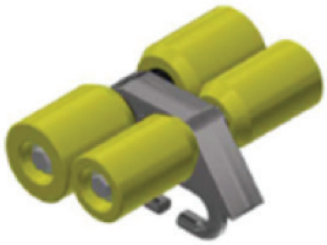
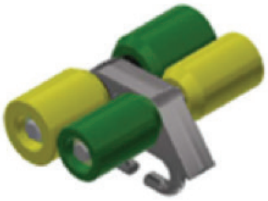
Injection Molded Rollers
Preliminary Testing Data and Approval

The aim of this report is to evaluate the suitability of injection molded rollers manufactured by Diversified Plastics for use in our supply chain, specifically on our 4-wheel rollers. The report is based on a field study conducted in the United States. The study examined the performance of five different roller configurations and a Control configuration, which uses machined UHMW rollers and represents our current production model. The data was collected over a period of 77,846 cars that were washed after the installation of the injection molded rollers on September 15th, 2022. An illustration of the different roller configurations is shown below. This report will provide information and recommendations on the implementation of the injection-molded rollers into our production process based on the findings and conclusions drawn from the study.



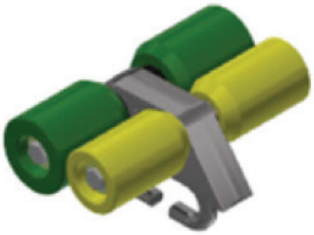
Control

Configuration 1

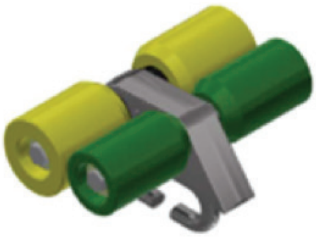


Configuration 2

Configuration 3



Configuration 4



Configuration 5

The roller assembly comprises two wheels: one with a larger diameter and the other with a smaller diameter. The following table provides measurements for both the Machined Sample (Control) and the Injection Molded Sample (Test Subject). The drawing below each table displays an identifier for each measurement.

Large Roller: Initial Measurements			
Machined Sample		**Injection Molded Sample**	
Length Through Bore	3.630"	Length Through Bore	3.621"
Counterbore Depth	.630"	Counterbore Depth	.624"
Outside Diameter	2.986"	Outside Diameter	2.987"
Counterbore OD	1.550"	Counterbore OD	1.530"
Inside Diameter	1.016"	Inside Diameter	1.012"
Small Roller: Initial Measurements			
Machined Sample		**Injection Molded Sample**	
Length Through Bore	3.981"	Length Through Bore	3.981"
Counterbore Depth	.624"	Counterbore Depth	.624"
Outside Diameter	2.500"	Outside Diameter	2.484"
Counterbore OD	1.552"	Counterbore OD	1.552"
Inside Diameter	1.013"	Inside Diameter	1.013"

Upon receiving the rollers, we recorded the roller configuration and wheel location for each roller. Our testing setup comprised five rollers for each of the five configurations, along with the Control configuration. We used the following notation to identify each roller:

Location: BL (Back Left), BR (Back Right), FL (Front Left), FR (Front Right)
Configuration: C1, C2, C3, C4, C5, C (Control)
Roller number: Each roller was labeled with a number from 1 to 5 to indicate its position within a given configuration.

These notations were used to organize the raw testing data, which we present in easy-to-read graphs in this report.

To further understand the physical characteristics and behavior of the injection molded and machined rollers, we conducted a closer examination of their components. The images below show some of the key observations we made during the inspection.

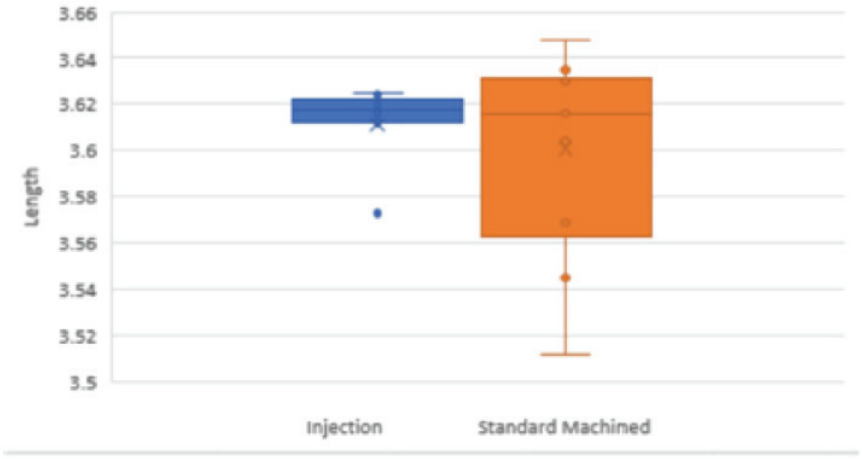
In the first image, we can see deformations on the outside of the counterbore of the pusher rollers. These deformations are caused by the reduced wall diameter thickness at that location, which is consistent between both types of rollers. However, it's important to note that we checked and verified the smooth operation of the rollers before disassembly, and we found that these deformations do not affect their functionality in any way.

The second image shows material removal and "gnawing" on the counterbore side of the outside diameter. This type of damage is usually caused by physical contact between the roller assembly and a component on the conveyor assembly. However, what's important to note is that there is no delamination or large separation on the roller, and the material that was removed is chipped away instead of peeling away. This indicates uniformity in the material and production process, which is a positive indicator of the quality of both types of rollers.

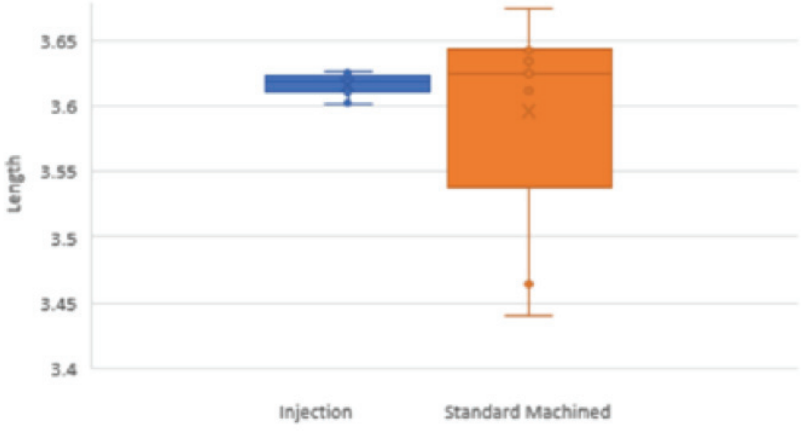
For the purposes of this report, we will focus on three key areas of the roller: the outside diameter, the inside bore diameter, and the overall length of the roller. Each of these three key areas will be analyzed for both the Back Rollers (Larger Diameter, Load-Bearing Rollers) and the Front Rollers (Smaller Diameter, Pusher Rollers). Each of the graphs below depict the entire sample size for the given wheel location and does not take the roller configuration into consideration.

The Back-Left and Back-Right rollers bear the primary load of the roller on the conveyor's top deck. We found that the length measurements for the injection molded rollers were much more consistent than those of the machined rollers, with a smaller deviation from the average.

Back Left Large Roller - Length

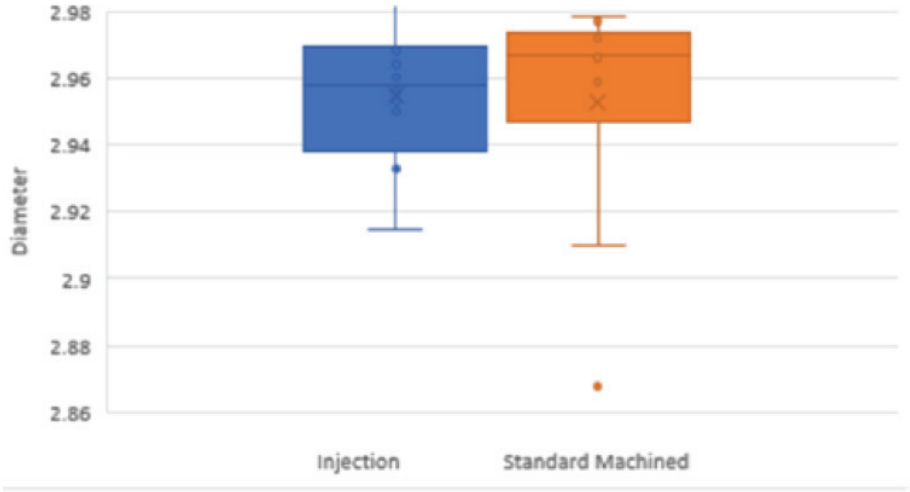


Back Right Large Roller - Length

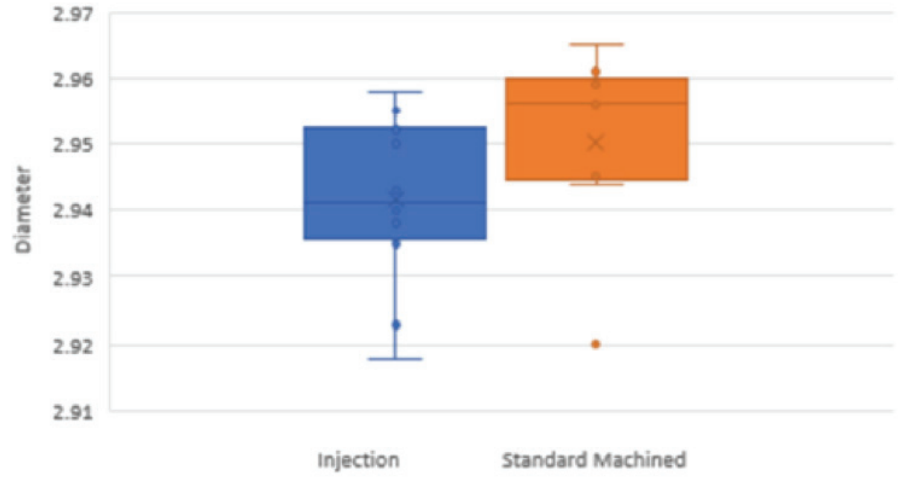


The outside diameter measurements for the Back-Left and Back-Right rollers were very similar. Both groups had comparable overall deviations from the average and wear. There were a few outliers for both types of rollers, but this was expected given the harsh environment they are exposed to. It's worth noting that an "outlier" in this graph represents additional wear of approximately 1/32".

Back Left Large Roller - Length

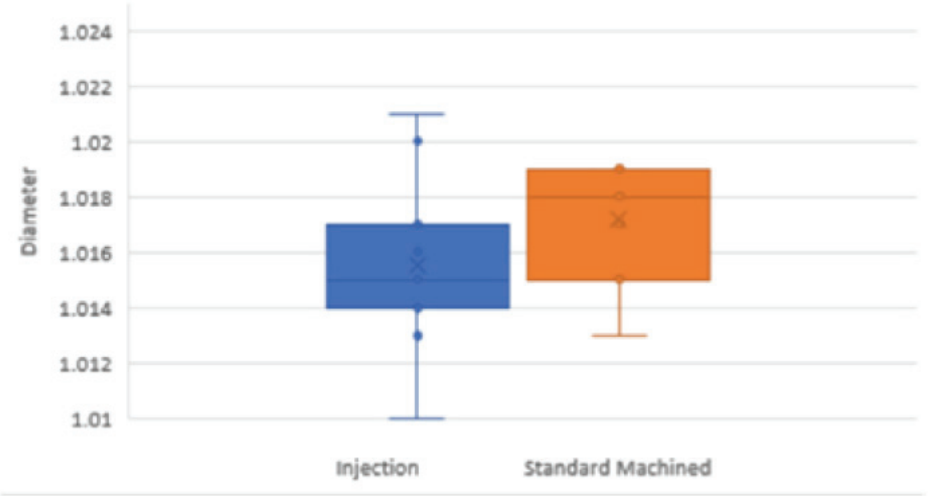


Back Right Large Roller - Length

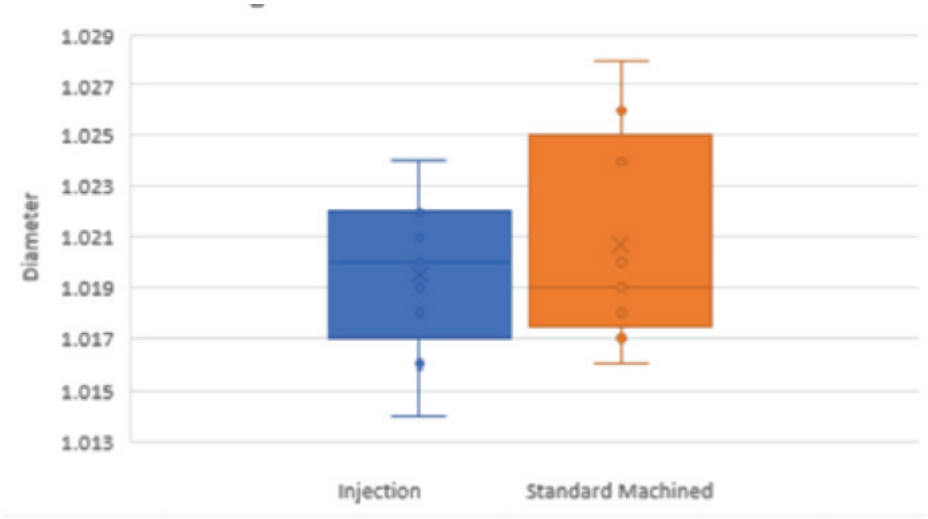


The following graph shows the internal bore diameter of the drive rollers, a critical dimension because an increase in bore diameter can cause the roller to shift on the pin of the roller frame. Additionally, excessive wear on the internal bore of the roller has been known to cause increased washer wear which results in premature failure of the entire roller assembly. The wear for both the injection molded and machined rollers was comparable, with differences within a few thousandths of an inch. The injection molded rollers exhibited less wear on the internal bore than the machined UHMW counterpart on average. It's worth noting that the right roller exhibited slightly more wear than the left roller, which is expected because the rollers tend to shift towards the right side of the conveyor during operation.

Back Left Large Roller - Length



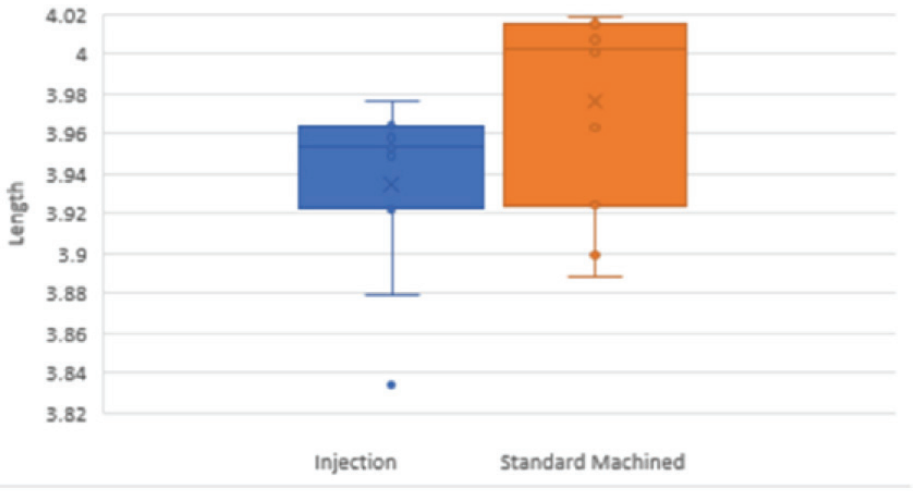
Back Right Large Roller - Length



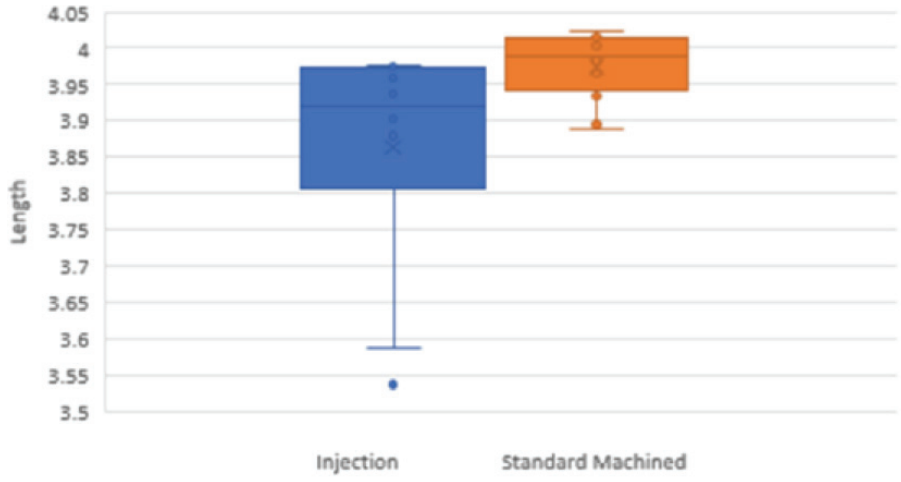
Based on the analysis of the data collected from the testing setup, it can be concluded that the quality of the injection molded rollers is comparable to the machined UHMW rollers for the large roller. The outside diameter measurements of the Back-Left and Back-Right rollers were found to be very similar, with both groups having comparable overall deviations from the average and wear. The internal bore diameter of the drive rollers was also comparable, with differences within a few thousandths of an inch. The rollers were found to be within acceptable tolerances of expected wear in both scenarios and there is no evidence to suggest that they would fail prematurely.

In the next section of our analysis, we will examine the front small rollers of the roller assembly, which make primary contact with the front or rear of the vehicle. These rollers are less critical to the overall success of the roller assembly and allow for slightly more wear and tolerance during operation. It is worth noting that the car wash where these rollers were installed is a front-wheel-pull car wash.

Front Left Small Roller - Length



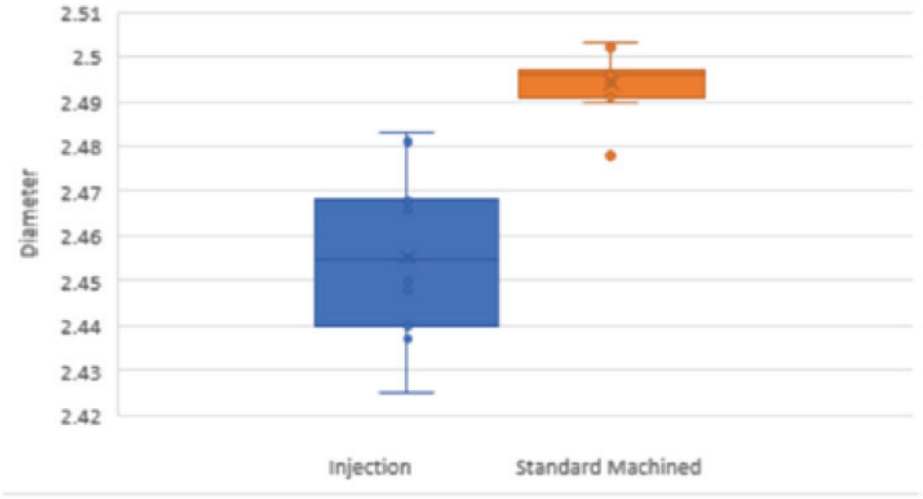
Front Right Small Roller - Length



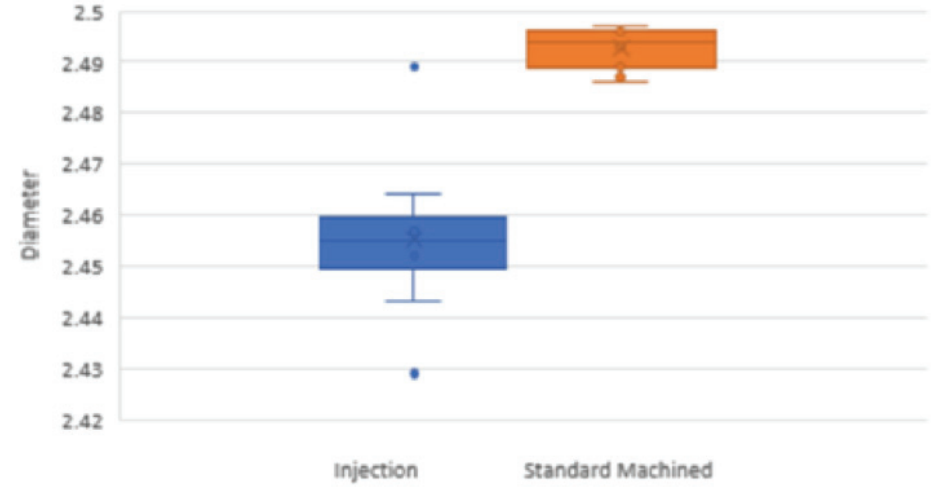
In terms of length, both the injection molded rollers and the machined rollers are quite comparable. There are a few outliers on the injection molded front right rollers, and those can be attributed to a site-specific issue where the rollers were contacting the right side of the conveyor for a period. However, it is important to note that even with the excessive wear due to the site issue, the roller still performed as necessary and did not show any signs of premature failure.

We also analyzed the outside diameter of the front left and right rollers, considering the initial measurements for each roller type. The UHMW machined rollers had an initial diameter of 2.500", while the injection molded rollers were slightly smaller at 2.484". The graphs above show that the injection molded rollers exhibit more wear than the machined rollers in this area. However, the wear is still within the acceptable tolerance range and profile. The initial machined tolerance is 2.500 +/- 0.060, and even after approximately 80,000 cars, the lowest roller diameter was still within the acceptable range. These dimensions are well within the acceptable range and do not indicate premature failure or render the rollers unusable.

Front Left Small Roller - Length

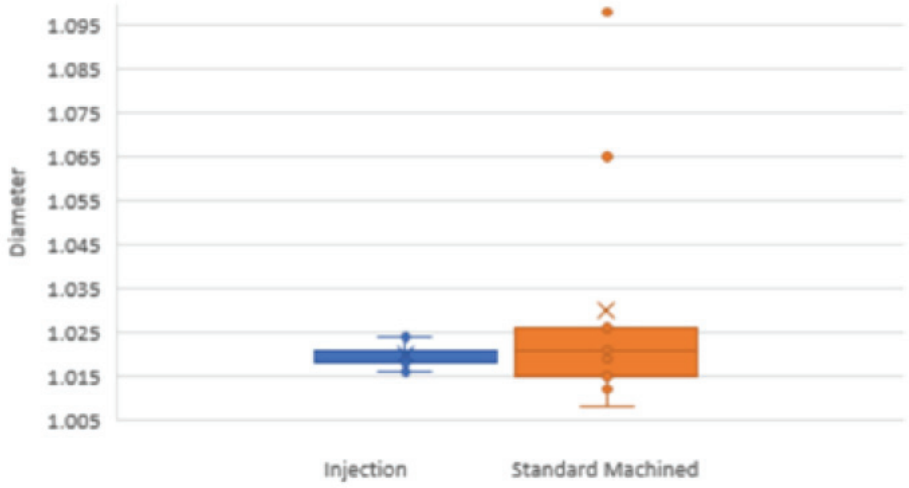


Front Right Small Roller - Length

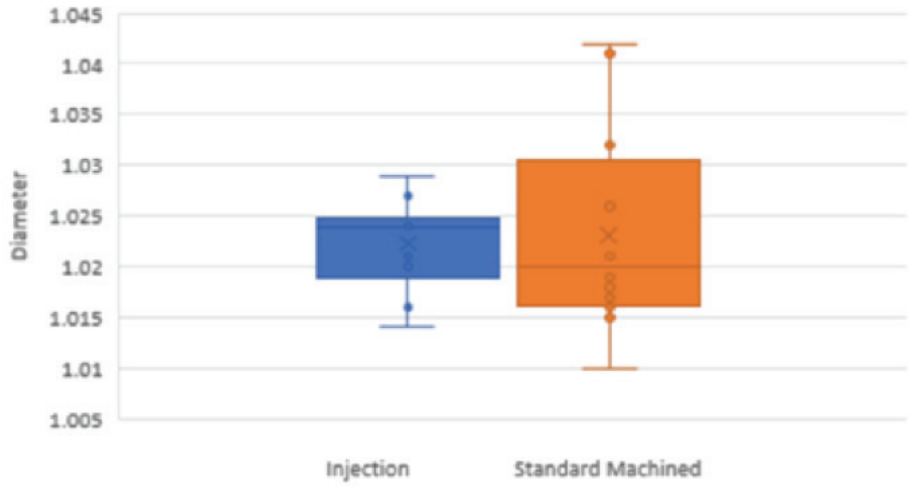


The following graph shows the internal bore diameter of the pusher rollers, a critical dimension because an increase in bore diameter can cause the roller to shift on the pin of the roller frame. Additionally, excessive wear on the internal bore of the roller has been known to cause increased washer wear, which results in premature failure of the entire roller assembly. The wear for both the injection molded and machined rollers was comparable, with differences within a few thousandths of an inch. The injection molded rollers exhibited less wear on the internal bore than the machined UHMW counterpart on average. It's worth noting that the right roller exhibited slightly more wear than the left roller, which is expected because the rollers tend to shift towards the right side of the conveyor during operation.

Front Left Small Roller - Length



Front Right Small Roller - Length



After a thorough analysis of the injection molded rollers and the machined UHMW rollers, it can be concluded that the overall quality of the injection molded rollers is comparable to the machined UHMW rollers. Our analysis showed that the dimensions of the rollers, such as the internal bore diameter and the outside diameter, are well within the acceptable range and wear profile. We found that the injection molded rollers showed slightly more wear in certain areas compared to the machined UHMW rollers, but this wear was still well within the acceptable tolerance range and did not show any signs of premature failure.

In addition, the physical observations of the rollers, such as the deformations at the outside of the counterbore and the material removal on the counterbore side of the outside diameter, do not impact the rollers' ability to function as intended. We also found that the material removed from the roller was chipped away instead of peeled away, indicating uniformity in the material and production process.

Based on these findings, we approve the use of both injection molded and machined UHMW rollers for use in the roller assemblies. It is our engineering sign off that the rollers have been tested and evaluated thoroughly, and we have found no evidence to suggest that they will fail prematurely or cause any issues in the operation of the car wash. We are confident that these rollers will provide reliable and long-lasting performance.