CONVERTING X-RAY MACHINES FROM WATER PASS-THROUGH TO RE-CIRCULATING

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Synopsis

Hospitals commonly have several medical x-ray processors operating 24 hours per day, 365 days per year. Published water flow rates for the 35 units on the market range from .2 to 2.5 gallons per minute (gpm), but can flow at much higher rates in practice. Units specified to operate at 2.5 gpm are very common while the .2 gpm units are rare.

This study tested a new technology that re-circulates the water to the film processor thereby reducing consumption to approximately 35,000 gallons per year. The Los Angeles Department of Water and Power has had several customers install the equipment with the savings verified by a meters specifically placed to measure processor flows. To gain more precise information on the effect, Irvine Ranch Water District used a datalogger that continuously recorded the flow prior to and after the installation. In all cases, the equipment performed well and saved the anticipated amount of water.

Background

Medical facilities commonly have x-ray film processors operating 24 hours per day, 365 days per year. Most hospitals have several processors. Flow rates for the 35 units on the market range from .2 to 2.5 gallons per minute (gpm) or 105,120 to 1,314,000 gallons per year (gpy), according to the manufacturers' specifications. Units operating at 2.5 gpm are very common while units operating at .2 gpm are rare. Although the manufacturer's specifications suggest the equipment operate at 2.5 gpm, it is not uncommon to find them actually flowing higher, up to 5 or 6 gpm.

The manufacturer of a new technology claimed to reduce consumption in x-ray film processors to approximately 16,000 gpy by re-circulating the water (plus an additional estimated 300 gpy for cleaning). This project tested the equipment by retrofitting existing x-ray film processors with this technology and then measuring the difference using meters specifically placed to measure processor flows. The meters were placed on the existing film processor for up to two weeks prior to the upgrade installation and remained in place for up to one month after the new equipment was operational.

Technical Description

X-RAY FILM PROCESSING WITHOUT THE ADDITIONAL UNIT

Film processors use water primarily to rinse processing chemicals from the film prior to the dryer section of the machine and secondarily to cool the machine. There are four stages of film development.

1) Film goes through the developer chemicals, which need to be at about 95 degrees. Processors contain a heating coil that heats the developer to the appropriate temperature. Developer is the only liquid in the processor that needs to be heated. After the developer, the film rolls through squeegee-type rollers to remove most of the developer chemicals.

2) Film then goes through the fixer chemicals, which stop the developing process. This is not temperature sensitive. From here, the film goes through another set of squeegee-type rollers to remove most of the fixer chemicals.

3) Film then goes through a rinse cycle to remove any remaining excess chemicals. In most machines, this rinse section of the processor receives a constant supply of running tap water, up to 2.5 gpm. This tap rinse water runs to a drain with a detour around the developer to keep it cool.

4) Finally, film goes through another set of squeegee rollers to remove the rinse water and enters the drier. The heating coils in the drier section run at about 120 degrees. This level of heat would overheat the developer if the tap water were not circulated around the machine to keep it cool prior to discharging to a drain.

Maintenance on all processors is ordinarily done every 1 to 2 weeks, depending on the processor and what it is used for.

X-RAY PROCESSING WITH THE ADDITIONAL UNIT

The unit (the Water Saver/Plus) is added onto an existing x-ray processor to capture and re-circulate water that would otherwise run straight through to a drain. It holds 15 gallons of water and pumps water from the bottom of the tank into the processor. A timer releases a set amount of cool, fresh water, up to 4 gallons per hour, into the unit for proper temperature control. The cool water enters at the bottom of the tank, near where water is pumped to the processor and an equal amount of "old" water flows out to the drain at the top, near where the "old" water is returned to the tank from the processor.

The device stands 26" high with a 15" x 15" footprint and uses up to 110 volts. No operational changes are necessary to use this technology, though the processor does need to be shut down during installation (approximately 1 hour). There is no additional chemical impact to the environment to operate this equipment. Hypo Retention tests can be conducted to determine whether the chemicals are being sufficiently washed off in the wash cycle.

The maintenance of the equipment requires a cleaning approximately every 2 weeks to ensure that the build-up of chemicals does not reach unacceptable levels. The unit is drained, rinsed, scrubbed, rinsed again and an algaecide is added. Cleaning cost is approximately $50.00, or $1300 per year. The maintenance of this equipment is independent of the processor maintenance.

Monitoring and Assessment

A water meter (a Neptune T-10, brass, 5/8") was affixed to the existing intake line for period of up to one month prior to the installing the new equipment and remained on the line for up to

one month after the re-circulating unit was installed. The meter was read at least once weekly by water agency personnel during the monitoring period, with one exception.

In place of reading the meter weekly, Irvine Ranch Water District affixed a datalogging device to the meter that recorded the flow through the meter every 15 minutes. Because of the detailed flow record, the meter recorded data for only one week prior to and one week after the processor was retrofit with the additional equipment.

Results

The project found that the WaterSaver did perform as per the manufacturer's claim in all cases. More than 30 units have been installed in the Los Angeles Department of Water & Power's service area. Those 30 machines had manufacturers' rated flow rates of between .2 and 2.5gpm. However, 14 of those machines were given a 5-second flow test and found to be flowing between .2 and 5.3gpm. Nine of those 14 were rated to flow at 2.5 gpm, but, on average, flowed at 3.9 gpm.

SAVINGS ON SEVEN PROCESSORS

Water savings were verified by meter readings on seven processors before and after the retrofit. The projected savings in water and costs are summarized as follows:

Average Per Cent Savings	98%	
Total Acre Feet Saved per Year	24.24	
Life expectancy of equipment	10 years	20 years
Expected Acre Feet Saved	242.4	488
Project Cost per Saved Acre Foot	$139	$69
Equipment-Only Cost per Saved Acre Foot	$103	$51

"Project costs" include the water agencies' staff time of arranging for installations, monitoring flows, analyzing data, and so on. Cost per acre foot refers to the agencies' cost of water.

DETAILED EXAMINATION OF ONE MACHINE

A datalogger placed on one of the retrofit machines indicted that the X-ray processor flows fluctuated, depending on the degree to which the maintenance staff happened to open the valves controlling water flow to the processor. In the recorded instance, the valve had been arbitrarily opened to permit flows at 1.825 gpm—lower than the manufacturer's specifications. At one point during the pre-installation test period, the drain from the processor had backed up (no connection to the processor operations) and the hospital's maintenance staff turned off the processor while they corrected the problem. When they turned the processor back on, they arbitrarily opened the valve to the degree that the processor then ran at 2.897 gpm—higher than the manufacturer's specifications. Consequently, the actual calculation of water saved depends on which pre-installation flows are used. However, even at the lower rate, the WaterSaver improved water efficiency by 98%.

Kodak M6B	Gallons per minute	Gallons per year	Acre Feet Per Year

Pre "drain problem"	1.825	959170	2.95
Post "drain problem"	2.897	1522594	4.69
After installation of WaterSaver	0.028	14641	0.05

Non-Technical Considerations

SPACE

Many hospitals have concerns about equipment taking up space. While the unit itself is fairly small, if necessary it can be located 25-30 feet from the processor. Distances greater than that would require an additional pump, which adds expense to the measure. Installing them in confined spaces, such as a closet, it completely acceptable. Processors are often located in dark room closets.

PAYING FOR WATER VS. PAYING FOR MAINTENANCE

Ordinarily, a customer that reduces their water consumption will reap the benefits by reducing their cost of water. However, this capitalistic model intended to result in the greatest efficiency of resources breaks down when the entity paying the water bill is not the same entity that must pay for the equipment upgrade and its on-going maintenance.

Such was the case with an X-ray clinic housed in a larger medical facility owned by a property management company. The solution in this case was that the property management company agreed to pay the additional $50 monthly directly to the vendor. Another option would have been to lower the clinic's rent by $50, but the property manager did not like that choice. The water agency picked up the cost of installation. The property owner benefited from the reduced water bills. The water agency gained the water savings. The clinic gained no financial benefit, but "did the right thing."[*] Without the water agency stepping in, it is unlikely the parties would have ever agreed to install the equipment.

"EMERGENCY" SUPPLY

The patent-holder of the tested unit invented the mechanism in response to a particularly damaging earthquake in California. To keep the hospital's processor operating while water supply was questionable, he devised the prototype so the diagnostic services could keep operating without city water during the seven-day crisis period. This feature may be of such intrinsic value that x-ray-dependent facilities may opt for the upgrade regardless of any possible assistance (such as a rebate) from water agencies.

WHAT TYPES OF BUSINESSES/ORGANIZATIONS HAVE X-RAY FILM PROCESSORS?

A wide variety of medical professionals use x-rays, but for many different reasons. Consequently, x-ray film processors come in a wide variety of sizes and operational designs. Dentists, doctors, chiropractors, veterinarians, imaging centers, health clinics, breast cancer

[*] While the clinic "gained" the free equipment upgrade, the upgrade does not in anyway improve (or detract) from their operations, so the effect is neutral.

screening clinics, and hospitals all own processors. All but dentists have the potential to have a high water-using unit.

Most smaller facilities do not use processors that operate with constant flow. Their processors typically fit on a desk top. Water is hand-filled, commonly filled just once per day. Even if these processors were filled several times each day, they would still use a minute fraction of the amount flowing through the larger machines. Because all dental x-rays are small, dental offices and clinics rarely, if ever, own the larger, constant-flow processors.

OTHER POTENTIAL MARKETS

While medical facilities have been the focus, other industries also use x-rays. The defense and aerospace industries extensively use x-rays for non-destructive testing of their manufactured and assembled products.

This study has focused entirely on *x-ray* film processors. However, the re-circulating design of the tested equipment will likely work for other film processors as well. Although most of the retail one-hour style photo developing sites do not use constant-flow processors, many of the commercial graphics enterprises do. Flow rates for the larger machines are likely comparable to the higher-flowing x-ray film processors.

"HAZARDOUS" MATERIAL

The algaecide used to prevent algae build-up contains two ingredients requiring a Material Safety Data Sheets. Since the algaecide is typically used in the processor as well for the same purpose, having the additional unit may be considered as the same risk. Nonetheless, the MSDS primary warnings bear mentioning. One ingredient is stated as corrosive and toxic by ingestion and skin absorption. and to eyes. Direct contact with skin "will cause severe delayed skin reactions or burns if not washed off immediately." Fire fighters are instructed to wear full gear primarily to protect their breathing. Ingredients are classified as a "serious" health hazard, a "slight" fire hazard, and a "minimal" reactivity hazard. Since bromide was used until fairly recently, these participating water agencies did not have any long-term experience to determine if the "corrosive" aspect of the ingredients would affect the plumbing.

Other Technologies

Phosphor re-usable plates transfer the image to a computer screen, which can then be enhanced with specialized software. They have no chemicals, no film, no disposables, and use no water. They use the same x-ray head that is currently used to imprint the image on film, using about 50% of the energy. May be cost-effective.

Like the phosphor plate, direct digital x-ray imaging is more sensitive, but much more expensive. Unfortunately it is most likely too expensive for most hospitals.

Any other re-circulating system may run into patent infringement from this tested equipment. A Canadian company has produced something that may have served as competition, but C & A X-ray is claiming patent infringement.