

Make-Up Water Treatment by Service Contract

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Historical

The mobile water treatment industry had its origins in the late 1960's, providing demineralized water for U.S. Navy ships at pier side. One cubic foot mixed bed cylinders were delivered to the dock, connected to the city water supply and the effluent was fed directly to the ship. Shortly thereafter a utility chemist, who had arranged to truck bulk demineralized water from one station to another, heard of this idea to bring regenerated resin to a jobsite and contracted for services to his power station. Whereas it would take 2 or 3 "milk" trucks to provide 10,000 gallons of water, less than 20 of the one cubic foot mixed bed "bottles" could provide the same quantity of water on a 200 ppm (mg/L) feed at a higher purity and with much less logistical problems.

In the early 1970's, the mobile market was generally an East/West coast market. In 1976, the market expanded to the Midwest with the opening of a St. Louis service center. By 1977, the first patent was issued for a mobile purification unit¹ and the mobile market for emergency DI services grew rapidly. By the 1980's, several new competitors and expansion by existing companies literally made mobile DI services available throughout the United States.

In 1983, a patent issued for a mobile purification device containing six, 115 cubic feet ASME code vessels which could be piped in any combination of series/parallel.² This unit not only ended the one cubic foot bottle era for GE Water & Process Technologies, but also brought to the market other options besides demineralization of city supplies. Soon coagulation/filtration of raw river supplies, carbon adsorption, side-stream condensate polishing, de-alkalization, softening, and deoxygenation services all became available to the market on an

emergency basis. Also, the mobile equipment design allowed in-place regeneration options that offered economic savings for longer-term needs.

The first mobile reverse osmosis unit was built in 1984.³ By 1986, a fleet of mobile reverse osmosis units were available for both long term and intermediate term (1-3 months) use. The first applications for mobile RO systems were for reducing the TOC content in make-up supplies at nuclear power stations.^{4,5,6} In many of these installations the RO was installed downstream of DI systems, which enabled the utilities to immediately meet newly imposed TOC specifications. However, the drought along the Mississippi River and in the Northeast United States in 1988 quickly brought a demand for mobile RO services to pre-treat existing permanently installed DI systems due to rapidly increasing TDS. At one refinery on the Mississippi River, there were no less than five 200 gpm RO units supplied by 3 competitors on an emergency basis to help keep the refinery on line.

The 1990's brought about the extensive growth of the extended term or base load business for the mobile water treatment services market. No longer were "rubber tire demineralizers" (RTD's) the best option. Extended term (3-10 year) make-up water services contracts using larger skid-mounted equipment houses inside buildings became common. Automation, expanded in-line analytical instrumentation, and remote monitoring data acquisition systems were installed. The latest double-pass RO, UF, EDR, UV, and continuous deionization (CDI) technologies have all been employed by the service companies for such installations.

The mobile water treatment market was estimated to be US\$107 million in 1991.⁷ The projected market in 1996 is US\$210 million.

The remainder of this article will discuss applications for mobile water treatment services and their advantages over capital systems.



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Emergency Services

The most successful players in the mobile water treatment market of today have all had their roots in providing emergency DI water services. Major investments in equipment, ion exchange resins, and instrumentation were made to meet the unknown demands of this segment of the industry. Job applicants interested in a 9.00am to 5.00pm five day work week need not apply, as emergency service requests rarely occur when it's convenient.

A typical application would be to provide DI water from a filtered water supply within 2 hours plus driving time of a call. The need for such a service could be for several reasons:

1. Mechanical problem with plant or DI system.
2. Ion exchange resin (fouling) problem.
3. Loss of ion exchange resin.
4. TDS increase of water supply.
5. Regenerant chemical supply problem / contamination.
6. New system start-up problems.

Upon arrival at the jobsite, the service company personnel will connect to the influent supply with fire hose, fill and rinse the unit, and test the effluent prior to routing the purified water to the customer's storage tank with fire hose. If desired, a Field Service Representative can be contracted to stay and provide full analytical testing and water inventory management during the entire requirement.

The cost for such emergency services is highly dependent on the influent TDS and the distance between the customer and the service company's regeneration facility. For TDS ranges 100 and 500 ppm (mg/L), the average cost will be between US\$5 to US\$35/kgal. If you are unfortunate enough to have a high TDS supply, the "apparent" high cost for emergency DI services must be balanced with the more expensive alternative of shutting down the plant. The May, 1990, issue of Ultra pure Water reported, "For many firms requiring DI water in an emergency, the mobile DI water concept has been a savior. This concept has also been a boon for cash-strapped firms."⁸ Emergency service does not mean reduced water quality as service companies routinely meet specifications of <0.1 $\mu\text{S}/\text{cm}$, 10 ppb SiO_2 , and 1 ppb Na and Cl.

Emergency services are no longer restricted to providing DI water from filtered supplies. Numerous applications have been provided by the service companies including:

1. In-line coagulation/filtration
2. Deoxygenation
3. Membrane technology
4. De-alkalization
5. Ion exchange softening
6. Side-stream condensate polishing
7. Carbon adsorption

By use of in-line coagulation/filtration technology, service companies are able to provide services to cover clarifier upsets/breakdowns or to provide Silt Density Index (SDI) reductions so as not to void membrane warranties.

Case History 1 - Steam Blow

A Southeastern U.S. coal fired generating station had a unit out of service for several years for repairs to the superheat and reheat sections. A steam blow was required to remove accumulated surface deposits and mill scale from new tubing. A conventional or intermittent steam blow would have taken up to three weeks. The plant preferred a continuous steam blow to save time, but lacked the DI water flow capacity to support the continuous operation.

A service company was contracted to furnish and operate a 720 gpm (2.7 m^3/h) continuous make-up system, using raw river water as feed, to supplement the plant's water treatment system. Two, 500 gpm

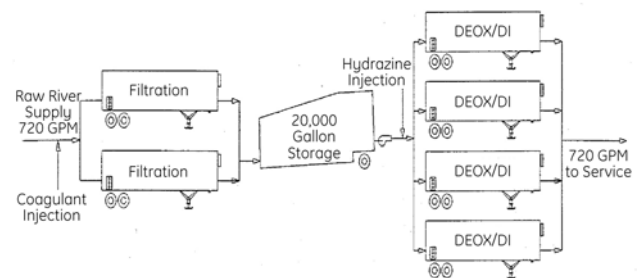


Figure 1: Supplemental Water for Steam Blow

Filter trailers clarified the raw river water and fed to a 20,000 gallon (76 m^3) mobile storage tank. A booster pump then sent the water through four combination deoxygenation/demineralizer process trailers piped in parallel. The deoxygenation process was the patented process of the service company.^{9,10}

The continuous steam blow was completed within 48 hours, which resulted in substantial savings in both contractor costs and unit availability.

Interim Term Needs

As the service industry grew, more facilities began planning on the use of mobile equipment in the overall operating scope of their plants. Permanent connections for emergency DI services were installed. Design criteria for new installations were reviewed in light of the availability of mobile equipment. Prototype testing of new or different technology without capital outlay was conducted.

Reasons for interim mobile services might include:

1. Change in effluent specifications
2. Increased flow/quantity required
3. Waste discharge limitations
4. Test make-up water quality on product/production
5. Bridge during upgrades/new construction
6. Planned extended maintenance of existing system

Case History 2 – Upgrade Bridge

A Western U.S. major oil refinery used a hot lime/ion exchange softening treatment for process steam make-up feed. Sludge disposal was becoming more difficult and costly as environmental regulations were tightened. At the same time there was a need to improve boiler feedwater quality to minimize shutdowns for boiler inspection and cleaning. Demineralizers were recommended, but environmental restrictions discouraged disposal of regenerant waste. Flow requirements were 3000 gpm (11 m³/h) peak and 1200 gpm (5 m³/h) continuous.

The interim solution was to contract for base load mobile DI services for a two-year period. The system consisted of 8 standard mobile demineralizer trailers, each rated at 400 gpm (1.5 m³/h). The feed was a municipal supply, which varied between 50 to 150 ppm (mg/L) TDS. Because the mobile demineralizers were the entire water plant, system reliability was essential. Effluent quality was monitored by in-line conductivity and silica monitors. Field Service Representatives provided around-the-clock service. Three 1000 gpm (3.8 m³/h) booster pumps were backed up by an equivalent capacity of diesel pumps.

Over 600 exchanges were made, 1 billion gallons (4 million m³) during the contract term without a single incident of off spec, water or inadequate flow. This, despite a major earthquake, a threatened strike, and the regeneration facility being 400 miles away. During this entire period, the water plant was a true zero discharge facility, producing no wastewater at the jobsite.

Case History 3 - TOC Reduction

Northeast Utilities, Millstone Station, was one of the earliest subscribers to the service approach, beginning in 1975.¹¹ The municipal supply (Table 1) originates from Lake Konomoc and prior to 1989 was only coarse screened, pH adjusted with NaOH, and chlorinated.

Table 1: Millstone Station Municipal Supply

	ppm (mg/l) as CaCO ₃		ppm (mg/l)
Ca	8 - 15	HCO ₃	6 - 12
Mg	3 - 5	Cl	6 - 12
Na	8 - 16	SO ₄	2 - 10
K	1 - 2	NO ₃	0 - 2
TOC	2 - 6 ppm (mg/l) as C	Iron	0.05 - 0.07 ppm (mg/l) as Fe
Silica	2 - 5 ppm (mg/l) as SiO ₂	pH	6.6 - 8.1
TDS	35 - 45 ppm (mg/l) as ions	Turbidity	0.5 - 2.0 NTU

On first review, one would not necessarily conclude that this would be a difficult water to treat. In practice, it is the variable nature and concentration of organics (10% to 20% of TDS), which has caused problems.

Although the exact structure of the organics reported as TOC has not been identified, it is known that there are several organic types present. For example, we estimate 10% to 20% are colloidal organics, removable by ultra filtration or coagulation processes, 70% to 80% are dissolved organic acids, removable by strong base ion exchange resins, and 5% to 10% “apparently neutral” organics, not removable by ion exchange, ultra filtration, or coagulation/filtration processes. TOC studies on Lake Michigan supplies showed similar results except that 30% to 35% of the organics present were colloidal.⁵

Figures 2 and 3 summarize the successful reduction of conductivity and TOC in the station’s make-up water as the treatment processes and technology changed. Had Millstone Station, in 1975, decided to

install additional capital equipment to meet their make-up water deficiencies, rather than contract for services, they may have been “stuck” with that technology for the next 20 years or forced to make further capital expenditures as specifications tightened in the industry.

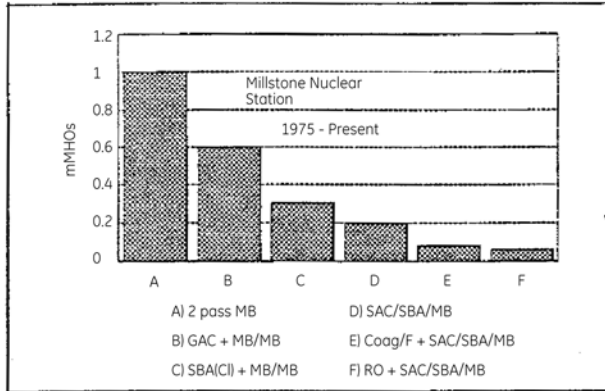


Figure 2: DI Effluent Conductivity

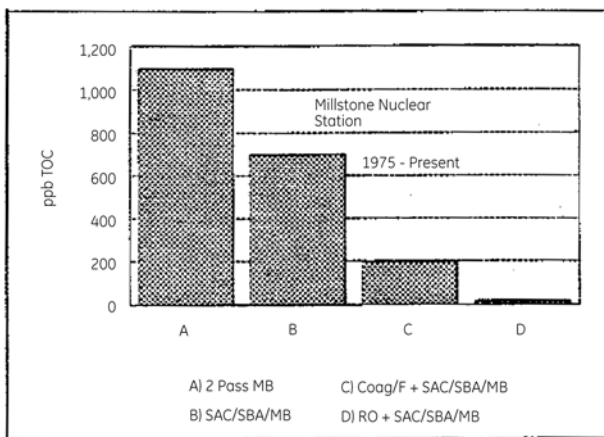


Figure 3: DI Effluent TOC

Through the use of mobile service companies, Northeast Utilities was able to evaluate a multitude of treatment designs and unit operations to determine the most effective method for improving make-up water chemistry. Because the tests were conducted on a full-scale basis, the total impact on system chemistry was easily obtained. Not only were no capital expenditures required, but also because mobile systems are self-contained, piped, and quality control tested, start-ups can occur within hours of arriving on-site. Furthermore, the actual cost of water delivered to the customer has actually gone down with the implementation of membrane technology while water quality has substantially improved.

Today, a 400 gpm (1.5 m³/h) vendor system is permanently on-site utilizing ultra filtration, reverse osmosis, deoxygenation and ion exchange technology. The site is manned 24 hours/day by Field Service Representatives, badged and trained for unescorted access, who perform all analytical testing, reporting, troubleshooting, and maintenance requirements. For periodic needs of 600 gpm (2.3 m³/h), such as during plant start-ups, an additional 200 gpm (0.8 m³/h) mobile reverse osmosis and deoxygenation unit is delivered to the site for the requirement. Water quality produced is shown in Table 2.

Table 2: Make-up Water Quality - Millstone Station

Parameter	Supply	Effluent	Specification
TOC (ppb as C)	5,000	< 20	50
Sodium (ppb as Na)	12,000	0.1	1
Silica (ppb as SiO ₂)	4,000	< 3	5
Conductivity (µS/cm)	60	0.056	0.061
Diss. Oxygen (ppb O ₂)	9,000	< 1	100

Extended Term Services

In the last 6 to 8 years, the mobile water treatment service industry has matured to the point that end users need not consider capital systems as the only alternative for long-term make-up water needs. Many new requirements now competitively evaluate traditional capital systems vs. service contracts. Reasons for extended term services might include:

1. Capital funds not available
2. Uncertain requirements (term/volume/quality)
3. Lower evaluated cost for 5-year term
4. Environmental restrictions
5. Fast track project
6. Fixed price for water
7. Need to focus on product, not water production

As will be seen in the following case histories, extended term jobsites have a permanent look to them. Often, equipment is skid-mounted and located inside a building. Any mobile equipment on site is generally “skirted” and hard piped. Automated operation, in-line analytical instrumentation, auto shutdowns with alarms, and remote monitoring are routine features.

Case History 4 - Extended Term New

Public Service Electric and Gas Company's (PSE&G) Unit 10, Burlington, NJ, is a recent example of choosing extended term water treatment services over a capital system. Burlington 10 is a repowering project that replaced an oil fired, combined cycle unit operating in simple cycle mode with a modern gas fired, combined cycle unit comprising four identical gas turbine power trains feeding a single steam cycle.¹²

The 300 gpm (1.1 m³/h) system includes multimedia filtration for Silt Density Index reduction, reverse osmosis, degasification, and mobile demineralizers, which eliminate the need for on-site regeneration and the disposal of regenerant wastes. Except for the mobile demineralizers, the entire system is housed inside a building, which the service company designed and installed to meet all local codes. Effluent water is stored in a 1.5 million gallon (5700 m³) tank, which is a 3-day supply for Burlington 10. Storage tank level controls allow the system to start/stop on demand.

Tom McNulty, PSE&G's Assistant Project Manager, was quoted in the March, 1993 issue of Electrical World as saying, "Historically, demineralized water supply is operations and maintenance intensive. Here, PSE&G has eliminated capital costs and long term operations and maintenance costs".

Case History 5 – Extended Term Upgrade

Virginia Power's, Surry Nuclear Station, Surry, VA, was another early subscriber to mobile water treatment services. From 1982 until 1988, the station used emergency DI services to supplement the station's make-up system, which consisted of flash evaporators and mixed bed polishing. In 1988, economic evaluations suggested that station shut down its make-up system and contract 100% of their make-up water requirements to a mobile service company. For two years, during normal operations, the station would average about one demineralizer exchange unit per 1.5 days.

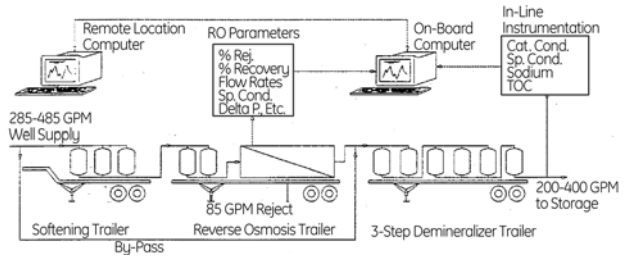


Figure 4: Surry Make-up System

In 1990, the system was upgraded to include reverse osmosis and softening pretreatment so that tightened specifications for organics and in-line analytical monitoring could be met.¹³ Ro technology also cut down truck traffic in/out of the facility from 15 to 20 per month to 1 per month. In addition, a remote monitoring system was installed so that real time system performance could be monitored not only on-site, but also around-the-clock at the service company's 24 hour/day dispatch center.

Table 3: Make-up Water Quality - Surry Nuclear

Parameter	Supply	Effluent	Specification
TOC (ppb as C)	1,600	< 10	50
Sodium (ppb as Na)	110,000	< 0.2	1
Silica (ppb as SiO ₂)	29,300	< 3	5
Conductivity (µS/cm)	483	0.056	0.08

All of the above was done at less cost than the previous system of DI exchanges. The only financial impact to the customer, other than some initial site preparation costs, was the receipt of a substantially lower monthly billing.

Ed Brennan, Water Treatment Coordinator for Virginia Power, Surry, characterized the system in Power, February 1993, as "Over 200 million gallons (757,000 m³) of raw water processed flawlessly, with no membrane deterioration evident or need for chemical cleaning." Recently, the excellent production and chemical monitoring of station make-up water was recognized by the Institute of Nuclear Power Operations (INPO) as an industry "Good Practice."¹⁴

The Decision Process - Capital Vs. Operating

A manager trying to decide whether to purchase a capital system to be amortized over 15 to 20 years or a 5- to 10-year operating contract does not have a straightforward decision. Length of contract, interest rates, amortization schedules, predicting

inflation, technology required, environmental constraints, site location, water quality, and manpower costs, are just a few of the issues. However, in our opinion, one way to not get a fair response from the service companies is to prepare a very detailed custom designed capital equipment specification and then ask for a bid for a service contract on this one of a kind specification.

If interested in pricing for a service contract, a suggestion would be to develop specifications that concentrate on the effluent quality and quantity. This is the product you will be purchasing and the service company will guarantee for the life of the contract. Allow the service company to quote its standard pre-engineered equipment and design criteria rather than forcing custom designs on it. Remember that what you put down on paper translates to real dollars that must be passed on in the cost of the service. Plot plans and process and instrument diagrams sent with the proposal should provide the end user with sufficient information to judge the worthiness of the proposal. Make every effort to visit jobsites, service centers, and headquarters of the service companies to see what's behind the "paper proposal." Be specific as to the normal vs. peak quantity of your water needs. The service companies might be able to reduce costs by installing a smaller base load system to meet 90% of the needs and utilize mobile equipment to supplement the higher volume requirements if they occur infrequently.

I think it is important for end users to acknowledge that the service companies can bring a lot of expertise and new technology to the table. Most service companies will already have experience on your water source and certainly will have (or should have) numerous practical application experiences with the technology being offered. They are experienced in producing in spec. Water within hours of equipment arriving on-site. They are experienced in in-spec water for 5 to 10 years and not just for 7 to 30 day performance tests. They are experienced in repairing any equipment failures within hours by having full inventories of back-up components housed on-site and at the various service centers around the country. They are experienced in knowing what pretreatment is required and what membrane type is best for a problem free application. And they are experienced in building reliable and well-engineered equipment that stands up to

the rigors of over-the-road trailer transport on a daily basis.

The value offered by a company does not just relate to the system hardware or process, but rather to the entire system "package". The company you select to provide your make-up water requirements for the next 5 to 10 years should have the following capabilities to ensure the service reliability you will be promised:

1. Immediate availability of duplicate system components "on wheels".
2. Complete analytical/applications laboratory.
3. Technical / Engineering / Marketing personnel qualified to discuss specific plant requirements with your chemists and engineers.
4. A full time staff of Field Service Representatives who are college degreed and trained in water treatment processes to operate and maintain the field systems.
5. Full service regional regeneration centers, including regeneration and maintenance facilities, mobile equipment inventory, spare parts, and a resident Plant Manager.
6. A 24 hour/day staffed dispatch/Operations and communications center, which can also monitor remote jobsite operation with a data acquisition system.

To truly be a service company, we believe it is imperative that a customer be able to dial a number and talk to a "live" person who has a technical background and can offer immediate assistance day, night, or holidays. Beepers, answering services, and voice mail all fall short of this service.

The purpose of this paper was to introduce one to the capabilities of the mobile service industry and recent trends toward extended term contracts. It is not intended to endorse one mobile company over another, or to contend that extended term service contracts are always better than purchasing capital equipment. It was intended to demonstrate that the mobile water treatment industry is not simply about tractor-trailers and emergency services and that a certain amount of expertise and technology exists within the industry which may be of benefit to some and users.

References

1. Dickerson, R. C., U.S. 4, 049, 548, Mobile Demineralizer, September 20, 1977.
2. Dickerson, R. C. and Muller, R. S., U.S. 4, 383, 920, Mobile Fluid Purification System, May 17, 1983.
3. Soule, C., "Outsourcing Water Purification," NUS Make-up Water Treatment Seminar, Clearwater Beach, FL, June, 1993.
4. Miller, W. S., Jones, V. W. and Langer, R. H., "TOC Removal From Make-up Water at Millstone Nuclear Generating Station," 47th International Water Conference, Pittsburgh, PA, October, 1986.
5. Fredrichs, T. L. and Miller, W. S., "Reverse Osmosis Treatment of Demineralized Make-up Supply to Improve Steam Generator Chemistry," EPRI Workshop on Condensate Polishing and Water Purification in the Steam Cycle, Oak Brook, IL, May, 1987.
6. Bossler, J. F. and Jones, L. B., "Containerized Treatment System Overcomes Problems, Delivers High Purity Water to Nuclear Power Plant," 48th International Water Conference, Pittsburgh, PA, November, 1987.
7. Henley, M., "Mobile Systems: Trailer-Mounted Treatment Market Growing," Ultrapure Water Journal, October, 1992.
8. Anon, "In the Spotlight: GE, Inc~ a Pioneer in the Mobile DI Industry," Ultrapure Water Journal, May, 1990.
9. Dickerson, R. C. and Miller, W. S., U.S. 4,556,492, "Deoxygenation Process," December, 3, 1985.
10. Dickerson, R. C. and Miller, W. S., U.S. 4,818,411, "Deoxygenation Process," April, 1989.
11. Painter, J. C., "Benefits of Non-Capital Make-up Systems," NUS Make-up Water Treatment Technologies Seminar, Clearwater Beach, FL, June, 1993.
12. Bretz, E. A., "Repowering Project Combines Experience, Innovation for PSE&G," Electrical World, p.75..-79, Mar.,1993.
13. Belsches, B., Brennan, E. and Miller, W. S., "Remote Monitoring and Performance of Ultrapure Make-up System at Surry Nuclear Station," 52nd International Water Conference, Pittsburgh, PA, October, 1991.
14. Institute of Nuclear Power Operations (INPO) Communication, January 29, 1993, Item PE-92-31 (CY.2-I) "Station Production of Excellent Water Quality."