Hydro-Excavation

A safe, cost-effective alternative for underground construction and municipal use

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Introduction

Every day, contractors, municipalities and utilities excavate for installation of underground facilities, or must locate existing pipes, cables and lines for maintenance and repairs. In the past, this usually involved digging by hand (often a slow and tedious process) or with a mechanical excavator, backhoe or similar machine.

Every year, there are numerous reports of injuries, deaths, explosions and fires from unsafe or poorly planned excavations that strike underground facilities or result from collapsed trenches. Many of these incidents can be avoided and the risks minimized by utilizing techniques such as vacuum excavation.

Definitions

Vacuum excavation is a general term that may include processes using either water (hydro-excavation) or high-pressure air to loosen soil. In either case, an air vacuum is used to move the loose soil and rocks, often into a debris tank for later disposal or back-filling the hole that's been made.

Hydro-excavation is a process that utilizes pressurized water to break up and remove the soil via air conveyance (vacuum) into a debris tank, providing a non-destructive means to safely locate utilities and precisely excavate an area.

This white paper will focus specifically on hydro-excavation and its origins, benefits, safety factors, applications and economic value.

Historical perspective

Hydro-excavation as we know it today can trace its growing popularity to the Canadian oil and gas industry, which realized years ago the efficiency of using a hydro-excavation machine to "daylight" buried gas pipes and other utility lines. With cold weather and permafrost, petrochemical plants and facilities in Canada found that using heated water made hydro-excavation the only viable option to excavate year-round.

In the early 1960s, catch basin cleaners were adapted for hydro-excavation use, but the technology was crude. Vactor® built its first hydro-excavation machine, the "ExcaVactor," in 1969. However, the market then was immature and it was the only unit built.

In the 1970s and '80s, customers modified vacuum trucks and sewer cleaners for hydro-excavation use. Some took vacuum components off the trucks and mounted them on all-terrain vehicles to get into remote locations. In the 1990s, a number of companies saw a growing demand for hydro-excavation machines and began manufacturing truck- and trailer-mounted units in varying configurations.

By 2000, hydro-excavation was widely used across Canada and was moving into the United States. In recent years, the practice has rapidly gained acceptance in the U.S.

Safety and damage prevention

Improved safety and damage prevention top the list of key benefits of hydro-excavation. An underground utility strike can be catastrophic, affecting thousands of people and costing millions of dollars. A single incident may cause personal injury or death, property damage, lost work opportunity, community disruption, ecological damage and insurance liability.

More than 40 percent of pipeline system leaks and ruptures are caused by damage from outside force, and more than half of all cable service outages are caused by excavation damage.

While disruption of a telecommunications network is not as inherently dangerous, it can be expensive and inconvenient, impacting traffic control systems, health services and emergency response activities. The importance of minimizing underground utility strikes and their consequences cannot be denied.

Using hydro-excavation in such situations can avoid:

- "Hits" or "strikes" on underground utility lines, cables and pipes
- High costs to repair damaged infrastructure
- Costs and inconvenience of interrupted utility services
- Serious injury or death to workers and the public
- Liability and increased insurance costs
- Loss of a company's reputation, revenues and employee morale

In addition, hydro-excavation can improve overall productivity and efficiency for contractors, municipalities and utilities.

Government regulation

The U.S. presently has more than 14 million miles of buried utilities and pipes. Current laws prohibit the use of mechanical means to dig within 18 inches of buried cable and pipe in the U.S., and 45 cm in Canada. Buried utilities are often mis-marked or maps are inaccurate, requiring underground facilities to be located by sight, either by hand-digging or another means, to maximize safety. This is often called "daylighting." Unfortunately, digging by hand is often time-consuming, and mechanical excavation is inherently risky.

The U.S. Department of Transportation's Damage Prevention Quality Action Team views the situation this way:

The United States has a vast underground infrastructure of pipelines, conduits, wires, and cables that affect every individual. This underground infrastructure is critical to our way of life, constantly providing oil and natural gas, telecommunications, electricity, water, sewage, cable TV, and other vital products and services. Disruption of any of these underground facilities could affect the safety of the public, the environment, and continued service reliability that could impact our entire economy.

One of the leading causes of disruption to our country's underground facilities is external force damage (sometimes called 'third-party damage') that occurs during excavation activities. This has been recognized by both industry and government. Although such damage occurs far too frequently, it is usually preventable. Responsibility for preventing excavation damage is shared by all stakeholders. Advanced planning, effective use of one-call systems, accurate locating and marking underground facilities, and the use of safe-digging practices can all be very effective in reducing underground facility damage. In most states, increased and mandatory use of the state's one-call system has significantly reduced the incidence of excavation damage. However, damage still occurs.

Risky business

Strikes on natural gas lines are particularly hazardous and occur all too often, resulting in significant property damage, injuries and even deaths. The tables below illustrate incidents for natural gas distribution pipelines during the years 2000-2004.

Natural Gas Pipeline Operators
Incident Summary Statistics By Year
2000 – 2004

Distribution Operators

Year	No. of Incidents	Fatalities	Injuries	Property Damage
2000	154	22	59	$23,398,834
2001	124	5	46	$14,071,486
2002	102	10	44	$23,804,202
2003	146	11	58	$22,293,833
2004	171	17	41	$54,079,550
Totals *	**2,580**	**318**	**1,404**	**$356,679,645**

* Totals include accidents from 1986 – 2004. Source: Office of Pipeline Safety Statistics.

As these statistics show, property damage from gas distribution pipeline incidents more than doubled from 2003 to 2004, from over $22 million to $54 million. Of the 171 incidents reported in 2004, 48 were caused by third-party excavation, resulting in more than $10.6 million in property damages.

Distribution Pipeline
Incident Summary By Cause
1/1/2004 – 12/31/2004

Cause	No. of Incidents	% of Total Incidents	Property Damages	% of Total Damages	Fatalities	Injuries
Car, truck or other vehicle not related to excavation activity	12	7	$18,010,380	33.3	1	2
Fire/explosion as primary cause	26	15.2	$5,874,315	10.9	0	4
Operator excavation damage	1	0.6	$0	0	0	0
Third-party excavation damage	48	28.1	$10,636,424	19.7	0	4
Totals	**171**	**100.0**	**$54,079,550**	**100.0**	**17**	**41**
Average			**$316,255**			

Totals and averages include all accidents from 2004. Source: Office of Pipeline Safety Statistics.
Data for 2005 not available at time of publication.

Applications

Virtually every construction contractor, municipality and utility does underground construction and/or has subsurface facilities. At times, a subcontractor with expertise or specialized equipment is needed to handle certain excavation jobs. There are many potential applications in which hydro-excavation is a viable option. These include:

- Line location, installation and repair for utilities and pipelines
- Sewer and pipe rehabilitation
- Telecommunications maintenance and repair
- Slot trenching
- Waterline maintenance and repair
- Directional drilling
- Sign and pole installation
- Landscaping (i.e., digging holes for new trees and shrubs)
- Repair work or excavation in tight spaces and congested areas
- Potholing

With hydro-excavation, buried natural gas and petroleum pipelines can be uncovered without risk of puncture. Fiber optic cables, telephone lines, water mains and other utilities can be efficiently located without damage. This method also causes less surface damage, traffic disruption and other potential digging drawbacks.

Operators can use hydro-excavators to dig with precision, offering a less invasive method for slot trenching, potholing or pipe location. In grassy areas, sod can be replaced and, within a week, a casual observer would never know a hole had been dug there.

Cost/benefit analysis

To effectively evaluate the costs versus benefits of hydro-excavation compared to mechanical excavation methods, worksheets such as the ones on the next page can be used. The first worksheet in each of the two sets includes typical figures for the example shown. Use the second, blank worksheets to plug in your own numbers and compare conventional digging and hydro-excavation.

In most cases, a yard-for-yard comparison between a hydro-excavator and a bucket machine favors the bucket machine. However, the actual removing of the dirt is only a small part of the overall job.

Let’s look at the following job as an example: Acme Utility Co. has contracted you to uncover a 2 ft. x 2 ft. area they believe to be six feet underground, then backfill with clean material and restore to its original condition.

Option 1: Conventional method

Open hole with sloped sides to allow for legal hand digging for exposure of utility.

Operation	Time	Cubic Yards	No. in Crew	Amount
Unchain, unload & stage equipment	0.5 hr.			
Uncover utility	3 hrs.	13.3	4	
Backhoe, Dump truck				
Backfill (compacted)	2 hrs.	12.1		
Restoration (196 sq. ft.)	1.5 hrs.			
Reload equipment	0.5 hr.			
Totals	**7.5 hrs.**	**25.4**		

Operation	Time	Cubic Yards	No. in Crew	Amount
Unchain, unload & stage equipment				
Uncover utility				
Backhoe, Dump truck				
Backfill (compacted)				
Restoration (196 sq. ft.)				
Reload equipment				
Totals				

Option 2: Hydro-excavation method

Open hole for exposure of utility. There’s no need to slope the sides, because this process keeps workers on the surface, not in the excavation.

Operation	Time	Cubic Yards	No. in Crew	Amount
Park truck, turn on vacuum & water	5 min.			
Uncover utility	0.5 hr.	0.9	2	
Hydro-excavator				
Backfill (compacted)	25 min.	0.9		
Restoration (sod was cut & peeled back at start of excavating)	1.5 hrs.	1.2		
Totals	**2.5 hrs.**	**3**		

Operation	Time	Cubic Yards	No. in Crew	Amount
Park truck, turn on vacuum & water				
Uncover utility				
Hydro-excavator				
Backfill (compacted)				
Restoration (sod was cut & peeled back at start of excavating)				
Totals				

These tables illustrate the time, labor and cost savings between the different methods. The Option 1 crew will likely be occupied onsite almost all day, while Option 2’s crew has time for multiple jobs in one day. This may or may not be a typical example in your area.

Cost/benefit analysis worksheets used with permission of www.safeshovel.com.

Today's technology

The most effective hydro-excavators today are dedicated units designed and built specifically for hydro-excavation. They combine high-pressure water systems that cut through and break up sod and soil with a high-flow air vacuum that lifts soil and small rocks out of the excavation area.

In the late 1990s, Vactor® Manufacturing saw that customers needed a dedicated machine, resulting in the Vactor HXX Hydro-Excavator introduced in 1999.

Fan or PD

On most dedicated hydro-excavators available today, customers may choose either a fan system or a positive displacement (PD) blower as the vacuum source. Each has distinct advantages:

- A fan system moves an incredible amount of air, excavating more rapidly than other systems. It's also easier to operate and maintain, and the unit's overall weight is usually less. Also, fan units are generally less expensive than the PD versions.
- A PD blower moves air over long distances, allowing for excavation at greater depths, but at slower speeds, than fan units.

Typical hydro-excavation jobs do not require digging to great depths or at long distances, so the fan type is more productive for the majority of hydro-excavation applications.

In either the fan or PD configuration, a simplified airflow path design will maximize pickup and filtration effectiveness. Additional features that improve the unit's overall productivity include extendable or telescopic booms offering a wide range of rotation and mounted on the curb side, large-capacity water tanks and debris bodies, heavy-duty solid construction, heated pump and hose reel cabinets, convenient operator controls and tool storage.

Water flow and pressure

There are several benefits to using water (vs. air) as a nondestructive excavation tool.

Water flow and pressure

- Acts as its own lubricant
- Controls static electricity
- Avoids the sandblasting effect of air
- Works in almost all soil conditions
- Can be heated to excavate frozen ground

Vactor recommends in most cases using three to nine gallons per minute (gpm) of water volume for hydro-excavation. Contractors are paid to excavate the soil, not to dump debris, recover water or get more water. Therefore, using the proper water volume is cost-effective and saves time. In addition, the resulting debris has minimal water content, not a slurry as with systems using high water volumes, which often allows debris to be put back into the excavation.

Vactor recommends using water pressures between 1,500 and 2,000 psi. Pressure higher than 2,500 psi is unsafe. Operating a hydro-excavator at the proper water pressure virtually eliminates the chance of damaging line covers or casings, as well as operator injury.

Industry outlook

Many facilities and areas in Canada have experienced intolerance to utility strikes and, as a result, they now rely heavily on hydro-excavation. The U.S. still has somewhat of a tolerance for hits as a "cost of doing business," although that's changing.

Enhanced enforcement from a government level may drive contractors increasingly toward vacuum and hydro-excavation in coming years. While legislation has been enacted in a few cities and states across the U.S., those examples are limited. However, many people in the industry say it's just a matter of time.

The vacuum excavation market will have to deal with plenty of unknowns in the near future – a recovery of directional drilling, the possibility of a fiber resurgence, and further legislation to prevent "hits" and enforce existing one-call regulations.

Conclusion

At the time of this publication, it looks like hydro-excavation will continue to grow in acceptance and popularity for the foreseeable future. Contractors are increasingly finding value in hydro-excavation for themselves and their customers. More municipalities are gaining confidence in the practice as new projects are completed.

Hydro-excavation can virtually eliminate the unknown or unintended consequences from any project involving drilling, trenching or excavation. Whatever the future holds, hydro-excavation is here to stay and gaining ground.

We trust that this information was educational and valuable.

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