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EVALUATING COMMERCIALLY AVAILABLE PUMPS FOR USE IN THE WILDLAND-URBAN INTERFACE

MERCEDES TEXTILES' PUMPS - WICK 375, WICK 100G, AND THE WICK SI 300-10B

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This document contributes to the state-of-practice review of water delivery systems (sprinklers) in the wildland-urban interface (WUI). Funding for this review was provided by the Forest Resource Improvement Association of Alberta (FRIAA).

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Several commercially available pumps for wildfire suppression are also used in sprinkler operations in wildland-urban interfaces (WUI). Given the variety of pumps on the market, a standard test methodology is needed to understand how different pumps perform against key metrics such as pressure, flow rate, casting distance, fuel economy, etc.

In this report, a standard test methodology was developed and used to evaluate three portable fire pumps: Mercedes Textiles' WICK 375, WICK 100G, and WICK Si 300-10B. Important data on key performance metrics were gathered and presented to help end users assess which pumps best suit their needs.

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TECHNICAL REPORT

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1. INTRODUCTION

This project is supported by the Forest Research Improvement Association of Alberta (FRIAA). Through a state-of-practice review of water delivery systems (sprinklers) used in the Wildland-Urban Interface (WUI), FPInnovations confirmed that there is no national approach to developing or evaluating wildfire equipment or techniques for the WUI in Canada.

FPInnovations believes that the lack of a process or organization to help foster and evaluate products, in Canada, limits the development and implementation of new technologies and information sharing between agencies. FPInnovations examined the feasibility of conducting these evaluations on wildfire pumps.

There are several commercially available pumps for use in wildfire suppression and community protection operations in the WUI. The Waterax Mark-3 pump is the most widely used pump for wildfire operations in Canada. Other pumps are commercially available to wildfire and municipal firefighting agencies. Knowledge of the strengths and weaknesses of different pumps is critical to make informed investment and tactical decisions.

The purpose of this project is two-fold: First, develop a standard test methodology to evaluate how well commercially available portable low-volume, high-pressure pumps support sprinkler operations. Second, use the methodology to evaluate different pumps based on five key metrics: pressure, flow rate, sprinkler casting distance, fuel consumption, and number of sprinklers supported without significant loss of head pressure. Data from this test will form a benchmark from which comparative analyses of other commercially available pumps can be conducted under the same conditions. The learnings from this evaluation will also allow FPInnovations to refine the methodology and establish a framework for a larger equipment evaluation program that will help enable agencies to select appropriate equipment based on their specific needs.

This test methodology is not meant to replace the tests done by the US Forest Service but rather to supplement the information presented there. Their Qualified Product List (QPL) focuses on endurance testing, which is a key indicator of pump performance. The test conducted during this project did not include or attempt to replicate the endurance test.

Three portable fire pumps were tested: Mercedes Textiles' WICK 375, WICK 100G, and WICK Si 300-10B. Mercedes Textiles pumps are not widely used in Alberta; therefore, their operational performance has not been well documented.

2. PUMP PROFILES

The three pumps selected for this test, the WICK 375, WICK 100G and the WICK Si 300-10B are all commercially available portable pumps. A comparative profile has been included below in Table 1.

Figure 1(a). WICK 375.*

Figure 1(b). WICK 100G.*

Figure 1(c). WICK Si 300-10B.*

Table 1. Pump profiles

Product	Engine	Pump	Dimensions	Weight (Dry)	Suction	Discharge	Max Pressure*	Cost**
WICK 375	10 HP, 2 stroke	4 stage	57.8 x 26.2 x 36.2 cm (22.7 x 10.3 x 14.2 in)	25.4 kg (56 lbs)	2” (50 mm)	1.5” (38 mm)	375 psi (2585 kPa)	4,500 CAD
WICK 100G	2.4 HP, 2 stroke	1 stage	33 x 28 x 29 cm (12.9 x 11.0 x 11.4 in)	7.9 kg (17.4 lbs)	1.5” (38 mm)	1.5” (38 mm)	100 psi (689 kPa)	1,675 CAD
WICK Si 300-10B	10 HP, 4 stroke	3 stage	55.9 x 47.6 x 46.4 cm (21.6 x 18.7 x 18.26 in)	39.5 kg (87 lbs)	2” (50 mm)	1.5” (38 mm)	275 psi (1896 kPa)	3,000 CAD

** Mercedes Textiles product flyers: WICK 375 (2018), WICK 100G (2018), and WICK Si 300-10B (2018).*

*** Manufacturer quotes obtained in October 2018. Pricing provided for comparison only and do not reflect the market price for anytime other than the date the quotes were received.*

The WICK 375 (Figure 1[a]) strikes a good balance between portability (weight) and pressure (owing to the four-stage pump head). The WICK 100G (Figure 1[b]) is a highly portable, lightweight pump. The WICK Si 300-10B ((Figure 1[c]) theoretically offers more volumetric efficiency and a longer engine lifespan due to its four-stroke engine.

Compared to the most common pumps used across Canada, the WICK 375 is comparable to the Mark-3 (Waterax), the WICK 100G is similar to the Mini-Striker (Waterax), and the WICK Si 300-10B is an approximate equivalent to the BB4 (Waterax).

3. RESEARCH SITE

The research site selection criteria included relatively flat ground with sufficient open space, minimal elevation gain or drop, and a consistent and reliable water source nearby. Flat ground minimized the influence of elevation changes on pressure readings. The research site selected for this project was the Athabasca Riverfront Park in Hinton, Alberta (Figure 2).

Figure 2. Research site - Athabasca Riverfront Park (white box).

Site information is shown above in Table 2. Areas of high slope/elevation were avoided as much as possible during testing. Testing occurred on October 4, 2018. The temperature was -5℃ at 9 a.m. and 8℃ by 4 p.m. The research site was initially covered with 2-4 cm of snow. However, as the day progressed, most of the snow cover disappeared (Figures 3[a] and 3[b]). Minimal wind/gusting occurred throughout the day.

Table 2. Athabasca Riverfront Park – site information

Water source	Athabasca River
Research site area	8,670 m^2 (28,444 ft^2)
Elevation gain/loss	0 – 2.3 m (0 - 7.6 ft.)
Max slope	10%
Average slope	2.8%

Figure 3(a). Research site: 9 a.m.

Figure 3(b). Research site: 4 p.m.

4. TEST ASSEMBLY AND METHODOLOGY

In order to evaluate the pumps, a closed loop sprinkler configuration was selected. A closed loop configuration facilitated equal pressure throughout the hose line, allowing all sprinklers to have approximately the same casting distance. Sprinklers with the same casting distance would be the ideal setup for wildland-urban interface (WUI) applications, since even coverage is achieved.

Figure 4 is a schematic of the equipment layout and water flow. Water from the Athabasca River was pumped by a Mark-3 pump to a 9463 L (2500 gallon) bladder (Figure 5[a]), which served as a relay tank. Each of the three pumps being evaluated drew their water from the bladder. During the test, each pump was connected to a flow meter (Figure 5 [b]) and a pressure gauge with one 30 m (100 ft.) long, 38-mm (1.5-in.) diameter forestry hose. The flow meter and pressure gauge were connected in tandem using quarter-turn connections with no hose between them. The pressure gauge outlet was connected to a wye from which a closed loop system was formed.

Water flowed from the wye through the closed loop system consisting of 17 units of 38-mm (1.5-in.) hose generating a total system length of 518 m (1700 ft.). At each hose junction, a Rain Bird (70CH) sprinkler with an orifice of 6.4-mm (1/4-in.) was connected to the supply line using a 16-mm (5/8-in.) garden hose. A total of 15 sprinklers were used during the tests. A second pressure gauge was installed at the location farthest from the pump to assess pressure in the weakest section of the loop and ensure that pressure loss due to friction was minimal. Operational data showed a difference in pressure gauge readings of one to five psi, a negligible value.

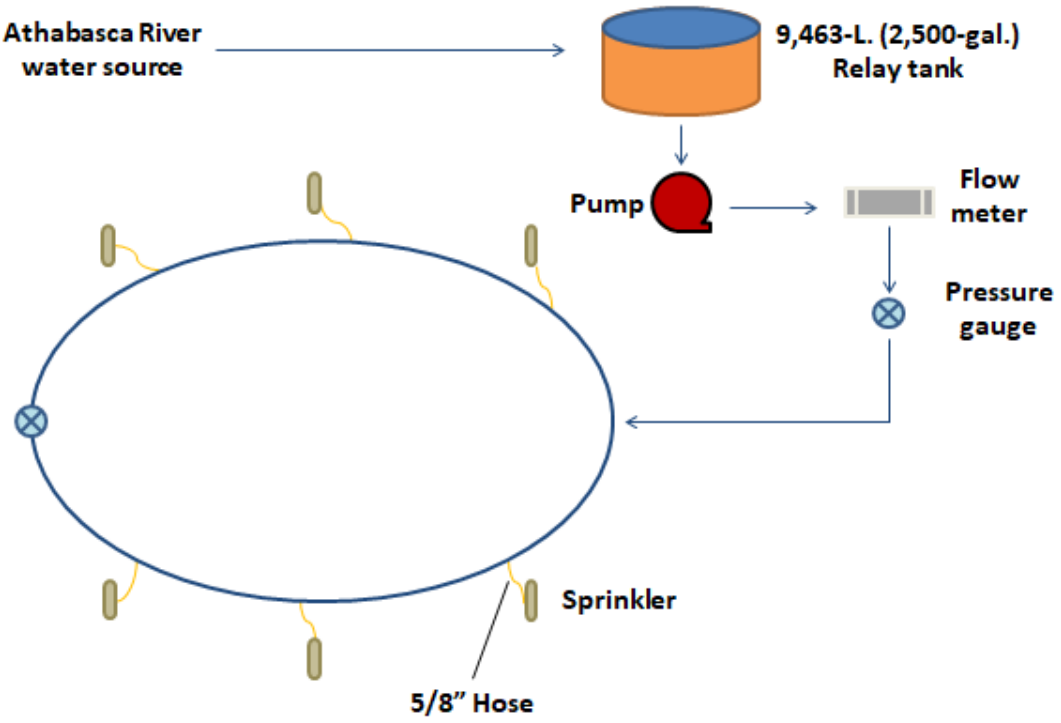

Figure 4. Equipment layout.

With the pump running and once the pressure gauges showed stable pressure, the sprinklers were opened one by one. Each time a sprinkler was opened, its pressure, flow rate, and casting distance were measured to help map pump curves and sprinkler coverage. The two pressure gauges validated that the pressure was approximately equal along the closed loop system. Testing was stopped when any of the 15 sprinklers stopped rotating. When a sprinkler stops rotating, it is an indication of insufficient pressure in the system and hence was selected as the stopping point.

Figure 5(a). WICK 375 connected to a 9,463-L. (2,500-gallon) bladder.

Figure 5(b). Flow meter and pressure gauge 30-m. (100-ft.) from pump.

Fuel consumption was also calculated during each test and determined by measuring the amount of fuel before and after each test and comparing that to the pumps run-time. Fuel consumption was expressed in L/hr.

5. RESULTS

WICK 375

PRESSURE VS. FLOW RATE

The maximum pressure observed when a single sprinkler was activated was 180 psi (1241 kPa). The flow rate was 30 gpm (6.8 m^3/hr) and the casting distance was 14.5 m (47.5 ft). As sprinklers were sequentially activated, pressure in the loop decreased and flow increased. When all 15 sprinklers were activated, the pressure in the loop was 35 psi (241 kPa), the flow rate was 89 gpm (20.2 m^3/hr) and the average casting distance was 8.6 m (28.2 ft).

The pump curve generated from the tests is shown in Figure 6 and is similar to the manufacturer-stated pump curve at higher flow rates. However, the pressure produced at lower flow rates (30-70 gpm or 6.8-15.9 m^3/hr) is lower than what is stated in the manufacturer's pump curve. A comparison of Figures 6 and 7 (manufacturer's pump curve) at these flow rates illustrates this difference.

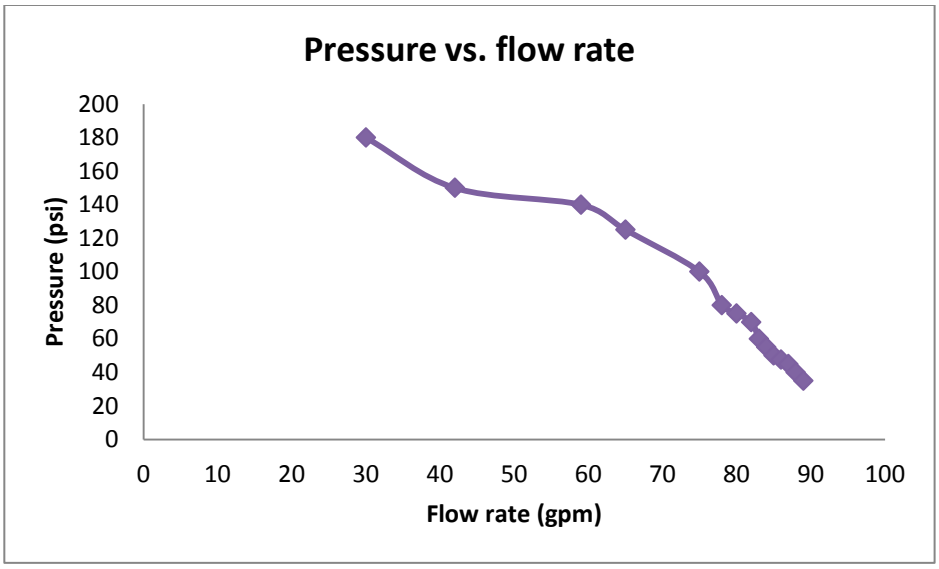

Figure 6. WICK 375 pressure vs. flow rate (pump curve from test).

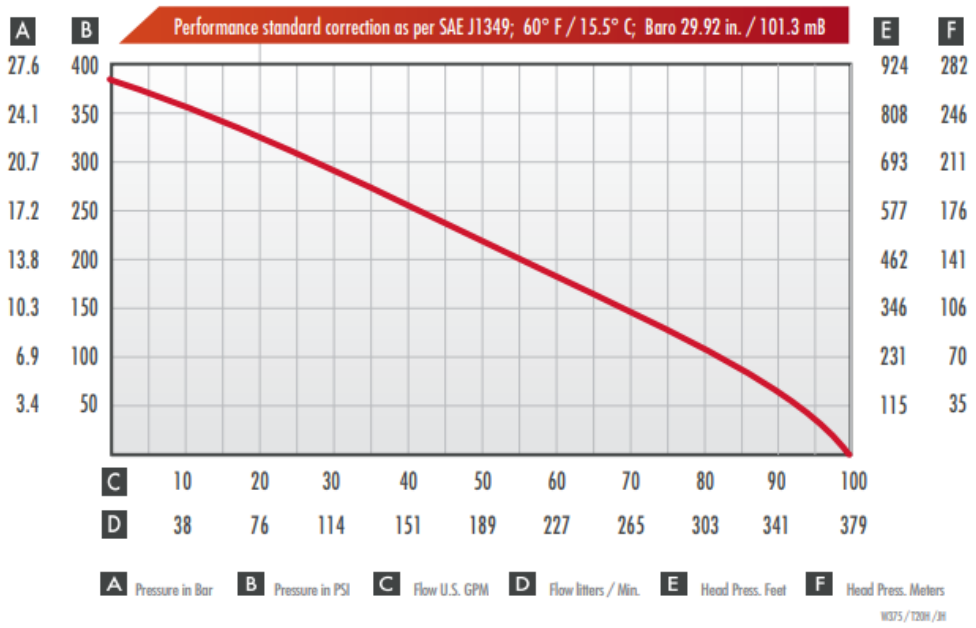

Figure 7. WICK 375 pressure vs. flow rate (pump curve from manufacturer - *Mercedes Textiles Product Flyer: WICK 375 [2018]*).

PRESSURE REDUCTION IN LOOP

Pressure reduction in the loop as sprinklers were activated is presented in Figure 8. As each additional sprinkler was activated, the pressure in the loop decreased. Pressure in the loop with the WICK 375 started off at 180 psi (1241 kPa) with one sprinkler open and subsequently dropped to 35 psi (241 kPa) when all 15 sprinklers were open and still operational. Based on this information, users will be able to determine how many sprinklers they can activate based on desired or known system pressure.

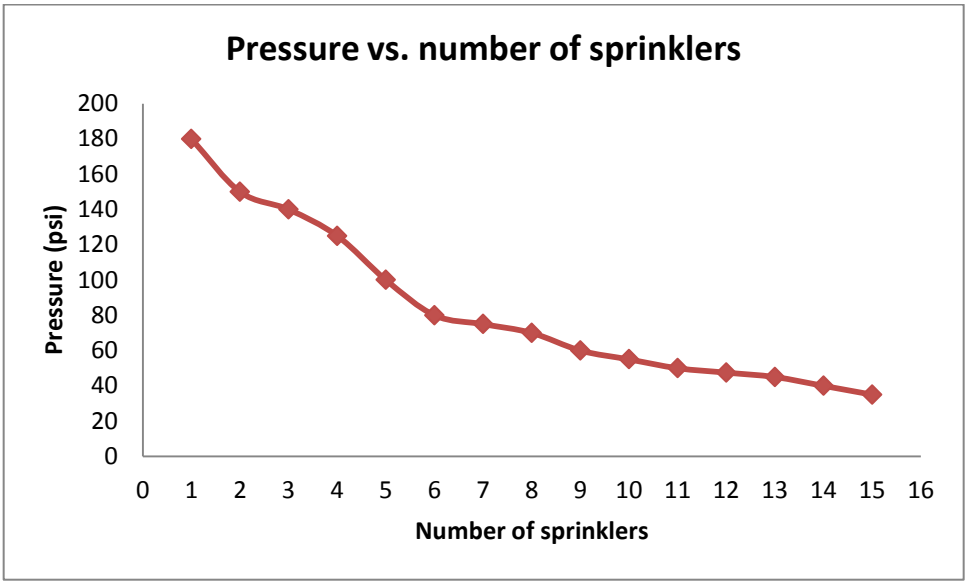

Figure 8. WICK 375 pressure vs. number of sprinklers.

CASTING DISTANCE

The casting distance with the activation of additional sprinklers is showing in Figure 9. The maximum casting distance observed in the setup was 14.5 m (47.5 ft.) when just one sprinkler was open. As subsequent sprinklers were opened, the casting distance was reduced, reaching 8.6 m (28.2 ft.) when all 15 sprinklers were open. Based on the user's casting requirements in terms of area to be covered, sprinkler placement, and required overlap, the number of sprinklers required can be derived from this graph.

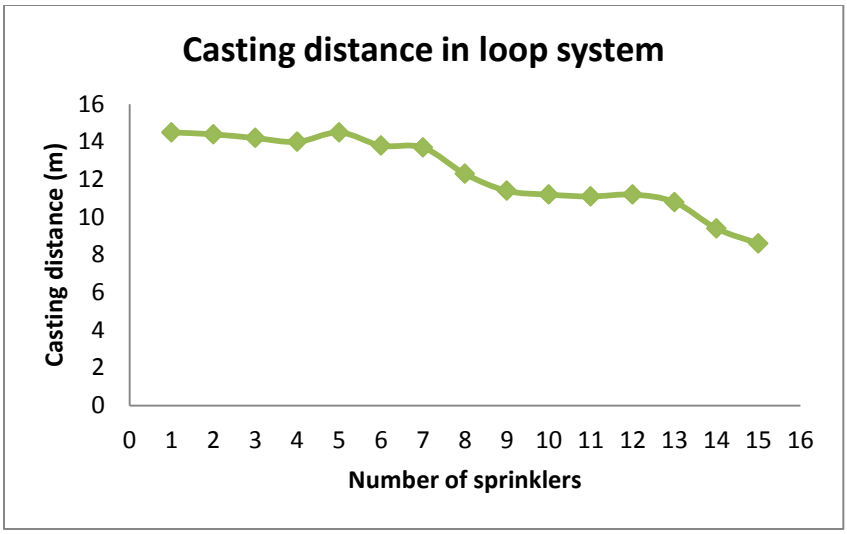

Figure 9. WICK 375 casting distance vs. number of sprinklers.

As a surplus data set, it was of interest to see the casting distance profile when the sprinklers were arranged in a linear configuration, i.e. dead end line, when all operational sprinklers in this setup are open. In the event a wet line needs to be created, this information would help to understand what casting distances can be expected when sprinklers are placed in a straight-line configuration using these pumps. A blank cap was installed on one outlet of the wye in order to switch the configuration from a loop setup to a straight-line setup. With 15 sprinklers open in a linear configuration, the casting distance was 14.5 m (47.5 ft.) at the first sprinkler and 2 m (6.5 ft.) at the fifteenth sprinkler (Figure 10). This shows us that only 5 sprinklers had a casting distance of above 8.6 m (28.2 ft.) in the straight line configuration whereas all 15 sprinklers had a casting distance of 8.6 m (28.2 ft.) in the loop configuration.

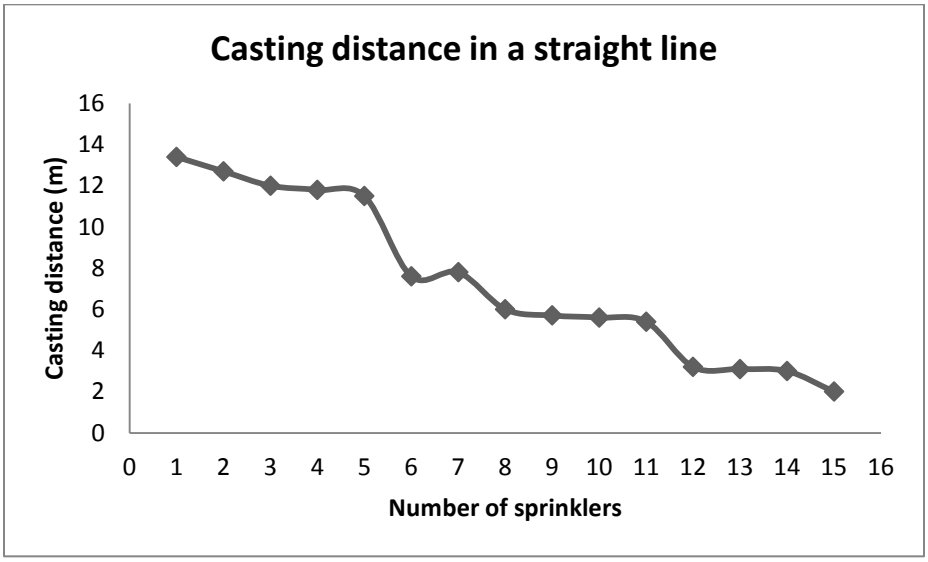

Figure 10. WICK 375 casting distance vs. number of sprinklers.

FUEL CONSUMPTION

Based on the WICK 375's run time and the quantity of fuel used by the pump, the rate of fuel consumption was calculated to be 4.84 L/hr (1.06 gal/hr).

WICK 100G

PRESSURE VS. FLOW RATE

With a single activated sprinkler, pressure in the loop was 75 psi (517 kPa), with a flow rate of 15 gpm (3.4 m^3/hr) and a casting distance of 15.2 m (49.8 ft.). As sprinklers were activated one by one, it was observed that when the twelfth sprinkler was activated, multiple sprinklers stopped rotating. Therefore, all results presented for the WICK 100G have data for 11 sprinklers only. With 11 sprinklers activate, the pressure in the loop was 30 psi (206 kPa), and the flow rate and casting distance were 50 gpm (11.3 m^3/hr) and 4.7 m (15.4 ft.), respectively. It can be stated that the WICK 100G can support a maximum of 11 sprinklers in this specific sprinkler configuration before one or more sprinklers become non-operational. The generated pump curve is quantitatively similar to the pump curve provided by the manufacturer. A visual comparison of the test-generated pump curve and the manufacturer-stated pump curve is presented in Figures 11 and 12.

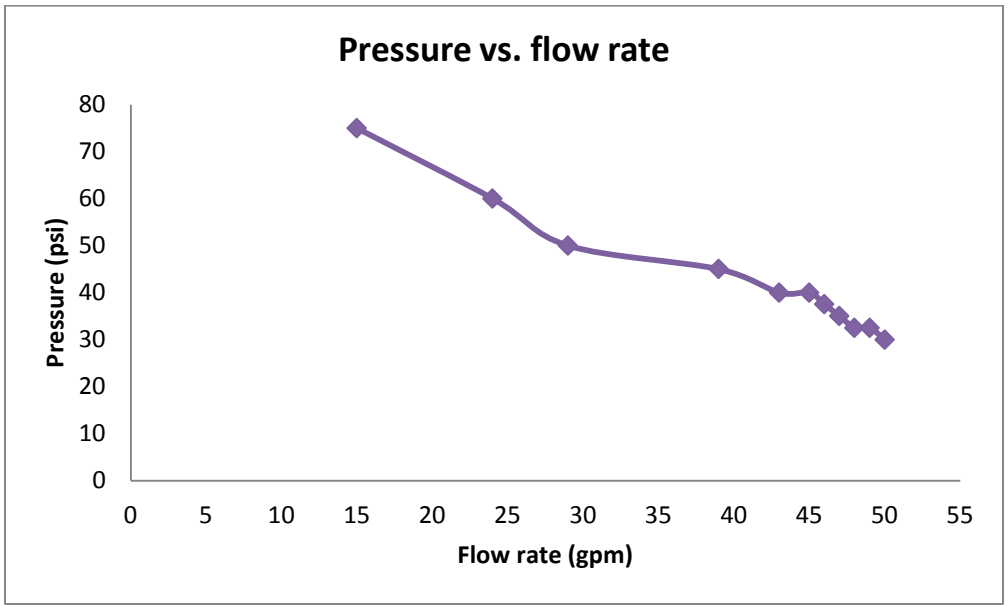

Figure 11. WICK 100G pressure vs. flow rate (pump curve from test).

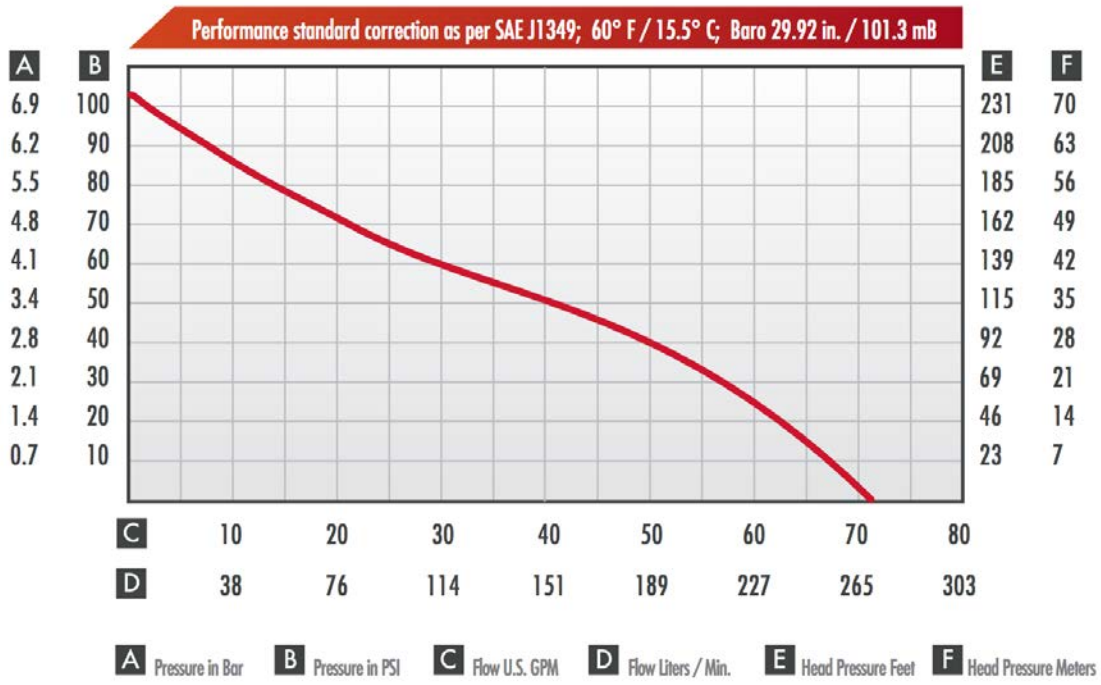

Figure 12. WICK 100G pressure vs. flow rate (pump curve from manufacturer - *Mercedes Textiles product flyer: WICK 100G [2018]*).

PRESSURE REDUCTION IN LOOP

Pressure reduction in the loop as sprinklers were opened is presented in Figure 13. Pressure in the loop with the WICK 100G started off at 75 psi (517 kPa) when one sprinkler was activated and dropped to 30 psi (206 kPa) when 11 sprinklers were activated. As mentioned before, the activation of the twelfth sprinkler resulted in a further drop in pressure, i.e. below 30 psi (206 kPa). Multiple sprinklers in the system stopped rotating because of this drop in pressure and were deemed non-operational.

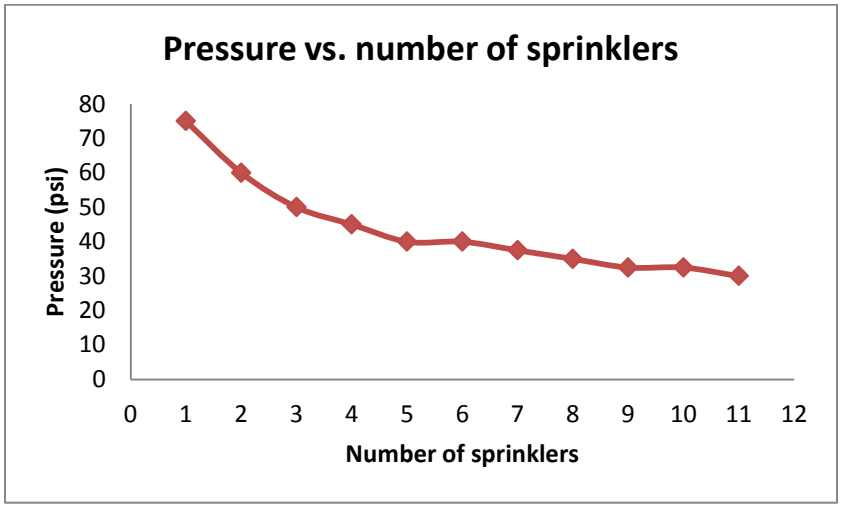

Figure 13. WICK 100G pressure vs. number of sprinklers.

CASTING DISTANCE

The variation in casting distance in the test involving the WICK 100G is presented in Figure 14. Casting distance decreased from 15.2 m (49.8 ft.) when one sprinkler was activated to 4.7 m (15.4 ft.) when 11 sprinklers were activated. It is important to note that while 11 sprinklers were still rotating and active, having a casting distance as low as 4.7 m (15.4 ft.) may not be beneficial in WUI applications.

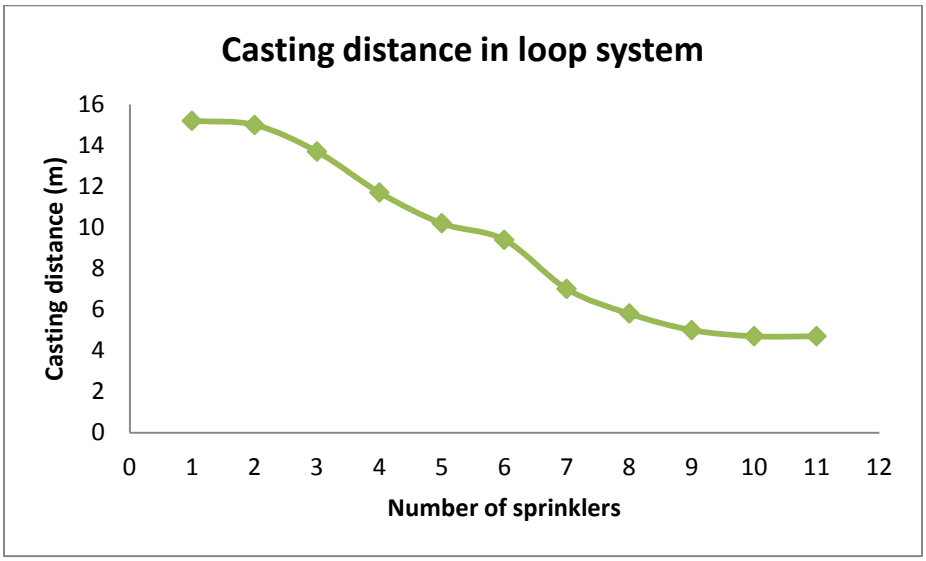

Figure 14. WICK 100G casting distance vs. number of sprinklers.

With 11 sprinklers open in a linear configuration, the casting distance was 8.4 m (27.5 ft.) at the first sprinkler and 4.4 m (14.4 ft.) at the eleventh sprinkler (Figure 15). The value of the loop configuration is highlighted again, where a total 15 sprinklers had a casting distance of 4.7 m (15.4 ft.) each whereas the straight line configuration had only 7 sprinklers with casting distances above 4.7 m (15.4 ft.).

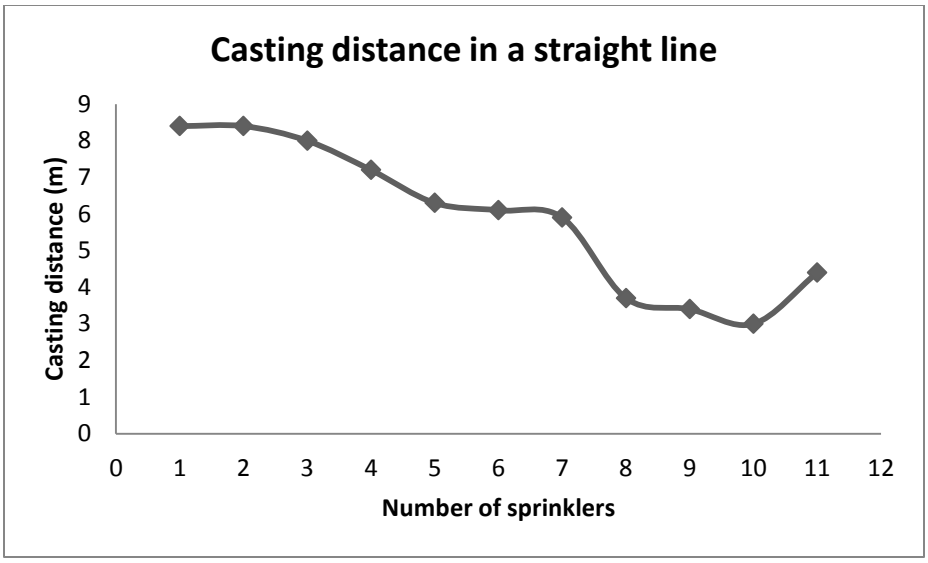

Figure 15. WICK 100G casting distance vs. number of sprinklers.

FUEL CONSUMPTION

Based on the WICK 100G's run time and the quantity of fuel used by the pump, the rate of fuel consumption was calculated to be 1.14 L/hr (025 gal/hr).

WICK Si 300-10B

PRESSURE VS. FLOW RATE

The pump curve generated from the WICK Si 300-10B tests is presented in Figure 16. Pressure in the loop was 195 psi (1344 kPa) when one sprinkler was activated and decreased to 47.5 psi (327.5 kPa) when all 15 sprinklers were activated, with respective flow rates of 24 gpm (5.4 m^3/hr) and 88 gpm (19.98 m^3/hr), and casting distances of 26 m (85.3 ft) and 10.1 m (33.1 ft). The pump curve generated from the tests is quantitatively similar to the pump curve provided by the manufacturer, as seen in Figures 16 and 17.

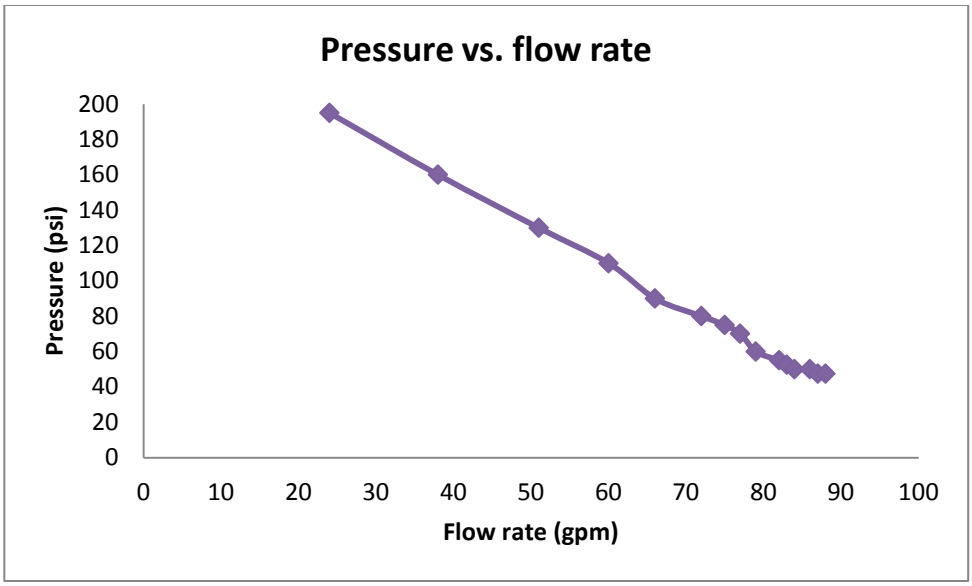

Figure 16. WICK Si 300-10B pressure vs. flow rate (pump curve from test).

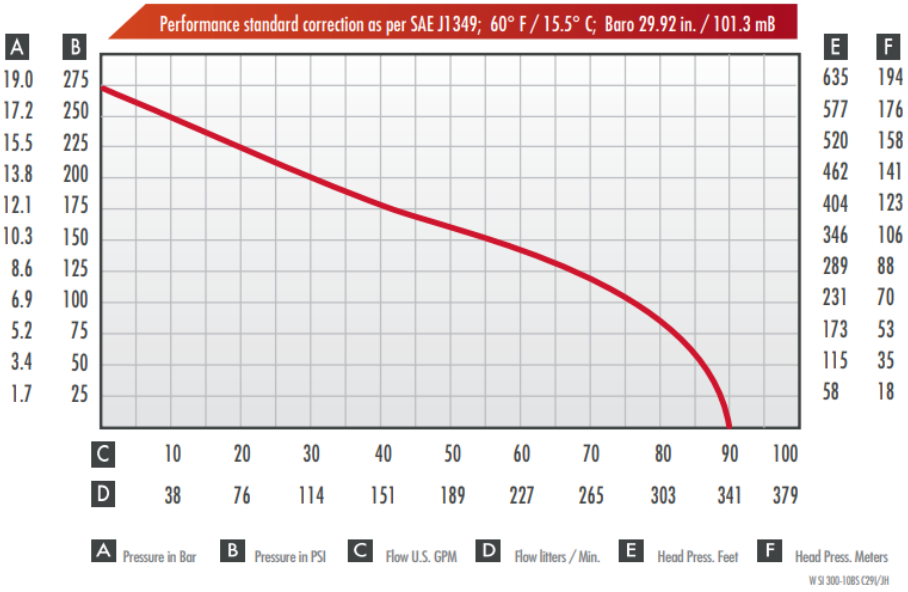

Figure 17. WICK Si 300-10B pressure vs. flow rate (pump curve from manufacturer - *Mercedes Textiles product flyer: WICK Si 300-10B [2018]*).

PRESSURE REDUCTION IN LOOP

The pressure in the loop with the WICK Si 300-10B was 195 psi (1344 kPa) when a single sprinkler was activate and subsequently fell to 47.5 psi (327.5 kPa) when all 15 sprinklers were active and still operational.

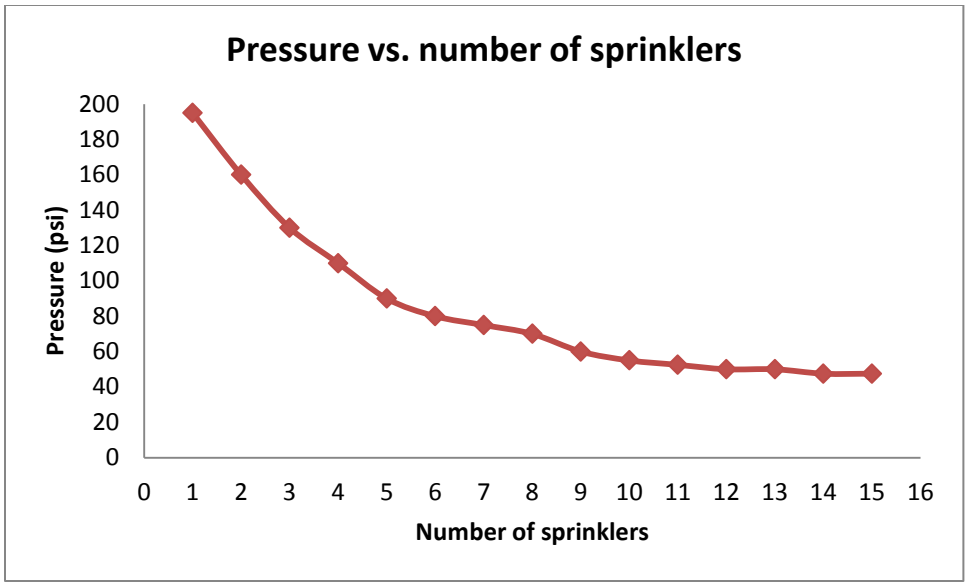

Figure 18. WICK Si 300-10B pressure vs. number of sprinklers.

CASTING DISTANCE

The casting distance in the system decreased from 26 m (85.3 ft.) when one sprinkler was activated to 10.1 m (33.1 ft.) when all 15 sprinklers were activated, as shown in Figure 19. It should be noted that there was significant misting for the first six sprinklers when the WICK Si 300-10B was used. Misting makes it difficult to measure casting distances and therefore must be taken into consideration when assessing data from Figure 19. An increase in casting distance was observed in sprinkler 15. This was caused by elevation changes.

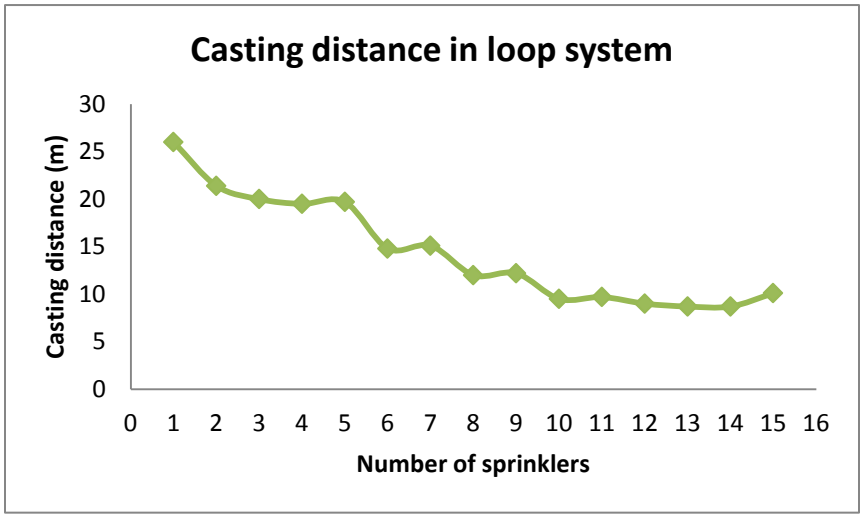

Figure 19. WICK Si 300-10B casting distance vs. number of sprinklers.

With 15 sprinklers open in a linear configuration, the casting distance was 15.2 m (49.8 ft.) at the first sprinkler and 2.6 m (8.5 ft.) at the fifteenth sprinkler (Figure 20). Once again, the loop configuration was able to sustain more sprinklers at a higher casting distance i.e. 15 sprinklers above 8.7 m (28.5 ft.) whereas the straight line configuration was able to sustain only 6 sprinklers above 8.7 m (28.5 ft.).

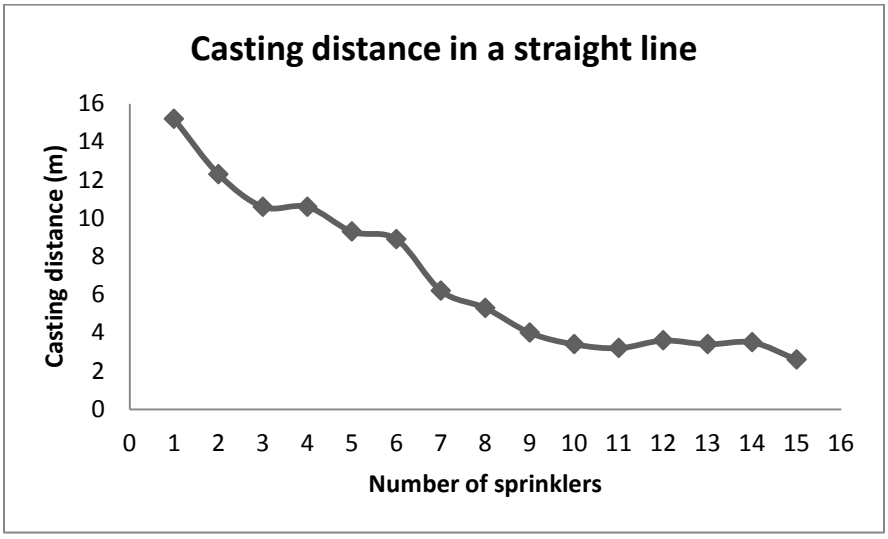

Figure 20. WICK Si 300-10B casting distance vs. number of sprinklers.

FUEL CONSUMPTION

Based on the WICK Si 300-10B's run time and the quantity of fuel used by the pump, the rate of fuel consumption was calculated to be 3.72 L/hr (0.82 gal/hr).

6. DISCUSSION

Test: The pressure and flow rate presented in this report represent what can be considered ideal logistic conditions for a sprinkler setup. In practice, variability in terrain, water source, environmental conditions, etc. will have to be taken into consideration. This test methodology does, however, provide a way to evaluate different pumps under the same conditions, allowing for new pumps to be evaluated against existing pumps under the same conditions.

Pump curves: The pump curves generated in this report are similar to, but not exactly the same as, the manufacturer-stated pump curves. These differences are to be expected and can be attributed to several factors, including, but not limited to, environmental factors such as pressure and temperature of surroundings and working fluids. (Manufacturer-stated pump curves are corrected as per SAE J1349, which standardizes the performance curve for a specific temperature and pressure [15.5℃ (59.9 F); 101.3 mB (75.9 mm of Hg)].) Minor differences in pumps were due to tolerances in the manufacturing process, system pipe friction, operational error, user error, etc. also contribute to any deviations from the manufacturers'' pump curve.

Coverage area: The establishment of the termination point of the sprinkler configuration was when one or more sprinklers were deemed non-operational. However, in practical sprinkler applications, the overlap of coverage area must be considered. If hoses are laid out to cover maximum ground, the minimum criteria for overlapping sprinklers are estimated to be ~14-15 m (~45.9-49.2 ft.) of casting distance. (The length between two sprinklers is approximately 30 m (100 ft.). Approximation here is a result of forestry hose not always being exactly 30 m (100 ft.) long. Based on the above criteria, the WICK 375 and Si 300-10B would be able to sustain seven sprinklers, while the WICK 100G would be able to sustain two or three sprinklers for optimum overlapping conditions, as seen in Figures 9, 13, and 16.

Nozzle size: The number of sprinklers that a pump can support is also dependant on the type of sprinkler used. Changing the nozzle size (orifice size) on a sprinkler changes its flow rate, which can result in a difference in establishing how many sprinklers can be supported on a specific pump for optimum overlapping conditions.

7. CONCLUSIONS

A standard test methodology was developed to evaluate different commercially available pumps for use in sprinkler operations in a WUI environment. Three portable fire pumps – Mercedes Textiles' WICK 375, WICK 100G, and WICK Si 300-10B – were tested in a closed loop system with 15 Rain Bird sprinklers. Pressure, flow rate, casting distance, and fuel consumption data were successfully gathered for all three pumps. Data from the tests were processed and presented so that end users can select pumps based on their desired use. The test methodology also allows for new pumps on the market to be tested and compared to existing pumps under the same conditions.

8. REFERENCES

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Mercedes Textiles Website – WICK Si 300-10B Product Specification Sheet - http://www.mercedestextiles.com/media/ecommerce_product.pdfFlyer/en-CA/Wick%20Si%20300-10B.pdf, Accessed on 18th October 2018.

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