

# A STUDY OF RAILCAR LAVATORIES AND WASTE MANAGEMENT SYSTEMS

MAY, 2004

A REPORT BY

THE CONNECTICUT  
ACADEMY OF SCIENCE  
AND ENGINEERING



FOR

THE CONNECTICUT DEPARTMENT OF  
TRANSPORTATION

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ORIGIN OF INQUIRY: CONNECTICUT DEPARTMENT OF  
TRANSPORTATION

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Richard H. Strauss  
Executive Director

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## EXECUTIVE SUMMARY

### STUDY OBJECTIVES

The Connecticut Department of Transportation (“ConnDOT”), Bureau of Public Transportation plans to purchase new railcars for its Metro-North rail operations within the next several years. Surveys of passengers continually identify user dissatisfaction, as well as operational and maintenance issues, with railcar lavatory facilities and systems. The acquisition of new railcars provides an opportunity to address current lavatory issues and concerns.

The objective of this study is to explore and identify lavatory design and operational issues to be considered by ConnDOT to assure improvement in lavatory cleanliness and customer satisfaction.

### SUMMARY OF FINDINGS

The cleanliness of railcar lavatories is an issue of critical concern that should be addressed to assure that the quality of service achieves acceptable standards that will meet the expectation of passengers and ConnDOT for both existing and new railcars.

Passengers regularly cite foul odor and cleanliness as areas of dissatisfaction, as documented in recent Metro-North customer satisfaction surveys. The lavatories are old and are not well designed for servicing. Re-circulating waste management systems installed in many lavatories will cause odor problems if not serviced frequently. Ventilation systems in older cars are not designed to effectively exhaust air from the lavatory or prevent foul odors from entering the interior of the railcar. Additionally, the very poor condition of many lavatories in existing railcars makes it difficult to achieve an acceptable level of cleanliness. Consequently, the unacceptably low cleanliness baseline makes it difficult for personnel to accomplish servicing tasks that they can be proud of. It is suggested that servicing practices and procedures be reviewed to determine if it is possible to improve the quality of cleanliness in existing railcars, until such time as these railcars can be replaced. This may result in creating an environment where employees believe that it is possible to produce quality outcomes from their efforts. It is believed that when clean facilities exist, both the public and employees take more pride in keeping them clean.

An Amtrak passenger focus group study that was conducted to help guide the design of lavatories for the Acela Express revealed that passengers expect, for all forms of transportation, routinely clean lavatories. Most passengers were reported to believe that they have a responsibility to help keep facilities clean, and the state of cleanliness appeared to have an impact on passenger behavior.

Areas for consideration by ConnDOT in the design of new railcar lavatories and systems include the engineering and design process, waste management system technology, ventilation, and materials. Additionally, ConnDOT should consider the development and implementation of servicing procedures and operations to assure that lavatories and the interior of the railcars

are clean at the start of a trip. No matter how well the systems are designed and how advanced the technology, service and maintenance must be performed regularly.

**Engineering and Design:** Railcar lavatory design should be integrated into the design of the railcar interior and systems, and determined at the front-end of the design process. Engineering/design companies that specialize in lavatory and interior railcar design may be helpful in assuring that the latest innovations, improvements, and materials are incorporated into the design specification.

Lavatories constructed of a molded fiberglass, or similar material, can be fitted with all necessary equipment and systems and installed in the railcar during its construction. A molded module also provides an opportunity to minimize seams where dirt and bacteria can collect, allowing for more effective cleaning. Major lavatory sub-assemblies should be designed for easy removal and replacement. Material selection for surfaces and components of the module can help make it easier to keep clean and perhaps extend its life cycle. Some suggestions include the following:

- Coat fiberglass module surfaces with a gel coat or polyvinyl fluoride over-laminating film (PVF) material similar to Tedlar®;
- Use anti-slip flooring materials without seams to help prevent dirt and bacteria from collecting in difficult to clean areas;
- Construct sink counters of acrylic resins and fire-retardant fillers similar to Gibraltar®. This material is stain resistant, can be repaired, and has seams that are smooth and rounded to prevent dirt build-up. Also, it is suggested that the counter be constructed with a lip on the edge to keep sink water from running onto the floor.
- Configure the sink faucet so that it is easy to operate and protected in order to ensure that water cannot be left running.
- Employ a disposable soap dispenser that is screwed into position on the sink.
- Use manually operated flush controls. The flush control should be very visible, easily recognizable and operable by users.
- Size trash container appropriately and make it easy to use with minimum user contact; and
- Select warm and pleasing colors for materials and surfaces in the lavatory.

The module design also may provide an effective way to retrofit the entire lavatory as needed at half-life or other designated overhaul period, since removal and replacement can be accomplished relatively quickly as compared to other lavatory designs.

**Waste management systems** commonly in use today in rail operations, as well as on Metro-North railcars, include:

- An on-board bacteriological sewage treatment system that eliminates the need to pump retention tanks. New Jersey Transit has been using this type of system for over 15 years and has approximately 300 systems in use today.
- Several different types of technologies are paired with retention tanks that require the periodic pumping of waste material, including chemical re-circulating, clean water

pressurized, macerator, and vacuum systems. The re-circulating system re-circulates a chemical blue water charge and waste material until the system is emptied and recharged. In rail operations, re-circulating type systems will generally cause odor problems keyed to the frequency that the system is re-charged. This type of system has been more acceptable in airline operations than rail operations, since in many cases the system is pumped and recharged with clean water after each flight. All other systems, each with their own set of advantages and disadvantages, should be considered as acceptable alternatives.

Consideration should be given to selecting a waste management system technology similar to those that have performed well and are in operation on other railcars in Metro-North's fleet or those consistent with Metro-North's plans for the future. System standardization will increase staff familiarity and efficiency in dealing with maintenance and servicing requirements.

- Vacuum systems offer advantages of very low water consumption, which translates into either the possibility of using a smaller retention/holding tank or decreasing the frequency of pumping if a larger tank is used. The vacuum system also helps to evacuate odor from the lavatory. Vacuum systems are reported to have a higher initial cost.
- It might be valuable to undertake a pre-qualification process for the waste management system through a prototype test period, similar to the process utilized by Long Island Railroad (LIRR). This process would provide an opportunity to judge equipment proposed for installation based on a variety of factors including reliability, service, manufacturer support and ease of maintenance, and would assure that the equipment meets required design specifications. Experience gained by Metro-North from operation of the vacuum type system installed in Test Car 8447 as part of the Metro-North M2 rehabilitation project will also be helpful.

**Ventilation** of the lavatory proved to be one of the most important and significant concerns reviewed by the Study Committee. The lavatory ventilation system should quickly and effectively remove foul odors from the lavatory and prevent them from entering the interior of the railcar. It should be independent of the cabin's HVAC system to prevent recirculation of lavatory air into the cabin. The design should include exhaust vents located behind and at the level of the toilet as well as to the rear and above the toilet. The lavatory door should be designed to provide for sufficient air circulation into the lavatory even with the door closed. The exhaust fan should operate continuously so as to create negative pressure in the lavatory; this will result in clean cabin air being drawn into the lavatory from around the lavatory door without the need for door louvers. This will also help prevent lavatory air/odors from entering the cabin.

**Servicing:** The purchase of new railcars with state of the art systems and materials will not completely solve the on-going day-to-day cleanliness and odor operational issues. Regular, consistent and thorough cleaning, servicing and scheduled maintenance are necessary to achieve the standard of service expected by passengers. Installation of a hose in the lavatory would provide a source of clean water to assist and facilitate lavatory servicing. Consideration should be given to establishing operational procedures and staffing to assure that all lavatories

are inspected, provisioned, and cleaned at a minimum prior to the beginning of any trip (New Haven – New York or New York – New Haven) to an acceptable cleanliness standard. **It is important to note that unless the lavatory is effectively serviced regularly, the issues of cleanliness and odor will re-appear.**

A new technology for use in railcar environments that processes waste material through a controlled thermal decomposition process into inert ash, water, and clean exhaust is currently under development and will be initially tested in China. This may be an alternative for future consideration. Additionally, automatic cleaning public restrooms are installed in cities in the United States and other areas of the world. Although automatic cleaning systems do not appear to be in use in rail operations, if adapted for rail operations, they would offer the potential to improve lavatory cleanliness.

In conclusion, acquisition of new railcars provides the opportunity to select reliable systems and materials for the lavatories. **However, servicing and maintenance procedures should be reviewed, modified, and established to assure that the condition of the new railcars and lavatories are operated to standards that maintain cleanliness on an on-going basis for day-to-day operations.**

A summary of the Study Committee’s findings is presented in Appendix A: Overview of Options.

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## INTRODUCTION

The Connecticut Department of Transportation (“ConnDOT”) Bureau of Public Transportation plans to purchase new railcars for its rail operations within the next several years. Surveys of Metro-North passengers continually identify user dissatisfaction, as well as operational and maintenance issues, with railcar lavatory facilities and systems. The acquisition of new railcars provides an opportunity to address current lavatory issues and concerns to assure improvement in the level of service in this area of railcar operations.

### SCOPE OF INQUIRY

This limited scope Railcar Lavatory Study conducted by the Connecticut Academy of Science and Engineering (the “Academy”) includes:

1. Review of the ConnDOT Metro-North passenger survey information.
2. Review of lavatory facilities and systems in use today on Metro-North and other rail systems.
3. Identification and discussion of lavatory systems and operations in use in other selected modes of transportation, with a focus on the airline industry.
4. Assessment of railcar lavatory facility features/alternatives for consideration by ConnDOT.

### APPROACH

This study was conducted according to the following steps:

1. A Study Committee was convened to oversee the study and provide guidance and an assessment of lavatory facilities, systems, and operations.
2. Interviews were conducted with several rail system operators, railcar manufacturers, lavatory system and materials vendors, and airline operations.
3. A field visit to Metro-North’s Croton-on-Hudson rail yard facility was conducted, including a meeting with Metro-North engineering staff.
4. Meetings were held with representatives of the major worldwide waste management system vendors, Metro-North and Amtrak.
5. The Study Committee conducted a tour of railcars at the New Haven train station to observe lavatories in service.
6. A field visit was made to a company specializing in railcar interior/lavatory design and manufacture.
7. Suggestions and findings were prepared by the Study Committee for consideration by ConnDOT.





## I. ATTITUDES & OBSERVATIONS

### **Metro-North Railcar Passenger Survey Findings:**

Metro-North's Annual Fourth Quarter 2002 Customer Satisfaction Survey rated a variety of factors including the cleanliness of restrooms on trains. Restrooms ranked as the lowest rated characteristic in the survey. On a ten-point scale (with one being very dissatisfied and 10 being very satisfied) the cleanliness of the restrooms was ranked 4.5 as compared to 4.9 in 2001. Restroom cleanliness ranked significantly lower than the overall rating for Metro-North service of 7.8 and 7.9 respectively for 2002 and 2001. 26% of the passengers responding to the survey indicated that they were very dissatisfied (ratings of "1" or "2") with restroom cleanliness. The analysis in the 2002 report indicated that the "cleanliness of the restrooms on the train was especially low-rated this year. This is likely due to a manufacturing error with a new lavatory freshener, which went into service just prior to the survey and caused an odor problem. The manufacturer has since corrected the error and the revamped freshener is currently being used in the train lavatories. However, the problem was a major factor in causing the score of this characteristic to drop in the 2002 survey." Although the lavatory freshener issue may have created a drop in ratings, it should be noted however that the satisfaction rating for restroom cleanliness remains an area of concern and an opportunity for improvement.

### **Study Committee On-Site Tour of Metro-North Railcar Lavatories:**

Members of the Study Committee observed lavatory conditions in two Metro-North railcars on one train during a layover at the New Haven Train Station on December 11, 2003. One lavatory was equipped with a re-circulating system and the other with a vacuum system. In this particular instance there was basically no odor issue in the car or lavatory equipped with the re-circulating system. However, the odor in the lavatory and throughout the car equipped with the vacuum system was very strong and smelled primarily of sewage. Additionally, in one of the lavatories the fact that the exhaust fan inlet was very dirty served as evidence that this system was not cleaned on a regular basis. These observations emphasize the point that simply improving the technology of lavatory systems alone will not solve the cleanliness problem and that regular servicing and maintenance are critical in maintaining a clean environment. Additionally, it appears that the very poor condition of many lavatories in existing railcars makes it difficult to achieve an acceptable level of cleanliness.

### **Amtrak Focus Group Study Results:**

Amtrak conducted focus group meetings with passengers to assist them in the design of the lavatories for the Acela Express passenger cars. TNS, formerly Intersearch Corporation of New York prepared the focus group study and resulting video summary in the mid 1990's for Amtrak's Northeast Corridor Mechanical & Marketing Research Departments. Two to four focus group sessions were held in each of four cities including Boston, New York, Philadelphia, and Washington. Approximately ten individuals attended each session. The findings of the study have been extracted and summarized as follows:

The focus group had an understanding that different levels of service and cleanliness were expected based upon price. However, they identified that a basic requirement for even the least expensive form of transportation is that it be clean, not almost clean. Most passengers agree that they have a responsibility to keep facilities clean and that the length of a trip affects cleanliness. It was suggested that initial passenger observations about their surroundings could have an impact on their behavior and that passengers acclimate to their surroundings on trains. If standards were set, so that facilities were clean at the start of the trip, then passengers would help maintain that standard.

The focus group made the following comparative observations regarding their experience with airline travel. Airline aircraft set the standard for public transportation. They are generally regarded as the cleanest mode of transportation available because of the relative ease of servicing the aircraft at the beginning of each trip, when it is cleaned and made ready for the next flight. Additionally, flight attendants provide on-board servicing, trash collection and lavatory checks during flights, whereas trains are not serviced en-route. Buses are perceived as being the worst in terms of cleanliness.

Bathrooms in general and odor were identified as the most important components of cleanliness on trains. The lavatories were described as disgusting, and passengers basically did not want to touch anything in them. When asked, passengers indicated that lavatory odor was a combination of disinfectant and human waste, as well as a lack of adequate ventilation. Other lavatory cleanliness issues included wet floors and sinks, and overflowing trash receptacles. Passengers expressed the opinion that their expectation was to simply have an opportunity to use a basically clean facility. Other areas of concern include:

- **Flushing:** Some passengers flush with a finger or their feet and others don't flush. Auto-flush, like that found in other public facilities, was suggested. However, the Study Committee did not suggest auto-flush since it added to system complexity, as well as creating the potential for inadvertent flushing due to the small size of the lavatory.
- **Lighting:** Poor lighting makes the lavatory appear too dark, adds to the sense that the bathroom is dirty, and makes passengers believe that there is something to hide.
- **Size:** Passengers indicated that the lavatories are too cramped for comfort, which contributes to the overall disorder. They believed that a little more space to maneuver and a place to put personal belongings would be helpful. Women especially would like extra space since many bring their personal belongings with them into the lavatory. Suggested improvements included a mirror, shelf for belongings, hooks and handrails/hand holds for bracing when train is moving. Men felt this would help them maintain their balance, improving sanitation. Many women do not like to sit on the toilet seat. Women would use handrails to help them position themselves over the toilet.
- **Toilet Design:** Current design is a bench type unit instead of a standard stand-alone toilet. This provides an opportunity for urine to collect in the toilet area and for clothing or other items to come in contact with it. Many feel the toilet seat is unsanitary and would like a paper liner to sit on.

- **Trash Receptacles:** Passengers believed that the trash receptacles are too small and observed that they are often filled or overflowing with trash. Additionally, passengers want to be able to put trash into the container without having their hands come in contact with the perceived dirty surfaces of the container's lid.

Several items were identified that make passengers more comfortable, including soap containers instead of bars of soap and hand towels and toilet paper. Additional observations include:

- Women indicated they would prefer a same sex restroom for privacy and security even if it meant longer lines. Men didn't have strong feelings about this as long as the lavatory had a urinal in it. However, women were adamant that they didn't want to see urinals in lavatories that they use.
- Passengers questioned why someone cannot be hired to be onboard the train to clean up the restrooms and cars. Passengers indicated that they would consider paying an increased fare for this service, as it is so important. Also, reminding passengers to clean up after themselves via signs and announcements is not considered an imposition. Customer service and satisfaction was viewed as critically important to the success of the rail operation.



## II. WASTE MANAGEMENT SYSTEM TECHNOLOGIES

Waste management system technologies for application in railcar operations are available from a limited number of vendors/manufacturers. In most cases the product lines of these vendors span the various modes of transportation, including rail, aircraft, buses, and ships. Several vendors were identified that offer systems for use in railcar operations. These include Evac Environmental Solutions, Indierail, Microphor, Monogram Sanitation, and Temoinsa.

The following types of systems/technologies are in use in railcar operations:

### On-Board Waste Processing System

- **Bacteriological System:** This is an on-board sewage treatment system. Waste material flows from a pressurized chamber into a waste treatment tank. The treatment tank contains filter columns made of either redwood bark or a special synthetic material. Solid waste material is retained over the filters and digested by bacteria, while liquid waste that passes through the filter is disinfected and discharged directly to the track bed. The waste processing time is 4-6 hours. Chlorine tablets are used during waste processing. The chlorine tablet dispenser needs to be serviced on a periodic basis. Water and CO<sub>2</sub> are the byproducts of the waste treatment process. If certain chemicals that are used to clean lavatories enter the system, the aerobic digestion process can be destroyed and it is necessary to entirely flush and clean the system in order for it to work properly. This system eliminates the need to pump waste material from retention tanks. The synthetic filter material is a recent improvement for this type of system that is expected to simplify tank cleaning and maintenance associated with the redwood bark filter system.



*Microphor's redwood bark, left, and synthetic filter, right, for use in an on-board bacteriological waste management system.*

### Retention Tank Systems with Sewage System Disposal

The following lavatory system technologies are paired with retention tanks that require periodic pumping of waste and its disposal into sewage treatment facilities:

- **Chemical Re-circulating System:** This is an open system where sewage and rinse water treated with chemicals are mixed and re-circulated. The odor of re-circulated water and sewage gets progressively worse until the next servicing. This type of system is the least attractive for use in rail operations, since it requires frequent pumping and recharging with clean “blue water” for it to work effectively without causing odor problems.
- **Clean Water Pressurized System:** This system utilizes water and air pressure in the flush cycle. Waste and water from the flush cycle flow into a lower chamber. Once a flapper valve closes, the lower chamber is pressurized and the waste material in the lower chamber is pushed into a retention tank.
- **Macerator System:** This type of system grinds effluent and other objects deposited into the system in a manner similar to a kitchen garbage disposal. The waste material flushes with water into a chamber, where it is then pressurized and pushed into the retention tank.
- **Vacuum System:** This is the most recent technological advancement in waste management system design. Sewage is transported by air and pressure differential, or vacuum, instead of water and gravity. Water is used only for rinsing the bowl and not for transporting waste material, thereby creating an opportunity to use very small quantities of water per flush. Limited vertical lifts and long horizontal transportation of sewage are possible. Advantages include: completely sealed system; fresh water flush with no chemicals required; and ultra low water consumption, which helps to maximize waste retention capacity and increase required servicing intervals. The commode bowl is often coated with a material such as Teflon to improve flushing performance with minimal water usage. However, care must be taken when cleaning and servicing the bowl surface to ensure that the coating material is not damaged. The vacuum also helps to serve as an exhaust system. Several variations of this technology are available including constant and on-demand vacuum systems. Some systems are designed for the operation of multiple toilets, such as in sleeper cars or on aircraft, and they are generally the most expensive. Other vacuum system technologies are more appropriate for consideration in applications on railcars with only one lavatory.

### **Waste Management System Processing Technology under Development**

ClearWater Technologies is in the process of developing a waste processing system technology that provides for the controlled thermal decomposition of solid and liquid waste material. This system eliminates the need to pump and dispose of sewage from retention tanks. The byproducts of this process are recyclable water, small quantities of inert ash and clean exhaust. Water can either be disposed of onto the track or reclaimed and used for a variety of purposes including sink water or to replenish the water holding tank for flushing. This system will undergo initial operational testing in China by the China Railway Construction Engineering Group (CRCEG) and the China Railway Construction Corporation (CRCC). The development of this technology should be monitored for potential future application for Metro-North rail operations.

### **Automatic Lavatory Cleaning System**

Public restrooms equipped with automatic cleaning systems have been installed in cities in the United States and other places around the world. This type of system does not currently exist for use in railcar lavatories and would need to be adapted for this type of application. Periodic automatic cleaning of railcar lavatories during daily operations may be an effective way to improve lavatory cleanliness in the future.





### III. RAILROAD OPERATIONS

#### **Metro-North**

Most railcars in the Metro-North fleet are around 30 years old and lack technical improvements and upgrades to lavatories and lavatory systems. Currently, a variety of different types of waste management systems are installed on Metro-North's fleet of cars, including re-circulating, macerator, vacuum, and bacteriological systems. In one case, Metro-North acquired railcars on a piggyback railcar purchase contract with New Jersey Transit, which resulted in the acquisition of cars equipped with a bacteriological type lavatory system. This purchase added a new type of lavatory system to a fleet that already lacked standardization. Each type of system requires its own operational, maintenance and servicing procedures.

Several different types of interior railcar ventilation systems are installed in the fleet. Older systems use interior cabin air to ventilate the lavatory, with the lavatory air actually being re-circulated throughout the interior of the cabin. Other systems use the cabin's HVAC system for intake air into the lavatory and an exhaust fan, mounted on the wall near the ceiling and vented to the outside of the car. Additionally, ventilation systems in older cars may not all be functional.

In newer railcars, such as the M7 fleet, an exhaust fan is located at the height of the toilet. The M7 railcar lavatories are constructed as modules and made of fiberglass.

Metro-North's M2 railcar fleet is currently undergoing a lavatory system retrofit for 60 cars (1/2 of the fleet). An option for retrofitting the balance of the fleet is scheduled for review in 2004. The selected system for the retrofit is a vacuum type system that includes a 22-gallon retention tank with a 100 flushes/day design capacity and an expectation that usage will be in the range of 40-80 flushes per day depending on the number of lavatories in the train set.

Daily servicing includes a wipe-down and mopping of the lavatory, pumping of retention tanks and re-charging of re-circulating toilet systems. A more detailed servicing is accomplished at the 90-day railcar inspection/servicing. Some additional cleaning is done at the 60-day railcar inspection.

See Appendix B for illustrations of existing Metro-North lavatory facilities.

#### **Amtrak**

Amtrak was actively engaged in the lavatory design for the Acela Express. They also incorporated information learned from their Passenger Focus Group study (see Passenger Attitudes - Amtrak Focus Group Results) in the design. They identified all lavatory design requirements including ventilation and location of vents as part of the design specification requirements. They did not assume that the manufacturer would automatically make the best decisions on detailed requirements. Discussions with Amtrak identified lessons learned and several issues for consideration in the design of railcar lavatories so as to best meet the needs of passengers including:

- Recognition that the standard for cleanliness of a public bathroom is the home bathroom and comfort is considered as a key attribute of the home bathroom;
- Passenger demographics;
- Color selection for materials and surfaces in the lavatory should be warm and human;
- The group that services the lavatories should be consulted and involved in the design process;
- Service staff and supervisors need to be trained to maintain the lavatories and systems to specified standards as provided for by the operator and systems' manufacturers;
- Signage should clearly identify location of the lavatories and indicators identifying that the lavatory is in use should be clearly visible inside and outside of the lavatory;
- Trash containers should be designed so people can easily dispose of waste materials with minimum effort, taking into consideration that passengers do not want to touch anything; and
- The flooring should be a non-slip type material.

### **Long Island Railroad**

Long Island Railroad operates vacuum type lavatory systems and has selected a vacuum system for their retrofit program. For their M3 overhaul program, they utilized a proto-typing process to pre-qualify equipment. Several vendors participated in the process. They indicated that re-circulating systems cause the greatest amount of odor problem. Additionally, it was cited that the maintenance/servicing interval, being as long as possible, was a significant component of the odor problem.

### **METRA -Chicago**

METRA - Chicago operates a total of 781 railcars. The average passenger trip is approximately 45 minutes with the longest trip being 1 hour 15 minutes. Last year they replaced their re-circulating toilets with clean water pressurized type flush toilets. The retention tanks for the new system are serviced once weekly as compared to a twice-weekly frequency for the re-circulating system. The lavatories are cleaned on a daily basis. They report much less odor associated with the operation of the new system. However, they have experienced more problems, such as bleeder valves and flush push button failures, than they expected. They have an additional 300 systems on order. They indicated that they did not select the vacuum type system due to its higher cost.

### **New Jersey Transit (NJT)**

NJT has used the clean water pressurized type flush toilet system with the redwood bark bacteriological treatment system for 15 years and has 300 systems in use. They estimate each

toilet is used 108 times a day. They report that these systems work well, if well maintained, and reported that maintenance is the key to continued reliable operation of the treatment system.

If service personnel introduce non-approved cleaning chemicals from mop cleaning or other operations into the system, the biological processing of the waste material is destroyed and the system must be cleaned out before it will work. Microphor, the system manufacturer, recently introduced a new synthetic material as an alternative to redwood bark for use in their systems. The synthetic material can be cleaned without replacement, as is required with the redwood bark system. This is expected to reduce maintenance costs and simplify the processing tank cleaning process in the event of a failure due to introduction of chemicals into the system that destroy the bacteriological processing of waste.

NJT suggests having quick disconnects installed at the processing tank to enable easy service and maintenance. Foreign objects that enter the system can be a problem and need to be periodically removed from the system. NJT now has 6" service plugs that provide for easy access for removal of foreign objects.

Additionally, they tested an electric eye flush control system but due to the small size of the lavatory the system was continually flushing whenever a user moved within the lavatory compartment.



## IV. THE AIRLINE EXPERIENCE

### Southwest Airlines

Southwest Airlines operates aircraft with re-circulating and vacuum systems. Vacuum systems have been installed and in operation on their newer aircraft for 5 years. Southwest's servicing procedures include:

- Daily Servicing: Retention tanks are pumped after every flight, except if the aircraft is on the ground for less than 30 minutes, in which case the system is only pumped if requested by the crew. In addition, during the day the lavatories are restocked, trash is removed and surfaces are wiped down after each flight. The crew has cleaning supplies available on board in the event of an incident that requires immediate attention. Every night service personnel clean and disinfect all surfaces throughout the lavatory.
- Monthly Servicing: A maximum effort, detailed cleaning of the lavatories is scheduled every 30 days.
- Periodic Servicing (110-125 days): Depending on the type of system, the entire lavatory system assembly may be removed, cleaned, and reinstalled. The area around the lavatory system (toilet assembly) is also thoroughly cleaned. Additional cleaning also includes flushing a citric acid solution through the system and retention tank.

Other lavatory characteristics include:

- Lavatory walls are constructed of fiberglass or a carbon fiber material and are covered with Tedlar, a protective film that is easy to clean.
- Floors are injected molded with a mat on top that is sealed with a high-grade sealer to prevent any leakage.
- Ventilation in the lavatory is part a closed system that re-circulates air throughout the cabin and lavatory. HEPA filters are utilized to remove bacteria.

See page 16 for illustrations of airline lavatory facilities.



*Example of sink (Southwest Airlines)*



*Example of re-circulating system (Southwest Airlines)*

## VI. SUMMARY OF FINDINGS & CONCLUDING REMARKS

The cleanliness of railcar lavatories is an issue of major concern that should be addressed to assure that the quality of service provided when new railcars go into operation achieves acceptable standards to meet the expectations of passengers and ConnDOT.

Passengers regularly cite foul odor and cleanliness as areas of dissatisfaction. The lavatories are old and are not designed well for servicing. Re-circulating waste management systems will cause odor problems if not serviced frequently. Ventilation systems in older cars are not designed to effectively exhaust air from the lavatory or prevent foul odors from entering the interior of the railcar. Generally, consideration should be given to establishing servicing goals to assure that lavatories and the interior of the railcars are in a clean condition at the start of a trip. Additionally, the very poor condition of many lavatories in existing railcars makes it difficult to achieve an acceptable level of cleanliness. Consequently, the unacceptably low cleanliness baseline makes it difficult for personnel to accomplish servicing tasks that they can be proud of. It is suggested that servicing practices and procedures be reviewed to determine if it is possible to improve the quality of cleanliness in existing railcars, until such time as these railcars can be replaced. This may result in creating an environment where employees believe that it is possible to produce quality outcomes from their efforts. It is believed that when clean facilities exist, both the public and employees take more pride in keeping them clean.

Acquisition of new railcars provides the opportunity to select reliable systems and materials for the lavatories. No matter how well the systems are designed and how advanced the technology is, service and maintenance must be performed regularly. Servicing procedures should be reviewed, modified, and established to assure that the condition of the new railcars and lavatories are operated to standards that maintain cleanliness on an on-going basis for day-to-day operations.

Areas for consideration by ConnDOT in the design of new railcar lavatories and systems include: the engineering and design process; waste management system technology; ventilation; and materials.

### **Lavatory Design**

Railcar lavatory design should be integrated into the design of the railcar interior and systems. Lavatory design specifications should be determined at the front-end of the design process to assure to the maximum extent possible that operational, service, and maintenance requirements are incorporated into the overall design, as compared to being an afterthought. To assure that the latest innovations, improvements, and materials are incorporated into the design specification, consideration should be given to employing the services of an engineering design company that specializes in lavatory and interior railcar design, independent of, but in conjunction with, the overall engineering design consultant for the project. Additional consideration should be given to a design/build contracting arrangement for the entire lavatory to include all systems, requirements and installation.

## Lavatory Module

Lavatories constructed of a molded fiberglass, or similar material, can be fitted with all necessary equipment and systems and then installed in the railcar during its construction. A molded module also provides an opportunity to minimize seams where dirt and bacteria can collect, and to build in design features such as smooth edges and adequate radii for all corners to allow for effective cleaning. It is suggested that major lavatory sub-assemblies such as the waste processing system, exhaust vent fans, sink, and holding tank be designed for easy removal and replacement. Material selection for surfaces and components of the lavatory module can help to make it easier to keep clean and perhaps extend its life cycle. Options for consideration include the following:

- Coat fiberglass surfaces with either a gel coating to decrease the porosity of fiberglass surfaces or a protective material such as a polyvinyl fluoride over-laminating film (PVF) similar to DuPont's Tedlar. Both gel and PVF coatings are helpful in making the module's surfaces more durable and easier to clean.
- Use flooring materials that are easy to clean with anti-slip characteristics. Two possible choices include a rubber-based material that is applied in sheet form and a product that is applied in place by rolling or spraying. Eliminating seams in the flooring material will help prevent dirt and bacteria from collecting in difficult to clean areas.
- Construct sink counters of a material similar to Gibraltar (Wilsonart International) that has been used in lavatory modules manufactured for Amtrak and others. This product is constructed of acrylic resins and fire-retardant fillers. The material is stain resistant, can be repaired, and has seams that are smooth and rounded to prevent dirt build-up. Also it is suggested that the counter be constructed with a lip on the edge to prevent sink water from running onto the floor. Additionally, this material is available in several colors.
- Configure the sink faucet so that it is easy to operate and protected in order that water cannot be left running.
- Employ a disposable soap dispenser that is screwed into position on the sink as compared to either soap bars or dispensers that are filled during servicing.
- Utilize a flush control that is manually operated by the user as compared to an automatic flush system. Although several methods of activating an automatic flush could be used, the inadvertent triggering of the automatic flush system is a disadvantage of this type of system. The flush control should be very visible and easy to operate by users. If possible the flush control should either be a push-button, common on aircraft and trains, or a device similar to the lever type used in public and residential applications.
- Size the trash container appropriately and make it easy to use with minimum user contact.
- Select warm and pleasing colors for materials and surfaces in the lavatory.



The construction of the lavatory as a module unit also provides an effective way to retrofit the entire lavatory as needed at half-life or other designated overhaul period since removal and replacement can be accomplished relatively quickly.

See Appendix C for illustrations.

### **Waste Management System**

The re-circulating type system appears to be the least acceptable of all the technologies available for rail operations. All other systems, each with their own set of advantages and disadvantages, should be considered as acceptable alternatives.

Vacuum systems offer advantages of very low water consumption, which translates into either the possibility of using a smaller retention/holding tank or increasing the frequency of pumping if a larger tank is used. The vacuum system also helps to evacuate odor from the lavatory. Vacuum systems are reported to have a higher initial cost.

If time permits, it might be valuable to utilize a pre-qualification prototype test period for waste management systems, similar to the process utilized by LIRR. The prototyping process would provide ConnDOT with an opportunity to judge equipment proposed for installation in new railcars for a variety of factors including reliability, service, and ease of maintenance, and to assure that the equipment meets the required design specifications. Experience gained by Metro-North from operation of the vacuum type system installed in Test Car 8447 as part of the Metro-North M2 rehabilitation project will also be helpful.

A major decision in selecting waste management system technology is the method of disposing or processing waste material. Systems that include retention tanks need to be pumped on a regular basis with the waste being disposed of in municipal sewage systems. The bacteriological waste processing system eliminates the need to pump and dispose of waste material. On-board waste processing has the advantage of eliminating the cost of pumping and sewage disposal. However, the bacteriological waste processing system also requires that maintenance and servicing procedures be followed vigilantly for the system to operate properly.

An important feature of the selected toilet assembly of the waste management system is that it should be easily and quickly removable and replaceable for servicing, maintenance and cleaning without the need for special tools.

Consideration should be given to selecting a waste management system technology similar to those that have performed well and are in operation on other railcars in Metro-North's fleet, or those consistent with Metro-North's plans for the future. System standardization will increase staff familiarity and efficiency in dealing with maintenance and servicing requirements. The selected system should be maintained according to the recommendations of the manufacturer.

### **Ventilation**

This area of investigation, along with cleanliness and servicing, proved to be one of the most important and significant concerns reviewed by the Study Committee. The lavatory ventilation

system should be designed to quickly and effectively remove foul odors from the lavatory and prevent them from entering the interior of the railcar. It should be independent of the cabin's HVAC system to prevent re-circulation of lavatory air into the cabin. Consideration should be given to incorporating features of recent lavatory module designs that include exhaust vents located behind and at the level of the toilet as well as to the rear and above the toilet. The exhaust fan should operate continuously so as to create negative pressure in the lavatory; this will result in clean cabin air being drawn into the lavatory from around the lavatory door, without the need for door louvers. The lavatory door should be designed to provide for sufficient air circulation into the lavatory even with the door closed. The continuous exhaust fan operation will also help to prevent lavatory air from entering the cabin. A properly designed exhaust system will play a critical role in eliminating foul odors from the lavatory as well as preventing them to the greatest extent possible from entering the interior of the railcar. Consideration was given to utilizing a HEPA type filter, etc. However, due to the relative openness of the railcar due to frequent stops and the exchange of air from door openings in commuter rail operations this type of filter would require constant replacement and maintenance, and is therefore not recommended.

### **Servicing**

The purchase of new railcars with state of the art systems and materials will not completely solve the on-going, day-to-day cleanliness and odor operational issues. Regular, consistent and thorough cleaning and servicing are necessary to achieve a standard of service expected by passengers – “clean – not almost clean.”

Recently, upscale bus manufacturing companies have installed a hose assembly in bus lavatories to facilitate servicing. Hose installation in a locked cabinet under the lavatory sink would provide a clean water source for cleaning the lavatory.

Consideration should be given to establishing operational procedures and staffing to assure that all lavatories are inspected, provisioned, and cleaned to an acceptable cleanliness standard at a minimum prior to the beginning of any trip (New Haven – New York or New York – New Haven). During the course of a day, cleaning should include trash collection and emptying the trash container, wiping down sink area, and lightly mopping the floor and rinsing the toilet, as necessary. It is important to note that unless the lavatory is serviced and maintained regularly, the issues of cleanliness and odor will re-appear.

### **New Technologies**

The development of the waste management system technology that reduces waste material into inert ash, water, and clean exhaust should be followed. It offers the potential to simplify waste disposal in an environmentally safe manner if it is reliable, durable, safe, easy to operate and cost effective. Automatic cleaning systems for public restrooms, if adapted for rail operations, may be able to provide a way to improve lavatory cleanliness in the future.

A summary of the Study Committee's findings is presented in Appendix A: Overview of Options.

**APPENDIX A**  
**OVERVIEW OF OPTIONS**

<b>Engineering and Design</b>	Integrate lavatory design into railcar design at front end of design process; utilize consultant with specialty in railcar lavatory/interior design.
<b>Waste Management System</b>	Consider equipment pre-qualification process; evaluate Metro-North past experience and future plans in effort to move to standardization.
	Should be easily removable & replaceable for servicing, maintenance, & cleaning.
	Teflon-coated bowl to improve performance.
<b>Lavatory Module</b>	Molded fiberglass or similar material; build off-site by specialty company and install in railcar.
	Avoid sharp edges and provide for adequate radii for all corners for effective cleaning.
	Major sub-assemblies should be easily removable and replaceable for servicing maintenance, & cleaning.
<b>Lavatory Features</b>	
Coat Hooks	1 to 2 coat hooks for users to hang belongings
Colors	Select colors that are warm and pleasing.
Flooring Material	Anti-slip flooring without seams.
Flush Control	Button or lever clearly marked.
Handrails, Hand Holds	Important for bracing while train is in motion.
Lighting	Provide adequate lighting
Signage	Identifies location & occupied/vacant status
Surface Coatings	Gel or Tedlar surface coatings to protect surfaces and for ease of cleaning.
Sink Counters	Similar to Gibraltar with lip on edge to retain water.
Sink Faucet	Easy to operate, protected to prevent water left running.
Soap Dispenser	Disposable container - screwed into position
Trash Containers	Sized appropriately - easy to use with minimum user contact.
Hose and Nozzle	Install under sink - clean water for cleaning.
<b>Ventilation</b>	Independent of railcar HVAC system. Utilizes continuously operated exhaust fan. Maintains negative pressure in lavatory to prevent odors from entering railcar.
<b>Servicing</b>	
General Servicing	Regular, consistent & thorough cleaning, servicing & maintenance should be established to maintain cleanliness.
Automatic Cleaning	Adapt automatic, self-cleaning technology for use in railcar lavatories.

**APPENDIX B**  
**EXISTING LAVATORIES ON METRO-NORTH RAILCARS**



*Typical M-4 re-circulating system*



*Typical Metro-North re-circulating system holding tank*



*M-2 ceiling vents*



*SPV Car (Shoreline East) - ADA flush control*

## APPENDIX B (continued) EXISTING LAVATORIES ON METRO-NORTH RAILCARS



*SPV Car (Shoreline East) - ADA lavatory overview*



*M-2 re-circulating system sink and counter*



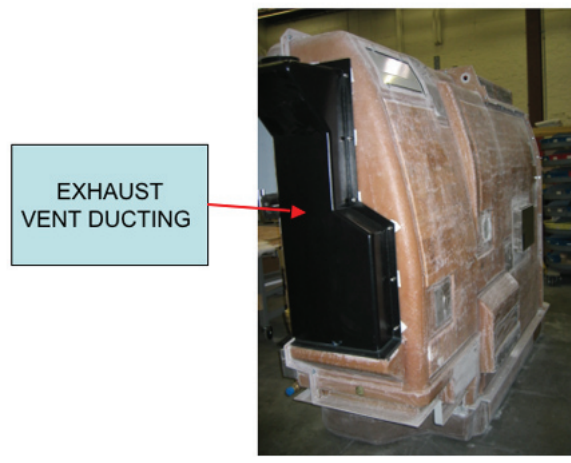
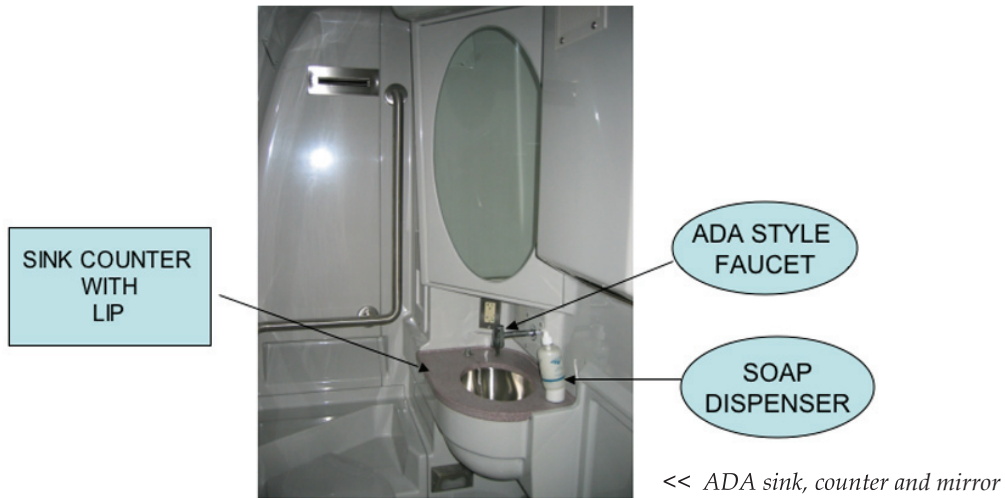
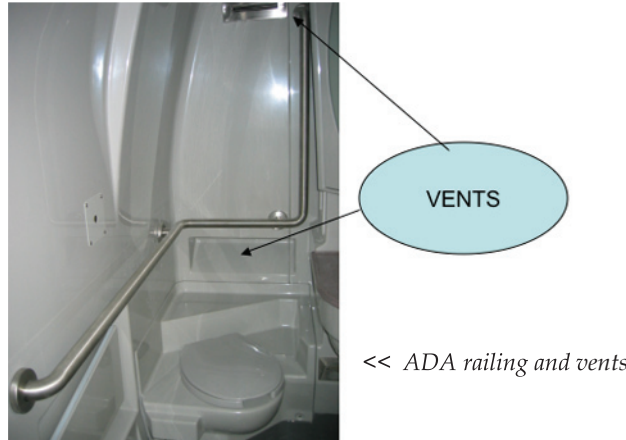
*Bombardier Car (Shoreline East) - ADA lavatory overview*



*M-4 re-circulating system sink and counter*

## APPENDIX C LAVATORY MODULE PHOTOGRAPHS\*

(\*photographs courtesy of RailPlan International, Inc.)



## APPENDIX C (continued) LAVATORY MODULE PHOTOGRAPHS\*

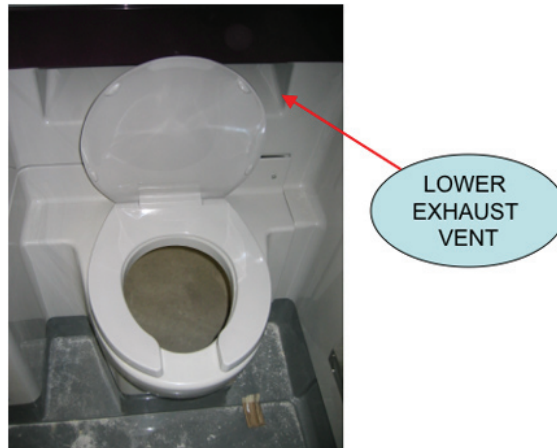
(\*photographs courtesy of RailPlan International, Inc.



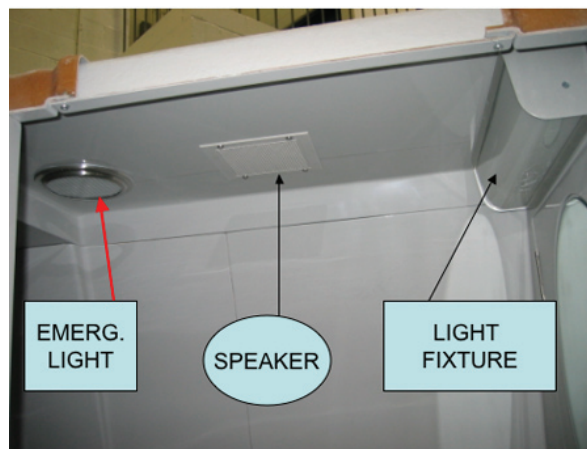
*Unisex - upper vent*



*Unisex - lower vent*



*Unisex - commode shroud with lower vent*



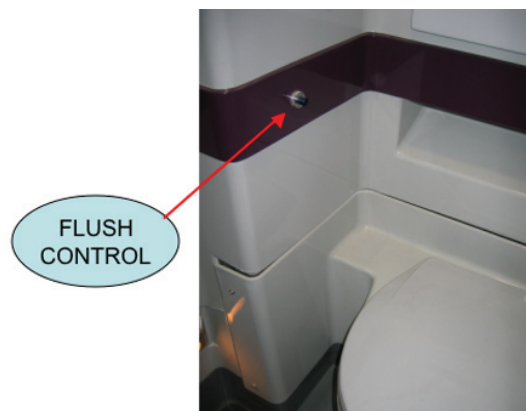
*Unisex - lighting and speaker*

### APPENDIX C (continued) LAVATORY MODULE PHOTOGRAPHS\*

(\*photographs courtesy of RailPlan International, Inc.)



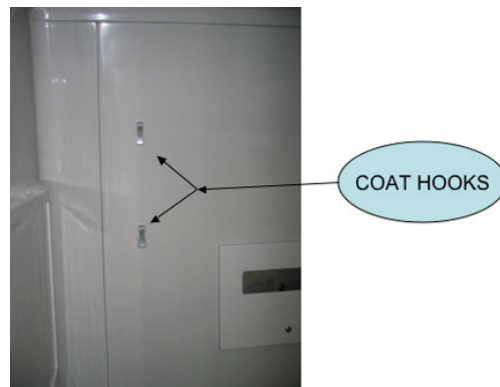
*Unisex -sink, counter and trash*



*Unisex - flush ontrol*



*Unisex - faucet control*



*ADA - coat hooks*



## APPENDIX D ACKNOWLEDGEMENTS

### Airline Operations

Southwest Airlines

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### Lavatory Materials

DuPont Tedlar®, P.O. Box 88, Sheridan Drive and River Road, Buffalo, NY 14207-0088  
Tele: 800-255-8386; Tedlar® - polyvinyl fluoride (PVF) overlaminating film for transit vehicle interiors.

Freudenberg Bausteme KG, D-69465, Weinheim, Germany; E-mail: nora@freudenberg.com  
Tele: +49 6201 80 5945; USA Office: Freudenberg Building Systems, Inc., 94 Glenn Street, Lawrence, MA 01843; E-mail: info@freudenberg.com; Nora rubber flooring covering for transportation applications.

Genesis Coatings, Inc., Jennifer Tankersley, Customer Service Manager;  
E-mail: jennifer@genesiscoatings.com; Tele: 800-533-4273; Flooring products for transportation vehicle applications.

Wilsonart International, Inc., 2400 Wilson Place, P.O. Box 6110, Temple, TX 76503-6110;  
Tele: 800-433-3222; Gibraltar® Solid Surface for counter surface applications.

### Lavatory Modules & Systems

ClearWater Technologies, Noah Newmark, President; E-mail: tni@comcast.net;  
2013 Canal Street, Venice, CA 90291; Tele: 310-305-1373

Evac Environmental Solutions

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Monogram Systems, Fred Kaviani, Sales Manager, Surface Transportation;  
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1200 Bernard Drive, Baltimore, MD 21223; Tele: 410-947-5900

### **Passenger Surveys/Focus Groups**

Metro-North Marketing Department, Results of the Annual Fourth Quarter 2002 Customer Satisfaction Survey; January 2003

Amtrak N.E. Corridor, Mechanical & Marketing Research Departments, Focus Group Video Presentation produced by TNS, formerly Intersearch Corporation of New York, 50 Main Street, White Plains, NY 10601; Tele: 914-684-6100

### **Railcar Manufacturer**

Bombardier

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Long Island Railroad, Robert Clinton, Senior Engineer, Tele: 718-558-4633

Metra-Chicago, Richard Sodkup, Chief Mechanical Officer; Tele: 312-664-7200, ext. 3445

Metro-North, Ken Barnish, Deputy Director Equipment Engineering & Maintenance of Equipment (NY); E-mail: barnish@MNR.ORG Tele: 914-271-1656

Peter DeCarlo, Assistant Director, Car Appearance (NY); Tele: 212-340-3198

John Hogan, Facilities Director, New Haven Line, Maintenance of Equipment (New Haven)

New Jersey Transit, Ed Baksa, Principal Project Manager; Tele: 201-955-5852

Virginia Railroad Express, Dennis Larson; Tele: 703-838-5439

### **Self Cleaning Public Lavatories**

Wall USA, Inc. – Boston, Martin McDonough; E-mail mcdonough@wall-usa.com;

Tele: 617-757-8500

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  - Study Update: Bus Propulsion Technologies Available in Connecticut
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  - An Analysis of Energy Available from Agricultural Byproducts, Phase 1: *Defining the Latent Energy Available*
- 2001**
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  - Indoor Air Quality in Connecticut Schools
  - Study of Radiation Exposure from the Connecticut Yankee Nuclear Power Plant
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  - VDT Radiation
  - Radiation Technicians
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  - New Haven Harbor
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  - Health Effects of Eating PCB-Containing Fish
  - Toxicity of PCBs
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  - CT Building Code; Energy Conservation
  - Nuclear Plant Capacity
  - Thermographic Mapping
  - Air Pollution in CT
  - SSET Program for CT
  - Urea-Formaldehyde Foam
- 1978**
  - Oil Spill Containment
  - PCB and the Housatonic River
  - The Opportunities and Limitations of Our Resource and the State of Our State in 2000 AD

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