Technical Note

TN 4.03 Abrasion Resistance of Polypropylene

Introduction

With the introduction of ADS High Performance (HP) polypropylene (PP) pipe for the storm drainage and sanitary sewer markets, it is necessary for designers to have confidence in polypropylene's expected performance in conditions where the effluent may carry debris or abrasive materials. To address designer's concerns, a comparative evaluation of whether polypropylene had similar abrasion resistance to high density polyethylene (HDPE) was undertaken. While it was initially hypothesized that polypropylene would have comparable, if not better, abrasion resistance, testing verification is essential. If it could be established that polypropylene and HDPE have similar resistance to abrasion, the more extensive history and test data for HDPE could be applied to polypropylene insofar that polypropylene would behave similarly to HDPE in abrasive environments. To test this hypothesis, two types of tests were conducted. The first test used Taber® abrading wheels directly on a sample of thermoplastic material. The second test, in order to more closely mimic drainage and sewer conditions, involved placing thermoplastic samples in water flow carrying abrasive sand. Both tests measured the mass loss over time and provide a direct comparison between the two materials.

Taber Abrasion Test

In April 2009, Polymer Diagnostics, Inc. conducted Taber abrasion testing on polypropylene, HDPE and PVC material samples in accordance with ASTM D3389 in order to determine the material's mass loss under direct abrasion. Although this test does not simulate pipe carrying effluent, the test still provides a standardized method for comparing the abrasion resistance, or hardness, of different materials.

Test Setup

Each material sample was mounted on a Taber Abrader Model 5130 where the sample is subjected to rub-wear action of an abrading wheel. An abrasion pattern of crossed arcs simulates abrasion of the material from all angles. Directly abrading material in this manner allows for quick results through accelerated testing in order to simulate long-term use, which may otherwise take years to compile.

The initial mass of each sample was recorded to determine the total mass loss of the respective material over the duration of the test. All samples were tested using a CS-10 abrasion wheel with 250 grams of force. The total test time was 40 hrs, allowing for 500 revolutions of the abrading wheel.

Results

Results in Table 1 indicate a greater mass loss of the PVC samples compared to both the polypropylene and HDPE samples. The mass loss of the HDPE sample was slightly higher than the polypropylene sample, but the proximity of values allows for the conclusion that both samples performed similarly. These results indicate a similarity between polypropylene and HDPE materials as it relates to material hardness. The final mass loss of PVC was 5 to 8 times that of polypropylene.

Table 1
Taber Abrasion Test Results for Material Mass Loss

Material	Start Mass (g)	End Mass (g)	Total Mass Loss (mg)
PP #1	30.6036	30.6034	0.2
PP #2	30.6868	30.6866	0.2
HDPE, 5% Carbon Black	31.6658	31.6655	0.3
PVC – white	50.8776	50.8759	1.7
PVC – gray	50.4187	50.4176	1.1

Abrasion Resistance in Water Flow

While a direct correlation between polypropylene and HDPE materials' abrasion resistance is supported by the Taber abrasion test results, a second test was conducted to confirm those results and simulate the abrasion resistance of a pipe's invert when carrying effluent with suspended abrasives.

ADS Facility Testing

First, material plaques of both polypropylene and HDPE were cut and weighed to determine the initial mass of the sample. The samples were then scanned into AutoCAD in order to precisely measure the surface area that will be abraded. Additionally, each sample was inspected for any signs of abnormality including splitting, cracking, material thinning, etc. No abnormalities were noted and product was considered to be in good condition.

Next, a closed-loop test system was constructed in order to achieve a controlled flow rate over the samples. A constant hydraulic loading was established in the system, which consisted of a 2" grinder pump, 18" trough and a collection basin as shown in Figure 1. OK-110 sand was added to the water flow so a relatively heavy sand loading was obtained. The grinder pump, in conjunction with a mixing tee, was used to ensure the sand stayed in a suspended state in the mixture. The flow rate of sand/water mixture over the plaques was 3 ft/sec.

In the trough, four sample plaques, two of polypropylene and two of HDPE, were placed at the bottom of the trough in the flow path, shown in Figure 2. With the exception of removing the samples for weighing, the test unit allowed for continuous subjection of the samples to the slurry mixture.

Figure 1
Close-Loop Test System

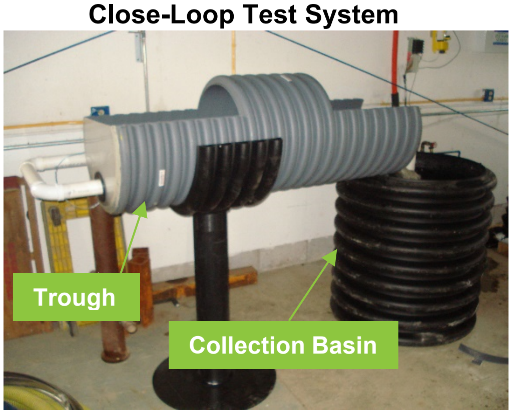
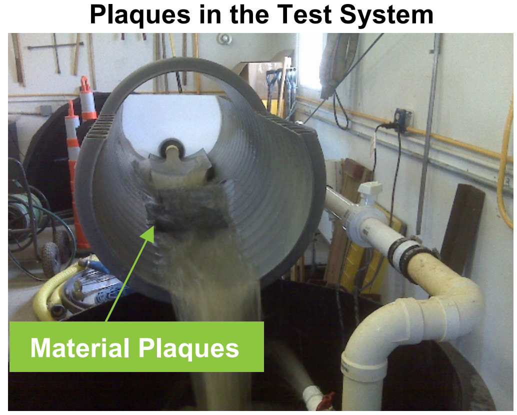


Figure 2
Plaques in the Test System



Results

It was noted during visual inspections of the samples throughout the test that minor scouring of the samples was occurring. These observations affirmed that the test was successful in creating the desired abrasive conditions for sample analysis. Comparing results in Table 2 of the mass and thickness loss, polypropylene performed slightly better than HDPE. The second sample of HDPE was removed from testing as it was damaged during detachment operations for periodic examinations; subsequently resulting in a large loss of material not related to the abrasion testing. Even so, results for both HDPE samples indicate a higher material loss value compared to the polypropylene sample results. Ultimately, these results favor polypropylene over HDPE for constant flow applications where the effluent carries a high bed load.

Table 2
Material Loss Results

	Initial Weight (g)	Final Weight (g)	Time (hrs)	Loss (g/hr)	Surface Area (in^2)	Loss (mils/yr)
PP large sample	221.5	221.5	4029	0.00000	110.34	0.00
PP small sample	27.101	27.099	3483	0.00001	15.43	0.02
HDPE large sample	141	140.75	4029	0.00006	89.47	0.39
HDPE small sample	Damaged during examination					

Conclusions

Both tests indicate high abrasion resistance of polypropylene material. The Taber test indicated that polypropylene and HDPE behaved almost identical to direct rub-wear abrasion, and significantly better compared to PVC material. The test simulating abrasive water flow reaffirmed the Taber test results and indicated that polypropylene performs similarly or slightly better than HDPE. From these results it is reasonable to conclude that other abrasion resistance tests using HDPE samples are also representative of polypropylene material. With this relationship in mind, the tests outlined in the Drainage Handbook *Durability* section that are specific to HDPE and establish the material's superior resistance to abrasion compared to other pipe materials also support the argument for polypropylene's superior abrasion resistance