SOBA
STATES ORGANIZATION FOR BOATING ACCESS
S.O.B.A. 50 Water St. Warren RI 02885

Performance Testing of Marine-Use Waste Pump-out Stations

October 2004

SPORT FISH RESTORATION

Performance Testing of Marine-Use Waste Pump-out Stations

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Preface

In 1992, Congress authorized the Clean Vessel Act Grant Program (CVA) making federal funding available for the construction and/or renovation of boat pump-out and dump stations, and for related educational programs. Since 1993, over $97 million has been granted to states for these purposes. The grant funds have created a great demand for useful and reliable equipment to meet the needs of today's marina owners and boaters. From the onset of the CVA program, there has been a lack of independent information available to the participating state coordinators and marina owners concerning the capabilities and maintenance requirements of the pump-out equipment. In addition, in the early years of the program, the influx of such large amounts of money into an area of the industry that had largely been ignored in the past created a flurry of new companies and the introduction of many new equipment types. By 1998, there were approximately 13 companies manufacturing single-point pump-out stations, up from a half-dozen only a few years earlier. By 2002, when the funding became available to perform this testing project, the number of manufacturers had dropped back to about six manufacturers, yet the number of different models and types available had more than tripled.

Since the initial authorization of the CVA program, SOBA has worked closely with the U.S. Fish and Wildlife Service (USFWS) to assist in implementing this program. Since 1997, the SOBA annual conference has included a segment dealing with CVA issues. The CVA sessions brought together all levels of state and federal staff responsible for implementing this program. The conference has provided a unique setting for open communications between all parties and as a result, the CVA program is recognized as one of the most efficient and cost-effective federal grant programs of its time.

Introduction

by Kevin Atkinson, SOBA Pump-out Project Committee Chairman

A NEED FOR PUMP-OUT EQUIPMENT TESTING

Beginning with the passage of the Clean Vessel Act (CVA) in 1992, the participating CVA states were continually being asked by marina operators, “What pump-out equipment should I use?” or “Which one works the best?” With the influx of such a large sum of money available to purchase pump-out equipment, states and grantees were being bombarded with pamphlets and sales literature from companies claiming to have a better “mouse trap.” New materials, different pump types, inconsistent pump performance data, and the lack of historical performance information made equipment selection difficult. With no independent information available, the states and marinas were left with a trial and error method of equipment selection. Sometimes this worked fine, but with others, the end product left a lot to be desired for both the marina and the boaters. Some companies were very knowledgeable and offered assistance when requested. However this new interest in pump-out equipment also caused an influx of new sales personnel, who were often not knowledgeable in terms of how to correctly select the right equipment based upon a marina’s site conditions.

A method of evaluating the effectiveness of the commercially available pump-out equipment was needed. In 1998, the Oregon State Marine Board initiated the idea to conduct a series of tests to evaluate the available equipment for capability and longevity and to share these findings with all interested parties. Over the next several years, SOBA’s CVA Committee also heard from many of the state CVA coordinators who needed help determining how to specify equipment that would work for their marina operators. With the support of the participating CVA states, as well as representatives within the pump-out industry, and the U.S. Fish and Wildlife Service, SOBA was able to obtain the necessary funding to conduct life-cycle testing through the Multi-State Conservation Grant Program in 2002.

The CVA Grant Program has had a great, positive impact on water quality in the United States, the results of which are well documented. Even though the CVA grant program has been funding pump-out installations since 1993, the equipment selection process continues to be done primarily through impulse buying or anecdotal reference. Over the next five years, an additional $50 million will be available for new and replacement pump-out facilities, making informed equipment selection even more important!

Until this project was conducted, there had been no side-by-side comparisons or independent testing of pump-out equipment conducted under such realistically simulated conditions or using such accurate recording methods. As future needs for pump-out equipment develop, SOBA anticipates the test results will provide CVA participants a better understanding of how to assess equipment capability and longevity, and how to select the best equipment for their CVA and matching dollars.

In the last ten years, the pump-out equipment industry has made great strides in terms of technology and equipment reliability. All of these advances will be useless, however, if the industry does not continue to improve customer service. It is imperative to the success of the CVA program and the industry as a whole, to work with the customers to insure that they correctly size and engineer the pump-out stations from the start, so they get it right the first time! This is not to say that the industry itself must bear the entire burden. It is also the responsibility of the participating CVA states and their coordinators to insure that the marinas follow the recommendations of the manufacturers for equipment installation, operation and maintenance. Great successes have been enjoyed from the CVA program; we should all strive to continue these successes as well as to improve on what we have created.

STUDY BACKGROUND

It is very important for marina operators to understand that different products are best for different situations. For instance a diaphragm unit, due to economy of price, may be best the best choice for low usage and low head requirements, but a peristaltic or vacuum unit may be a better choice if high volumes are to be pumped or the site has significant head conditions. It is up to the marina operator to decide which pumpout unit is appropriate for their site and which information contained within this report may be appropriate or acceptable for their circumstances.

When dealing with a national program such as the CVA, there are unlimited variables. Marine conditions and even personal attitudes in California may not be the same or even acceptable in Florida or elsewhere. This test does not presume to address all the variables that exist, nor could it ever attempt to do so. This test and its conditions were picked as a starting point. The test conditions simulated an actual piping network and the environmental conditions these units could be subject to at any marina. The conditions for this test may or may not be similar in some respects to a particular area. The reader must decide which information may be appropriate or acceptable for their circumstances.

Pump-out equipment manufacturers all offer statistics regarding the capability of their equipment. However, no two manufacturers test their equipment in the same manner, nor do they use the same piping network during their in-house testing. In many instances, the pump-out equipment is also tested using only simulated head conditions against a pump and/or without using the actual intake hose that is supplied with the pump. This can have a dramatic effect on the pumping capabilities. This pump-out testing was intended to provide an independent assessment of the capability of the equipment from startup to 1000 hours of operation under the same conditions. Also, the testing was intended to evaluate the capability of pumping a more realistic medium that includes paper products, personal hygiene items, pieces of plastic or foam cups, plastic bags and other common materials commonly dumped into boat holding tanks. An assessment of the equipment to withstand environmental effects such as salt spray and ultraviolet exposure is also important information needed in making decisions for placement of new pump-out equipment, especially in coastal areas. These are just a few of the areas that this project attempted to help address.

All known pump-out manufacturers (single-point units) were invited to participate in this testing project. The manufacturers were sent a letter (Exhibit A) that detailed the testing and plumbing system that the project would entail. Each manufacturer was asked to supply a pump(s) from their product line of diaphragm, vacuum or peristaltic pumps that they felt would be capable of performing under these conditions. In all, seven manufacturers submitted 13 different models for testing. Represented were:

Edson International (one each of a diaphragm, vacuum and peristaltic pump),
Exstar International Corporation (one diaphragm pump),
Keco Pump & Equipment Co. (one each of a diaphragm, vacuum and peristaltic pump),
EMP Industries (two peristaltic pumps),
Chesapeake Bay Marine (one vacuum pump),
Waubaushene Machine and Welding (two vacuum pumps) and
Mariner Technologies (one peristaltic pump).

The pumps were shipped to Underwriters Laboratories, Research Triangle Park, in North Carolina for assembly and testing. The testing was conducted over a nine-month period between November 2003 and August 2004. Originally it was intended to test all equipment for a period of 1,000 hours on each unit, however due to equipment repairs and other time constraints, it was necessary to stop the testing on June 4, 2004. (The Chesapeake Bay unit was allowed to continue to run beyond the June 4th cut-off due to the discovery that the lubricating oil chosen for the test was causing the system to inadvertently overheat and shut down. A discussion of this is found in Annex 4.2 discussing this unit.) (Special note: Since the testing project began, Mariner Technologies has ceased to do business. This unit was withdrawn from the testing, and no results are shown for this unit.)

Generally, all of the equipment performed as intended. There were some surprises and some unexplained issues (such as breakers tripping for no apparent reason). SOBA believes that this is the best effort, to date, to run this type of equipment through a well-documented life-cycle test protocol, utilizing the same conditions for each unit. The results of this testing will share information that is of interest to the manufacturers, state representatives, marina operators and boaters.

This test report is not intended to eliminate or reject any particular type or brand of equipment from use. It is intended to give the responsible federal, state, and local grant participants a baseline of information that can be used to help them rationally chose the type of equipment that is best suited to their particular needs and to give them an idea of what may be experienced in the maintenance of this equipment over its useful lifespan. It is also hoped that the manufacturers will use this report to analyze and make improvements to their equipment to benefit all users.

Acknowledgments

This project was funded through a Multi-State Conservation Grant, with funding provided by the Sport Fish Restoration program. The States Organization for Boating Access (SOBA) would like to thank the International Association of Fish and Wildlife Agencies and the U.S. Fish and Wildlife Service for their support of this project.

SOBA was fortunate to be able to draw upon its members and the marine manufacturing industry for support and assistance in conducting this life-cycle testing project of pump-out station equipment.

SOBA would like to thank the following individuals and organizations for their support:

Pump-out Project Committee Members:
KEVIN ATKINSON, Committee Chairman, California Department of Boating and Waterways
ROCKY BROWDER, South Carolina Office of Ocean and Coastal Resource Management
JILL MURPHEY, Idaho Department of Parks and Recreation
RON RHODEHAMEL, Oregon State Marine Board
RICK HUNTLEY, Connecticut Department of Environmental Protection
ED POOLOS, Tennessee Wildlife Resources Agency
BOB CLARK, Virginia Department of Health
TOM CALLAHAN, EMP Industries
PETER BURLINSON, Edson International

U.S. FISH &WILDLIFE SERVICE, DIVISION OF FEDERAL AID, with a special thanks to Chris McKay and Tony Faast whose continuing support and guidance are greatly appreciated.

Special appreciation is also extended to those pump-out equipment manufacturers who cooperated and supported SOBA in conjunction with this project.

Edson International
EMP Industries
KECO, Inc.
Waubaushene Machine and Welding
Exstar International Corporation
Chesapeake Bay Marine Pump-out Systems
Mariner Technologies

Exhibit A: Manufacturer's Invitation and Equipment Specifications

STATES ORGANIZATION FOR
BOATING ACCESS
S.O.B.A. P.O. Box 25655 Washington, D.C. 20007 (202) 944-4987

August 27, 2002

Mariner Technologies
Attn: Greg McGinnis
P.O. Box 58272
St. Petersburg, FL 33715

Dear Pump-out Equipment Manufacturer:

As you are probably aware, the States Organization for Boating Access (SOBA) has been a strong supporter of the Clean Vessel Act since its creation in 1992. SOBA maintains a strong presence within the boating access community throughout the U.S. and is constantly striving to help address members' concerns. Over the last several years, SOBA has been asked by its members involved in the Clean Vessel Act program to help develop some useful life cycle data concerning pump-out stations and equipment.

SOBA has subsequently been awarded a grant from the U.S. Fish and Wildlife Service to conduct such life cycle testing of various types of boat pump-out equipment.

SOBA has made arrangements with Underwriters Laboratories (U.L) to conduct this testing which will evaluate the performance of the pump-out equipment while subjected to various environmental and physical conditions over a simulated 10-year life cycle. The results will be published in a performance report that is distributed to the Clean Vessel Act coordinators throughout the U.S. and its territories.

Testing of the equipment will consist of connecting the pump-out equipment to a simulated piping network of a predetermined length and composition, while recording flow rates over the life of the project. The equipment will also be subjected to UV and saltwater spray exposure. (Please see attached testing criteria fact sheet for more information.)

SOBA is currently seeking pump-out stations to test. It is anticipated that the makeup of the test group will be approximately: 4 peristaltic pump-out systems, 5 diaphragm pump-out systems, and 4 vacuum pump-out systems.

SOBA is therefore requesting pricing from you to supply 1 complete standard model pump-out station of each type that you manufacture (diaphragm, vacuum or peristaltic). Each pump-out station and ancillary equipment shall meet the minimum specifications attached. Shipping costs should be estimated to Underwriters Laboratories, Research Triangle Park, North Carolina 27709.

Selection of the pump-out equipment for this project will be based upon:

(1) Type of pump-out station proposed. (SOBA will try and maintain the composition of the test group discussed earlier.)
(2) Cost.

Funding for this project is limited, and it is not possible for SOBA to purchase all of the different manufactures and models available. So as an incentive to make this testing program available to as many manufacturer's as possible, SOBA is offering to pay all shipping costs associated to any manufacturer who donates his equipment for testing and to return the pump-out equipment at the end of the testing period.

If you wish to participate in this project please send your price estimate along with a copy of your product catalog or product cut sheet, with the model(s) that you propose for testing clearly marked to:

Kevin Atkinson
SOBA CVA Chairman
372 Florin Road, PMB #286
Sacramento, CA 95831

Your price estimate must be received by September 16, 2002 at 5 p.m. PDT.

SOBA anticipates ordering the pump-out equipment within 30 days after the above deadline.

Sincerely,

Kevin Atkinson
SOBA CVA Chairman
(916) 263-8149

Attachments

SOBA PUMP-OUT EQUIPMENT TESTING OVERVIEW

Identify Independent Testing Facility: In order to produce viable test results an independent testing facility has been selected. SOBA has contracted with Underwriters Laboratories (UL) to conduct the testing.

Test Samples: The vessel waste disposal industry branches into three different categories of pump-out units. These are the diaphragms, peristaltic, and vacuum based pump-out systems. Ideally, every pump-out unit from all known pump-out manufactures would be tested in order to achieve a true unilateral test field. However, there are currently 18 different manufactures of pump-out equipment, and in addition many different models from each manufacture. Therefore, this initial testing regiment will be conducted on a representative sample of pump-outs. This representative group will consist of approximately five diaphragm pump-outs, four peristaltic pump-outs, and four vacuum pump-outs meeting a predetermined minimum "stock" specification.

Publish Evaluation Findings: Results will be published and distributed to all CVA coordinators on both the State and Federal level and to all known industry representatives.

C. RESULTS AND EXPECTED BENEFITS

The test results will put to an end any doubts or misconceptions about:

-which unit(s) perform and which unit(s) do not perform under the test conditions,
-which unit(s) resists the effects of the environment better than other units, and
-which unit(s) broke down during the evaluation and how long it took to fix them.

Based on the evaluation findings, the States will be better able to select what unit best suits their specific needs without second guessing their design and without being mislead by any preconceived notions that the designer may have about a particular brand of pump-out unit.

Rating System: A numerical rating system shall be developed as a means to interpret the findings of the test. The following should be incorporated into the rating systems major headings:

-Overall Volume Pumped
-Average Weekly Flow
-Average Test Flow
-Beginning Test Average Flow -vs. End of Test Average Flow
-Broken Units
    *Cost to Repair
    *Length of Time to Repair
-Corrosion Resistance
-Resistance to deterioration due to elements (sun, salt, rain, etc.)
-Ability to pass foreign objects

Report Format: The following major headings should be used in the Final Report:

- Objective
- Define the differences between diaphragm, peristaltic, and vacuum pumping systems.
- Description of pump-out units tested

- Testing procedures
- Testing environment
- Rating systems
- Results
- Conclusion

D. ASSUMED PARAMETERS

Life Cycle: The assumed average useful life cycle of a typical pump-out is 10 years. A typical pump-out in a medium use area pumps 175 gallons per day according to a study developed by the Oregon State Marine Board on the "Effects of Boat Waste at Municipal Wastewater Treatment Facilities." Over a 10-year period, a typical pump-out will pump 638,750 gallons of fluid.

Accelerated Life Cycle: Assuming a pump-out has a minimum acceptable working flow of 10 g.p.m., the 10-year life cycle volume could be accomplished in an Accelerated Life Cycle volume in as little as 45 days of continuous pumping or in 90 days of split pumping (10 minutes pumping, 10 minutes resting).

Piping Network: Due to our nations extreme environmental diversity, choosing a piping network that's representative of all the possible conditions that a pump-out could encounter is impossible. The following piping network is recommended, as a median network that would represent 60% of the possible conditions a pump-out unit would face.

Suction Head: Shall be eight vertical feet as measured from the tip of the pump-outs' hose nozzle to the base of the pump-out unit.

Discharge Head: Pump-out shall discharge through a 2" diameter, schedule 40, PVC piping. The discharge head shall simulate a 10' vertical rise and a 200' horizontal run with six (6) 90 degree elbow bends and a gate valve. Distance is as measured from the base of the pump-out unit to the invert of the discharge line.

Run Time: All units shall be started and stopped simultaneously except when being individually tested. This will ensure that all the units have an opportunity to an equal run time and are therefore playing on the same field of battle. If a unit should malfunction and need to be turned off until repairs can be made, then only that particular unit will be turned off. This will be done to prevent all the units from suffering subtraction of evaluation points due to falling short of the life cycle pumping volume in 90 days.

Environment: In order to create a worst-case scenario, a representative coastal environment will be created. The test shall simulate the salt-water marine environment complete with misters to imitate sea spray.

E. DRAFT TEST CRITERIA

Any stationary pump-out with a 30' suction hose may be admitted to this test. The suction pool shall be filled with fluid that has similar properties to the fluid held in a typical boat holding tank. Sufficient chemicals need to be determined to imitate this mixture. Soft solids that range in diameter of up to one inch must also be added to simulate typical solids found in a boat holding tank. Care shall be taken to maintain a consistent chemical pool level throughout the testing process. The pool shall be checked weekly and corrected as necessary.

Suction lift will be 8' (Vertical - as measured from the nozzle of the 30' hose to the base of the pump-out unit). The hose shall only be unrolled enough to make submerging of the nozzle possible in the suction pool. The discharge head shall simulate a 10' vertical rise (as measured from the base of the pump-out unit) and a 200' horizontal run through a 2" diameter pipe, schedule 40 PVC pipe.

The average flow (in g.p.m.) shall be logged weekly. The average flow shall be acquired mechanically or through computation, for all units. After the average weekly flow has been logged, the unit shall be simultaneously forced to pump dry by lifting all the nozzles out of the suction pool for a period of 30 seconds and the units shall then be shut off.

The units shall then be tested individually to see how long it takes to pump 30 gallons of water through the unprimed system and the results logged (Average Test Flow). The units shall be pumped dry again for a period of 30 seconds. All nozzles shall be repositioned back in the suction pool and started simultaneously.

The test shall last for a period of 90 days, during which time the equipment shall be concurrently subjected to continuous UV exposure and a saltwater spray. One scratch shall be made on each unit's exterior housing, pump body, and interior frame. These scratches shall simulate accidental, but likely blemishes that occur during installation. The scratches shall be approximately 4" in length and not more than 1/64" in depth. As much as humanly possible, care shall be taken to ensure that all units have identical marks. Photographs of each unit shall be taken as well as close up photos of the scratches. The units shall be checked monthly to monitor physical changes (i.e.: fading, cracking, etc.). Pictures of each unit shall be taken each month to record any changes.

Any defective / broken units that need to be repaired during the test (i.e.: hole in diaphragm, broken switches, etc.) shall have the incident logged and then shall be fixed to allow continuing the testing. Logging of the incident shall include description of which parts failed, how long it took to fix the unit (including time to receive the applicable parts once ordered), and the price of the replacement parts.

Pictures shall be taken with the units in the same position, lighting and background as the ones at the beginning of the test.

At the conclusion of the life cycle testing a separate test shall be run to determine the ability of each pump-out to pass materials not commonly associated with the characteristics of sewage, but commonly found in boat holding tanks. These components are rags, paper towels, paper and Styrofoam cups, and personal hygiene products. This test shall consist of attempting to pump a 50-gallon tank of fresh water containing a predetermined quantity of each of the above products through the pump-out equipment. Each product shall be tested separately. The ability of the pump-out equipment to pass these materials through the discharge piping shall be recorded and rated.

MINIMUM SPECIFICATIONS FOR PUMP-OUT STATIONS (SALTWATER ENVIRONMENT)

Pump-out Equipment shall be sized to meet the following Site Conditions:

Suction Head: Shall be eight vertical feet as measured from the tip of the pump-outs' hose nozzle to the base of the pump-out unit.

Discharge Head: Pump-out shall discharge through a 2" diameter, schedule 40, PVC piping. The discharge head shall simulate a 10' vertical rise and a 200' horizontal run with six (6) 90-degree bends and a ball valve. Distance is as measured from the base of the pump-out unit to the invert of the discharge line.

PUMP-OUT STATION- Diaphragm Type

A. **PUMP -** The pump diaphragm shall be constructed of Nitrile. The pump body shall be constructed of marine grade aluminum, bronze, or cast iron.

The pump shall be operated by: (a) One green ON push button with a 10 minute automatic shut-off timer The automatic timer shall be preset at 5 minutes. One red OFF push button may also be supplied at your option.

B. **MOTOR -** The motor shall be totally enclosed, 115/230 volt, 1 phase, of standard off-the-shelf material and construction typical for each manufacturers model submitted.

C. **FRAME** – Standard off- the- shelf material and construction for each manufacturers model submitted.

D. **ENCLOSURE -** The enclosure shall be easily removable for component servicing and shall be standard off- the- shelf material and construction typical for each manufacturers model submitted. The enclosure shall not enclose the pump-out hose.

E. **HOSE HANGER -** An external hose hanger shall be provided. The hanger may be an integral part of the enclosure or bolted securely to the enclosure. The hose hanger shall be able to hold 30 feet of 1 1/2 inch diameter suction hose. The hose hanger shall be standard model as normally supplied by manufacturer.

F. **PUMP-OUT HOSE -** The pump-out hose shall be of 1 1/2 inch nominal inside diameter, minimum 25 **-** 30 feet in length (standard length as typically supplied by manufacturer that meets minimum requirement), reinforced flexible hose. The hose shall be able to withstand a full vacuum of 29 inches of mercury, a maximum working pressure of 20 psi, and an operating temperature range of –40 degrees F to 140 degrees F. The hose shall have a smooth interior to prevent the collection of solids and be non-kinking, collapse proof and flexible. The hose shall have excellent ozone, UV, sewage, seawater, and petroleum resistance.

The pump-out hose shall be equipped with a heavy-duty vandal resistant nozzle assembly. The assembly shall include the following: hose adapter, cam action coupling, ball valve, universal suction nozzle, and a clear plastic site tube.

G. **HOUR METER -** The pump-out station shall come equipped with an hour meter, which records the accumulative usage of the pump-out station. Minimum capacity of the hour meter shall be 9,999.9 hours. The hour meter shall be mounted so that it is easily readable without removal of the enclosure.

MINIMUM SPECIFICATIONS FOR PUMP-OUT STATIONS
(SALTWATER ENVIRONMENT)

Pump-out Equipment shall be sized to meet the following Site Conditions:

Suction Head: Shall be eight vertical feet as measured from the tip of the pump-outs' hose nozzle to the base of the pump-out unit.

Discharge Head: Pump-out shall discharge through a 2" diameter, schedule 40, PVC piping. The discharge head shall simulate a 10' vertical rise and a 200' horizontal run with six (6) 90-degree bends and a ball valve. Distance is as measured from the base of the pump-out unit to the invert of the discharge line.

PUMP-OUT STATION- Vacuum Type

A. **VACUUM PUMP -** Standard off-the-shelf material and construction typical for each manufacturers model submitted.

B. **MOTOR -** The motor shall be totally enclosed, 115/230 volt or 208/230 volt, 1 phase, of standard off- the- shelf material and construction typical for each manufacturers model submitted.

C. **CONTROLS -** Vacuum systems intended to be operated by the general boating public (ie. no attendant) shall be controlled by: (a) An ON-Off push button with a 10 minute automatic shut-off timer. The automatic timer shall be preset at 5 minutes. The switches shall be labeled ON and OFF in the appropriate positions.

D. **ENCLOSURE -** The enclosure shall be the standard off-the-shelf material and construction typical for each manufacturers model submitted.

E. **TANKS** – The vacuum system tank shall have a minimum capacity of approximately 60 gallons. All tanks shall be designed and constructed in accordance with ASME Pressure and Boiler Vessel Codes.

F. **FRAME -** The frame shall be made of standard off-the-shelf material and construction typical for each manufacturers model submitted.

G. **HOSE HANGER -** An external hose hanger shall be provided. The hanger may be an integral part of the enclosure or bolted securely to the enclosure. The hose hanger shall be able to hold 30 feet of 1 1/2 inch diameter suction hose. The hose hanger shall be standard off- the- shelf material and construction typical for each manufacturers model submitted.

H. **PUMP-OUT HOSE -** The pump-out hose shall be of 1 1/2 inch nominal inside diameter, minimum 25 - 30 feet in length (standard length as typically supplied by manufacturer that meets minimum requirement), reinforced flexible hose. The hose shall be able to withstand a full vacuum of 29 inches of mercury, a maximum working pressure of 20 psi, and an operating temperature range of –40 degrees F to 140 degrees F. The hose shall have a smooth interior to prevent the collection of solids and be non-kinking, collapse proof and flexible. The hose shall have excellent ozone, UV, sewage, seawater, and petroleum resistance. The pump-out hose shall be equipped with a heavy-duty vandal resistant nozzle assembly. The assembly shall include the following: hose adapter, cam action coupling, ball valve, universal suction nozzle, and a clear plastic site tube.

I. **HOUR METER -** The pump-out station shall be equipped with an hour meter to record accumulative usage. Minimum capacity of the hour meter shall be 9,999.9 hours. The hour meter shall be readable without removal of the enclosure.

MINIMUM SPECIFICATIONS FOR PUMP-OUT STATIONS
(SALTWATER ENVIRONMENT)

Pump-out Equipment shall be sized to meet the following Site Conditions:

Suction Head: Shall be eight vertical feet as measured from the tip of the pump-outs' hose nozzle to the base of the pump-out unit.

Discharge Head: Pump-out shall discharge through a 2" diameter, schedule 40, PVC piping. The discharge head shall simulate a 10' vertical rise and a 200' horizontal run with six (6) 90-degree bends and a ball valve. Distance is as measured from the base of the pump-out unit to the invert of the discharge line.

PUMP-OUT STATION- Peristaltic Type

A. **PUMP –** The pump body and construction shall be made of standard off- the- shelf material and construction typical for each manufacturers model submitted.

The pump shall be operated by : (a) One green ON push button with a 10 minute automatic shut-off timer. The automatic timer shall be preset at 5 minutes. One red OFF push button may also be supplied at your option.

B. **MOTOR -** The motor shall be 115/230 volt or 208/230 volt, 1 phase, of standard off-the-shelf material and construction typical for each manufacturers model submitted.

C. **FRAME -** The frame shall be made of standard off-the-shelf material and construction typical for each manufacturers model submitted.

D. **ENCLOSURE -** The enclosure shall be easily removable for component servicing and shall be made of standard off- the- shelf material and construction typical for each manufacturers model submitted. The enclosure shall not enclose the pump-out hose.

D. **HOSE HANGER -** An external hose hanger shall be provided. The hanger may be an integral part of the enclosure or bolted securely to the enclosure. The hose hanger shall be able to hold 30 feet of 1 1/2 inch diameter suction hose. The hose hanger shall be made of standard off- the- shelf material and construction typical for each manufacturers model submitted

E. **PUMPOUT HOSE -** The pump-out hose shall be of 1 1/2 inch nominal inside diameter, minimum 25 - 30 feet in length (standard length as typically supplied by manufacturer that meets minimum requirement), reinforced flexible hose. The hose shall be able to withstand a full vacuum of 29 inches of mercury, a maximum working pressure of 20 psi, and an operating temperature range of –40 degrees F to 140 degrees F. The hose shall have a smooth interior to prevent the collection of solids and be non-kinking, collapse proof and flexible. The hose shall have excellent ozone, UV, sewage, seawater, and petroleum resistance.

The pump-out hose shall be equipped with a heavy-duty vandal resistant nozzle assembly. The assembly shall include the following: hose adapter, cam action coupling, ball valve, universal suction nozzle, and a clear plastic site tube.

G. **HOUR METER -** The pump out station shall come equipped with an hour meter, which records the accumulative usage of the pump-out station. Minimum capacity of the hour meter shall be 9,999.9 hours. The hour meter shall be mounted so that it is easily readable without removal of the enclosure.

Performance Testing of Marine-Use Waste Pump-out Stations

Prepared for

States Organization For Boating Access
50 Water Street
Warren, RI 02885

October 19, 2004

Project Manager:

Warren A. ReBarker, P.E.
Senior Project Engineer
Commercial Testing Services

This Document was prepared by:

Underwriters Laboratories, Inc.
12 Laboratory Drive
Research Triangle Park, NC 27709
(919) 549-1400

Underwriters Laboratories Inc. reports apply only to the specific samples tested under stated test conditions.

1.0 EXECUTIVE SUMMARY

1.1 Introduction

This report documents the evaluation of 12 marine-use waste pump-out stations by Underwriters Laboratories Inc. (UL) to the testing specification presented by the States Organization for Boating Access (SOBA) in the proposal entitled *Pump-out Equipment Standards and Life-cycle Testing* included as Annex 1.

The following testing was conducted at Underwriters Laboratories Inc. at the Research Triangle Park, North Carolina facility as part of the evaluation:

1. Pump-out Station Life-cycle Testing
2. Corrosion Resistance of Pump-out Unit Materials: Salt-Spray Test Method (ASTM B 117-03)
3. Ultraviolent Exposure of Pump-out Station Non-metallic Materials (ASTM G 155-00a)

Testing was conducted November 24, 2003 – September 15, 2004 by engineers and technicians of Underwriters Laboratories Inc. The test methods are described in more detail in Section 2.0.

1.2 Project Team

UL Technical Staff: The following personnel supervised and/or performed technical aspects of testing and repairs to the pump-out units:

Warren A. ReBarker, P.E.
Senior Project Engineer

Terry W. Fisher
Marine Engineering Technician

States Organization for Boating Access (SOBA) Representative: The following member of SOBA's Clean Vessel Act (CVA) Committee was available throughout the evaluation to assist UL engineers and technicians with development of the test methods:

Mr. Kevin Atkinson
SOBA CVA Committee Chairman (1997-2002)
California Department of Boating and Waterways
2000 Evergreen Street, Suite 100
Sacramento, CA 95815

1.3 UL Testing Facilities

Test Category	Location	Nationally Recognized Testing Laboratory (NRTL)
Pump-out Station Life-Cycle Testing	UL; RTP, NC	Yes
Pump-out Station Salt-Spray Testing	UL; RTP, NC	Yes
Pump-out Station Ultraviolet Exposure Testing	UL; RTP, NC	Yes

2.0 ANALYSIS SCOPE

2.1 Pump-Out Units Evaluated

The tables below provide information on the pump-out systems that were evaluated in this study:

Diaphragm Units

Manufacturer	Model
Edson International	284EB-40
Exstar International	Sani-Station SS-100 Deluxe
Keco	PAH-175

Peristaltic Units

Manufacturer	Model
Edson International	286EP-40
EMP Industries	Sanisailor Sentinel - M300
EMP Industries	Sanisailor Sentinel - EV405
Keco	PER900.1PH

Vacuum Units

Manufacturer	Model
Chesapeake Bay Marine	CB70HD
Edson International	290-35-1HP
Keco	Vacuum 1000V-3 HP
Waubaushene	AVR60
Waubaushene	LD125

Note: The results herein should not be evaluated on any one-test item; such as how many hours each unit ran. This project was intended to simulate how each unit could be relied upon to operate and stand up to a lifetime of use and exposure. In order to fully evaluate each unit, one must look at all of the results including the breakdowns, maintenance requirements and how the unit can be expected to withstand environmental conditions such as UV exposure, freezing temperatures and wet conditions. The project team did their best to ensure that each unit ran the full 1000 hours originally intended, however the time and effort required to operate 13 pumpout units simultaneously proved to be a formidable task and some unforeseen delays were encountered.

2.2 SOBA Life-Cycle Testing Set-up

Physical Layout

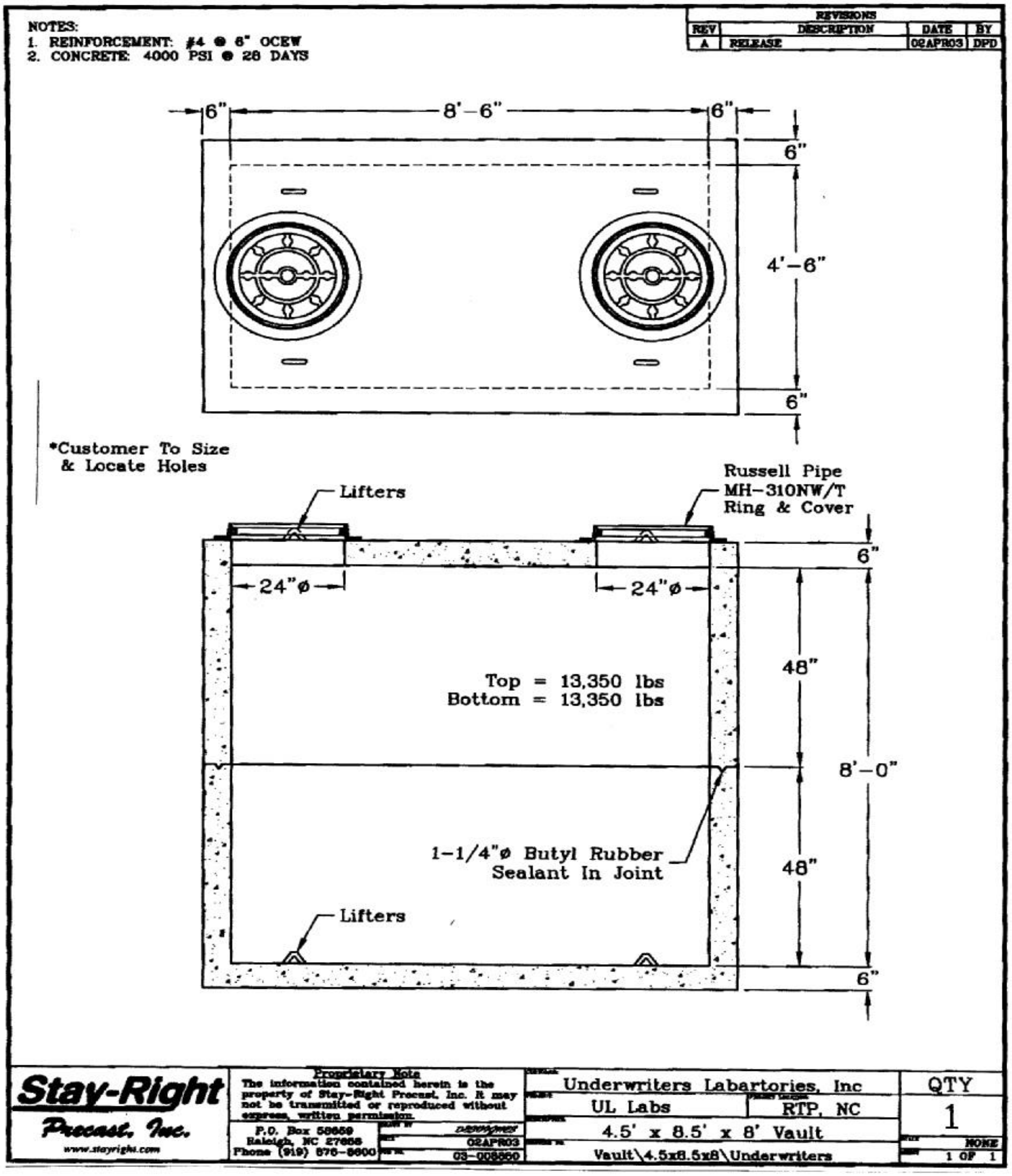
In order to perform life-cycle testing of the pump-out units for this study, a custom test set-up had to be constructed at UL's Research Triangle Park, N.C. facility. The photograph of the test setup below illustrates the mounting of the units for life-cycle testing.

The units were mounted on a simulated dock structure to closely match the actual mounting of the units in a marina. The dock structure was supported on a concrete pad.

As specified in Annex 1, the following critical parameters were constructed into the life-cycle testing set-up for each pump-out unit:

Suction Lift: 8 feet
Discharge Head: 10 feet
Discharge Piping: 200 feet of 2-inch Schedule 40 Polyvinyl Chloride (PVC) piping

The suction pool, specified in Annex 1, was provided through the installation of an underground storage tank adjacent to the dock structure. An engineering drawing of the tank is shown below.



The underground storage tank was constructed of reinforced concrete and had the following internal dimensions:

Height: 8 feet
Length: 8 feet, 6 inches
Width: 4 feet, 6 inches

The tank was constructed with two 24-inch man-ways on the top that were used as penetrations to allow access of the suction hoses of the pump-out units. The tank was coated on the internal surfaces with coal tar epoxy to prevent leakage of groundwater into the tank, and prevent leakage of the test media out of the tank. The tank was filled to approximately 40 inches in depth with the test media, and each inch of tank volume represented approximately 25 gallons, so the volume of the test media in the tank was approximately 1000 gallons. The suction hoses for the pump-out units were routed into the tank through the 24-inch man-ways on the top of the tank and supported so the tip of the suction hose was suspended approximately 6” below the surface of the test media in the underground storage tank.

Annex 1 specified that all pump-out units be subjected to a suction lift of 8 feet during life-cycle testing. The suction lift was measured from the surface of the test media in the underground storage tank to the base of the pump-out units mounted on the dock structure. The suction lift was monitored on a daily basis during life-cycle testing by using a calibrated tape measure to determine the vertical distance between the base of the pump-out units and the surface level of the test media in the tank. The suction lift was maintained at 8 feet +/- 3 inches throughout the test.

As specified in Annex 1, all pump-out units were connected to a discharge piping network that was constructed with the following piping details:

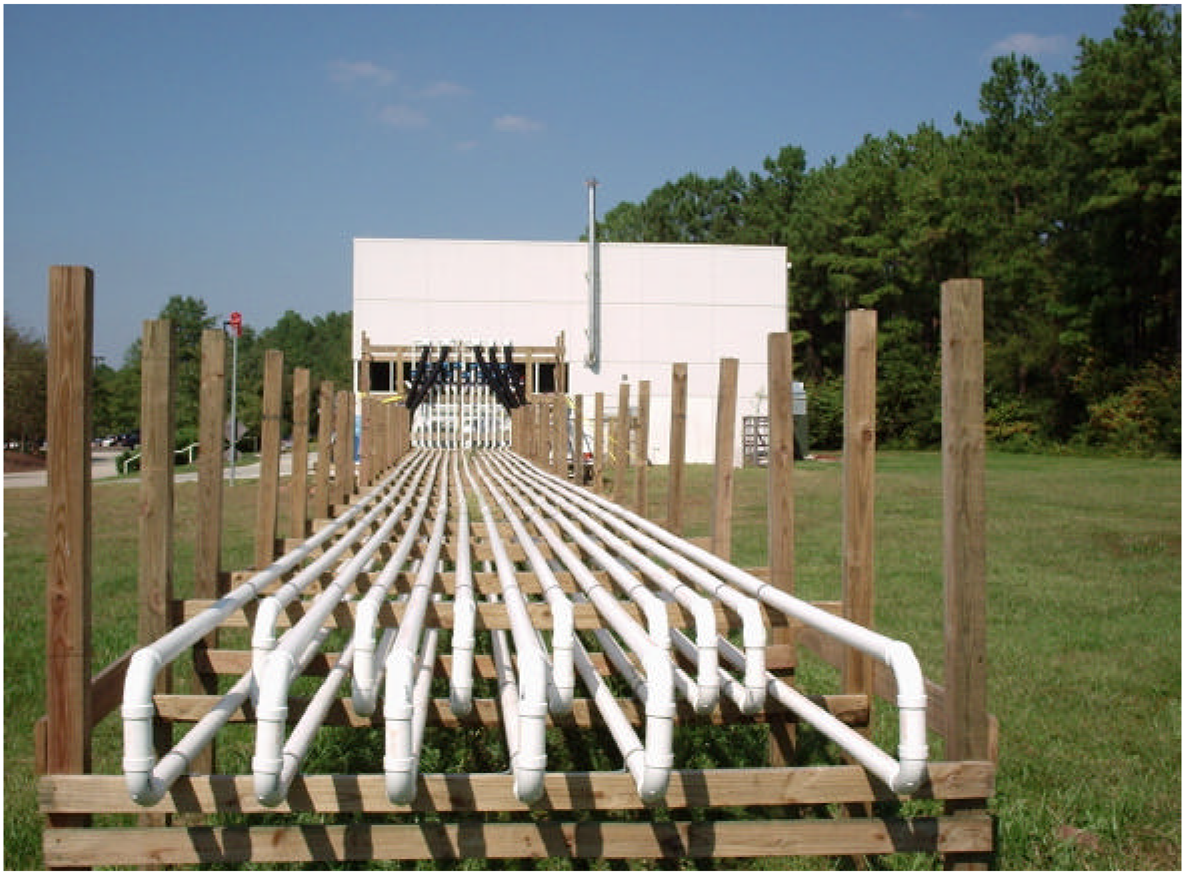
1. 200 feet of 2-inch Schedule 40 Polyvinyl Chloride (PVC) piping;
2. six 2-inch, 90-degree PVC elbows – Note: A minor modification to the specification for 90-degree elbows was made to facilitate the construction of the test set-up and approved by SOBA. Instead of six 90-degree elbows, the piping arrangement for each unit was constructed using five 90-degree elbows and two 45-degree elbows to allow the routing of piping down the discharge header shown above with more reasonable physical space constraints. Sweep elbows were used for both the 45-degree and 90-degree elbows because this type of elbow is most commonly used in marina installations of pump-out units to help minimize clogging of the discharge piping; and
3. one 2-inch gate valve – installed in piping network adjacent to the flowmeter for measuring the flow of media through the discharge piping network of each pump-out unit.

In order to achieve this piping arrangement, the piping was run down a wooden support structure for approximately 90 feet. The piping was then directed upward and the direction of flow was reversed using two 90-degree elbows, and the piping was run back down the support structure an additional length of approximately 90 feet. The piping was then directed upward using a 90-degree elbow and extended to 10 feet above the base level of the pump-out units to meet the requirements specified in Annex 1. Two 90-degree elbows were used at the end of the piping runs to direct the outlet of each pump-out unit into a return duct that dumped the test media back into the underground storage tank. The total volume of the piping runs for all pump-out units was approximately 500 gallons.

In summary, the flow path for each pump-out unit was:

1. the test media in the underground storage tank was pumped up into the pump-out unit through the 30-foot suction hose supplied with each unit;
2. the test media was then pumped down the discharge network described above and the flow of test media was measured for each pump-out unit using a flowmeter described in a later section; and
3. the test media then dumped into the open-air return ducts that dumped the test media to the underground storage tank so the media could be recycled in the process.

The discharge piping runs are shown in the photograph below.



The return ducts in the discharge piping network are shown in the photograph below.

Test Media

As specified in Annex 1, the underground storage tank was filled with a fluid that had similar properties to the fluid held in a typical boat holding tank. The following mixture of three components was chosen by SOBA as the test media after thorough discussion with professionals familiar with the characteristic of boat holding tank waste:

1. ***Water with a slightly acidic pH (6.0-6.5)*** **–** The water volume of the tank (filled to a depth of approximately 40 inches) and pump-out station piping was approximately 1500 gallons. The pH range of 6.0-6.5 was chosen because it closely matches the pH of uric acid found in urine.
2. ***Toilet tissue*** - 15,000 sheets of 2-ply toilet tissue were shredded and added to the water in the tank to achieve a concentrate of approximately 10 sheets/gallon in the 1500 gallons of test media.
3. ***Sponge Material*** **–** Small pieces of sponge material were added to the water in the tank to simulate typical solids found in a boat holding tank. Sponges that are commercially available (Q.E.P Brand – Super Sponge) for use with tile and flooring installations were cut into small rectangular pieces ranging in size from to 1/8” to 3/4”. This type of sponge was chosen for use because the material used in this sponge became neutrally buoyant after immersion in water. A total of 144 sponges were cut up into pieces for the test media, which yielded a total dry weight of 11.1 pounds of sponge material.

The underground storage tank was filled to a depth of approximately 40 inches using tap water from the city water supply. Test runs on the life-cycle testing setup were then performed with water to ensure that all units operated properly in the setup prior to the addition of the toilet tissue and sponge material.

Following the successful completion of several test runs of the pump-out units with water, the toilet tissue and sponge material was added to the tank and the tank contents were thoroughly agitated by running the pump-out units. The pH of the media was then measured using a calibrated pH meter after the water had been in the tank for several weeks. Several pH measurements taken over several days revealed that the pH was within the range of 6.0-6.5, so no chemical adjustment of the water was required. The pH of the media was measured periodically using the calibrated pH meter to ensure that the pH of the test media was within the specified range throughout life-cycle testing.

Electrical Power

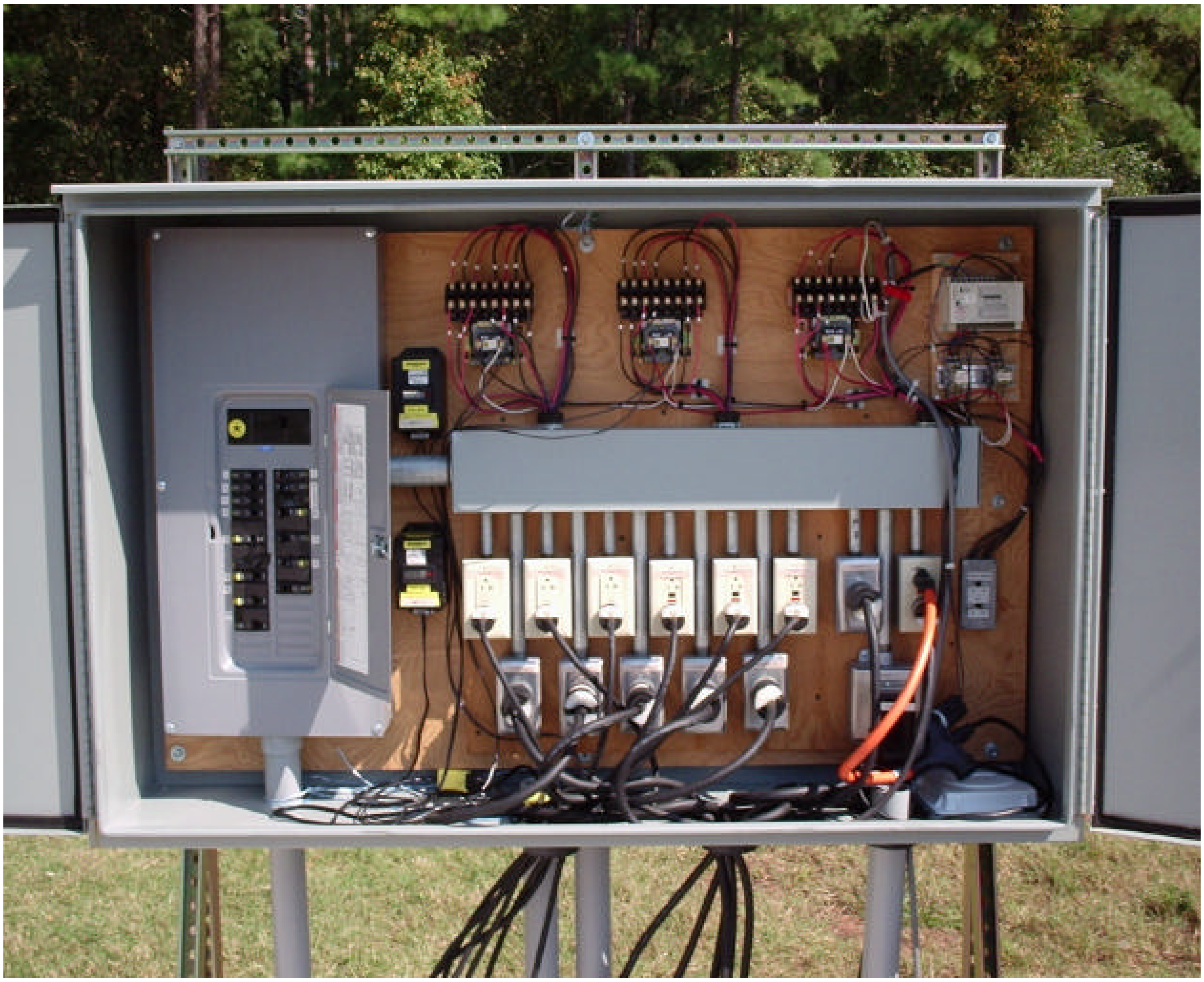
Electrical power for the pump-out units was provided from a 200-Ampere service that was supplied from a custom electrical panel constructed specifically for this test program. SOBA chose to have the pump-out units run in the split-pumping sequence (10 minutes pumping, 10 minutes resting) specified in Annex 1. In order to support running the pump-out units in the split-pumping sequence, the electrical panel was designed to supply power to only a portion of units at any one time. This minimized the electrical current requirements of the electrical connection and the associated cost of the electrical installation. The total power requirement for all pump-out units was evaluated and the pump-out units were then divided into two sets that had nearly equal electrical current requirements. The tables on the following page show the distribution of the pump-out units into the two sets.

Set 1	
Manufacturer	**Model**
Edson International	286EP-40
Edson International	290-35-1HP
EMP Industries	Sanisailor Sentinel - M300
EMP Industries	Sanisailor Sentinel - EV405
Keco	PAH175

Set 2	
Manufacturer	**Model**
Chesapeake Bay Marine	CB70HD
Edson International	284EB-40
Exstar International	Sani-Station SS-100 Deluxe
Keco	PER900.1PH
Keco	Vacuum 1000V-3 HP
Waubaushene	AVR60
Waubaushene	LD125

In the split-pumping sequence, Set 1 pumped test media for 10 minutes, while Set 2 was resting for 10 minutes. Then, Set 2 pumped test media for 10 minutes, while Set 1 rested for 10 minutes. This sequence was repeated over and over through the use of a timing circuit described later.

A photograph of the electrical panel is shown below.



The electrical panel was constructed with the following features in order to achieve the split-pumping sequence:

1. *Individual circuit breakers for each pump-out unit* – Each unit was powered from individual circuit breakers that were installed in the electrical panel. The current rating for the individual breakers for each unit was based on the electrical rating of the pump-out unit and the manufacturer's instructions for installation of the unit. Details of the circuit breakers that were used with each individual pump-out unit are included in Annexes 2, 3, and 4;
2. *Ground Fault Circuit Interrupters (GFCI)* – GFCI protection was provided for each unit by use of a GFCI circuit breaker or by use of a GFCI receptacle outlet in the power supply circuit for the unit. Details of the GFCI protection for each unit is outlined in Annexes 2, 3, and 4;
3. *Relay Contactors* – Three sets of relay contactors were used to cycle power to the two sets of pump-out units for the split-pumping sequence of 10 minutes pumping followed by 10 minutes resting;
4. *Programmable Logic Controller (PLC)* – A PLC was installed in the electrical panel to provide the control circuit and timing for cycling the three relay contactors;
5. *Calibrated Timers* – To precisely measure the amount of time that each set of pump-out units were running during life-cycle testing;
6. *Power Supply for Electrical Panel Accessories* – Power for the following accessories contained in the electrical panel: PLC, relay contactors, and calibrated timers;
7. *Power Supply for Flowmeters* – Power for the flowmeters for the 12 pump-out units was supplied from the electrical panel.

Flow Measurements

During life-cycle testing, the flowrate of test media through each pump-out unit was measured using an electronic flowmeter. A separate flowmeter was installed in the discharge piping network of each pump-out unit. A photograph of the flowmeters installed in the discharge piping network of the life-cycle testing set-up is shown below.

The flowmeters selected for use in the study were the Kronhe Model IFS 1000 Wafer Style Flowmeter with the Model IFC 090 Converter. This type of flowmeter was selected for the following reasons:

1. *Flowmeter Construction* – The flowmeter consists of a 2-inch diameter flow-tube and an electronic converter. The flow-tube is essentially a 2-inch diameter pipe section that connects into the 2-inch Schedule 40 PVC piping, allowing precise flow measurement of media passing through the flow-tube with minimal flow restriction in the piping. Metal flanges were used to support the flow-tube in the discharge piping runs. Internally, the flow-tube is surrounded by a set of electrical windings and the rate of flow of media through the tube is measured using *Faraday's Principle*. Faraday, a physics pioneer, discovered that when a conductor is moved through a coil of wire, an electrical voltage is induced in the coil. In this case, the conductor is the test media moving through the flow-tube. The voltage produced in the flow-tube is proportional to the rate of flow of test media through the flow-tube and the electronic converter mounted on the flow-tube converts the voltages produced in the flow-tube to an accurate measurement of flow of media through the flow-tube in gallons per minute. The flowrate of test media was displayed on the electronic converter's display;
2. *Measurement of Mixed Media* – This type of flowmeter is specifically designed for flow measurement of mixed media such as the mixture of water, toilet tissue, and sponge material that was used in the study;
3. *Superior Accuracy of Flow Measurement* – The manufacturer's specified accuracy of this flowmeter is less than +/- 1%; and
4. *Flow Totalizer Feature* – In addition to measuring the rate of media flow through the flow-tube in gallons per minute, the electronic converter also keeps a running total of the number of gallons that have passed through the flow-tube. This feature was utilized to measure the total volume of test media in gallons that each unit pumped during a run of the test set-up.

As specified in Annex 1, Average Flow measurements were taken on all pump-out units periodically during life-cycle testing. The Average Flow for each pump-out unit was calculated for each run of the life-cycle testing set-up by using the following equation:

$$\textit{Average Flow (gallons/minute)} = \frac{\textit{Volume of test media pumped by the pump-out unit (gallons)}}{\textit{Run Time for the pump-out unit (minutes)}}$$

where:

Volume of test media pumped by the pump-out unit (gallons) – measured by the Flow Totalizer feature of the flowmeter.

Run Time for the pump-out unit (minutes) – measured by the calibrated timer in the electrical panel for each set of pump-out units.

The Average Flow data for all pump-out units during life-cycle testing is documented in the tables in Annex 5.1. The Flow Totalizer for each pump-out unit and the calibrated timers for each set of pump-out units was reset to zero at the beginning of each run of the life-cycle testing set-up.

Life-cycle testing commenced on November 24, 2003 and was conducted until 1000 hours was accumulated on the pump-out units, or until an end date of June 4, 2004 was reached.

Data Recording

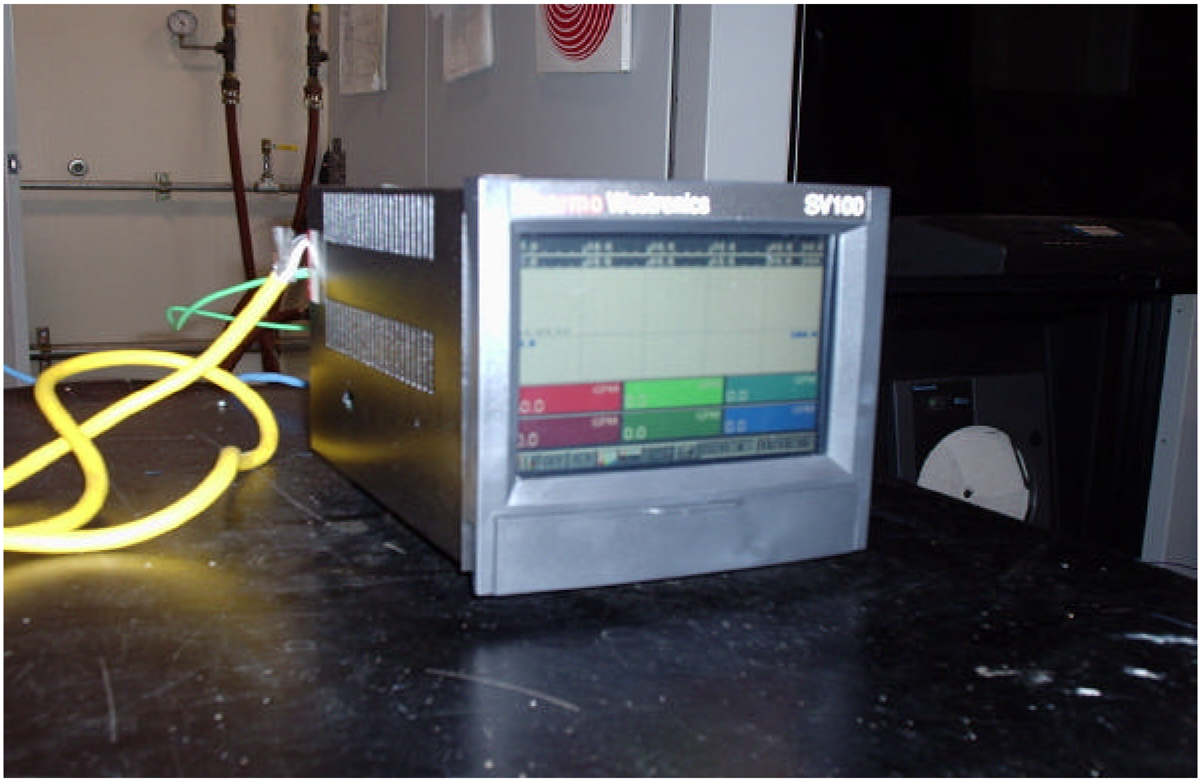
In addition to the data that was recorded by hand from the Flow Totalizers and calibrated timers, the flowrate in gallons/minute was recorded using an electronic data recorder that was used to collect flowrate data for all units. This data recorder was set up in a laboratory building adjacent to the life-cycle testing set-up. Twisted-pair data cables were run from the flowmeters to the electronic data recorder through an underground pipe in order to supply the electronic signals from the flowmeters to the data recorder.

The flow data that was recorded by hand from the flowmeters and calibrated timers was used as the official data for the evaluation, but the flow data displayed on the electronic recorder was very useful in analyzing the flow patterns generated by the pump-out units when the units were pumping. This real-time flowrate information displayed on the electronic recorder was very useful in allowing the personnel to monitor the units on a daily basis and check that the flow patterns of each pump-out unit were consistent from day to day. This real-time information was also extremely helpful in troubleshooting flowrate fluctuations in the units that indicated when the unit needed to be repaired.

The *Thermo Westronics SV100 Paperless Recorder* was selected as the electronic data recorder for the following reasons:

1. *Cost Effective* – This data recorder provided a useful data display at reasonable cost; and
2. *Data Storage* – The data recorder stored the flow data on an internal storage card. The data recorder was attached to a Local Area Network (LAN) and the flow data was transferred from the internal data card to a network storage location once per day.

A photograph of the Thermo Westronics SV100 Paperless Recorder is shown below.



Periodic Flow Checks and Vacuum Checks

As specified in Annex 1, the pump-out units were also periodically tested to see how long it took to pump 30 gallons of test media through the unprimed system (Periodic Test Flow). SOBA also requested that periodic vacuum measurements be made on each pump-out unit in conjunction with the periodic flow checks. For these checks, the life-cycle testing set-up was temporarily shutdown for the periodic flow and vacuum checks. These measurements were made between the life-cycle testing runs outlined in Annex 5.1, and the data from the periodic flow and vacuum measurements are documented in Annex 5.2.

The following method was used to collect the periodic flow and vacuum data for each pump-out unit:

1. Each pump-out unit was pumped dry by disconnecting the suction hose connection at the unit and the unit was operated for 30 seconds and then shut off;
2. A calibrated vacuum pressure gauge was connected to each pump-out unit and the unit was operated until maximum vacuum was achieved. The vacuum reading was recorded for each unit; and
3. A 50-gallon test cylinder was filled with test media and a 30-foot suction hose was attached to the pump-out unit under test. Each pump-out unit was individually operated with the 30-foot suction hose drawing media from the 50-gallon test cylinder and the time required to pump 30 gallons of test media was measured using a calibrated stop watch and recorded.

The calibrated vacuum gauge used for the study was an Ashcroft Gauge with the following specifications: Part # 35-1009AW-02L; 3.5" Dial; 1% Full-Scale Accuracy with National Institute of Standards and Technology (NIST) Certification.

Ability to Pass Foreign Objects

At the conclusion of the life cycle testing, a separate test was run to determine the ability of each pump-out unit to pass materials not commonly associated with the characteristics of sewage, but commonly encountered in boat holding tanks. The components chosen by SOBA were rags, paper towels, Styrofoam cups, and personal hygiene products. The test consisted of attempting to pump a 50-gallon tank of fresh water containing the following mixture of each of the above products through the pump-out unit:

1. Rags (Type = 12-inch square shop rag, Quantity = 1)
2. Paper Towels (Type = Standard kitchen paper towel, Quantity = 6)
3. Styrofoam cups (Type = 14 oz cup, Quantity = 6 cups broken up into 1-inch squares)
4. Personal hygiene products (Type = Tampax Super Absorbent Tampon, Quantity = 6)

Each pump-out unit was tested separately, and the Pass/Fail results of this test are recorded in the tables below.

<u>Diaphragm Units</u>

Manufacturer	Model	Results (Pass/Fail)
Edson International	284EB-40	Unit removed from study
Exstar International	Sani-Station SS-100 Deluxe	Unit removed from study
Keco	PAH175	Fail

Peristaltic Units

Manufacturer	Model	Results (Pass/Fail)
Edson International	286EP-40	Fail
EMP Industries	Sanisailor Sentinel - M300	Fail
EMP Industries	Sanisailor Sentinel - EV405	Fail
Keco	PER900.1PH	Fail

Vacuum Units

Manufacturer	Model	Results (Pass/Fail)
Chesapeake Bay Marine	CB70HD	Fail
Edson International	290-35-1HP	Fail
Keco	Vacuum 1000V-3 HP	Fail
Waubaushene	AVR60	Fail
Waubaushene	LD125	Fail

All units that were subjected to the *Ability to Pass Foreign Objects* test developed clogs in the suction piping and failed to pass all of the materials through the unit. The most common point of clogging was in the 1 ½-inch suction hose where the hose narrows at the coupling to the pump-out unit.

Repairs Required to Pump-Out Units

As specified in Annex 1, any defective/broken units that needed to be repaired during life-cycle testing (i.e. hole in diaphragm, broken switches, etc.) had the incident logged and the pump-out unit repaired to allow continuation of life-cycle testing. Logging of the incident included a description of which parts failed, how long it took to fix the unit (including time to receive the applicable parts once ordered), and the price of the replacement parts. The details of repairs that were required for each pump-out unit are included in Annexes 2, 3, and 4 as part of the detailed descriptions of each pump-out unit.

Note: This project required running 13 pumpout stations simultaneously utilizing a split pumping sequence. This requirement proved a formidable task in terms of time and labor for the UL staff, especially when repair work was required. In several instances multiple pumpout units required repair at the same time; thus requiring the staff to choose which unit to repair first. The project team did their best to ensure that each unit ran the full 1000 hours originally intended, however the time and effort required to operate and maintain the 13 pumpout units proved to be a formidable task and some unforeseen delays were encountered that were not the fault of the equipment manufacturers..

Environmental Testing

Annex 1 specified that the pump-out units be tested in a worst-case scenario of environmental conditions. Ideally, a representative coastal environment would have been created to simulate the worst-case corrosive conditions. Because of the complexity of creating this type of environment and the associated costs of construction, SOBA decided to use alternate methods of determining the ability of the pump-out units to operate in a corrosive environment. The test methods outlined in Sections 2.3 and 2.4 were used to evaluate pump-out station materials for resistance to salt-water exposure and ultraviolet exposure.

2.3 Corrosion Resistance: Salt-Spray Test Method

Samples of pump-out unit metallic materials were subjected to salt-spray testing in accordance with *ASTM B 117-03 (Standard Practice for Operating Salt Spray Apparatus)*. The samples were exposed to a controlled corrosive environment in an exposure chamber for approximately 30 days to simulate a life-cycle of exposure based on the recommendation of a UL engineer who has expertise in the field of metallic corrosion. The samples were evaluated for evidence of corrosion at the end of the exposure period. The results of this testing for each unit are included in Annexes 2, 3, and 4 as part of the detailed descriptions of each pump-out unit.

2.4 Ultraviolet Exposure Resistance: Xenon Arc Light Exposure Test Method

For units with covers constructed of non-metallic materials such as fiberglass and plastic, samples of the materials were subjected to xenon arc light and water exposure in accordance with *ASTM G 155-00a (Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials)*. This method reproduces the weathering effects that occur when materials are exposed to sunlight and moisture as rain or dew in actual use. The samples were exposed to this ultraviolet exposure for a period of 1000 hours based on the recommendation of a UL engineer who has expertise in the field of ultraviolet exposure of plastic and fiberglass materials to simulate a life-cycle of exposure.
The results of this testing for each unit are included in Annexes 2, 3, and 4 as part of the detailed descriptions of each pump-out unit.

2.5 Evaluation of Test Results

The results contained herein should not be evaluated on any one-test item; such as how many hours each unit ran. This project was intended to simulate how each unit could be relied upon to operate and stand up to a lifetime of use and exposure. In order to fully evaluate each unit, one must look at <u>all</u> of the results including the breakdowns, maintenance requirements and how the unit can be expected to withstand environmental conditions such as UV exposure, freezing temperatures and wet conditions.