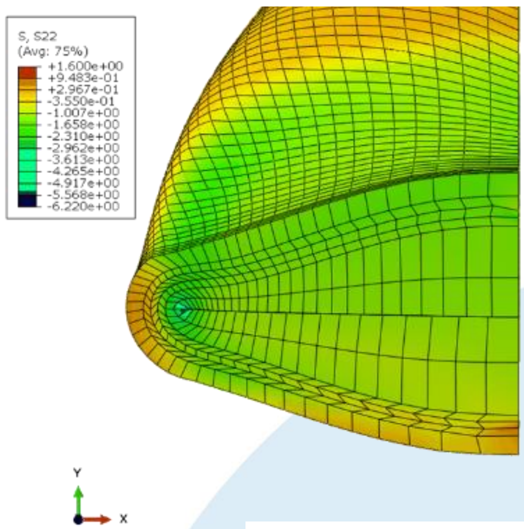



Figure 5: Stresses in Elliptical Hose

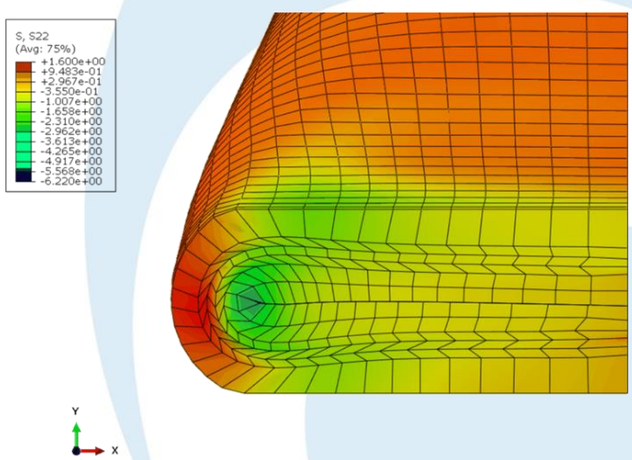



Figure 6: Stresses in Circular Hose

## Rollers versus Shoes

There is considerable debate in the industry regarding the use of rollers versus shoes. Shoes are thought to be less troublesome and less expensive than rollers. For example, if slurry gets into a roller bearing as a consequence of an end-of-life hose rupture, that bearing has to be replaced.

On the other hand, rollers offer considerably less resistance to rotation than shoes and require much less glycerine to keep the hose lubricated.

The largest manufacturers offer shoes on their larger pumps. These manufacturers do not offer quantitative data to justify this choice, only opinions. If they were to switch over to rollers, they would have to change their hose changing protocols. They use a threading method that requires the shoe to 'grab' the hose and pull it through the pump. In addition, they might be stuck with a lot of dead parts inventory.

After very careful consideration, Sepro has decided to incorporate rollers complete with permanently sealed bearings into the E100 for the following reasons:

1. Power consumption is considerably lower than for shoes*.
2. Lower operating temperatures can be achieved*.
3. Very well sealed bearings are now available at reasonable cost.
4. Less glycerine is required to lubricate the hose. In low pressure, low flow applications, it is possible to run without lubricant.
5. Sepro has developed a safe, easy method for changing hose that does not require removal of inlet and discharge piping. This method has now been proven on the preproduction E100 and solves the common industry complaint of having to remove piping to change a hose.
6. The new hose shape offers better resistance to bending around a roller than a circular hose.

* Please refer to performance data in the Preproduction Manufacturing and Testing section of this report.

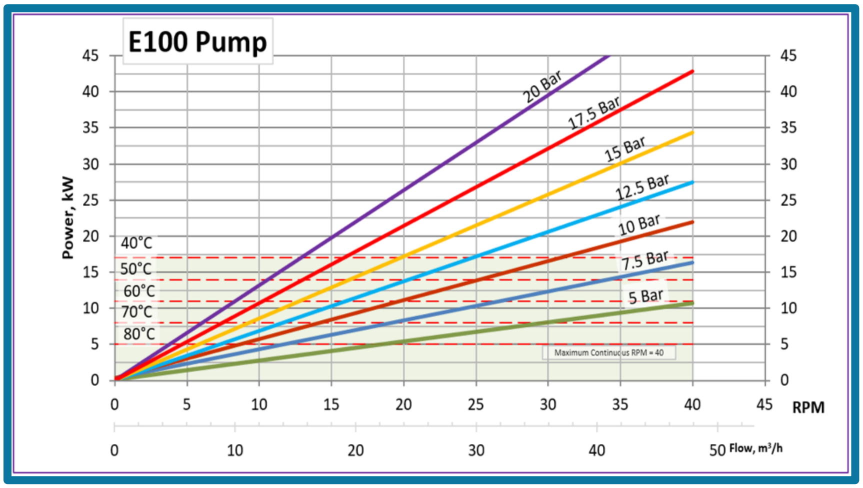
## Hose Grinding

With conventional, circular peristaltic pump hose an extremely small change in gap between the track and roller (or shoe) makes a very large difference in the stress regime within the hose. For example, Sepro found that a 1 mm reduction in gap resulted in ~12 Bar difference in sealing pressure. This makes it very important to have very close tolerances on the hose, casing, and rotating parts. While it is relatively easy to maintain tolerances in the metal parts, it is much more difficult with the hose. Some manufacturers grind their hoses to achieve precise dimensions in the hose. This increases cost. Other manufacturers take great care to build hose to close tolerances.

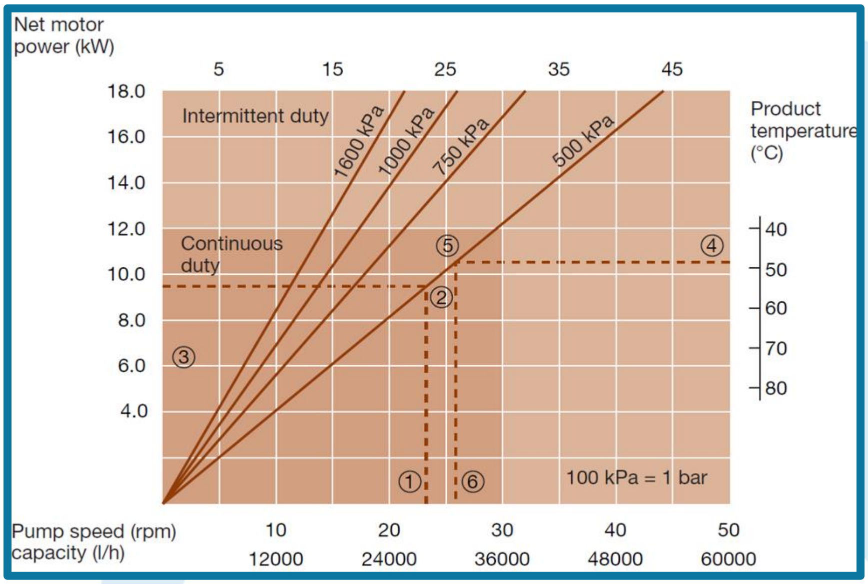
With Sepro's new elliptical hose, a 1 mm gap reduction results in ~4 Bar difference in sealing pressure. This means that the effect of over or under shimming is significantly reduced.

Sepro has decided to use unground hose from high quality vendors and to hold metal parts to very close tolerances.

<u>E100 Performance versus Competitor</u>



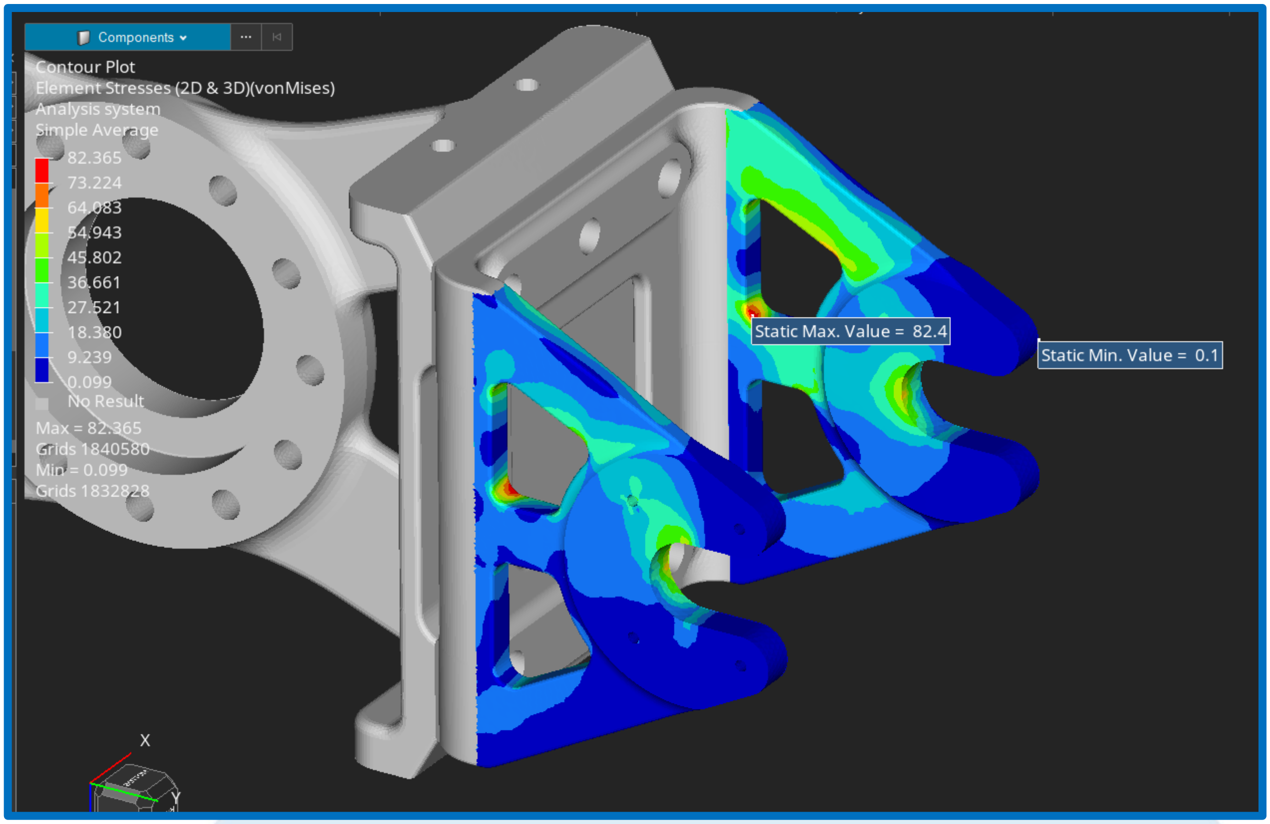

| SEPRO E100 | |
|---|---|
| Maximum RPM: | 40 |
| Temperature @Max RPM | <45° C |
| Maximum Pressure: | 20 Bar |
| Power Difference: | -28% |

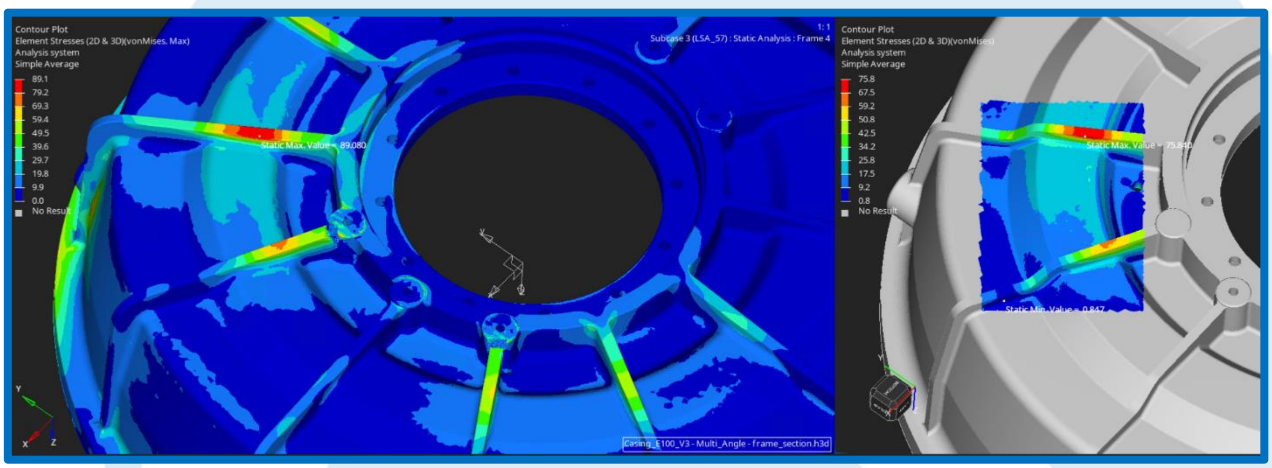



| COMPETITOR | |
|---|---|
| Maximum RPM: | 30 |
| Temperature @Max RPM | >60° C |
| Maximum Pressure: | 16 Bar |
| Power Difference: | +39% |

It is clear from the performance charts above that the Sepro E100 Peristaltic Pump represents a step-change in the field of peristaltic pumping. It opens the possibility for very much larger peristaltic pumps that can withstand considerably higher pressures. In addition, the unit power consumption in any given application will be significantly reduced.

Below are typical FEA outputs for metal parts:



After the parts had been modelled and analyzed, they were compiled into a full assembly and rendered as shown on the following page. The casing is white to keep heat absorption at a minimum.


E100


sepro
E100
elliptical

## Preproduction Manufacturing and Testing

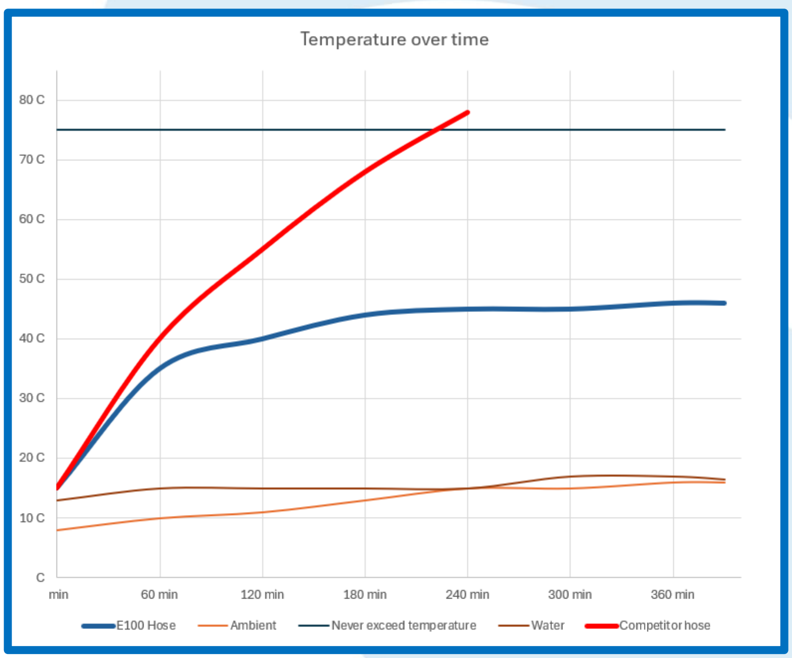
The Bill of Material was purchased for a ‘preproduction’ pump. It is shown partially assembled in the photo below.

The assembly went well and testing at Sepro’s Factory is almost complete.

**Here, the pump is being tested on water at various maximum discharge pressures.**

Here is temperature data recorded during testing at **40* rpm @ 6 Bar**

*Compared to 30 rpm maximum for competitors.




It is clear from this test that the E100 pump can produce at least **<u>33% more output</u>** than *any* known 100 mm peristaltic pump.

Consistent with the outstanding temperature performance is that power consumption was measured at **<u>28% lower</u>** than a competitor pump at the same output. Less heat coming out must mean that less energy is going in...

**<u>Half the stress!</u>**

Industrial Field Trial

The preproduction pump was installed in an industrial plant in August 2024 where Sepro peristaltic pumps have a 9-year history of operation. The E100 pump reaches a steady state operating temperature about 15 Degrees above ambient whereas a predecessor shoe-type pump previously installed in the same duty operated at about 30 degrees above ambient. In addition, lower power draw has been confirmed.

Historically, the operation consumed 3 hoses per year. Based on the lower operating temperature, a much longer hose life is expected. The trial continues.

Next Steps

There were a few very minor and immaterial fit and finish details on the preproduction machine that have been resolved and will be carefully documented before the Sepro E100 Peristaltic Pump goes into full production. These small items are typical of what distinguishes a prototype from a proven product.

Hose changing procedure will be refined further even though the hose was installed and removed from the preproduction machine without difficulty. Further refinements are being trialed.

The supply chain is already in place for supply of large volumes of E100 pumps. Serial production is expected to begin in early 2025.

**Take the Sepro Challenge: If the E100 does not outperform your existing 100mm peristaltic pump with respect to *any* of the following parameters, Sepro will refund the purchase price, no questions asked:**

- **Hose Life**
- **Power Consumption**
- **Output**
- **Hose Temperature**
- **Maximum RPM**
- **Maximum Pressure**

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