Vacuum Sewers - Operation and Maintenance and System Management Guidelines

An Online Continuing Education Course for Engineers

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Vacuum Sewers: O&M and System Management Considerations

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I. Introduction

From the time the very first public sewer system was constructed until the 1960s, a conventional gravity system was the only choice U.S. engineers had when considering a public sewer collection system. This changed about 50 years ago when the USEPA challenged the industry to develop alternative collections by providing special funding for such endeavors. One of the alternative collection systems is vacuum sewers.

At one time, vacuum sewers were regarded as "new" and only to be used as a system of last resort. Improvements in the technology later led to acceptance as "alternative" sewers, but still only to be used when significant savings would result. Now, vacuum sewers have become an acceptable alternative in the proper application and are providing efficient and reliable sewer service to communities all around the world. In addition to proper design, proper operation, and maintenance (O&M) is of utmost importance for these systems to perform efficiently.

This course is Part III of a three-part series on vacuum sewers and will focus on operation & maintenance and system management considerations for vacuum sewer systems. Part I discusses the basics of vacuum sewer technology by providing a broad overview of the technology, while Part II focuses on the design and installation aspects related to vacuum sewers.

II. Evaluation of Operating Systems

A. Operating History of Vacuum Sewers

Early vacuum systems were often plagued with consistent operational problems. Small diameter vacuum mains improperly planned vacuum main profiles, too large liquid slug volumes, and insufficient air all resulted in transport problems[1]. Adding to the difficulties was the fact that they were installed without sufficient field experience, and with system components that were not yet fully reliable. In addition, operation and maintenance guidelines were not yet available. Frequent service calls and high power bills were common during this era.

Several breakthroughs occurred in the 1980s that led to significant improvements in the technology. These included the introduction of the saw-tooth profile, an improved valve controller, the use of gasketed pipe, and the use of larger pipe and vacuum pumps. Many feel that more progress was made in the vacuum sewer industry during this decade than in other times. Service calls were less frequent, systems were more energy-efficient, and overall, the systems were becoming more reliable.

Improvements in technology continued throughout the 1990s to the present day. A better understanding of vacuum sewer hydraulics, improved system components, and established operation and maintenance guidelines have combined to lead to significant operational improvements.

Today's vacuum systems are significantly different than the systems of the 1970s. Efficiency and reliability are the two areas where the most improvement has occurred. Continuing research and development is expected to further improve the technology.

B. Published O&M Data

The 1991 EPA Manual, *Alternative Wastewater Collection Systems*[2], contained O&M data from projects in operation from the early 70's up to 1989. This data was representative of O&M for vacuum systems during that era.

The 2008 WEF Manual, Alternative Sewer System[3], contained O&M data from a 2003 survey that was sent to selected operators of vacuum systems. An attempt was made to survey systems that would give a good cross-section of the technology. Age of the system, topography, geographical location, and size were considered in the selection process. O&M data from about 20% of the operating systems in the U.S. was gathered. To be consistent with the O&M data previously reported in the 1991 EPA Manual, the survey requested information on labor, power, and service call history. As was the case with the EPA data, the WEF data revealed that the older, earlier systems had the highest O&M rates, while the more recent ones fared much better. Again, the data was considered to be representative of O&M for vacuum systems at that point in time.

There has been no published O&M data on vacuum systems since; however, Airvac routinely gathers O&M information from most of its 350+ existing systems in order to provide realistic data to other entities contemplating the use of vacuum. Data from projects installed in the past ten years is considered to be representative of modern systems and is used in project-specific budget estimates prepared for these entities. This data includes an estimate of the annual labor and power costs as well as the expected Renewal & Replacement costs of the major systems components. Not surprisingly, advancements in the technology and improvements in system components continue to result in declining O&M costs.

C. Mean Time Between Service Calls (MTBSC)

MTBSC is calculated by dividing the number of valves by the number of service calls over a 1-year period. For example, a system with 500 valves that required 50 service calls in a year would have an MTBSC of 10 years.

An EPA *Technology Transfer Seminar Publication*, prepared in 1977, detailed the failure rate (MTBSC) of some of the early vacuum systems. In general, the MTBSC of the early systems ranged from less than 1 year to more than 8 years; all but one of the systems had an MTBSC of less than 4 years (EPA, 1977).

In the 1991 EPA Manual, the MTBSC of the systems visited ranged from 1 year to 22.5 years with an average MTBSC of 2.2 years.

The 2008 WEF manual showed a range of MTBSC of 2 to 27 years, with the average being 5.1 years even though it included many of the early systems that have lower MTBSC values. Even with these included, the overall MTBSC figure has increased over the years.

Data from recent Airvac systems (2010 to 2019) indicates that an MTBSC ranging from 7.5 to 15 years can be reasonably be expected with modern systems that use the latest technology and system components.

Table 1 Mean Time Between Service Calls (MTBSC) Trend		
Era	Source	MTBSC
1970 - 1975	1977 EPA Manual	<1 to 8
1970 - 1989	1991 EPA Manual	2.2 yrs
1970 - 2003	2008 WEF Manual	5.1 yrs
Modern Systems 2010 - 2019	Airvac (data from recent projects)	7.5 to 15 yrs

D. Effect of Extraneous Water

As is the case with other system types, extraneous water (I/I) often is the root cause of most problems, whether it is heat build-up in the vacuum station due to excessive pump run-times or problems with the valve controller due to excessive cycles. In a vacuum sewer system, the only potential source of I/I is the homeowner's building sewer, where even a small amount of I/I can have a detrimental effect. Accepting flow from an existing gravity system, where I/I is common, further exaggerates the problems. (see box below).

Until recently, the number one component-related problem has been "water in the controller." Water in the controller is a by-product of system problems that occur as a direct result of extraneous water (I/I) that is allowed to enter the system. The incidence rate of this happening has drastically fallen over time, especially with the introduction of Airvac's H.P. Controller that contains design features that make it much more water tolerant than previous valve controllers.

SITUATION TO AVOID!
ACCEPTING FLOW FROM AN EXISTING GRAVITY SYSTEM

Of all of the potentially bad situations that can occur, perhaps none is more damaging to a vacuum system than excessive flow that enters a vacuum system via an existing gravity system. Problems ranging from sluggish, inefficient flow transport to temporary system failure have resulted. With new construction, one can fairly accurately predict average and peak flow and design the vacuum mains and vacuum station accordingly. By accepting flows from an existing system, another element is introduced into the equation: infiltration & inflow (I/I).

Should it be possible to accurately predict I&I, this situation can be considered, but still with caution. An analysis of the existing gravity system must be done. This would include having flow records that identify the magnitude of flow that can be expected during normal periods as well as rain events (minimum 1 year of flow data). Even then, should there be a large difference between normal daily flow and flow during a rain event, it is recommended that the existing gravity flow be handled by other means.

(Airvac, 2019)

III. Operation & Maintenance Considerations

A. Staffing Requirements

Because they are mechanized, vacuum systems have a reputation as being O&M intensive. This may have been true of the early vacuum systems; however, information from system operators suggests that the effort to operate and maintain a modern vacuum system is typically overstated.

One key to a successfully operating system is the attitude, training, and skill of the system operator. An even more important consideration may be how the maintenance staff is structured and organized. Maintenance staffs that divide operating responsibility by system components, e.g., one division responsible for the vacuum station, another responsible for the vacuum mains, and a third responsible for the valves are rarely successful. Successful operations are those that have at least one operator who is responsible for the entire system *(see box below)*.

The major components … g network, and the vacuum station, are ir … ***ystem***. Even more importantly, they must b …

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For this reason, the most … up with a single thought process. There is … as long as they all know how the ***system*** …