Final Report

Polymer Bead Laundry

Prepared for: Sothern California Gas

Prepared by: Western Cooling Efficiency Center

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ABSTRACT

According to manufacturers' estimates, commercial laundries use significant amounts of gas. It is estimated that commercial laundries in the US use 440,000 therms of gas daily for heating water used in the laundry cycle. The polymer bead technology developed by Xeros significantly reduces the use of water by partially filling the drum with polymer beads. These beads, due to their ability to agitate, attract, and transport stains and soil away from textile surfaces, are claimed (by the manufacturer) to reduce water heating by 47% and water use by 72% when compared to standard laundry washers.

The WCEC performed a year long field study that monitored the performance of the Xeros laundry machines in real world operations. The study was conducted at a local athletic club. The study found that the Xeros laundry machine reduces water consumption by roughly 60%. Additionally, it found that energy savings, primarily due to not needing hot water, were roughly 87% when measured on a source energy basis. Significant cost advantages were also found, especially when used for high volume laundry operations.

TABLE OF CONTENTS

Technology

About the Technology

Polymer bead laundry (PBL) technology is an innovative approach to washing laundry. The technology uses millions of small polymer beads, about the size of a pebble, that augment the cleaning process and reduce the total water needed to complete a typical wash cycle. Due to the beads' inert absorption properties, they are able to remove stains, dyes, and soils from fabrics more effectively than water alone. After the wash cycle, an extraction cycle removes the beads from the laundry and returns them to a storage hopper. The beads can be used for hundreds of washes before they need to be replaced. The hopper is also periodically refilled with new beads to make up for the inevitable loss of some beads due to incomplete extraction. The beads are fully recyclable and the manufacturer typically takes care of the replacement, recycling and disposal processes. Polymer bead laundry technology is claimed to greatly cut down on cold and hot water usage when compared to a typical washing machine.

About the Xeros Models

Xeros invented the PBL laundry process and currently offers a single commercial model, the XSL5025, which it markets to hospitality, dry cleaning, industrial, and fitness facilities. The company is exploring an entry into the domestic laundry market; however, challenges with the non-uniformity of the domestic laundry and the low volume make this a more difficult application to design for. The commercial model can handle 60 lbs. of dry laundry and completes a full cycle in roughly 45 minutes.

Field Testing

A polymer bead laundry system built by Xeros was evaluated in the field to determine the potential energy and water savings that this equipment might have over more traditional laundry equipment. The field-testing started in December of 2013 and has been on-going.

Equipment

Baseline System

Figure 1 – Baseline Machine

The baseline system was a commercial laundry machine manufactured by Unimac. The test site used one of these machines to wash towels comparable to those washed in the tested system. Laundry equipment similar to this is typical and representative of machines currently in use.

Product Name	Unimac Industrial Washer Extractor – 65lb Capacity
Product Serial Number	3090343272
Product Manufacturer	Uni-Mac
Date of Purchase/Installation	March 2009

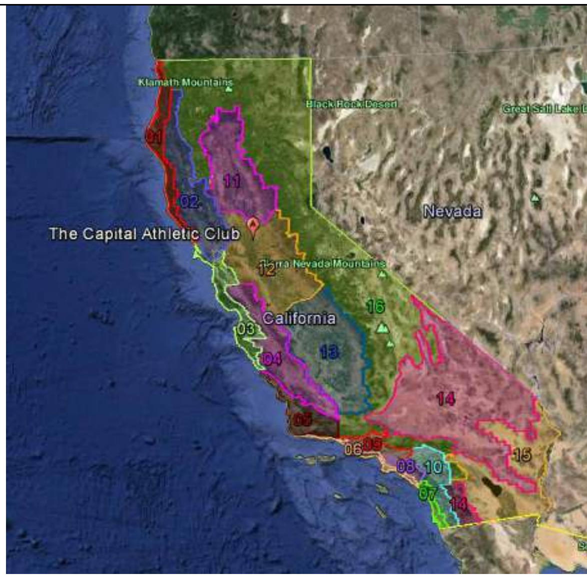
Retrofit System

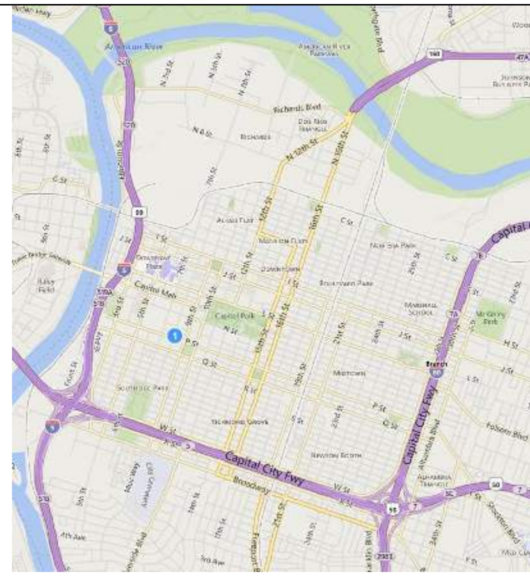
Figure 2 – Xeros Retrofit Machine

The retrofit system was a commercial laundry machine manufactured by Xeros. This system incorporates a unique washing cycle that includes thousands of polymer beads. The manufacturer claims energy and water savings can be achieved through the use of this system. However, the system is not suitable for all laundry purposes and is most applicable to high volumes of laundry that do not contain pockets, folds, or other features that might trap the polymer beads. Items such as towels, sheets, and coveralls are good candidates for this system.

Product Name	Xeros Washing Machine – 60lb Capacity
Product Serial Number	XSL5025
Product Manufacturer	Xeros
Date of Purchase/Installation	November 2013

Field Test Site





The host site chosen was the Capital Athletic Club in Sacramento, California. The Capital Athletic Club was opened in 1985 and offers state-of-the-art equipment, educated and trained instructors, personal amenities and other services in downtown Sacramento. The club is over 52,000 square feet and includes multiple fitness rooms, a pool, a sauna, a steam room and racquetball courts.

The facility cleans its own laundry on-site, which consists primarily of towels used by patrons of the facility and, to a lesser extent, clothing and uniforms of the staff. Towels are ideal for cleaning with the Xeros system, as they contain no pockets or folds that may trap beads.

The baseline system, tested system, and dryers are all located in a laundry room on the main floor of the site. The laundry is separated before cleaning so that towels used by patrons during exercise and after showering are cleaned in the baseline and tested machine. More complex laundry, such as employee uniforms, and any laundry that needs to be separated into mesh bags is washed in the third machine that was not included in testing. Both streams of laundry are dried in the same machines.

Instrumentation and Monitoring Plan

The baseline and tested systems were monitored to determine the usage profile and the amount of electrical energy, cold water, and hot water that each consumes. The hot and cold water temperatures were also be measured so that embodied energy in the hot water can be estimated.

Instrumentation

Table 1 – Baseline Monitoring Point list

Mesurment Point Name	Description	Units	Device Name	Accuracy
Timestamp	Time			
B_Unit_Energy (kWh)	Cumulative energy	kWh	Dent Power Scout	± 1%
B_Unit_True_Power (kW)	Active power	kW	Dent Power Scout	± 1%
B_Unit_REACT_Power (kVA)	Apparent power	kVA	Dent Power Scout	± 1%
B_Unit_pF_L1	Powerfactor L1	PF	Dent Power Scout	± 1%
B_Unit_pF_L2	Powerfactor L2	PF	Dent Power Scout	± 1%
B_Unit_pF_L3	Powerfactor L3	PF	Dent Power Scout	± 1%
B_Unit_L1_Current (A)	Current L1	A	Dent Power Scout	± 1%
B_Unit_L2_Current (A)	Current L2	A	Dent Power Scout	± 1%
B_Unit_L3_Current (A)	Current L3	A	Dent Power Scout	± 1%
B_Unit_L1_POT (V)	Voltage L1	V	Dent Power Scout	± 1%
B_Unit_L2_POT (V)	Voltage L2	V	Dent Power Scout	± 1%
B_Unit_L3_POT (V)	Voltage L3	V	Dent Power Scout	± 1%
Hot_Water_Flow (gal)	Hot water consumption	gal	OMEGA FTB 4105 A P	± 1.5%
Cold_Water_Flow (gal)	Cold water consumption	gal	OMEGA FTB 4105 A P	± 1.5%
Hot_Water_Temp (F)	Hot water temperature	F	Omega TH-44000	± 0.36 °F
Cold_Water_Temp (F)	Cold water temperature	F	Omega TH-44000	± 0.36 °F
Dryer_Status	Dryer active	V		
Air_Comp_Status	Air compressor active	V		

Table 2 – Retrofit Monitoring Point list

Label	Description	Units	Sensor	Accuracy
Timestamp	Time			
Xeros_Energy (kWh)	Cumulative energy	kWh	Dent Power Scout	± 1%
Xeros_True_Power (kW)	Active power	kW	Dent Power Scout	± 1%
Xeros_REACT_Power (kVA)	Apparent power	kVA	Dent Power Scout	± 1%
Xeros_pF_L1	Powerfactor L1	PF	Dent Power Scout	± 1%
Xeros_pF_L2	Powerfactor L2	PF	Dent Power Scout	± 1%
Xeros_pF_L3	Powerfactor L3	PF	Dent Power Scout	± 1%
Xeros_L1_Current (A)	Current L1	A	Dent Power Scout	± 1%
Xeros_L2_Current (A)	Current L2	A	Dent Power Scout	± 1%
Xeros_L3_Current (A)	Current L3	A	Dent Power Scout	± 1%
Xeros_L1_POT (V)	Voltage L1	V	Dent Power Scout	± 1%
Xeros_L2_POT (V)	Voltage L2	V	Dent Power Scout	± 1%
Xeros_L3_POT (V)	Voltage L3	V	Dent Power Scout	± 1%
Water_Flow (gal)	Cold water consumption	gal	OMEGA FTB 4105 A P	± 1.5%
Water_Temp (F)	Cold water temperature	F	Omega TH-44000	± 0.36 °F
Dryer_Status	Dryer active	Boolean		
Air_Comp_Status	Air compressor active	Boolean		

Other Data Collection

Table 3 – Survey Data Point list

Mesurment Point Name	Description	Units	Device Name	Accuracy
Time	Time of Wash	time		
LoadWeight_pre	Before Wash (lb.)	lbs	UWE APM-60	± .05
LoadWeight_post	After Wash (lb.)	lbs	UWE APM-60	± .05
LoadWeight_final	After Dry (lb.)	lbs	UWE APM-60	± .05

Calculations and Results Reporting

Load Sizes

Measurement of the load sizes is important in determining energy and water consumption values per unit pound of laundry and will be useful for comparing the results of the baseline and tested units to each other. Measurements of the weight of every load washed over the course of the study is impractical; therefore, a sample of loads over a sufficient period of time were measured in order to establish an average load size for each machine.

Electrical Consumption

The electricity consumed by each machine is reported by direct measurement of voltage and current delivered to the machines. Power consumption for the dryer is not monitored and was sampled during the testing period to determine a representative consumption per cycle. The drying machines are basic and operate by drying clothes at a single power setting for a set period of time. The operational state of the dryer is monitored in order to estimate the electrical energy usage for drying.

Water Consumption

Both hot and cold water consumption for each machine is measured using a high accuracy totalizing flow meter. The flow is totaled over each period of measurement and recorded. The consumption information is used to determine when the machines are operated and also as part of the energy consumption calculations.

Hot Water Energy Calculation

In addition to water consumption information, the temperature of inlet cold water and hot water are used to make estimations for the energy needed to heat the water that is used by each machine. This calculation is made by estimating a temperature for the daily cold water temperature and a daily hot water set point.

Equation 1

$$\dot{q} = \dot{m} c_p (T_{Hsetpoint} - T_C)$$

Post-Wash Clothing Water Content

Estimations were made for post-wash water retention by each machine to better understand the amount of energy required to dry the clothing. Lower water retention within a load implies less energy needed for drying. This was achieved by weighing the laundry at various points in the process. The laundry was first weighed before it entered the washing machine, then after it left the washing machine, and finally after removal from the dryer. The amount of water retained after washing was calculated using Equation 2.

Equation 2

$$m_{retained} = m_{postwash} - m_{postdry}$$

System Performance and Cost

	Baseline		Xeros	
	Average Load Size	41.8	Average Load Size	59.6
Load Stats	Average Loads / day	12.1	Average Loads / day	6.6
	Average Lbs / day	**503.9**	**Average Lbs / day**	**394.6**

Figure 3 – Load Statistics

The data for the polymer bead laundry system was collected over a period from January 2014 to February 2015. Data was reduced and metrics were developed that compared the machines on a per pound of dry laundry basis. The statistics for the usage of each machine is shown in Figure 3.

	Baseline		Xeros	
Fixed Costs				
Fixed Costs	Purchase Price	$13,000.00	Yearly Lease	$11,700.00
	Yearly Machine Amortized Cost (3% for 12 years)	$1,291.35	Deposit	$2,500.00
			Borrowing Costs on Deposit (3%)	$75.00
Total Yearly Fixed Costs		**$1,291.35**		**$11,775.00**
Variable Costs				
Electical	Electricity / 1000 lb. (kWh)	9.8	Electricity / 1000 lb. (kWh)	20.1
	Electricity Cost ($ / kWh)	$0.12	Electricity Cost ($ / kWh)	$0.12
	Electricity Cost / 1000 lbs.	**$1.17**	**Electrical Cost / 1000 lbs.**	**$2.42**
Water + Sewage	Water Cost / 1000 gal	$2.55	Water Cost / 1000 gal	$2.55
	Water Used / lb Laundry (gal)	1.55	Water Used / lb Laundry (gal)	0.64
	Water Cost / 1000 lbs.	**$3.96**	**Water Cost / 1000 lbs.**	**$1.64**
Gas	Gas Cost ($ / Therm)	$1.00	Gas Cost ($ / Therm)	$1.00
	Hot Water (gal / 1000 lbs)	1233	N/A	
	Gas Use / 1000 lbs. (therm)	12.8		
	Gas Cost / 1000 lbs.	**$12.80**		
Chemical	**Chemical Cost / 1000 lbs.**	**$14.88**	**Included In Yearly Lease**	
Maintenance	Yealy Maintenance Cost	$350.00	**Included In Yearly Lease**	
	/ 1000 lbs	**$1.90**		
Total Variable Costs / 1000 lbs.		**$34.71**		**$4.06**

Figure 4 – Cost and Resource Analysis

Consumption Analysis

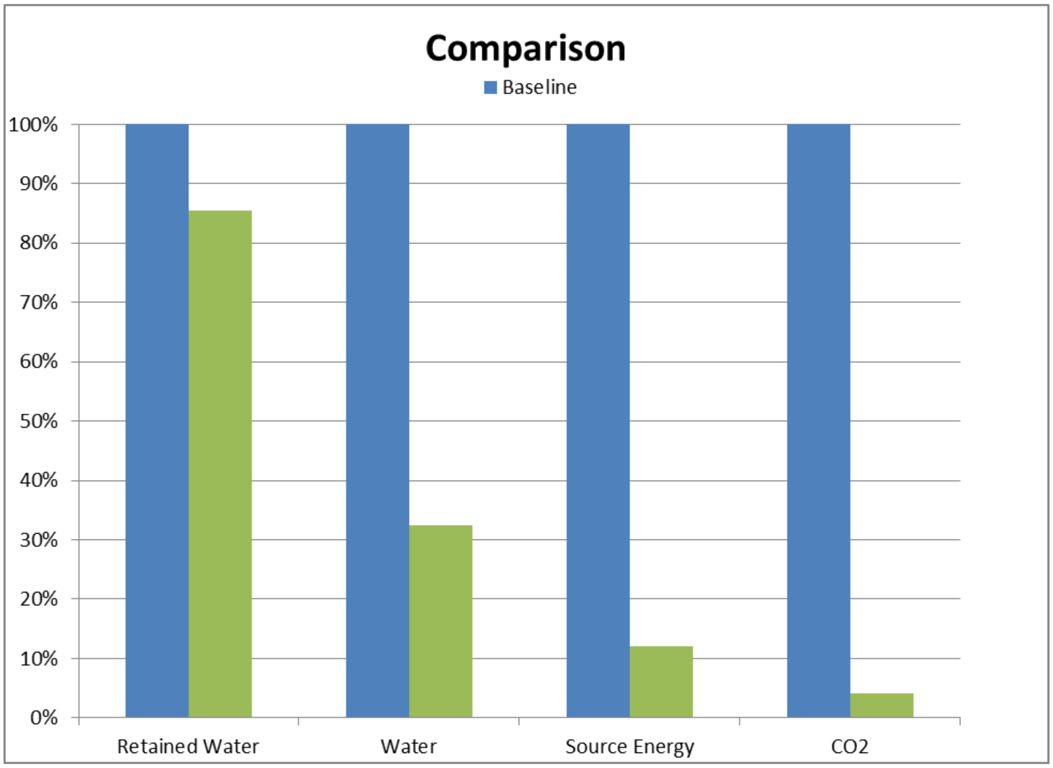


Figure 5 – Resource Usage

Retained Water

The amount of water retained by the clothing at the end of the wash cycle was measured for both the baseline and the tested machine. It was found that the Xeros laundry retained roughly 15% less water than the baseline machine. This indicates that laundry washed in the Xeros machine has the potential to use less dryer energy if dried in a machine that can carefully measure clothing moisture and stop the drying cycle when complete. While it is clear that less retained water should translate to less dryer energy, it is unclear that 15% less water retained translates directly into 15% less dryer energy. The actual relationship may not be a linear correlation and might be an interesting question to explore further.

Water

Water usage of the Xeros machine was found to be roughly 68% less than water usage for the baseline machine. This is close to the manufacturer specification and the field study clearly supports this claim. This metric is a combined hot and cold water consumption metric.

Source Energy

On a source energy basis, the Xeros machine used roughly 88% less energy than the baseline unit. The primary reason for this energy reduction was that the baseline unit used hot water while the Xeros machine did not. Inspection of Figure 4 actually shows that the Xeros machine uses over double the electrical energy as the baseline unit; however, this is far outweighed by the hot water usage of the baseline unit.

Carbon Footprint

Due to the elimination of hot water in its wash cycle, the Xeros machine's carbon dioxide production is only about 4% of the baseline unit.

Life Cycle Cost Analysis

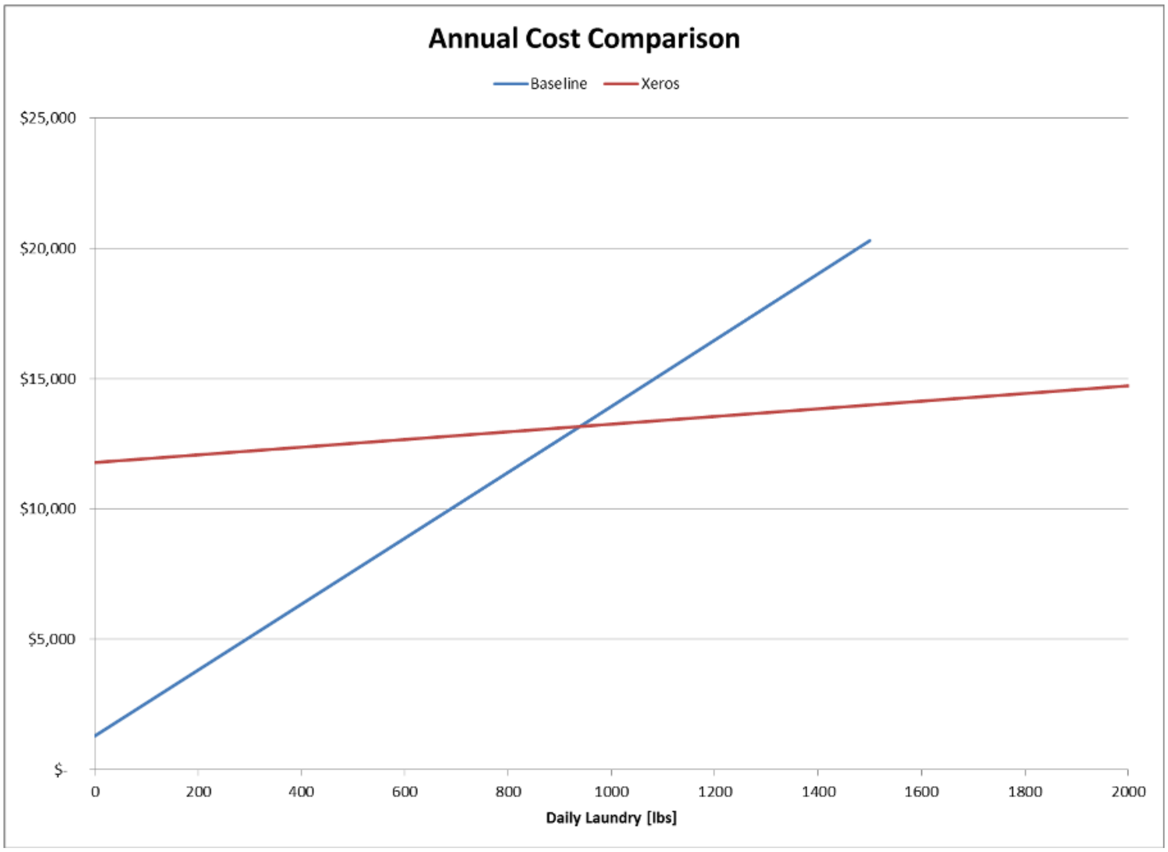


Figure 6 – Cost Analysis (Site Specific)

An analysis was performed to estimate the life cycle costs associated with operating each machine. Using the results shown in Figure 4, the cost of processing laundry in each machine was calculated. Figure 6 illustrates the circumstances at which the Xeros machine costs are less than the baseline machine. It can be seen that even though the Xeros machines fixed yearly costs are higher, the cost of operation per unit of laundry is much lower. This is indicated by the small slope of the Xeros line as compared to the steep slope of the baseline machine line.

Conclusions

Conclusions

The Xeros polymer bead laundry system has shown impressive savings in terms of water usage, source energy consumed, and carbon emissions. This field test monitored a unit that used no hot water and this change alone accounted for much of the impressive energy savings. The Xeros machine clearly uses more electricity than the baseline washing machine. However, even if hot water were used in this machine, it would still show impressive savings due to the fact that it uses only about 1/3 as much water as a conventional machine.

In addition to the direct savings that the Xeros machine has demonstrated, it was also shown that it removed roughly 15% more water from the clothing than the baseline technology. It is clear that with the proper drying equipment this reduction in water will result in less dryer energy used. However, it is unclear as to whether this 15% reduction in retained water will yield a direct 15% reduction in dryer energy.

In use, subjective comparisons of the wash quality to the comparison baseline unit showed no change, or even perhaps some improvement from the Xeros wash system. Even with the reduction in water, the wash quality appears to be unchanged or improved.

The Xeros wash system can, by most measures, be considered a success. Water is becoming an increasingly relevant issue in California and a laundry system that can achieve impressive reductions in its use deserves a closer look.

APPENDIX I

Baseline Machine Specs

UW SERIES HARDMOUNT WASHER-EXTRACTORS 45-65 LB – UNILINC™ CONTROL

SPECIFICATIONS		UW45	UW65		
Control Options		UniLinc™	UniLinc™		
Capacity - lb (kg)		45 (20)	65 (30)		
Cylinder Diameter - in (mm)		31 (787)	31 (787)		
Cylinder Depth - in (mm)		16.5 (419)	22 (559)		
Cylinder Volume - cu. ft. (liters)		7.3 (207)	9.7 (275)		
Height - in (mm)		64.63 (1642)	64.63 (1642)		
Width - in (mm)		34.12 (867)	34.12 (867)		
Depth - in (mm)		44.33 (1126)	49.83 (1266)		
Door Opening Size - in (mm)		17.8 (452)	17.8 (452)		
Door Bottom to Floor - in (mm)		28.09 (713)	28.09 (713)		
Motor Size - HP (kW)		5 (3.7)	5 (3.7)		
Total # of Speeds		V Sp	L Sp	M Sp	V Sp
		9	5	6	9
Cylinder Speed - RPM (G-Force)	Gentle	30 (0.4)	30 (0.4)	30 (0.4)	30 (0.4)
	Wash	42 (.78)	42 (.78)	42 (.78)	42 (.78)
	Distribution	75 (2.5)	75 (2.5)	75 (2.5)	75 (2.5)
	Very Low	248 (27)	248 (27)	248 (27)	248 (27)
	Low	477 (100)	477 (100)	477 (100)	477 (100)
	Medium	674 (200)	–	674 (200)	674 (200)
	High	754 (250)	–	–	754 (250)
	Very High	826 (300)	–	–	826 (300)
	Ultra High	954 (400)	–	–	954 (400)
Drain Diameter - in (mm)		3 (76)	3 (76)		
Steam Connection (Optional) - in (mm)		1/2 (13)	1/2 (13)		
Water Inlet Connection - in (mm)		4 @ 3/4 (19)	4 @ 3/4 (19)		
Shipping Dimensions	Width - in (mm)	37.2 (945)	37.2 (945)		
	Depth - in (mm)	53.8 (1370)	53.8 (1370)		
	Height - in (mm)	65 (1650)	65 (1650)		
Net Weight - lb (kg)		1020 (463)	1060 (481)		
Standard Shipping Weight - lb (kg)		1065 (483)	1105 (501)		
Slat Crate Shipping Weight - lb (kg)		1190 (540)	1230 (558)		
Agency Approvals		ETL, CE	ETL, CE		

To learn more, or to find a distributor in your area, visit UNIMAC.COM

Alliance Laundry Systems - Shepard St, Ripon WI 54971 - 1.800.587.5458

Consult your UniMac® distributor for details. For the most accurate information, the installation guide should be used for all design and construction purposes. Due to continuous product improvements, design and specifications subject to change without notice. The quality management systems at Alliance Laundry Systems' Ripon facility has been registered to ISO 9001:2008.

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Figure 7

Tested Machine Specs

The Power of Polymer Cleaning®

Introducing the Xeros XSL5025 Open Pocket Polymer Washing Machine

Equipment Features:

- Patented polymer washing system provides superior cleaning performance at a fraction of the cost
- HMi touch screen and customized software allows for simple, intuitive operation
- Powerful data capturing capabilities for tracking productivity and utility consumption
- Multiple water configurations to accommodate the widest array of laundry applications

Model:	XSL5025
Capacity	60 pounds
Cylinder Size	39" x 26"
Cubic Content	17.9 cu. ft.
Water Inlets (2)	1.5" NPT
Drain	3.5" O.D.
Drive System	Inverter
High Extract	Up to 800RPM
G-Force	Up to 350 G
Extract Motor	10 h.p.
Circuit Breaker	30 amp
Control	Touch Screen
Programs	50
Features	Custom Reporting
Dimensions:	
Width	47.2"
Depth	57.1"
Height	73.0"
Net Weight	3,968 lbs.
Shipping Weight	4,070 lbs.

Standard voltage is 480/3/50. Consult Xeros for other available electrical voltages.

Figure 8