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# Evaluation of Venturi Pump Blower Attachment Prototype

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**PURPOSE:** The US Air Force Civil Engineer Center (AFCEC) tasked the US Army Engineer Research and Development Center (ERDC) with (1) developing a prototype venturi pump blower attachment for removing standing water from open excavations and (2) comparing its performance to that of traditional pumps. This technical note summarizes testing conducted as a part of the development of the prototype and provides analysis and conclusions based on the results.

**BACKGROUND:** Repair of pavement damage whether on roads or airfields is an important task for many groups within the Department of Defense. When preparing the damaged pavement for repair, large amounts of water can often enter excavations through rainfall or runoff, directly from the water table, or by other means. Standing water must be removed to ensure repairs do not fail prematurely due to excessive deformation under traffic that can be caused by wet, soft underlying materials.

Many different styles and models of pumps designed for water removal are available commercially. Simple sump pumps are powered electrically and require a generator, while gas- or diesel-powered pumps typically provide higher output. AFCEC currently includes a trash pump in both its Sustainment Pavement Repair (SuPR) kit and its Rapid Airfield Damage Recovery (RADR) tool trailer (typically a Multiquip QP3TZ or equivalent).

The venturi effect is the observation of a reduction in pressure when fluid travels through a constricted portion of a pipe. Figure 1 graphically represents the venturi effect, showing the static pressure ($h$) being lower at the constricted area. When Bernoulli's principle is applied as shown in Equations (1) and (2), the reduction in pressure results in an increase in fluid velocity (which can be air or water) at the constricted area, since the cross-sectional area is smaller (Munson et al. 2006). Venturi pump manufacturers take advantage of this principle to create pumps that use air pressure to increase velocity and cause a vacuum to be formed at the restricted area. The vacuum moves standing water from the intake end of the pump to the discharge end either to open air or to a discharge hose. A screen is located on the intake side of the pump to prevent any large pieces of debris from blocking flow. Since no moving parts are involved in the pump itself, there is a lower risk of pump malfunction or damage from debris.

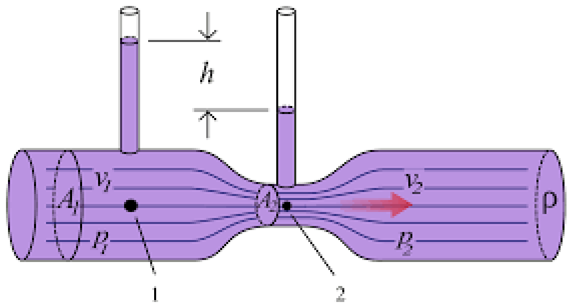


Figure 1. Graphical representation of the venturi effect.

$$Q = v_1 A_1 = v_2 A_2, \quad (1)$$

where

$Q$ = flowrate,
$v$ = velocity, and
$A$ = cross-sectional area.

$$p_1 - p_2 = \frac{\rho}{2}(v_2^2 - v_1^2), \quad (2)$$

where

$p$ = pressure,
$v$ = velocity, and
$\rho$ = density of the fluid.

**TEST PROCEDURE:** AFCEC tasked ERDC with fabricating a prototype venturi pump attachment that utilizes the Husqvarna 350BT backpack blower for air pressure, since these are already included in the SuPR kit and RADR major repair kits. Figure 2 shows the components of the prototype venturi pump blower attachment. On the far left is the end of the blower pipe attached to the backpack blower. The end of the blower pipe was attached to a straight piece of pipe, which is smooth on one end and threaded on the other. A hose clamp and a spare piece of hose were used to attach the smooth end to the blower pipe, and the threaded end was attached to a reducer, which enabled the assembly to connect to a commercial venturi pump device. The commercial venturi pump was also tested on its own without modification. It requires compressed air with a flow rate of 80 $ft^3$/min at 100 psi.* To meet this capacity, a large tow-behind-style air compressor with ¾ in. hose was used and attached to the connection point identified in Figure 2.

* For a full list of the spelled-out forms of the units of measure used in this document and their conversions, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office, 2016), 248–52 and 345–47, https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf.

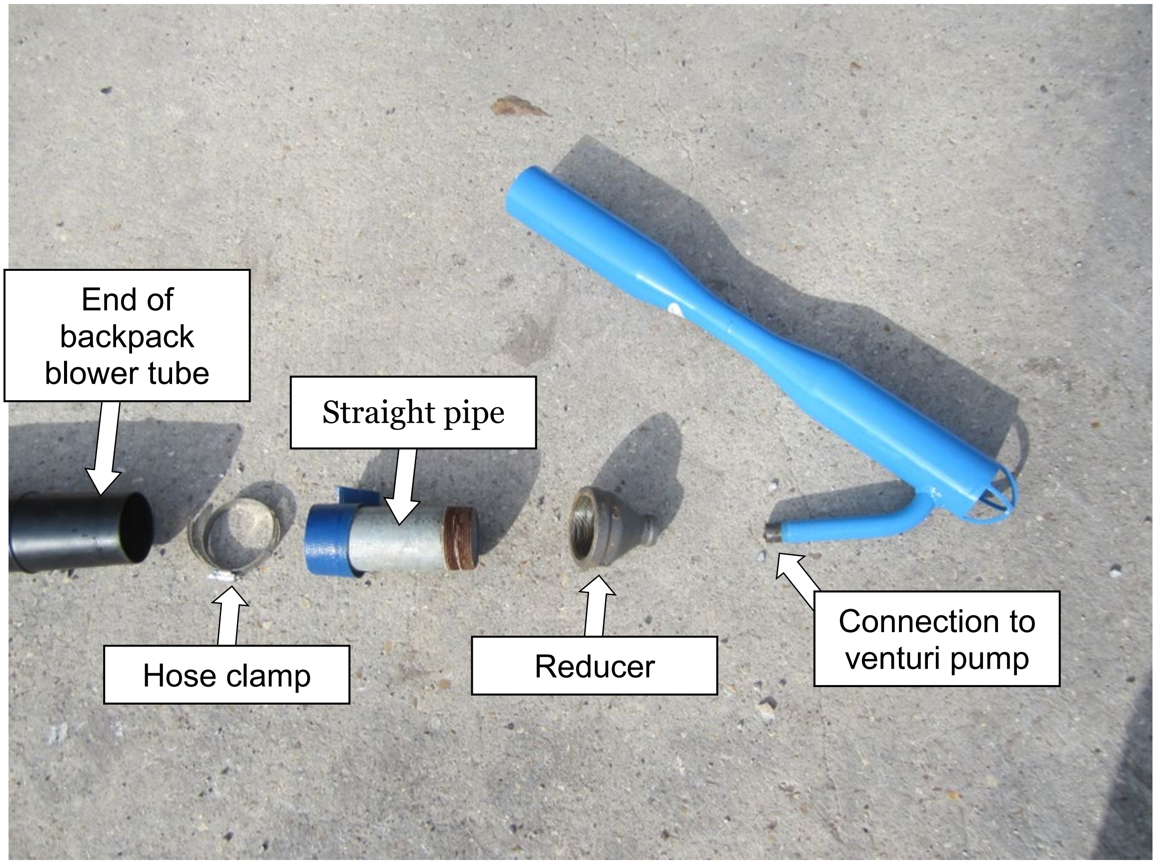


Figure 2. Prototype backpack blower venturi pump components.

**RESULTS:** Once the prototype venturi pump was completed, it was evaluated along with pumps similar to those included in existing RADR kits and the commercial venturi pump. Figures 3, 4, 5, and 6 show operation of the prototype venturi blower attachment, commercial venturi pump, Honda WX10, and Honda WB20XT3, respectively. To evaluate each pump, a 55 gal. drum was filled with water, and the approximate time needed to empty the drum was recorded for each device. The data were used to estimate the gallons per minute each device could remove.

Table 1 shows the results, with overall pump capacity provided in gallons per minute (gpm). For all devices, the measured capacity was slightly lower than the published capacity, likely due to the relatively small amount of water being removed. The measured capacity values generated were considered adequate for comparison purposes. The prototype venturi pump blower attachment produced the lowest output capacity. The commercial venturi meter used without a discharge hose exhibited over twice the output capacity of the prototype. Use of a 10 ft discharge hose decreased the output capacity of the commercial venturi meter by approximately 50%, likely due to friction opposing the discharge and occasional kinks that developed in the hose. Using a 20 ft discharge hose further reduced the discharge capacity. Additionally, the diameter of both hoses was 0.75 in., which was much lower than the 2.4 in. diameter opening at the discharge end of the venturi pump, resulting in a smaller cross-sectional area. Per Equation (1), if the discharge area is reduced, the flowrate will also be reduced. The two Honda pumps both outperformed the prototype and commercial venturi pumps substantially. The trash pump currently included in the SuPR kit and the RADR tool trailer was not tested, but the published rate is much higher than any of the other pumps evaluated.

Figure 3. Operation of prototype backpack blower venturi pump.

Figure 4. Operation of a commercial venturi pump.

Figure 5. Operation of a Honda WX10 pump.

Figure 6. Operation of a Honda WB20XT3 pump.

**Table 1. Pump test results.**

| Device | Discharge Hose Size (in.) | Published Capacity (gpm) | Measured Capacity (gpm) |
|---|---|---|---|
| Multiquip QP3TZ[a] | 3 | 383 | Not tested |
| Honda WX10 | 1 | 32 | 26.7 |
| Honda WB20XT3 | 2 | 164 | 134.7 |
| Commercial Venturi (no hose) | — | 21 | 15.3 |
| Commercial Venturi (10 ft hose) | 2 | 21 | 10.3 |
| Commercial Venturi (20 ft hose) | 2 | 21 | 8.2 |
| Prototype Backpack Venturi | 2 | N/A | 6.3 |

[a]Model currently included in USAF kits

Overall, the prototype backpack blower venturi pump produced a much lower discharge capacity than the alternatives. The small output capacity and low discharge distance would likely not be able to remove a relevant amount of water from an open excavation although it does offer the advantage of relying on a simple gas-powered blower instead of a more sophisticated pump device and air compressor. The issue is believed to be the amount of airflow generated by the backpack blower. While the published air flow for the Husqvarna 350BT is nearly 500 cfm, the air is not under high pressure, as it is with the air-compressor-powered commercial venturi pump.

The commercial venturi pump produced a much higher output capacity than the prototype venturi pump, but still much less than the other trash pumps and water pumps tested. If desired, the commercial version could be used in conjunction with the existing SuPR kit. Because of its absence of moving parts, it would provide a redundant water removal capability that is much less likely to experience damage from any rocks or other hard objects that enter the intake side. The air compressor in the SuPR kit has enough capacity to operate the commercial venturi pump. The prototype venturi pump did not produce enough water removal capacity to justify inclusion in the RADR kit. Thus, the commercial trash pump already included in the kit appears to be the most effective alternative for removing standing water from a crater.

**SUMMARY:** Overall, the prototype produced a much lower discharge capacity than the water pumps and trash pumps tested, but the commercial venturi pump tested could be added to the SuPR kit to provide a redundant water removal capability.

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Carruth, William D. 2023. *Evaluation of Venturi Pump Blower Attachment Prototype*. ERDC/GSL TN-23-2. Vicksburg, MS: US Army Engineer Research and Development Center. http://dx.doi.org/10.21079/11681/47580.

## REFERENCE

Munson, B. R., D. F. Young, T. H. Okiishi, and W.W. Huebsch. 2006. *Fundamentals of Fluid Mechanics*. Hoboken, NJ: John Wiley & Sons. Inc.