THE THEORY OF EVAPORATION ENABLING THE DESIGN OF THE TURBOMISTER

In a natural environment such as a lake, only the top portion of the top layer of water droplets are exposed to the air, this allows natural evaporation to occur to that top layer of water.

Common sense dictates that natural evaporation can be accelerated by:

1.) Exposing more of the water droplets to the air.
2.) That increased evaporation will occur as more air is allowed to surround each individual droplet. It would follow that if a water droplet is exposed to the air, given enough time, that droplet would evaporate entirely, and that natural acceleration can be achieved by placing more water droplets into the air and keeping them suspended long enough for the natural evaporation to occur.

The Slimline theory to accelerate evaporation, is to mechanically expose more water to the air, and maintain those droplets aloft long enough to evaporate them naturally. To achieve this goal, our company designed a machine utilizing our turbine technology to produce airflow sufficient to accomplish this goal. We call our machine a Turbo-mist evaporator; it utilizes known technology to accelerate natural evaporation by doing just that, suspending a large quantity of water droplets into the air, and keeping them aloft long enough to enable nature to work. In our theory, this “hang time”, which is our reference to the time the water droplet is suspended in the air, is the essential ingredient in successfully accelerating natural evaporation.

The success of the Turbo-mist evaporator, is based upon its ability to use mechanical means to achieve sufficient “hang time” to let nature work, the simplicity of which allows man to use nature and the environment to clean up man made problems by simple evaporation, naturally, to a point where they became manageable by other means if necessary.
THE FACTS BEHIND THE THEORY

To show why we designed our evaporator as we did, I offer the following assumptions that are based upon tests completed at the Ohio State University and the extension department of Virginia Tech.

Fact #1: It is generally accepted that evaporation is effected by humidity, temperature and wind conditions. The greater the temperature, the less the humidity and the greater the wind conditions (which lengthen hang time), the greater the amount of evaporation. We have accepted these factors as truths.

Fact #2: The smaller the droplet size the faster it will evaporate and the greater the potential is for drift.

This bulletin is a 3-page report, which addresses nozzle orientation and droplet size. I will publish only portions of this report but the entire report is on the internet at http://ohioline.ag.ohio-state.edu/b816/b816_8.html.

See report results on the next page. Direct quotes from this report:

“Spray droplet size is by far the most important factor affecting drift. Spray droplet diameters are measured in micrometers. A micrometer is 1/25,000 of an inch and is usually referred to as a micron (Fig. 3). For reference, the thickness of a human hair or a sheet of paper is roughly 75 microns.”
In general the longer the droplets remain airborne, the greater the chances they are going to be carried by wind away from the application site. Small spray droplets are more susceptible to drift than the larger droplets because they tend to remain airborne much longer than the larger droplets.

Research shows there is a rapid decrease in the drift potential of droplets greater than about 150 or 200 microns. Droplet size where drift potential becomes insignificant depends on wind speeds, but lies in the range of 150 to 200 microns for wind speeds of 1 to 9 miles per hour (Bode, 1984). Small droplets can drift long distances because of their light weight. For instance, as shown in Fig. 5, the theoretical distances that water droplets would be carried while falling 10 feet in air having a uniform horizontal velocity of 3 miles per hour would be only about 8 feet for 400-micron droplets, but about 1,000 feet for 20-micron droplets.

Spray particles under 50 microns in diameter remain suspended in the air indefinitely or until they evaporate.
Fact #3 Based upon finding by Virginia Tech, we accept the following: A water droplet size of 150 microns will drop at 1.7 ft/sec, and take 16 seconds to evaporate, therefore it must fall 27.2 ft to evaporate. A water droplet of 100 microns will fall .91 ft/sec and take 7 seconds to evaporate, which is a drop of 6.37 ft. See chart of finding from their Internet site, http://www.vtpp.ext.vt.edu/psecenter/drift98vt/sld015.htm.
Fact #4 Supported by the following bulletin:

**Bulletin #816**

**Nozzle Orientation**

Orientation of nozzles is not critical for ground applications, but plays an important role in reducing drift from aircraft applications. When a nozzle is pointed backward toward the tail of the aircraft, larger droplets are produced (Fig. 9). The same nozzle produces medium droplets when pointed downward and smaller droplets when pointed into the air stream.

*Fig. 9. Nozzle orientation is critical with aircraft applications.*

We have assumed that since our application uses an axial flow fan to produce a wind speed of in excess of 100 mph exiting the top of our wind tunnel, the result is the same as an aircraft traveling at 100 mph, therefore by placing our nozzles at an angle, as we do, to the wind, we are shearing our water droplet size from a nozzle calibration using a teejet or Bete spiral jet TF6M nozzle, from a water droplet size average of 95 microns down to 65 microns. (Approximately 1/3 reduction)
CONCLUSIONS BASED UPON THESE FACTS

To successfully build a machine that will accelerate evaporation, we need to achieve a hang time of at least 20 seconds for a water droplet that is 180 microns.

We could achieve smaller water droplet sizes, however the tradeoff is drift, and many customers have the restriction of retaining all drift within a lined area, to comply with the EPA. In addition, our turbine has the capability of generating enough loft to produce an average hang time for water droplets in the range up 180 microns, thereby allowing good average returns on evaporation, of the total water droplets set aloft while restricting drift due to utilization of this droplet size, or larger.

If we wish to increase the overall percentage evaporated of the total pumped aloft, we can easily achieve this by reducing the nozzle size, thus the water droplet size, however, this not only increases the drift potential, but it in fact has diminishing returns, in that it reduces the overall output of a evaporator unit. That is, it is advantageous to evaporator 60% of 100 gallons per minute rather than 100% of 50 gallons per minute, unless other variables dictate the fall out is problematic.

Evaporator design configuration on the following page is based upon these conclusions; this machine was built from the ground up as an evaporator, with a specific goal, to accelerate natural evaporation.
The above diagram outlines the initial pattern for our standard calibration, which at 150 psi will pump 80 gallons per minute aloft.

The percentage evaporated, of the total pumped aloft, will vary greatly depending upon the temperature and relative humidity, and to a lesser extent by the wind speed, due to the fact, we generate our own wind speed of in excess of 100 mph.

Virginia Tech established a water droplet of 150 microns would have a terminal velocity of 1.7ft/sec. They also established that this size water droplet (150 microns) would evaporate in 16 seconds. These figures are from an average of results shown on slide 15 of 20, shown on a previous page, with conditions of 90 degrees F at 36% humidity as noted.

In the above configuration, the evaporator will put 100% of the water droplets above the elevation required to evaporate a droplet of 150 microns, which is 40 feet. Bete, one manufacturer of these nozzles, advice that with an average water droplet of 95 that 10% of the droplets would be above 160 micros, so an estimate of 15% of pumped will cannot evaporate, making your best case 85% efficiency in ideal conditions. As you can see, when variables change, the results will change, which make this more of an art than a science.
SUCCESS IS THE PROOF

To date we have sold and delivered over 600 units worldwide since the original prototypes were developed at Mascot mine (currently Barrick property) in Hedley, BC Canada.

Pictured below are before and after shots of the original project where the prototypes were developed.

1999  2003

Following is information regarding the design of the S30P turbomist evaporator.
THE TURBO-MIST EVAPORATOR
SPECIFICATIONS

OVERVIEW Model S24P Mini
This unit is a smaller (24 inch turbine) unit with less nozzles (20), capable of lower volumes only and can be utilized in smaller ponds where our standard large S30P cannot due to the pattern of spray. This mini unit is mounted on 3 wheels, and includes a 5 hp submersible pump to feed it at a rate of 40 gpm at 95 psi. This unit is less efficient than its larger brother due to the lower elevation of the spray pattern and the small volume pumped. Creates less drift and can be utilized in much smaller ponds.

THE STANDARD MINI will throw waste approximately 70 feet to an elevation of 30 feet
The S24P Mini is built in the same way to the same standards with the same material utilizing a smaller electric motor (25 HP custom built) and smaller turbine (24”) for smaller situations. The S24P mini can be ordered with a 5 hp submersible pump to feed it.
OVERVIEW Model S30P

The evaporator design incorporates our patented 30-inch diameter axial flow turbine, which we have used successfully for 35 years in our agriculture division. This proven turbine is connected by a elastomer type coupling to a custom built 40 horse power electric motor with dual inpro seals ™ and utilizes a 100,000 hour precision matched bearing system. This combination is mounted on a frame, which is designed to allow 360degree rotation at the base.

Our evaporator was designed from the ground up to be just that, an evaporator. This unit is not a snowmaker or a conversion from another application. The design maximizes efficiencies of airflow and maximizes evaporation thru shearing of water droplets in the air stream. The more droplets that can maintain “hang time”, meaning the time they are airborne, before falling back to the pond, the greater the evaporation rate, of the total amount pumped aloft, will be!

This product which now has over 500 installations worldwide, it is designed to operate 24 hours per day, 7 days a week, with a minimum of maintenance. To achieve this we generally over spec most features of the unit, to ensure the product exceeds expectations in use.
EVAPORATOR DESIGN FEATURES
SIZE OF S30P

The unit as shipped on a deck, without the crate, weighs 1575 lbs, if crated the unit requires 7 feet cubed, that is 7’ x 7’ x 7’.

When the stainless steel wind tunnel is attached to the turbine making the unit operational, this increases the size to 7’ x 7’ by 10’8”

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1. 3411 PLUS BUILT BY U.S. MOTORS, 40 HP 575 VOLT OR 480 VOLT
2. MAIN LIFT PONT, TOTAL WEIGHT APPROX 1550 LBS
3. DIA METER 3IP AXIAL FLOW TURBINE, STAINLESS STEEL HOUSING, ALUMINUM FAN
   FAN IS DYNAMICALLY BALANCED
4. STAINLESS STEEL AIR NOZZLE
5. WATER MANIFOLD, 36 NOZZLES, TOTAL GPM = 53.3 @ 200PSI, 80.7 @ 150PSI
   OTHER CALIBRATIONS AVAILABLE
6. CARBON STEEL STAND, LEGS ARE ADJUSTABLE, LEGS UP TO 10 FEET LONG AVAILABLE
LEGS:

- Our four-leg design allows for storage of the wind tunnel during shipment, or the ability to span objects that one might encounter in severe terrain.

- The legs are adjustable in length to allow for traverse ground, so the machine may be leveled for operations.

- The legs can be ordered with either spike feet (shore legs) for setting in soil or with flat plate feet (barge feet) for bolting to a barge or float or concentrate pad. Suggest 7' x 7' pad is sufficient for each machine.

- The adjustable legs are open on both ends so that they do not trap contaminated water in the legs.
FRAME:

The frame design allows the ability to rotate the unit in a 360 degree horizontal circle, which means it can be set up to avoid or take advantage of prevailing winds.

The 360-degree feature has 8 preset lock out positions to avoid rotation of the cannon accidentally.

A large bearing surface area, complete with grease inserts makes ease of rotation of the unit a one-person job.

The stand is constructed of 3/16 steel tubing members and cross braces which are completely sealed from outside contaminates, which is extremely important when operating in such a wet and corrosive environments.

The motor base was designed with the service mechanic in mind by locations of the highly visible grease ports in easily accessible exterior positions and requires no guards be removed for grease maintenance. The motor is supplied with purge port extensions, installed for easy accessibility and cleaning.
MOTOR MOUNT & COUPLING:

The motor utilized is a custom-built super hostile duty 40 horsepower electric motor, available in 230/460 volt or 575 volt models and naturally is CSA and UL approved.
The unit is custom designed with dual VBX inpro seals™ to make this unit as close to water tight as can be obtained on the market and is custom built for Slimline Manufacturing Ltd by US MOTORS. See section on motor for information.

The motor mount base is designed with push rods for alignment. Each unit has 8 separate push bolts, 4 for the actual motor and 4 for the turbine housing. This is to ensure that our alignment sequence of the motor and turbine are easily achievable during and after manufacture. The bearing mounting area in the turbine is machined to insure alignment during manufacture and maintenance.

The coupling manufacturer states the maximum parallel misalignment is 0.015 inches, angular misalignment is 0.025 inches. Slimline Manufacturing Ltd specs are tighter at parallel misalignment of .007” an angular misalignment of .010”. To ensure these specifications are met, each machine is quality inspected and the actual misalignments are recorded for each unit by serial number.

To ensure the unit is ready to go upon delivery, each unit is PDI at the factory, that is grease lines have been purged and bearings are greased correctly. Then each unit is run to full rpm and vibration analysis is done and recorded, before shipping.
Slimline Manufacturing Ltd has this motor custom built for use on our evaporator. The utilization of VBX inpro/seals in the motor make the unit virtually waterproof and allows it to operate in extreme conditions.

This Premium Efficient 841 Plus Motor is remanufactured for Slimline Manufacturing Limited to new exacting standards. This severe duty motor originally developed for applications in petro-chemical, pulp and paper plants. It has been specially adapted for the use in the Turbo-mist Evaporator, the dual inpro seal system and the upgrading of all exterior joints is crucial in the success of the evaporator durability.

The 841 plus exceeds IEEE 841, Espact “92” and NRCan efficiency legislation has been brought to a new level of severe applications standards. The following is just of few of the standards features of the Slimline 841 Plus:

-841+Exceeds IEEE 841, Exceeds EPACT “92” and NRCan efficiency Legislation.
-Fully complies with NEMA MG-1 Part 31 specifications for INVERTER DUTY
- MOTORS 1.15SF on sine wave power (1.0 SF on inverter power)
-40 C ambient NEMA design B, Class F insulation.
-Class B rise at full load on sine wave, Regreasable bearing, and internal bearing.
EVAPORATOR MOTOR INFORMATION CONTINUED

- All grease ports have been extended for simplicity of greasing.
- All grease clean outs have been extended for easy access.
- Suitable for 10:1 variable torque and 5:1 constant torque on inverter power.
- Precision balanced rotors to -<0.08 in/sec vibration, <0.005 in foot flatness form mounting hole to mounting hole. Conduit boxes twice NEMA volume standards. All cast iron construction.
- Paint withstands 250 hr. salt spray test.
- Inpro Seals on both drive and non-drive ends.
- In EXTREME DUTY SITUATIONS an optional 302 stainless steel shaft is available.

THE FOLLOWING IS ACTUAL LOADED FAN OPERATING DATA

<table>
<thead>
<tr>
<th>AMP FACTOR</th>
<th>KW</th>
<th>POWER VOLT</th>
<th>KVA CODE</th>
<th>EFFICIENCY @</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>10.45</td>
<td>.99</td>
<td>450</td>
<td>G</td>
</tr>
</tbody>
</table>

In the three phase motors we utilize this translates to 17 kilowatts of power per hour.

POWER CONSUMPTION

<table>
<thead>
<tr>
<th>POWER RATE (cents/hr.)</th>
<th>5.0</th>
<th>8.0</th>
<th>10.0</th>
<th>12.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOURLY RUN COST</td>
<td>.85</td>
<td>1.36</td>
<td>1.70</td>
<td>2.04</td>
</tr>
<tr>
<td>COST/24 HR DAY</td>
<td>$20.40</td>
<td>$32.64</td>
<td>$40.80</td>
<td>$48.96</td>
</tr>
</tbody>
</table>

All test data was recorded at 1200 feet above sea level at 40 degree F, by independent service agency. Chart recorder data available upon request.

SWITCH GEAR SUPPLIED WITH ALL MOTORS
TURBINE & FAN ASSEMBLY:

• The cast aluminum fan and air diffuser nozzle has been coated with a special anticorrosive powder. Each fan is precision balanced to within ½ mill and is machined to within 50 thousands clearance of the turbine housing, which is extremely important to insure maximum efficiency.

• Stainless air straighteners, direct the air to the fan, allowing the fan to maximize every cubic foot of air and minimize horsepower.

• The intake is protected by ½ inch solid round screen to keep objects out of the turbine, but allow for maximum intake efficiency.

• Two (2) stainless steel covers have been installed, one covers the motor to redirect any water falling on the motor, the other over the coupling unit and turbine input shaft, keeps the water off the shaft but allows visual inspection of this area.

• Each unit is equipped with a center lifting point to ease movement of the unit at the site by forklift or crane.
WIND TUNNEL & MANIFOLD

The wind tunnel, constructed of type 304 stainless steel, is easily adjusted to allow variable heights and loft to give control to the operator to ensure fallout is retained in the required containment area within the liner, if necessary.

A quick detachable 100 percent stainless steel water nozzle ring, with 30 stainless steel nozzles, give us the ability to vary the output rate to meet the customer pumping requirements.

Each unit is shipped with a hanger support unit, which can be utilized for positioning the evaporator wind tunnel on site without danger that the unit could fall off and enables one man to adjust the direction of the tunnel. (OSHA Compliant)

WIND TUNNEL DIRECTONAL ABILITY

The wind tunnel can be adjusted to accommodate prevailing winds or a combination of units on a float, to ensure containment by fallback within the liner.
Every unit sold, goes into different operating circumstances, that is, each of our customers have their own special requirements, related to their own special problems.

*Scotchkote™ 134_-Fusion bonded epoxy coating (powder coating)*

This product has been tested for over 165 chemicals, for resistance. In each case the coating has been tested for over two (2) years at 73 degrees F, with no effects shown. If you have a special problem, contact us for the complete list of chemicals tested to see if we can solve your problem.

**THIS IS OUR STANDARD FINISH**

Some situations call for extra protection from the solution being evaporated.

Our standard evaporator has a type 304 stainless steel turbines and wind tunnel, in addition to all stainless steel bolts and stainless steel hoods.

For more aggressive environments, we offer, for an additional cost the following choices:

- Type 316 stainless steel construction. Type 904 stainless steel construction.
WATER ATOMIZER MANIFOLD

Slimline Manufacturing Ltd offers two different types of nozzles in the same manifold layout. Each type of nozzle has pros and cons and the type of solution being pumped will likely be the determining factor in making a choice for your project.

The Teflon spiral nozzle: Option # 1010

Advantages: Smallest water droplet – average 65 microns after air shear effect Less likely to clog due to design Less likely to scale in many solutions due to Teflon One piece nozzle & ease of replacement.

Disadvantages: Cost – this is an industrial product and has limited volumes

The Stainless Steel disc and core hollow cone nozzle system: option # 1020

Advantages: Cost – we can source this product through agricultural sources and because of the high volume are inexpensive in comparison to spiral industrial nozzles.

Disadvantage: Multiple pieces, very easy to confuse when replacing. Each nozzle consists of a disc and core, which fits inside a nozzle body and has a cap to hold it together. If incorrectly reinstalled efficiency is affected. In scaling type solutions, stainless steel is more likely to scale then Teflon.

Please note the output on these two nozzles are identical, the initial cost on a unit is only a difference of $100.00 so the deciding factor in choosing which option is best for your solution, is the water quality and catch basin size.

The output for either nozzle is 66 gallons per minute at 100 psi, 80 gallons per minute at 150 psi. We can provide large nozzles that increase volume pumped aloft, however it is our opinion that this volume results in the most efficient evaporation. We are available for discussion and explanation on this point, at the factory during office hours.

Spray system Spiraljet hollow cone flow rates

<table>
<thead>
<tr>
<th>Size</th>
<th>Angle</th>
<th>Size 100 PSI</th>
<th>150 PSI</th>
<th>200 PSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>90 degrees</td>
<td>2.2</td>
<td>2.69</td>
<td>3.11</td>
</tr>
</tbody>
</table>
OPERATING NOISE LEVEL OF THE
S30P EVAPORATOR

EVAPORATOR SOUND TEST  Technician: Gordon Spelay  Test date: February 16, 1999
Location: AC Motor Electric, Penticton, BC  Weather conditions: Overcast and calm  Meter: No. 33-2055

<table>
<thead>
<tr>
<th>Distance from the evaporator in feet</th>
<th>Readings in db’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ft</td>
<td>99db</td>
</tr>
<tr>
<td>5 ft</td>
<td>98db</td>
</tr>
<tr>
<td>25 ft</td>
<td>93db</td>
</tr>
<tr>
<td>50 ft</td>
<td>89db</td>
</tr>
<tr>
<td>75 ft</td>
<td>85db</td>
</tr>
<tr>
<td>100 ft</td>
<td>75db</td>
</tr>
<tr>
<td>200 ft</td>
<td>65db</td>
</tr>
</tbody>
</table>

NOTES

1 Test site was flat and unobstructed.
2 Test readings were also taken from behind surrounding buildings at a distance of approximately 150 feet. These reading ranged from 65 Db to 75 db.
3 Normal speech pattern will register between 65-70 db’s.
SURE-FLO SELF CLEANING FILTERS

These filters are built from PVC and stainless steel to withstand various solutions. The design utilizes high performance plastic wheels and wheel bushings, special drive cleaning nozzles provide a flat, wide hard-hitting uniform spray pattern. Flow controlling entry ports prevent hot spots on the screen, all fasteners are Stainless Steel.

Screens that revolve, past stationary internal nozzles, blows debris off the screen. They are built to last with low coefficient of friction, high mechanical strength, UV light resistant and very low moisture absorption.

The model we have chosen for use in our pumping package for one unit is a dual drive unit, model number SCS3-DD-SS which has a capacity of 190 gpm and requires 15 gpm to operate. The perforated Stainless Steel screen (.117” Perf.) 16ga. 316 SS, is 6 inches high by 10 ½ inches wide with an overall height of 15 ½ inches. This type of filter requires a minimum of 55 psi to operate. The package will include a stainless steel foot valve with loss of prime warning and a manual-priming pump.

Pictured below is the model SCS4-DD-SS often utilized by Slimline Mfg for multiple unit installs.
HOSES & CONNECTORS

When providing a pumping package, the hose supplied from the pump to the evaporator unit is GOODYEAR FABCHEM TRANSFER HOSE

GOODYEAR FABCHEM TRANSFER HOSE

This product is a state of the art chemical transfer hose that will handle up to 98% of all known chemicals. Its slightly corrugated cover permits extra flexibility and ease of handling on site.

It is a lightweight hose that is highly resistant to kinking, weathering and abrasion. This product can safely be steam cleaned without affecting performance.

The temperature range of Fabchem transfer hose is –40 degrees C (-40 F) to 66 degrees C or 150 degrees F.

Construction: Tube, smooth, clear plyocin. Cover: slightly corrugated green wrapped EPDM. Reinforcement Synthetic fabric with two wire helix.

Normal size used unless sources differently for specific purpose will by inside diameter of 2 inches, outside diameter of 2.44 inches.

This product has a working pressure of 200 PSI, bend radius of 6 inches, and Weighs .94 lbs per foot. The standard price per foot in excess of 100 ft would be $18.07 US per foot. This price is subject to change.

If you have questions about our design, please contact sales at 1 800 495 6145