

A New High Efficiency Automatic Car Wash Water Recycling System

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ABSTRACT

A new system has been developed in Spain for recycling of water from automatic car washing systems. The recycled water is of very good quality and very suitable for reuse. Detergent use is reduced as well.

The system combines gross physical separation of the oil and solid particles using a plate separator system, fine separation of solids with an automatic filter system, and ozone treatment for disinfection and odor control. Other systems recycle water, but do not remove oil and solids as well.

Over 150 systems have been installed. The initial test system has washed over 6000 cars and is operating at about 75% water recycle (most of the non-recycled water leaves the carwash as a water film on the cars) and about 70% reduction in detergent use.

The system is a good tool for water conservation in desert climates or other situations where water conservation is important. It is expected that this system may be useful at airports and truckstops for equipment washing as well as for automobile washing.

KEYWORDS

Carwash, recycle, automatic, filtration, water, reuse, ozonation

INTRODUCTION

In many parts of the world, potable water shortages are causing interest in recycling and reusing water as much as possible. One major use of water in developed countries is automobile washing. It is not convenient to recycle the water from home auto washing, but the recycling of water in commercial wash systems is very feasible and can be done economically with the use of suitable equipment.

In the United States, groundwater withdrawals provide about 39% of public water supplies with surface water providing the balance. In the US Southwest groundwater constitutes 55% of water supply withdrawals and water usage has more than tripled over the period from 1965 to 1990 and increased further since ¹. Public supplies are used for domestic, commercial, power generation, irrigation and fire fighting. Populations in the desert US Southwest as well as in other populated areas are growing and continue to require more and more potable water. It is reasonable, therefore, to be interested in conserving and reusing water as much as possible in commercial and industrial applications to preserve as much water as possible for the growing domestic uses. Recycling car washing water is one good way to preserve water resources without causing inconvenience or undue extra costs to anyone.

The waste water from professional fixed car wash facilities is directed to city sanitary sewer systems, but water from home car washing usually flows directly into storm sewers or onto lawns, constituting a

potential pollution problem. Water use per car in automatic systems is often considerably less than the use from home washing. Estimates of water use in car washing are shown in Table 1 below ²:

Table 1: Water Consumed in Car Washing		
Type of Car Wash	Gallons	Liters
Self Serve (Coin operated)	8-12	30-45
Conveyor	15-32	57-121
In bay roll-over	24-45	91-170
Home Car Washing	80-140	302-530

Notes:

- 1) Ranges denote varying use of recycled water.
- 2) The roll-over is a system where the car is stationary while the machine moves over the car while washing, rinsing and waxing.
- 3) Table adapted from Western Carwash Association (1990)²

Automatic carwashes at gasoline filling stations are becoming more popular because stations that install them often see 15% to 25% increases in gasoline sales ³

LEGAL CONSIDERATIONS

The legal requirements concerning carwashing water in the US vary widely depending on local requirements of sewer authorities. Almost all cities require car wash water to be treated through a sand trap to remove most of the grit. This is usually provided as part of a three tank system that also removes bulk oil before the water is directed the sanitary sewer system ⁴.

Temporary water use restrictions including banning of home auto washing is common during times of drought. Regulations have been instituted in some areas concerning the use of water. During the drought of 1990, the editors of the Los Angeles Times advocated banning home car washing and pointed out that automatic car washes can use recycled water. ²

The city of Chula Vista, CA is soon to be the first city in the United States to outlaw charity carwash functions to protect against oil and grease from reaching the storm sewers, which connect directly to the ocean. City ordinance calls for a penalty of \$1000 and up to a six month jail term against a property owner that allows an unregulated car wash. The cities of Tacoma and Olympia, WA are taking a different position by offering the free use of storm drain block kits to charities to bring car washing functions into compliance⁵. The Greater Vancouver (Canada) Sewerage and Drainage District does not mention charity carwashes in the regulations, but specifically allows home car washing water to be directed to storm sewer⁶.

All of the units installed to date are in Europe. In Spain and other countries where units are installed, installations must comply with both local and European Economic community (EEC) regulations. The Spanish regulations for water effluent discharges are set by:

- EEC regulations
- "Ley de Aguas". Ley 29/85. ("Law of Water". Law 29/85)
- "Reglamento de Dominio Público Hidráulico". RD 849/1986.

The above regulations set different effluent requirements depending on the location of the water discharge. These requirements are detailed in Table 2 below:

CONTAMINANT	MUNICIPAL SEWER	PUBLIC RIVER T-1	PUBLIC RIVER T-2	PUBLIC RIVER T-3
BOD5 (mg/l)	1000	300	60	40
COD (mg/l)	1750	500	200	160
OILS (mg/l)	100	40	25	20
SUSPENDED SOLIDS (mg/l)	1000	300	150	80
DETERGENTS (mg/l)		6	3	2
pH	6 - 9	5.5 - 9.5	5.5 - 9.5	5.5 - 9.5

Conditions T-1, T-2 and T-3 designate different river discharge classifications. Permits for discharging under the T-3 designation are less expensive than for T-2 or T-1 permits.

SYSTEMS USED FOR RECYCLING WATER

Systems for recycling carwash water range are often very simple settling pits designed simply to remove the large grit and bulk oil from the cars. A typical system consists of a three pit system with the first pit functioning as a grit and bulk oil removal device, the second pit functioning as a secondary oil removal device, and the third pit functioning as the suction chamber for the recycling pump⁷. A typical schematic is shown in Figure 1.

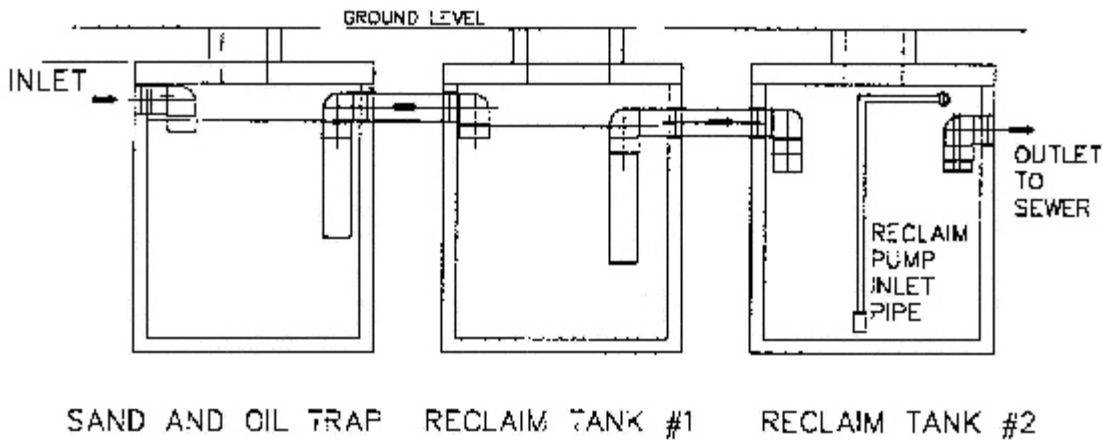


FIGURE 1
WATER RECLAIM SYSTEM WITHOUT COALESCING PLATES

Other recycling units make use of a small hydrocyclone to remove grit and sand and some units incorporate filtration to remove smaller particles⁸.

The cost of recycling equipment can range from \$10,000 to \$50,000 depending on the complexity of the system provided. This equipment is usually provided in cities with high water and/or sewer costs⁴.

DESIGN OF THE RECYCLING SYSTEM

General:

The system consists of a sludge decantation tank, a high efficiency multiple angle coalescing plate hydrocarbon separator, a stilling well and a compact recycling equipment skid. The recycling equipment skid includes a micronic filter for removal of very small solid particles as well as controls and an ozone generator for disinfection of the water. The sludge decantation tank is located below grade, but the hydrocarbon separator and the stilling well can be either above or below grade, depending on the demands of the site location. A system schematic for the underground design is provided as Figure 2. The above grade unit schematic is shown as Figure 3.

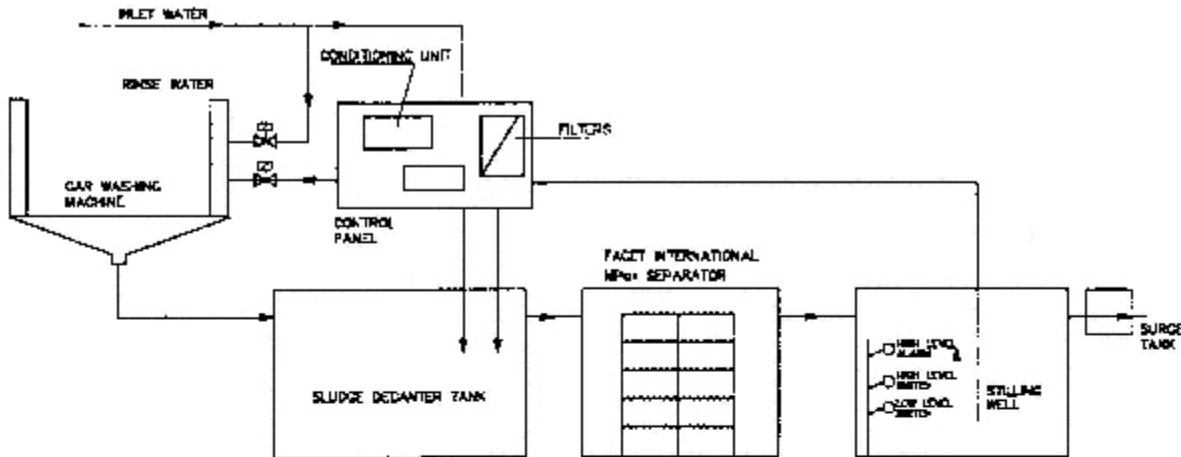


FIGURE 2: RECYCLING SYSTEM SCHEMATIC, UNDERGROUND DESIGN

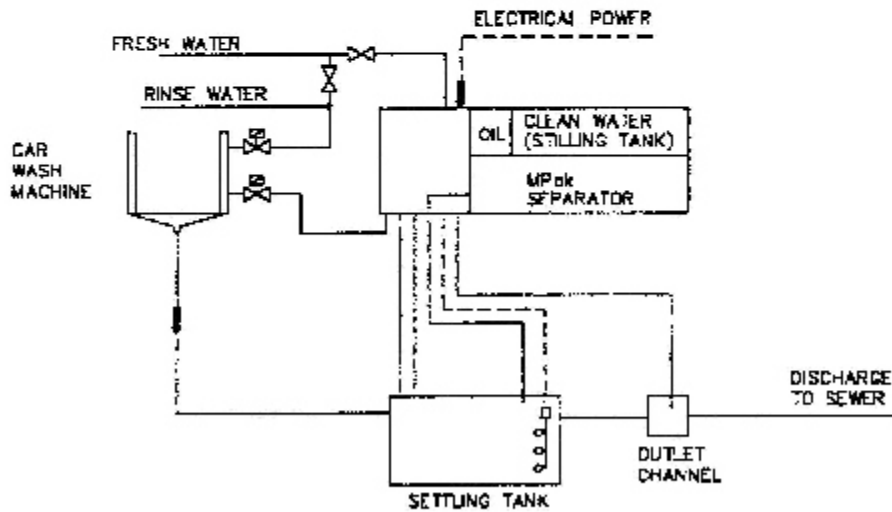


FIGURE 3: RECYCLING SYSTEM SCHEMATIC, ABOVE GROUND DESIGN

Operation and description:

The wash water from the car wash is collected and directed by gravity flow to the sludge decantation tank where the settleable solids precipitate.

From the sludge decantation tank, the wash water is directed to the multiple-angle plate hydrocarbon separator where droplets of lubricating oil and fuels are separated from the water and subsequently float to the surface. The separated hydrocarbons are automatically skimmed to a separate oil chamber for eventual recycling. Some solid particles which are too small to precipitate in the decantation tank where flow is not laminar will be precipitated by the coalescing plates and directed to the bottom of the hydrocarbon separator as a secondary sludge.

The multiple-angle coalescing plate separator is a passive gravity-flow system for the separation of oil from oil-water mixtures. The design utilizes the difference in specific gravities between oil and water (buoyancy force) enhanced by the use of coalescing plates. The coalescing plates are manufactured of an oleophilic (oil-loving) polypropylene material with calcium carbonate added for additional strength.

The oil in water from the car washing is the form of droplets of various sizes. The oily water flows horizontally through the spaces between the plates, following a sinusoidal path, flowing alternately upward and downward. The oil droplets rise due to their buoyancy, impinge on the undersides of the plates and are captured. (The droplet rise rate is governed by Stokes's Law.) As more and more droplets are captured, they coalesce into larger droplets and eventually form an oil film. Because the multiple-angle coalescing plates slope upward from every angle, this film then migrates upward along the surface of the plates to the oil ports, eventually collecting on the surface of the water.

The coalescing plates are securely held together by specially molded polypropylene supports and stainless steel rods. The supports provide the double benefit of holding the packs together as well as elevating them above the vessel floor, creating space for solids retention. In the above grade units troughs are provided under the packs for solids retention and withdrawal.

The plates are provided with oil ports, positioned uniformly throughout the width and length of the multiple-angle plates in vertical columns providing the coalesced droplets with direct access to the surface of the separator. This design allows for effective oil capture and its rapid release to the surface.

The upper surfaces of the plates constitute a solids removal system. In addition to the oil ports in the peaks of the plates, solids removal holes are provided in the valleys of the plates. Solid particles entering the packs settle on the upper sides of the plates, slide down to the solids removal holes and exit the bottom of the pack.

From the hydrocarbon separator, the water is directed to the stilling well. The stilling well is equipped with three float switches. These are a low-low level shutoff which turns the pump off when low level in the stilling well is reached, a low level switch which activates the water makeup (refilling) valve, and a high level switch that on high level opens the discharge valve to sewer.

The pump takes water from the stilling well and pumps it to the pressure chamber and from the pressure chamber to the other equipment on the recycling equipment skid. The pressure chamber acts as a surge tank for both pressure and volume surge reduction. From the pressure chamber, the water passes through the filters of the recycling equipment to the car washing machine at a pressure of between 60 and 90 psig (4 and 6 bars). When water is not required for washing, it is continuously circulated back to the sludge decantation tank to ensure against bacterial growth. The pump operates about 9 hours a day.

When the car wash machine is operating, water from the recycling equipment skid is directed through a water meter to the machine. The purified water from the recycling skid is directed to the recycled water

inlet on the car washing machine through an automatic ball valve. The washing machine utilizes purified recycled water for both the prewash and main washing water.

The final rinse is carried out with fresh water from the local water supply, taken directly by the washing machine through the fresh water valve. In the event that makeup is required, the low-low level switch will open the fresh water makeup valve and water will flow directly to the sludge tank. The water flow from the ozone generating circuit and filter emptying when this is done are also directed to the sludge tank.

The ozone is produced in the high frequency ozone generating unit which utilizes oxygen from the atmosphere, and injects the ozone into the water passing through the circuit. In the recycling unit the ozone is introduced into the water stream through a venturi eductor and metering system and then dissolved in the water. The ozone causes a polarization in the water molecules, which increases the ionic strength of the water, producing a very similar effect to that produced by flocculents.

The ozone oxidizes detergents, waxes and oils present in the water. These are separated, forming a sediment that settles in the sludge decantation tank, as well as a floating phase that is removed along with the hydrocarbons by the multiple angle separator system.

The use of ozone prevents the growth of anaerobic bacteria, which can cause odor problems with the recycled water. The purpose of treatment with ozone is to purify the water for reuse without requirement for chemical additives as flocculents, polyelectrolytes or bactericides.

The dosing of ozone is carried out through a special ball valve and metering system. Ozone dosing is continuous for 16-24 hours per day.

The final rinse is carried out with fresh water from the local water supply. This method also provides most of the water needed to makeup for water lost on the vehicles washed as well as by evaporation. When the water level in the stilling well reaches the maximum level, the high level switch opens a solenoid valve and excess water is dumped to the city sewer. A water meter is provided in this line to monitor sewer usage.

INITIAL TESTING

Initial testing conducted at the first site indicated that the solenoid valves sometimes need cleaning and different valves were provided that are easier to clean. It was found to be necessary to provide a trash basket for floating solids in the stilling well to protect the pumps and it was eventually found that aboveground pumps were more suitable to the application than submersible pumps.

OPERATING EXPERIENCE

The car wash water recycling unit design project began in January 1995 and the startup of the first unit was in September 1996. As of February 1999, 150 units of this type have been installed in four countries in Europe (Spain, Hungary, Austria and Portugal) at installations owned by major auto and oil companies as well as smaller companies.

Results of operations of the nine oldest units installed in Spain (each with more than two years operation) are shown in Table 3:

Water recycled to car wash machine	19,961 M3 / 5,3000,000 gallons
Number of filter set replacements	41
Water supplied per set of replacement elements	487 M3 / 129,000 gallons

Monthly analyses are made of the water supplied to the car washing machines as well as the overflow water to sewer. Averages of these analyses for two test units in Madrid, Spain are:

Table 4: Average Analytical Results	
Analysis	Result
BOD5	26 mg O2/L
COD	159 mg O2/L
Oils	2 mg/L
TSS	64 mg/L
Detergents	2 mg/L
pH	7

Analyses were performed according to international analytical protocols:

BOD5	UNE 77-003-89	COD	UNE 77-004-89
pH	Potentiometer	Oils	DIN 38409 Part 18
TSS	EPA 2540 B	Detergents	EPS 425.1

The combined experience with many systems indicates an average water reuse of 85% of the water. All pre-washing and main wash cycles are accomplished with recycled water. Only the final rinse is carried out with fresh water. Approximately 15% of the water used is makeup rinse water. The 15% of the water that is not reused leaves the car wash as drippings on the automobiles or is discharged as overflow to sewers.

The values of the effluent and recycled water characteristics meet all of the requirements of the most stringent regulation, that for rivers designated "T-3," and analyses indicate good overall performance. The quality of water supplied to the car washing machine is better than required for optimum performance.

The quantity of soap added to the car washing machine is substantially reduced. When the system is in use, soap use and therefore wastage is reduced approximately 70%. Organic loading on sewer plants due to oil and soaps from the car washing operations is therefore reduced as well.

MAINTENANCE REQUIRED

Because the separation process is purely physical, it does not require the use of absorbents or periodic replacement of reagents, or addition of other chemicals. The use of gravity to effect the primary separation of the oil, which is washed off of the automobiles and the grit from road dust, minimizes energy cost as well as maintenance requirements. Only one pump is required in the process, which simplifies maintenance and reduces the possibility of pump failure. In the event of pump failure, the car washing unit can be operated on city water pressure during repairs. The system is designed for fully automatic operation and does not normally require operator attention. The operator's only duties are to check that no warning lights are lit, indicating a failure, and to perform periodic cartridge changes.

When the differential pressure across the filter system increases to 20 psig (1.3 bar), it is necessary to change the filter cartridges. To change the cartridges, it is necessary to turn off the general switch in the control panel of the recycling unit. The automatic dump valve on the recycling unit then opens and the water in the filters is emptied into the sludge decantation tank.

FUTURE OF CAR WASHING

In many parts of the world, water shortages and restrictions on use are expected to continue or worsen as populations grow and resources are increasingly spread among more people and industries. Water recycling of all sorts will be utilized to decrease the stress on shrinking resources. Recycling water in car washing is ideal because it is only the dirt and road grime the car owners do not want – they have no interest in whether the water is reused or not. Balanced against the need to recycle water is the automobile owners wish to preserve their autos finish in the best possible condition. Recycled water containing grit of any size will cause deterioration of automotive finishes, and recycling the oil and grease washed off of the car's surface will defeat the purpose of the washing and leave cars looking less than clean. A study conducted by the Journal of Petroleum Marketing⁹ indicated that 23% of automatic carwash user's complaints concerned poor wash quality and another 31% of complaints concerned damage to vehicles. Of course, damage due to grit would not be immediately obvious, but would accrue over a number of washes. Damage to paint surfaces may not be obvious, but wearing of nozzles is often experienced. Worn nozzles due to pressure drop and grit in the water can cause excess water and detergent use³

It is therefore likely that the car wash of the future will utilize coalescing plate type oil separation equipment as well as micronic filters to remove even small dirt particles. Some system of disinfection will be required to avoid the sewer smell common in systems with bacterial contamination as well as to avoid allergic reactions among workers and the possible spread of disease. Disinfection systems will probably incorporate some form of oxidation such as hydrogen peroxide, oxygen, or ozone to avoid the use of chlorinated compounds, due to possible generation of organochlorine compounds such as chlorophenol¹⁰. The use of oxygen or oxygen compounds also avoids the hazards to personnel from the use of chlorine containing compounds such as sodium hypochlorite.

CONCLUSIONS

The use of water is constantly increasing in most parts of the world as populations grow. New water supplies are increasingly difficult and expensive to bring on line and environmental challenges to new supply projects are becoming more serious. Groundwater withdrawals are greater than recharge in many areas. All of these factors combine to decrease water supplies at the same time that other demands are increasing. One way to help alleviate this problem is increased conservation efforts of all types. Professional car washes, particularly automatic car washes are generally more conservative of water than home washing and car wash systems with recycling systems are even more conservative. The automotive public, however, wants a high quality wash at a reasonable price in pleasant surroundings, so a system that removes the damaging grit and particles from the water, recycles it for conservation, and sanitizes the recycled water for odor control is ideal for use in today's urban areas.

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