An Overview of U.S. Sweeping Equipment and Technology

This sweeping industry informational white paper was written by Ranger Kidwell-Ross, Editor of WorldSweeper.com, and Roger Sutherland, Vice-President of Pacific Water Resources, Inc.. Its intent is to assist U.S. and international sweeping industry professionals in reaching a better understanding of the differences between the major types of sweeping equipment being used in the American road sweeping marketplace. First, a brief overview is provided of some of the emerging concerns in the sweeping industry.

Since its inception, power sweeping has been used to remove what might be termed 'cosmetic' or 'political' debris from roadways and other paved surfaces. It has been so-called because of consensus that if a street looked clean, it was clean. Today, however, this reason for sweeping is undergoing significant re-appraisal by the U.S. Environmental Protection Agency (EPA), as well as by public works professionals and others throughout the country.

That's because recent studies have shown that more than 50% of heavy metals and other serious pollutants are attached to particles which are 60 microns in size and smaller (as a comparison, a human hair is about 70 microns in width), even though particles of this size compose a relatively insignificant amount of the total weight and volume of a typical sweeper's hopper load. It has been confirmed that even though a street may look clean (before or after being swept), there still may be a significant loading of small-micron, pollution-laden debris on it. From an environmental standpoint, it is exactly this material that it is most important to remove. A high level of increased emphasis, by the EPA and others, is now being placed upon the removal of small-micron debris as a Best Management Practice (BMP) for reducing storm water runoff pollution.

These small-micron particles are now seen to pose a significant environmental concern. That's because with rainfall they tend to run off into storm water systems as total suspended solids (TSS), or to get pounded into the air by passing cars (or blown into the air by wind) as fugitive dust (PM-10s).

Either way, these particles pose an environmental challenge. According to EPA estimates, 30,000 people in the U.S. are killed each year by pollutants attached to small-micron dust particles, and 1,000,000 more sustain serious lung impairment. And for pollutants such as zinc, which tend to become dissolved in water, there is not even any effective way to filter them out through sophisticated catch-basin or other storm water filtration technology.

On the following pages are brief overviews of the major types of sweeping equipment available, as well as examples of usage and applicability:

Mechanical Broom Sweepers

Mechanical broom sweeping technology may be likened to cleaning with a broom and a dustpan. For years, mechanical broom sweepers were the only machines that were used for road sweeping by municipalities and departments of transportation. Mechanical broom sweepers are still the primary machines in use by municipalities around the US.

Typically, these machines have a 'main broom' that runs transversely – from one side of the sweeper to the other – such that the broom bristles contact the paved surface the full width of the sweeper unit. The broom rotates in a clockwise fashion when viewed from the left side of the vehicle, and collected debris is swept onto some type of a conveyor belt for transfer to a containment hopper.

Mechanical broom machines may or may not be outfitted with a 'gutter broom' on one or both sides of the sweeper. Gutter brooms are relatively small (typically 36 to 50 inches in width), are located to the left, right, or both sides of the sweeper, and are primarily used to transfer debris from the gutterline into the path of the main broom. Even though mechanical sweepers are usually outfitted with a series of water spray nozzles, because they have no vacuum component, they still tend to create a substantial amount of dust in dry weather.

In recent times, it has been recognized that modern air sweepers have many advantages over mechanical broom sweepers for general road sweeping usage. One reason is that most mechanical sweepers only give the illusion of leaving a clean pavement surface. Although large debris is removed by mechanical broom sweepers, they are virtually ineffective at removing particles 60 microns and smaller. Studies have even shown that from an environmental standpoint mechanical broom sweepers may actually have a negative effect on the amount of storm water runoff pollution. This is because the action of the broom tends to break larger particles down into smaller ones, creating more small-micron particles than there were to start with. And, whenever debris pickup is via an elevator, rather than involving any type of air/suction action, a large amount of these small particles are left on the pavement's surface.

Any municipality with a fleet of mechanical broom sweepers should re-evaluate its street sweeping needs, given today's EPA requirements for reducing storm water runoff as part of its storm water management plan. Because modern regenerative air sweepers can remove a much higher percentage of the more highly polluted small-micron debris, material removal may be significantly improved by replacing current mechanical broom sweepers with regenerative air sweepers. The latter are also much less expensive to operate. However, especially for snowbelt areas of the US, initial spring sweeps may still have to be done by mechanical broom sweepers. However, some mechanical sweeper models are now available for use without dust suppression water.

Advantages: Mechanical broom sweepers remain the standard for sweeping extremely heavy or packed-down material such as road millings. This type of sweeper is also still required for 'spring cleanup' in snowbelt areas of the U.S. where a large amount of sand and other abrasives are put down in the winter as traction aids. Some mechanical sweeper models are now available for use without dust suppression water.

Disadvantages: A mechanical sweeper is a poor choice where environmental concerns exist about storm water pollution or air quality. Also, mechanical sweepers are significantly more expensive to maintain than comparable air sweepers, due to having so many moving parts (including continuous ground contact by main broom and mechanical movement by the elevator system). Because of the vast improvement in air-based sweepers in the last few years, they are now better suited for many types of general road sweeping.

Vacuum Sweepers

Vacuum sweepers may be compared to a household vacuum system. An engine powers a fan, which creates vacuum/suction. Typically, there is a suction inlet on one side of the sweeping head, and then the 'used' air is constantly exhausted during the sweeping process. Most vacuum sweepers do not have an air blast that transfers to the vacuum opening. Instead, they employ some type of broom system to brush debris toward the vacuum opening in the head.

Part of the impetus for the advent of vacuum sweepers was the recognition that the majority of debris, especially the heavy debris, collected within 36 inches of the curb line. Vacuum sweepers are designed to do an effective job of cleaning within that area. They may well be the current top choice for 'storm water runoff abatement sweeping' in areas where the majority of the debris is within 36" of the curbline.

However, in areas where cleaning the entire lane width via air is considered paramount, vacuum sweepers are probably not as effective as the 'blast and suction effect' of regenerative air sweeping technology. The blast force employed by regenerative air sweepers (see next section) cleans more thoroughly across the entire path of the sweeper.

A disadvantage of vacuum sweepers is that their windrow broom tends to fill pavement irregularities with debris that the suction effect isn't strong enough to remove. Vacuum machines also have more moving parts than comparable regenerative air sweepers, as well as smaller diameter curb brooms. As is illustrated in the next section, the regenerative air technology has become widely seen as having a number of advantages: cleaning a wider path, removing small particles better, and limiting the amount of dust-laden air that is exhausted back into the atmosphere.

Even though they typically use water-based dust suppression systems, traditional vacuum sweepers exhaust a high level of particulates into the atmosphere on a continual basis. As a result of the studies by the EPA and others, it is now known that these are pollutant-laden particles that pose a quantifiable hazard to human health and safety.

Another disadvantage to vacuum sweepers is their relatively small intake tubes. These are often as small as 8 inches in diameter, so they are more likely to become plugged with larger debris. Also, the sweeping width of vacuum sweepers is generally less (62 to 68 inches wide) than that of regenerative air sweepers (up to 90 inches wide).

Advantages: Thorough cleaning near the curb line. Less dust created than with mechanical broom sweepers. Fewer moving and wear parts than mechanical sweepers. Some models are now available for use without dust suppression water. Appear to do a more thorough job on uneven pavement over the (relatively narrow) width of the sweeping head itself.

Disadvantages: Because suction nozzle must be located on one side or the other of the sweeping head, vacuum sweepers cannot operate with both gutter brooms working. Suction tubes must be smaller than on regenerative air sweepers (generally 8 inches wide vs. as much as 14 inches on regeneratives), so vacuum sweepers can't handle as large of debris.

Regenerative Air Sweepers

Generally speaking, regenerative air systems are more environmentally friendly than are vacuum or mechanical broom sweepers. There are several factors that contribute to this.

Regenerative air sweepers employ a closed loop, 'cyclonic effect', to clean. They are similar to vacuum sweepers, in that there is a similar vacuum inlet located on one side of the sweeping head. Unlike vacuum machines, however, regenerative air sweepers constantly re-circulate (regenerate) their air supply internally. To accomplish this, the re-circulating air is blasted into the sweeping head on the side opposite the pickup, or inlet, tube.

Essentially, the air 'blasts' down onto the pavement on one side of the head, travels across the width of the head (gathering debris with it as it goes), and then travels up the pickup hose on the other side with the debris. Manufacturers design their sweeping heads so as to swirl the air, so it will retain the collected debris within the airstream as it moves from the blast to the intake side of the head.

Like any other sweeper type, regenerative air machines can be equipped with gutter brooms to brush material accumulated against the curb into the path of the sweeper. Regenerative air models, like any other type of sweeper designed to clean the entire lane, can be equipped with gutter brooms on both sides of the machine. This affords the operator the opportunity to effectively sweep both sides of a one-way street without creating a traffic hazard.

Because of the way they operate, regenerative air sweepers are recognized as providing a more thorough cleaning action – even though a vacuum system may be able to boast a greater airflow per horsepower. Because they 'air-blast' the pavement across the entire width of the sweeping head, regenerative air sweepers tend to do a better job of cleaning over the entire pavement surface covered and are recognized for this capability.

Although some air is lost by the regeneration process (due to unevenness of the pavement, which allows air to escape from under the sweeping head's rubber flaps, etc.), the amount of exhausted, pollutant-laden air is typically much less than with a vacuum sweeper. Because of this, and the fact that regenerative-based machines also tend to pick up the small micron particles across the entire sweeping head, regenerative air sweepers are usually a better choice where either air quality or storm water runoff pollution are concerns.

All standard regenerative air sweepers (excluding high-efficiency models discussed in the next section) have the means to introduce water into the vacuum intake on the curb side to help knock down the dust in the hopper. Plus, many believe the blast-and-pickup cycle of these machines also makes them more capable at picking up heavy debris, since the blast is more able to dislodge heavier materials and get them into the airflow. Due to fewer moving parts, none of which touch the pavement, a regenerative air machine is less expensive to maintain that the mechanical brush sweeper.

The blast-and-pickup cycle also makes these machines more capable at picking up heavy debris, since the blast is more able to dislodge heavier materials and get them into the airflow. However, it should be noted that some vacuum sweepers have been able to remove concrete chunks up to 8" in size as part of bridge deck reconstruction, for example. Plus pure vacuum machines have been shown to be the best choice in rejuvenating plugged porous pavement and the stronger the airflow the better the results.

However, regenerative air sweepers are also able to support larger intake tubes, so larger debris may be removed without clogging. This is especially important when sweeping material such as leaves.

Today's air machines, which include regenerative air and vacuum sweepers, are able to supplant mechanical broom sweepers for all but the most challenging applications. Several air machine models are now available with fugitive dust controls and these will be discussed in the next section. In most applications, they also are a better choice than are vacuum sweepers. Some models are now available for use without dust suppression water, as will be discussed in the following section.

Regenerative air sweepers are more suitable for most everyday road sweeping needs, and also cost significantly less to maintain. For these reasons, regenerative air sweeping equipment is now often being specified by U.S. governmental agencies that are involved in paying a portion of sweeping equipment being purchased.

Advantages: Best all around, multi-purpose sweeper. Can clean a wide range of debris in a large variety of situations. Work very well under routine street maintenance-type operations, for cities or contractors in their routine cleaning programs. Air system makes them better for leaves than mechanical broom sweepers, and larger intake hoses makes them better than vacuum sweepers for leaves. Fewer moving and wear parts than mechanical sweepers. Can be used to clean catch basins by adding hand hose. The sweeping industry's most multi-purpose machine. Some models are now available for use without dust suppression water.

Disadvantages: Can't handle millings, spring cleanup and other extremely heavy-duty applications as well as can mechanical sweepers. They use water for dust suppression, which leaves some dissolved small-micron debris in pavement cracks and on the surface. They exhaust some amount of particulates into the atmosphere.

High-Efficiency Sweepers

This is a relatively new technology that employs various fugitive dust loss controls. The roster of current high-efficiency sweepers includes a variety of different types of machines, including vacuum, regenerative air and one known mechanical broom machine, for example, to efficiently remove accumulated particulate material (PM) and associated organic material.

The key to the current definition of a high-efficiency sweeper is that these machines not only remove a high level accumulated material of all sizes (but especially small-micron material less than 60 microns) but are designed to control fugitive dust losses. This means they are designed to exhaust no visible fugitive dust and most are designed to sweep without water. Not having to deal with water is a huge plus in terms of time savings and fuel savings since water is heavy and adds to the machine's weigh that has to be transported.

The term high-efficiently sweeper was first coined by the author in 1997 to describe a brand new vacuum sweeping technology that employed a sophisticated filtration system for dust containment in combination with the use of both main and gutter brooms (Sutherland and Jelen, 1997). This high-efficiency vacuum sweeper (which is no longer in production) was developed by Enviro Whirl Technologies of Centralia, Illinois in 1995 and later acquired by Schwarze Industries of Huntsville, Alabama in 1999.

The EV-series machines that Schwarze then built and marketed based on the original Enviro Whirl design employed a unique self-cleaning filtration system that can filter 'dust' and only exhaust PM less than 2.5 microns. Fugitive dust control was not available at that time by any other sweeper in the nation. And since the EV-series fan operated only in filtered air with no debris or dust coming in contact with the blades, the manufacturer could provide a lifetime guarantee for the fan, which was unheard of at the time.

Tests showed that the pickup ability of the EV-series' sweeping technology surpassed even that of the regenerative air sweepers that were available at the time (Sutherland and Jelen, 1997). Because the EV used no water for dust suppression, and because it cleaned to a very small-micron level, these machines were ideal for any application where dangerous or toxic materials are present. This includes usage in industrial and manufacturing settings where material needs to be recycled, reused or securely contained and disposed of after pickup.

Unfortunately, the EV machines were much more expensive to purchase and the relatively unknown cost of maintenance remained a concern. More importantly, because they were mounted onto a tractor chassis instead of a truck chassis, their top non-sweeping speed of about 25 mph was seen as a huge disadvantage in the municipal sweeping marketplace especially for large cities. Schwarze no longer produces the EV machines and their only established market was as an industrial sweeper, for exclusive use on industrial sites where toxic and/or hazardous materials needed to be cleaned up and/or recycled. Historically that's where the vast majority of the extremely limited EV-series sales actually occurred.

However, the invention of the Enviro Whirl sweeper and its subsequent testing, in conjunction with the purchase of this technology in 1999 by Schwarze Industries, a major sweeper manufacturer, signaled to the power sweeping industry that air filtration systems needed to control fugitive dust losses and allow machines to sweep dry was the way of the future. Two other companies have subsequently responded with the development and release of several sweeper models that vie for the coveted label as a high-efficiency machine.

Elgin Sweeper Company of Elgin, Illinois, developed a patented dust suppression system with a powerful vacuum fan to create an airstream, main and side broom skirting for dust capture, and a long-life, low maintenance filter between the hopper and the vacuum fan.

These components together create a highly effective method for controlling fugitive dust generation that usually occurs during sweeping. This dust suppression system is also available for their mechanical sweeper called the "Eagle". In addition, Elgin just released another fugitive dust control system that is available on their regenerative air model called the "Crosswind NX". Real world pick-up performance testing of the waterless Eagle and the Crosswind NX conducted by Pacific Water Resources, Inc. in July 2008 verified that these sweepers provided excellent overall pick-up including small micron particles and did not create any observable fugitive dust losses (PWR, 2008). These are the underlying requirements for classification as a high efficiency sweeper.

Tymco of Wasco, Texas is another street sweeper manufacturer that has developed a dust suppression system available on two of its sweeper models which should qualify these models as high-efficiency machines. Tymco prides itself as the originator of regenerative air sweeping technology, which is the only type of sweepers they manufacture.

Two of their sweeper models (that is, “DST-4” and “DST-6”) currently have a dust control system. The system is a multi-pass cylindrical centrifugal dust separator that they claim provides for maximum particulate separation. The small amount of air that is diverted from the regenerative air system to achieve the dustless effect is filtered through TYMCO’s patented DST system. The DST system filters 90 percent of the diverted air through a pre-cleaner. The remaining 10 percent is filtered through cartridge filters. An intermittent air pulse cleans these filters automatically.

Schwarze Industries recently introduced a new waterless regenerative air sweeper called the “DXR” that employs a fugitive dust loss control technology that should qualify it as a high-efficiency machine. Schwarze claims that the DXR sweeper is a heavy-duty, chassis-mounted, dustless regenerative air sweeper with an 8 cubic yard hopper and its basic design has over 20 years of successful operation.

The DXR sweeper’s dust containment chamber is integral to the hopper and utilizes a series of cartridge filters that filter 100 percent of the air prior to insertion into the blower. Schwarze claims this design reduces overall wear to key components including the blower fan and sweeping head while providing dust control in the most extreme conditions. The sweeping head is also equipped with a suction side skid nozzle to further eliminate dust from becoming airborne. The sweeping head suction tube is equipped with suction hoses that are connected to the shrouded gutter brooms that provide additional dry dust control.

Closing Remarks

As early as 1997 the authors called for accurate street sweeper pick-up performance testing by an independent third party using realistic loadings and operational characteristics on a measured curbed test track with at least fair pavement conditions (Sutherland, 1997). What was envisioned then and still now is an independent “Consumer Reports” of all available street-sweeping models. This fair and unbiased information could be used by storm water and public works personnel throughout the nation for either acquisition purposes or the development of specifications for contract street-sweeping services.

This type of data is vital for storm water, air quality and public works personnel to change the focus of their sweeping programs from not only the removal of “cosmetic” debris but the effective removal of containments that continue to pollute our nation’s air and water. We believe it is time that the USEPA or another independent third party contributes the resources needed to make this dream a reality.

We invite your questions and comments...

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