Sculpey® Packaging Integration for Cost Reduction

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Abstract

Polyform Products Company manufactures a variety of polymer clay products that are used by a diverse set of customers and which can be permanently hardened by heating in a conventional household oven rather than in a kiln. The clay is currently extruded, cut, and wrapped in a primarily manual and decoupled process that results in excess labor costs of $123,406 per year. Polyform Products wishes to introduce appropriate automation to reduce labor costs by integrating the extrusion, cutting, weighing, and wrapping processes. The 1-ounce bar was selected as the highest volume product which could yield the greatest savings. The project team calculated a total budget of $307,000 with a 2-year payback period. The project team has also been in contact with multiple domestic and international vendors to inquire about potential equipment that could integrate the process. A couple of solutions have been proposed including utilizing and integrating new equipment and finding a new cutting machine and wrapping machine that could be retrofitted to the current extruders. Once specific machinery is identified and quoted by vendors, the project team will perform economic analysis in order to reach conclusions that can then be used to provide recommendations to Polyform Products Company.

Keywords:

Extrusion

Cutting

Wrapping

Weighing

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1) Introduction

Polyform Products Company is the largest domestic manufacturer and marketer of oven-baked polymer clays (See Figure 1). Since its founding in the 1940s, Polyform Products inspires new ideas with innovative Sculpey® products for beginners to advanced clay users. Sculpey® is differentiated from other clays due to its ability to be hardened by heating in a typical household oven, which allows the product to be marketed to a wide variety of customers and makes it perfect for crafting. Polyform markets its products both domestically and internationally. Most of the products are distributed through major retailers such as Michaels, Target, Walmart, Joann's, Dick Blick, and AC Moore.

Figure 1: 12 piece kit of 1-ounce bars of Sculpey®.

Currently, the processes to extrude, cut, and wrap the polymer clay are labor intensive and decoupled. The extrusion and cutting (See Figure 2) processes are done manually before weighing and placing the bars on pallets to harden for 1-2 weeks. Hardening is done to prevent deformation to clay caused by material handling throughout the packaging process. Once hardened, the clay is then taken to the wrapping machine where an employee places each individual bar into the machine to be wrapped (See Figure 3) in a die-fold or a fin seal (See Figures 4 and 5 respectively).

Figure 2: Clay in the process of being extruded. Also seen is the wire cutter, noted by the white arrow.

The lack of integration and the large amount of manual handling in the packaging process has led to high labor costs. The manual process has also led to losses from overweight bars being sold, as well as from damage to the clay due to the required re-extrusion of underweight and deformed bars. Polyform Products has expressed that the high turnover rate for their temporary employees and increasing minimum wages across Illinois will only exacerbate the issue of high labor costs. Additionally, current wrapping machines are obsolete, and the manufacturer, who also provides machine maintenance, is closing their business.

Figure 3: The wrapping process for a die-fold wrap.

Figure 4: An example of a die-fold wrap.

Figure 5: An example of a fin seal wrapper.

2) Problem Statement

Polyform Products Company desires to integrate the extrusion, cutting, and wrapping processes in order to save on costs that fall under a variety of cost categories.

Scope of Work

1. Analyze all costs, production times, and all process parameters and quality characteristics related to the extrusion, cutting, and wrapping process.
2. Develop and determine the best wrapping/packaging scenarios to facilitate cost-effective integration with the extruding and cutting processes by researching alternatives and working with potential vendors. The solutions must allow for the use of current outer packaging such as the boxes for the kits. The focus will be on reducing costs related to labor and material handling, and consumable material savings. Part of the consumable material savings will be due to tightening the overweight tolerance.
3. Focus the solution and analysis on the highest-volume 1-ounce bars with the intention of expanding the solution to other Sculpey® products in the future. This expansion will ultimately be implemented in phases based on bar size and production volume.
4. Ensure that the solution maintains the quality of the product by reducing material handling and shearing during the extrusion process and cutting processes. Weighing the bars after cutting must also be done to ensure that all the bars meet minimum weight standards and stay within a desired tolerance of less than 5% for the maximum weight.

Deliverables

1. Detailed report of possible integration solutions, including vendor information.
2. Data, figures, and a thorough economic analysis of each viable solution.
3. Recommendations for the best solution based on our economic analysis and ease of use.

3) Team Objectives

1. **Analyze current extrusion, cutting, and wrapping processes.** Knowledge of the entirety of the packaging process must be acquired. This includes identifying both critical and unnecessary portions of the operation. These non-value-added steps are the primary factors guiding the project team to the conclusion and recommendations.

2. **Determine economic and other constraints.** Constraints like budget, weight tolerances, and ease of operation for the employees must be determined in order to effectively research solutions.
3. **Research potential vendors and solutions.** Research from vendors, trade journals, articles, and engineering texts must be completed in order to discern the best possible solutions to the problem at hand through benchmarking.
4. **Compare the viable alternatives and perform economic analysis.** The potential alternatives must be compared with one another so that the project team can accurately identify the best solution for Polyform Products Company. The alternatives will be analyzed on an economic basis with the requirement that ultimate solution fits within a 2-year payback period.
5. **Generate conclusions.** The project team will formulate a summary of solutions and analysis, including the economic benefits and any other relevant decision criteria.
6. **Provide recommendations.** A strategy for implementation will be recommended based upon previous conclusions and financial analysis.

4) Initial Analysis

4.1) The Current Packaging Process

4.1.1) Extruding and Cutting

Figure 6: This is the view of the inside of the hopper with the shovel used to pick up the clay laying to the right of the

Once the mixing and aging process has been completed and the clay has passed quality inspections, the clay is ready to be extruded, cut, and wrapped. First, the clay is dumped from their bins onto a large piece of cardboard. An employee takes small chunks of clay and places them into the hopper of the running extruder (See Figure 6). Polyform Products Company has multiple extruders and augers which are listed in Appendix A. An example of a max uninterrupted extrusion rate for an extruder is detailed in Table 1. Due to the start-

and-stop nature of the current process, Polyform Products Company is only extruding 93.75lbs/hour of clay.

Table 1: Extrusion Rate of Black Premo 1-Ounce Bars

Input (lbs)	Run Length (min)	lbs/hr
82	2	2460

The employee then manually pulls and guides the clay out of the extruder (See Figure 7) and aligns the clay onto the cutting board. Once aligned, the employee will then use the harp to cut the clay into the desired size (See Figure 8 and Figure 9). The wires on the harp are fixed and do not change. The employee then weighs about three of the bars from each cut, usually from the ends and the middle to ensure that the bars are not underweight or outside of a [0, 0.1] weight tolerance in ounces. If the bars are underweight, Polyform Products Company will be fined, and if the bars are too far overweight, they are too costly. Overweight and underweight bars are put back into the hopper to be extruded again. The worker would change the speed that they are pulling and guiding the clay out of the extruder based on whether the clay was overweight or underweight.

Figure 7: Here an operator pulls the clay out of the extruder to the end of the cutting board.

Figure 8: The operator pulls down the cutting wires to cut the clay into the correct sized bars.

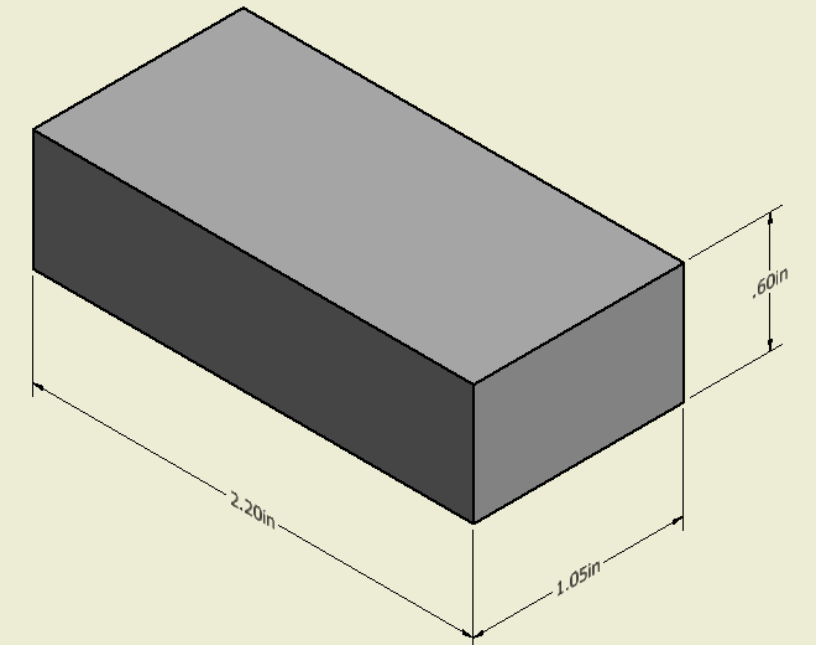


Figure 9: This is a schematic of the 1-ounce bar. Volume = (2.20x1.05x0.60) = 1.39 in^3. The density of the 1-ounce bars is then: Density = Weight/Volume = (1.00 ounce)/(1.39 in^3) = .723 ounce/in^3.

The clay is easily deformed by the employees picking and placing the bars into the wrapping machine when it is too soft (See Figure 10). After the bars are extruded and cut to the correct weights, they are stacked onto a pallet in layers divided by paper or film. Then the pallet is stored for about one to two weeks to harden before being wrapped. Hardening is necessary to prevent damage due to handling in the wrapping process. The hardening process reduces these deformities caused by the material handling inherent in Polyform's current process.

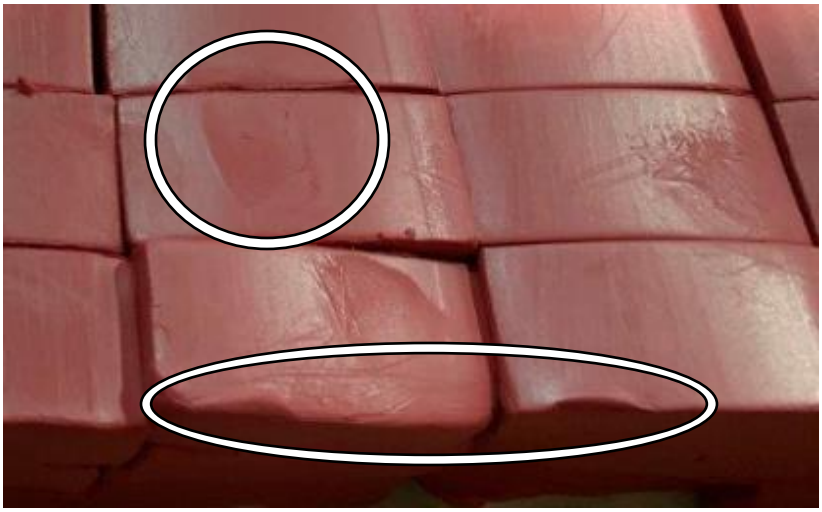


Figure 10: This image shows finger prints and dents in the clay caused when transferring the clay from the cutting boards onto the pallets.

4.1.2) Wrapping

There are two main wrapping processes currently in use at Polyform Products Company. The first process results in a die-fold style wrap (See Figure 4) and is used for many of their products including the 1-ounce bars. An employee individually places each bar in a slot that is fed into the wrapping apparatus. Once wrapped, the bars fall off the assembly line into a large cardboard box. The other wrapping process results in a fin-seal wrap (See Figure 5). First, a small cardstock is placed down to prevent the clay from sticking to the line. Then the clay is placed on top of the cardstock where it is pushed into the wrapping machine and wrapped (See Figure 11).

Figure 11: The clay is being placed by the operator and is pushed along the line.

4.2) Downtime Analysis

Because there are so many colors, a lot of downtime is spent cleaning the extruders and wrappers so that the next color can be processed. All that needs to be done when switching between different sizes of the same colored bar is that the die needs to be switched out or a

different extruder can be used. Normally, there are about 2-3 color changeovers per extruder per day and each changeover takes approximately 25 minutes for the cleanout and change of die.

Currently, there are two wrappers using clear film for the 1-ounce bars with one operating full time and the other only operating half of the time. The color changeover for the wrapping machines occurs 4 times per day per wrapper without a film change. Every changeover takes about 15 minutes on average to clean. Three wrappers are used for the 2-ounce bars with two running for printed film and third one running for clear film. For the clear film wrapper, there are 4 color changeovers per day which take 15 minutes each time. The changeover frequency for the printed film wrapping machines is also 4 times per day per wrapper, but each changeover for these machines takes approximately 20 minutes to clean and change the film (See Table 2).

Table 2: Changeover Summary per Day

Job		Number of Equipment	Changeover Frequency	Activity	Downtime (min)
Extruding		5 Extruders	2-3 changeovers per extruder per day	Cleanout & Change of Die	25
Wrapping	Clear Film Wrapping	3 Wrappers	4 times per wrapper per day	Cleanout	15
	Printed Film Wrapping	2 Wrappers	4 times per wrapper per day	Cleanout	15
				Change film and new boxes	5

4.3) Initial Analysis of Conclusions

There are two main areas of concern related to Polyform Products Company's current packaging process.

1) The most significant issue with the current process is the excessive amount of labor and manual material handling.
    a) The excess labor for 1-ounce bars is currently the biggest cost at $123,406 per year. The state of Illinois has recently passed a law to increase the minimum wage to $15 per hour by 2025, which will only serve to increase

the future cost of labor. There are positions, like that of the employee who places the bars into the slots in the wrapping machine, that could be eliminated by simply feeding the bars directly into wrapping after cutting and extruding (See Figure 12).

b) The production rate could increase with system integration which would reduce the number of hours that employees would be required to work assuming that the same amount of clay were produced.

c) There are inconsistencies that arise from the manual extrusion of the clay. If the weight is outside of the set tolerance, it can simply be put back in the hopper, but there are slight changes to the material properties caused by the shearing of the auger.

d) Additionally, this rework slows down production and ultimately increases labor costs.

2) The second problem is the impending obsolescence of the die-fold wrapping machine.

a) The current manufacturer and source of maintenance for that machine is closing their business. As a result, it will become increasingly difficult and potentially impossible to continue to maintain the machine. The machine must be replaced.

b) The machines are also limited to certain bar sizes and cannot be used for all the bars. This limits flexibility in production planning and prevents the company from being able to run certain bar sizes on the machines even if the machines are not currently in use.

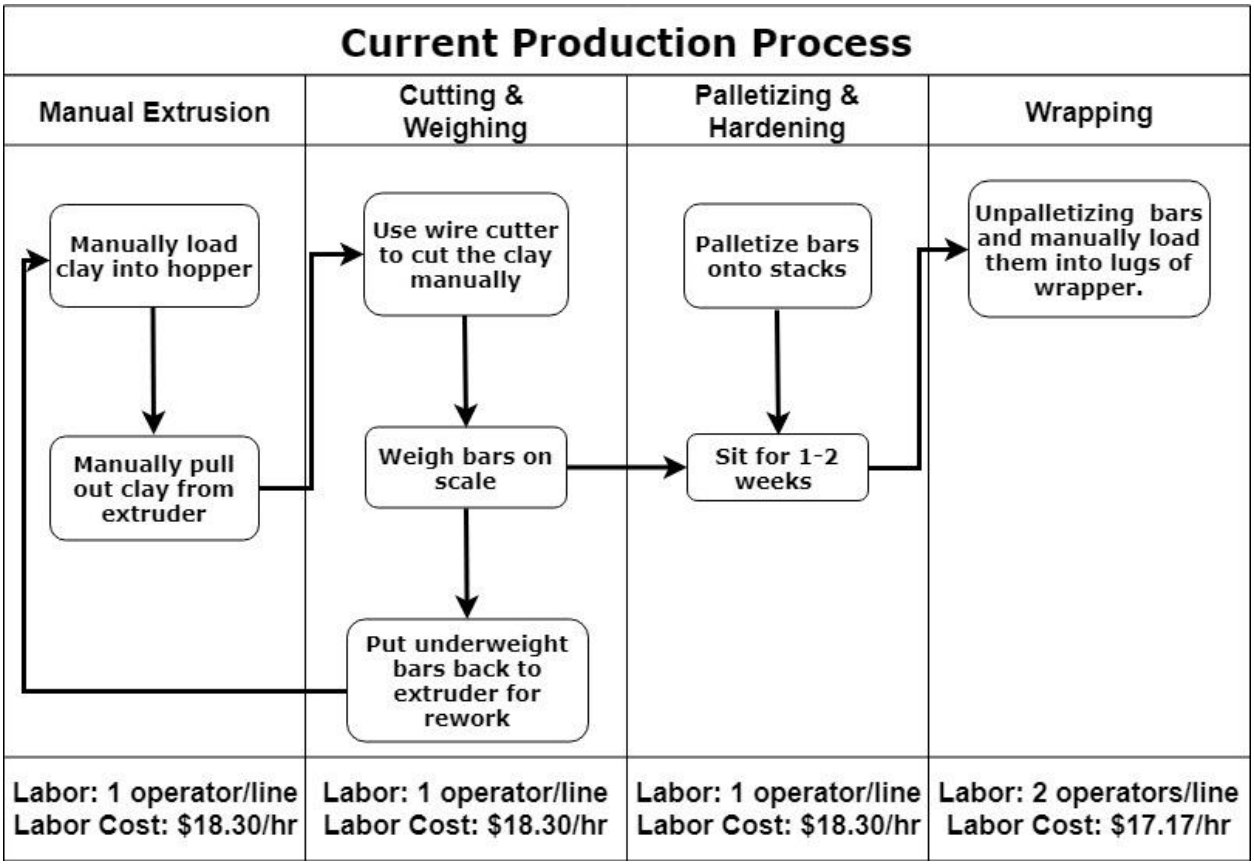


Figure 12: This is a chart detailing the current process. After weighing, if the bars are underweight or too overweight, they are placed back in the hopper to be re-extruded. If the bars are the correct weight, they move on to the palletizing and hardening stage. Currently, one employee is running the extrusion, cutting, and weighing processes. A separate employee puts the hardened clay into the wrapping machine. By integrating the process, these positions could be combined into one employee who feeds the hopper.

4.4) Initial Economic Analysis

Integrating the current packaging process can save Polyform Products Company a total of about $154,000 each year. These costs are a result of the following factors:

1) Excess Labor: $123,406.09

   The excess labor cost is derived from employee wages and hours worked in non-essential processes like the palletizing and hardening stage.

2) Overweight 1-ounce Clay Bars: $27,945.65

   This is the yearly cost of the excess clay being packaged and sold outside of the target tolerance [0, .05]. The average weight of the 1-ounce bars in 2018 was 1.1

ounces, but the company desires the tightened tolerance so that the average weight is 1.05 ounces. The current cost per year of this excess .05 ounces of clay is nearly $28,000.

3) Film Scrap: $2,434.07

This is the annual cost of 30% of the cost of excess film from the wrapping process.

Utilizing a payback period of 2 years, the project team has concluded that the total budget is $307,000.

4.5) Roadmap to Future Work

To reduce production costs and maximize efficiency, the project team has chosen to take the following course of action:

1) Eliminate the Palletizing and Hardening stage and go directly from cutting and weighing to wrapping.
2) Focus on solutions that can be applied to other bar sizes in the future.
3) Research many vendors and ensure that the machinery is within budget and has the necessary features.

5) Process and Machinery Research

5.1) Ultrasonic Cutting Technique

Ultrasonic cutting can be utilized to replace the standard cutting wire or blade. It creates microscopic vibrations between 20 and 40 Hz in the blade which cuts through objects with very little applied pressure. The Ultrasonic cutting system is ideal for cutting sticky products since its advantages include high cutting precision and easy cleaning. Additionally, testing at Polyform Products Company showed that even the stickier Premo clays barely stick to the blade. Ultrasonic cutting technique is widely used in the industrial sector and has great potential in improving manufacturing efficiency.

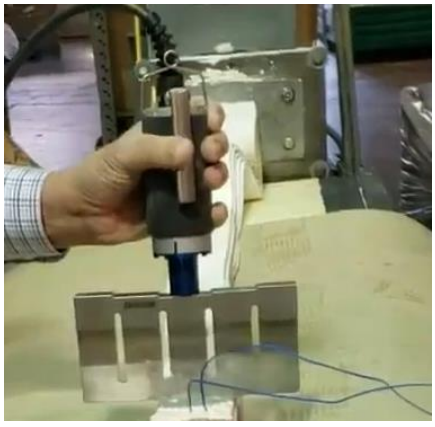


Figure 13: This image shows the handheld version of the Dukane Ultrasonic Blade being used to cut clay at Polyform Products Company. The blue wires are being used to measure any temperature changes in the clay.

Dukane provides ultrasonic cutting horn blade with iQ ultrasonic probe systems. The testing results from the experiment at Polyform Products Company indicates a several-degree increase in the surface temperature of the clay but no significant change in the clay property in both the short and the long term (See Figure 13). The cutting blade can be easily cleaned with wet towels. In order to implement the ultrasonic cutting technique, a cutting station is also required to integrate the in-line cutter with extruder system. This cutting station would need to be supplied by a separate vendor than Dukane.

5.2) In-Motion Checkweighing System

In order to tighten the tolerance of clay bar weight and remove underweight or significantly overweight bars, the project team recommends an in-motion check weighing system, also known as in-line checkweigher or in-line scale. A typical in-line check weighing system consists of three belts: an infeed belt that change the speed of the products for weighing, a weigh belt that weighs the products and records data, and a reject belt that removes out-of-tolerance products (See FIGURE 14).

A&D is a checkweigher vendor which has performed tests on Polyform Product Company's clay products. A dual flipper system is used to kick out rejected clay bars and a blinker signals whether the product is out of tolerance. The test results showed that the bars over 1.05 ounces were successfully rejected, and the data was stored for further analysis.

Figure 14: This is a photo of the A&D checkweigher. Currently a 1-ounce bar is going down the line, and its weight here is displayed in grams.

5.3) Flow Wrapping Machine

The flow wrapping machine, also known as a fin-seal wrapping machine, is a widely used wrapping technique in the manufacturing industry. Flow wrapping is a horizontal-motion process in which products are wrapped in clear or printed film. In order to ensure the wrapping machine does not wrap an empty space after the out-of-tolerance clay bars are kicked out in the check weighing station, the flow wrapping machine needs to have "No product, No bag" technique where the wrapping machine skips the space when no

products flow through. The implementation of flow wrapping machines can be used to expand to the manufacturing process of other-size bars in the future.

ValTara is a flow wrapping machine vendor which sells the servo driven Sleek Wrapper. The machine uses 5 servo motors that create quick changeovers and reduce film waste. The film is fed from below the products which prevents the sticky products from touching the conveyor belts.

5.4) Dough Chunker and Elevator Conveyor

The dough chunker feeds chunks of clay in batches to the downstream extruders. The inclined elevator conveyor carries the chunked clay from the dough chunker to the extruders. Both the elevator conveyor and the dough chunker are easy to clean and maintain. Additionally, the heavy-duty welded round tubing and drive motors found in dough chunkers ensures high performance which could ultimately increase efficiency. The dough chunker automatically transfers and gently breaks apart dough-like substances without adding stress to the material which will ultimately prevent any changes to the clay properties during this process. Incorporating dough chunkers into the production lines helps the company meet the requirements of OSHA (Occupational Safety and Health Administration) for industrial productions by reducing instances of manual loading clay into the hoppers so that the clay can be continuously loaded and extruded.

5.5) Nitrogen Generator Blasting

A Nitrogen Generator is a device that can be used to surface freeze clay bars after they have been extruded. Polyform Products Company has informed the project team that cold temperatures do not affect the properties of the clay, but warmer temperatures, even below the hardening temperature, can negatively affect the properties of the clay. Manipulation of the clay as it goes through the extruder and is cut raises its temperature. This generator would be used to prevent any sticking to the conveyor belt as well as to mitigate any rise in clay temperature from the dough chunking, extrusion, and cutting processes.

5.6) Programmable Logic Controller (PLC)

A PLC is a device used for the automation of industrial electromechanical processes, such as the control of machinery on a factory assembly line. It is composed of three main

components: an input and output system, the central processing unit, and the power supply rack. The input and output system is where all external components are connected via digital or analog signals. The central processing unit uses ladder logic to carry out the operations of the process it is designed for. Finally, the power supply rack is the physical entity that holds the entire system together.

6) Potential Solutions

The project team has devised a few potential solutions, which will be compared economically using a 2-year payback period. Figure 16 details the general order of the new process that are scenarios follow. The project team will also take into consideration the following when comparing alternatives:

1) Whether or not the new wrapping fits into the current outer packaging as is.
2) Whether or not the die-fold wrapping machine is replaced.
3) The amount of material savings from the paper used on pallets, reduced film scrap, and a tightened weight tolerance.
4) The quantity of features and quality of the machinery.

The project team will measure the extrusion rate in lbs/hr of the new process to ensure that the new process can match or exceed the current production rate. Per safety regulations, the extruder cannot be run while the hopper lid is open. This is to prevent employees from injuring themselves while feeding clay into the hopper. A conveyor line must be fed into the hopper for the extruder to run continuously with the lid open and since the solution must allow for continuous extrusion and feeding of the hopper, each solution starts with a dough chunker at the beginning of the line. The dough chunker breaks down the clay and can directly convey the pieces of clay into the hopper to be extruded (See Figure 15). Additionally, each solution includes a Nitrogen Generator from Barrington to ensure that the bars do not overheat and undergo irreversible property changes. The project team has also elected to include the cost of the integration of all the different machines and systems through Chicago Electric. This cost will be necessary no matter the scenario since different vendors were required and work must be done to code the PLC.

The project team has also concluded that the clay should be extruded lengthwise rather than widthwise in order to reduce weight errors caused by cutting the clay since less surface area will

be in contact with the blade. The error reduction with this change is due to decreased variance since the length is greater than the width of the bar. Although most of the error is due to manual extrusion, this change will still contribute to the error reduction.

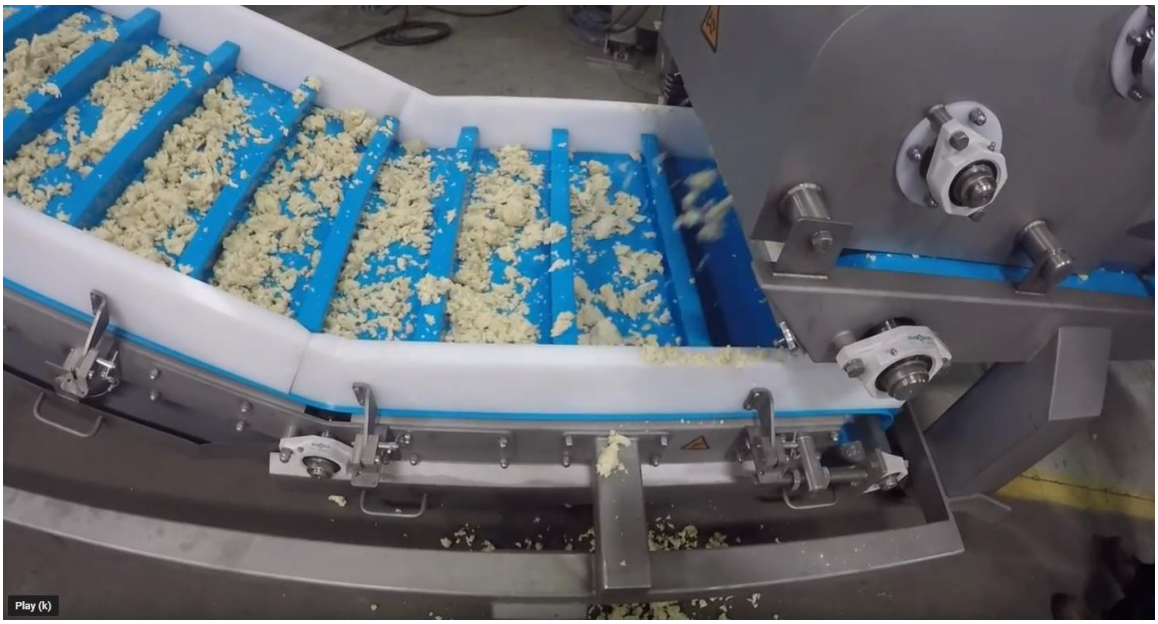


Figure 15: This image show a conveyor and a dough chunker which can help Polyform to break up the clay before it enters the extruder.

6.1) Scenario 1: Bonnot, Dukane, and Barrington

The first scenario would involve purchasing a new extruder and cutting machine from The Bonnot Company (See Figure 16). The cutting machine from Bonnot would be customized to fit an ultrasonic blade from Dukane. This solution would also utilize a checkweigher and wrapping machine from the Barrington Packaging Systems Group (See Figure 17). Appendix C contains details regarding the vendors the project team has been in contact with as well as machine specifications.

Figure 16: This is an image of the extruder provided by the Bonnot Company.

Figure 17: The Barrington flow wrapper (above) and checkweigher (below).

Some benefits of this scenario are that it uses a small number of vendors, so it will be relatively easier to integrate the various components, and there is more potential for negotiating pricing. Additionally, the cutter from Bonnot would be customized, so it would be purpose built to suit Polyform Products Company's specific needs. The project team and Polyform performed testing on clay cut with the ultrasonic blade and concluded that the material properties of the clay were not significantly changed for both the long and short term. The ultrasonic blade also did not significantly deform or stick to the clay. With this knowledge, it is beneficial to be able to integrate this style of blade to the rest of Bonnot's cutting equipment.

The Barrington checkweigher has a bilingual screen operation, which can help to increase productivity in employees where English is not their first language. The checkweigher and wrapper have a two-year parts and labor warranty which can help to reduce any short-term maintenance costs. The wrapping machine, like all the options, utilizes the fin seal style of wrapping. Additionally, all the wrapping machines can support "No Product-No Film" functionality. This feature stops the wrapping machine from wrapping when there is no clay bar ready to be wrapped. This would save on film scrap as gaps will form on the line when bars are kicked off the line for being outside of the set weight tolerance. The project team is still waiting on testing results from Barrington to ensure that this style of wrapping will still allow the bars to fit in their outer packaging.

The total cost of this scenario is the second highest at $358.6K, and the lead time is estimated to be between 24 and 26 weeks.

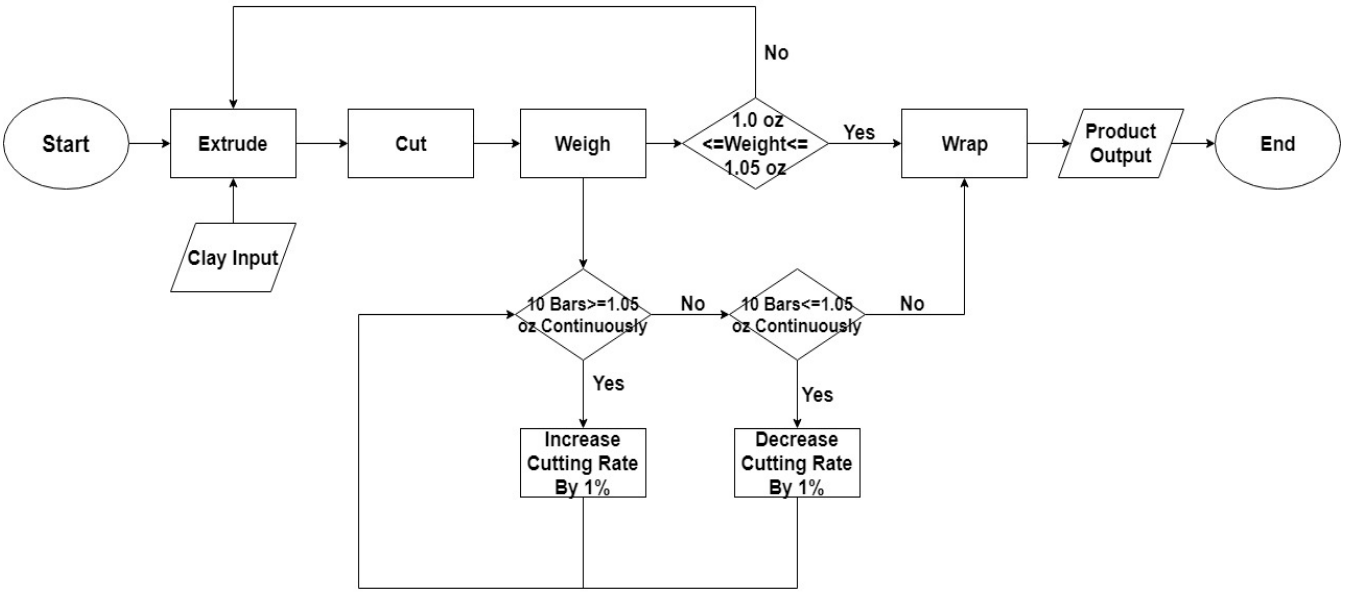


Figure 18: This flow chart details the order of the new process which eliminates the hardening period and goes directly from extruding, cutting, and weighing to wrapping. When bars are not the correct weight, they are kicked off the line to be re-extruded, and when the bars are the correct weight, they continue down the line to be wrapped. If 10 bars in a row are outside of the set tolerance, the PLC will increase or decrease the cutting rate by 1% accordingly. This is so that the next bars are cut and extruded to the correct size.

6.2) Scenario 2: Reiser and Barrington

Scenario 2 would use the extruder and cutting machines from Reiser. The blade would not be ultrasonic in this scenario. Like in Scenario 1, the checkweigher and wrapping machine would be provided by Barrington Packaging Systems Group.

The biggest negative of Scenario 2 is that it has the largest cost of the three scenarios at $362.1K, but it also has the shortest estimated lead time of 20-22 weeks. These costs will be discussed further in section 6.

6.3) Scenario 3: VFD, Starkey, A&D, and ValTara

The final scenario utilizes the current extruders at Polyform Products Company by updating the motor to have a Variable Frequency Drive. This VFD will allow the speed of the motor to be controlled and adjusted as needed. This time the cutting machine would be provided

by Starkey Machinery (See Figure 19). A&D would provide the check weighing system, ValTara would provide the wrapping machine (See Figure 20), and Siemens would provide the PLC system that would allow for communication between the various pieces of equipment.

Figure 19: This is the cutting machine provided by Starkey Machinery.

Figure 20: This is the SleekWrapper provided by ValTara.

The use of the current extruders reduces the total cost of this solution, but also risks potential problems related to the age of the current equipment as it stands. A benefit to utilizing the current extruders is reduced capital and training costs for those pieces of equipment. The current extruders were tested and can output about 2500 pounds of clay per hour. Thus, the current extruders do not limit the possible output rate of the bars, which was a potential concern. A concern with using the current extruders is that the equipment is estimated to be over 20 years old. Despite a new VFD motor extending the life of the equipment, the age is still a potential future problem. The project team received the tags on the current motors which provide important information such as horsepower, RPM, and max amperage (See Appendix B).

This scenario is the most cost-effective at $281K, but also potentially has the longest lead time of 25-30 weeks and requires the largest number of vendors. The large number of vendors may potentially cause integration and negotiation issues.

A benefit to the Starkey cutter is that it is very cost effective. One issue with this cutter is that the conveyor system is not provided, so that system would need to be added on to this solution.

The ValTara wrapper is the cheapest wrapping machine of the three mentioned. In addition to the “No Product - No Film” feature, the ValTara machine also gives the option of purchasing the “No Gap – No Seal” feature which prevents wrapping if there is no gap between bars like in the case where the bars have stuck together. This could potentially save on film scrap costs, but this is not necessarily required and is an optional additional feature.

6.4) Downtime Solutions

The costs related to changeover have the potential to be very high with the project team’s current scenarios because the solution has consolidated the production of bars that were on multiple lines to be on a single line. To reduce this potential downtime for extruder changeover, the project team recommends that Polyform Products Company uses a second extruder so the company can start processing another color while the first extruder is cleaned. Once in Phase 2, it would make sense to do all the 1-ounce bars and then move on to the 2-ounce bars so that production would be split into two shifts. Additionally, the project team has concluded that because all of the wrapping machines are flow wrappers, the downtime required for cleaning the wrapping machine will virtually be eliminated. There will still be downtime to change film in

Phase 2, but this can again be reduced by first wrapping all of bars with the non-printed film first, and then moving on to the bars with the printed film.

7) Economic Analysis

The cost reduction resulting from the manufacturing process integration is analyzed under three phases. Phase 1 focuses on the automation of the 1-ounce bar production line. In Phase 2, the automated manufacturing solution provided by the project team would be expanded to the production of the 2-ounce bars. In Phase 3, Polyform Products Company would be able to achieve overall automation of all their product types and sizes. The project team has focused their economic analysis on Phases 1 and 2.

7.1) Phase 1: 1-Ounce Bar Budget Analysis

The total current budget for Phase 1 based on a 2-year payback period is about $307,000. Polyform Products Company currently produces 6.2 million 1-ounce bars (See Table 3). The entire process has several non-value-added steps that the project team plans to eliminate by automating certain parts of the production process. The budget was calculated by considering all major variables, which are labor cost, storage cost, and material savings from overweight bars and film scrap (See Table 4).

Table 3: Rates of Production of the 1-Ounce Bars in 2018

Total Number of 1-Ounce Bars Extruded	6,199,143
Labor Hours for Extruding, Cutting, and Wrapping	9097.92
Bars Produced per Hour	1,505
Bars Produced per Minute	25
Cost of Labor per Bar	$0.03

Table 4: Phase 1 Budget Overview with a 2-Year Payback Period for 1-Ounce Bars

Total Labor Savings	$246,812.19
Total Overweight Bar Savings	$55,891.30
Film Scrap Savings	$4868.14
Total Budget	$307,571.63

The labor cost was calculated by taking the average hourly rate paid to full time and temporary workers for 2018 and scaling the rates by the hours worked respectively (See Table 5). Furthermore, labor savings were calculated by analyzing what and how many positions could be eliminated by the project team's solution. For example, one worker will still be required to supervise the production line process. This is further analyzed in Table 6.

Table 5: Total Labor Cost of 1-Ounce Bars Scaled

	Regular Hours	Overtime	Total
Total Labor Hours	8834.42	263.5	9097.92
Total Cost of Labor	$153,293.40	$6,954.98	$160,248.39
Cost per Hour of Labor	$17.35	$26.39	$17.61

Table 6: Overview of Labor for the 1-Ounce Bars

Current Cost of Labor	$160,248.39
One Worker 2080 Hours Full-Time Rate	$36,842.29
Labor Savings	$123,406.09
Budget of Labor Savings with a 2-Year Payback	$246,812.19

The cost savings calculated from the production of overweight bars assumes that the project team can reduce the average bar weight from the current 1.1 ounces to 1.05 ounces. This assumption is in fact an underestimate of what is possible in terms of tightening the tolerance according to Polyform Products Company (See Table 7).

Table 7: Savings from Tightening the Overweight Tolerance for 1-Ounce Bars

Total 1-Ounce Bars Extruded in 2018	6,199,143
Average Cost per Pound in 2018	$1.44
Average 1-Ounce Bar Weight in 2018	1.1 Ounces
Target Weight for 1-Ounce Bars	1.05 Ounces
Pounds of Excess Clay Saved	19,372.3
Total Overweight Bar Savings	$27,945.65
2-Year Payback of Overweight Bar Savings	$55,891.30

Film scrap is defined as wasted film from misprints and incorrect wraps caused by the aging wrapping machine. Film scrap was calculated by noting the amount of film scrap for the 1-ounce bars in 2018 and reducing the waste by eighty percent. This is possible because much of the scrap is due to the manual nature of the current process (See Table 8).

Table 8: Total Savings from Eliminating 80% of Film Scrap Waste

1-Ounce Bar Film Scrap Cost in 2018	$2,434.07
2-Year Payback of 1-Ounce Bar Film Scrap	$4,868.14

7.2) Phase 1: 1-Ounce Bar Economic Analysis

7.2.1) Scenario 1: Bonnot, Dukane, and Barrington Economic Analysis

In Scenario 1, the project team selected the dough chunker from Bundy Solutions, extruder and cutting equipment from Bonnot which the Dukane ultrasonic blade, and the checkweigher and flow wrapper from Barrington. In addition to the equipment listed above, the Bonnot Company is also able to provide a communication system for the integration. The total equipment cost for Scenario 1 is $358,600 (See Table 9). With a MARR of 25% at year 5, the payback period is three years due to the additional need of the dough chunker as the infeed conveyor to the extruder so that the clay can be continuously extruded. Despite this, the internal rate of return is still 32% at the end of year 5 (See Table 10 and Figure 21).

Table 9: Equipment Costs for Scenario 1 in Phase 1

Equipment	Cost
Dough Chunker (Estimate)	$60,000.00
Barrington (Nitrogen Generator) (Estimate)	$6,000.00
Bonnot (Extruder)	$ 69,000.00
Bonnot+Dukane (Cutter) (Estimate)	$ 47,500.00
Barrington (Checkweigher)	$ 16,900.00
Barrington (Flow Wrapper)	$ 114,200.00
Chicago Electric (Integration) (Estimate)	$ 45,000.00
Total Cost	$ 358,600.00

Table 10: Cash Flow table for Scenario 1 in Phase 1

Scenario 1					
MARR	25%				
Year	Cap Cost	Net Cash Flow	Nominal Worth	Net Present Value	IRR
0	$358,600.00	$(358,600.00)	$(358,600.00)	$(358,600.00)	
1	0	$153,785.82	$ (204,814.19)	$ (235,571.35)	-57%
2	0	$153,785.82	$ (51,028.37)	$ (137,148.43)	-10%
3	0	$153,785.82	$ 102,757.45	$ (58,410.09)	14%
4	0	$153,785.82	$ 256,543.26	$ 4,580.58	26%
5	0	$153,785.82	$ 410,329.08	$ 54,973.12	32%

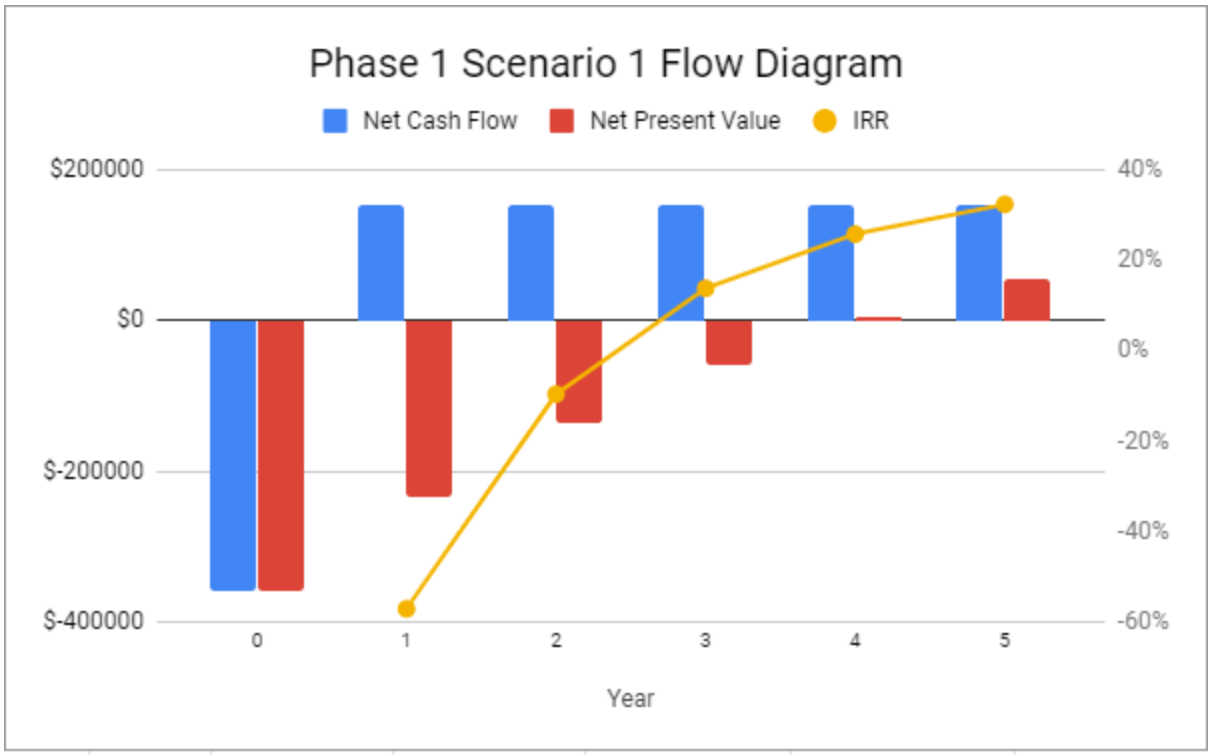


Figure 21: Phase 1 Cash Flow Diagram for Scenario 1

7.2.2) Scenario 2: Reiser and Barrington Economic Analysis

In Scenario 2, the extruder from Reiser will be used. Scenario 2 also includes the dough chunker from Bundy Solutions, the cutting equipment from Reiser, and the checkweigher and flow wrapper from Barrington. The total cost for Scenario 2 is about $362,100 (See Table 11). The payback period for Scenario 2 is 3 years. The internal rate of return at the end of year 5 is 32% (See Table 12).

Table 11: Equipment Costs for Scenario 2 in Phase 1

Equipment	Cost
Dough Chunker (Estimate)	$60,000.00
Barrington (Nitrogen Generator) (Estimate)	$6,000.00
Reiser (Extruder) (Estimate)	$70,000.00
Reiser (Cutter) (Estimate)	$50,000.00
Barrington (Checkweigher)	$16,900.00
Barrington (Flow Wrapper)	$114,200.00
Chicago Electric (Integration)	$45,000.00
Total Cost	$362,100.00

Table 12: Cash Flow Table for Scenario 2 in Phase 1

Scenario 2					
MARR	25%				
Year	Cap Cost	Net Cash Flow	Nominal Worth	Net Present Value	IRR
0	$ 362,100.00	$ (362,100.00)	$ (362,100.00)	$ (362,100.00)	
1	0	$ 153,785.82	$ (208,314.19)	$ (239,071.35)	-58%
2	0	$ 153,785.82	$ (54,528.37)	$ (140,648.43)	-10%
3	0	$ 153,785.82	$ 99,257.45	$ (61,910.09)	13%
4	0	$ 153,785.82	$ 253,043.26	$ 1,080.58	25%
5	0	$ 153,785.82	$ 406,829.08	$ 51,473.12	32%

7.2.3) Scenario 3: VFD, Starkey, A&D, and ValTara Economic Analysis

Scenario 3 is considered to be the most cost-effective solution. The team has again selected the dough chunker from Bundy Solutions. The cutter is from Starkey, the checkweigher from A&D, flow wrapper from ValTara, and the PLC system from Siemens. In this scenario, a VFD needs to be added to the current extruder in order to control the extrusion rate. The total

cost for Scenario 3 is about $280,970 (See Table 13). Since Scenario 3 is well within budget, the internal rate of return at the end of year 5 is 47% (See Table 14). The payback period is also shorter at 2 years instead of 3 years as it is in the other two scenarios.

Table 13: Equipment Costs for Scenario 3 in Phase 1

Equipment	Cost
Dough Chunker (Estimate)	$60,000.00
Barrington (Nitrogen Generator) (Estimate)	$6,000.00
Variable Frequency Adapter	$1,500.00
Starkey (Cutter) (Estimate)	$35,000.00
A&D (Checkweigher)	$38,470.00
ValTara (Flow Wrapper)	$95,000.00
Chicago Electric (Integration) (Estimate)	$45,000.00
Total Cost	$280,970.00

Table 14: Cash Flow Table for Scenario 3 in Phase 1

Scenario 3					
MARR	25%				
Year	Cap Cost	Net Cash Flow	Nominal Worth	Net Present Value	IRR
0	$ 280,970.00	$ (280,970.00)	$ (280,970.00)	$ (280,970.00)	
1	0	$ 153,785.82	$ (127,184.19)	$ (157,941.35)	-45%
2	0	$ 153,785.82	$ 26,601.63	$ (59,518.43)	6%
3	0	$ 153,785.82	$ 180,387.45	$ 19,219.91	30%
4	0	$ 153,785.82	$ 334,173.26	$ 82,210.58	41%
5	0	$ 153,785.82	$ 487,959.08	$ 132,603.12	47%

7.3) Phase 2: Addition of 2-Ounce Bars Budget Analysis

The Phase 2 budget is based on a 2-year payback period and includes the labor savings, overweight savings, and savings from film scrap waste from both the 1-ounce and 2-ounce production lines. Polyform Products Company produced a total of 5.3 million 2-ounce bars in 2018, and the cost of labor per bar was about $0.05 (See Table 15). The total budget for Phase 2 adds up to $848,193 (See Table 16).

Table 15: Rates of Production of the 2-Ounce Bars in 2018

Total 2-Oz Bars Extruded	5,303,846
Labor Hours Packing + Wrapping	16000.55
Bars Produced per Hour	483.65
Bars Produced per Minute	8.06
Cost of Labor per Bar	$0.0531

Table 16: Phase 2 Budget Overview with a 2-Year Payback Period (1-Oz and 2-Oz Bars)

	1-Oz Bars	2-Oz Bars	Total Phase 2 (1-Oz+2-Oz)
Labor savings	246,812.19	489881.74	736,693.93
Overweight savings	55,891.30	47819.33	103,710.63
Film Scrap Savings	4,868.14	2920.88	7,789.02
Total Budget	307,571.63	540621.95	848,193.58

7.4) Phase 2: Addition of 2-Ounce Bars Economic Analysis

As 2-ounce bars will be manufactured on the same integrated system as the 1-ounce bars, the project team recommends purchasing a second extruder or a second variable frequency device for downtime reduction. This would allow production to continue with a second shift while the first extruder is being cleaned. The total equipment costs for the three scenarios are listed in Table 17. All three scenarios are within the Phase 2 budget, and the payback period is one year for all three scenarios (See Tables 18, 19, and 20 respectively. Additionally, see Figure 22 for the Scenario 1 cash flow diagram).

Table 17: Total equipment costs for three scenarios in Phase 2

	Total Cost
Scenario 1	$487,600.00
Scenario 2	$492,100.00
Scenario 3	$342,470.00

Table 18: Cash Flow Table for Scenario 1 in Phase 2

Scenario 1					
MARR	25%				
Year	Cap Cost	Net Cash Flow	Nominal Worth	Net Present Value	IRR
0	$ 487,600.00	$ (487,600.00)	$ (487,600.00)	$ (487,600.00)	
1	0	$ 424,096.50	$ (63,503.50)	$ (148,322.80)	-13%
2	0	$ 424,096.50	$ 360,593.00	$ 123,098.96	46%
3	0	$ 424,096.50	$ 784,689.50	$ 340,236.37	69%
4	0	$ 424,096.50	$ 1,208,786.00	$ 513,946.29	78%
5	0	$ 424,096.50	$ 1,632,882.50	$ 652,914.24	83%

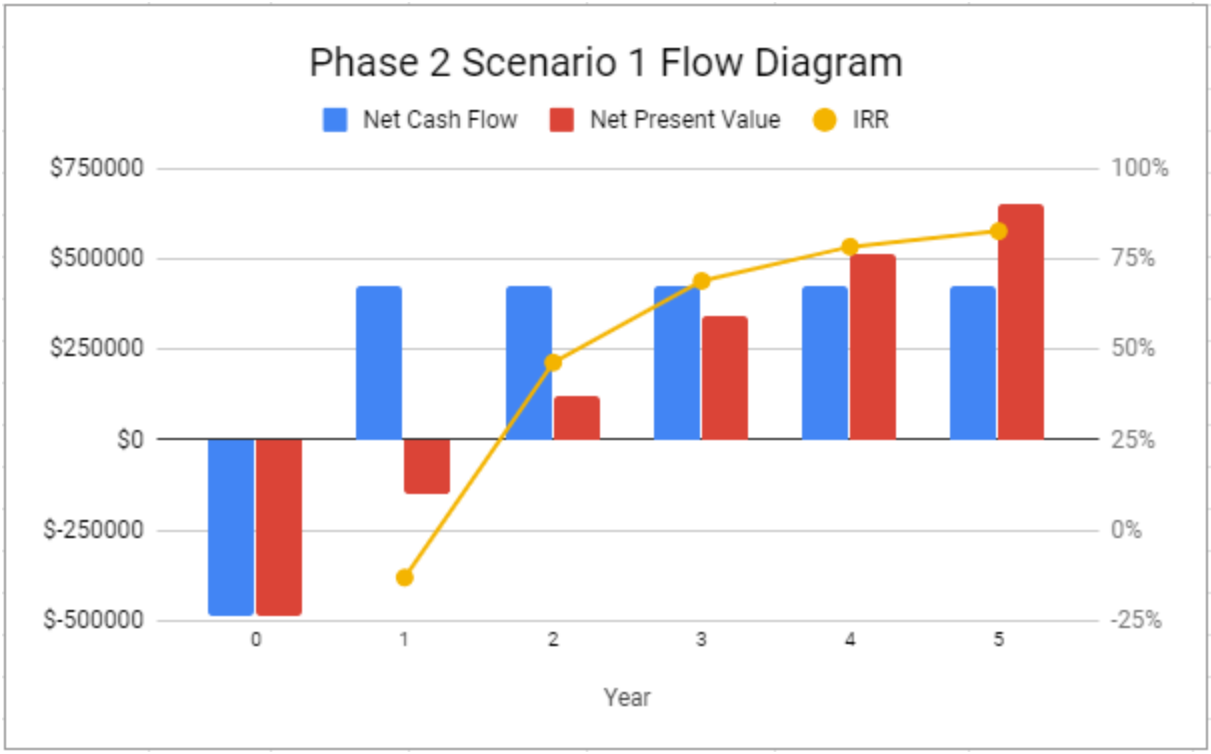


Figure 22: Phase 2 Cash Flow Diagram for Scenario 1

Table 19: Cash Flow Table for Scenario 2 in Phase 2

Scenario 2					
MARR	25%				
Year	Cap Cost	Net Cash Flow	Nominal Worth	Net Present Value	IRR
0	$ 492,100.00	$ (492,100.00)	$ (492,100.00)	$ (492,100.00)	
1	0	$ 424,096.50	$ (68,003.50)	$ (152,822.80)	-14%
2	0	$ 424,096.50	$ 356,093.00	$ 118,598.96	45%
3	0	$ 424,096.50	$ 780,189.50	$ 335,736.37	68%
4	0	$ 424,096.50	$ 1,204,286.00	$ 509,446.29	77%
5	0	$ 424,096.50	$ 1,628,382.50	$ 648,414.24	82%

Table 20: Cash Flow Table for Scenario 3 in Phase 2

Scenario 3					
MARR	25%				
Year	Cap Cost	Net Cash Flow	Nominal Worth	Net Present Value	IRR
0	$ 342,470.00	$ (342,470.00)	$ (342,470.00)	$ (342,470.00)	
1	0	$ 424,096.50	$ 81,626.50	$ (3,192.80)	24%
2	0	$ 424,096.50	$ 505,723.00	$ 268,228.96	89%
3	0	$ 424,096.50	$ 929,819.50	$ 485,366.37	111%
4	0	$ 424,096.50	$ 1,353,916.00	$ 659,076.29	118%
5	0	$ 424,096.50	$ 1,778,012.50	$ 798,044.24	122%

8) Conclusions

From the analysis of the current packaging process and the potential new process, the project team has come to the following conclusions:

1. **The current process is very labor intensive and can be more efficient.**
   Currently, every step of the packaging process involves some sort of manual labor. Because of this, various non-value-added steps such as the 2-week hardening period have added to the process to offset the pitfalls of the current process. By automating the process, entire steps can be eliminated, and bars can be processed faster. Additionally, less money can be spent on paying wages because automation would significantly reduce the need for labor.
2. **The new process must be able to extrude, cut, weigh, and wrap the bars in one continuous process without damaging the bars.**
   Because of the reduced material handling inherent in the design of the new process, the clay bars will be deformed and damaged less often. The bars will be the correct weight more often, and there will be less clay going back into the extruder as a result. The clay will then experience less shearing stress from the augers and will better retain its desirable molecular properties by not heating up as much.

3. **There are many vendors to work with and the vendor for a portion of the process can be swapped with a different vendor who also provides that equipment.**
   The project team communicated with many vendors, most of whom were more than willing to work with other vendors on integrating other portions of the line. There were also many ways to combine the various pieces of equipment. The project team used various criteria to come up with the best three scenarios for a fully automated line. The main factors in narrowing down the vendors was budget and feasibility.
4. **The economic return is much higher after the implementation of Phase 2.**
   As seen above, the project team is not able to meet Polyform Products Company's desired 2-year payback by solely doing Phase 1. The solution to this problem was to introduce 2-ounce bars in Phase 2. This is possible due to the fact that the lines have excess capacity and can handle more volume. Phase 2 increases the budget to nearly $850,000 and meets the 2-year payback period in each of the three proposed scenarios.
5. **Scenario 1 is the best solution.**
   Scenario 1, which includes the Bonnot extruder and cutter, Dukane blade, and Barrington checkweigher and flow wrapper, is the best solution. Scenario 1 has the best cutting blade and station, uses a small number of vendors, and has an adequate checkweighing and wrapping system. Scenario 1 was chosen over Scenario 2 because Scenario 1 required less capital investment, and it had a slightly higher IRR with the implementation of phase 2 while having similar equipment quality. Additionally, it utilized the ultrasonic blade which has been tested and proven to be particularly effective at cutting the clay. Scenario 1 was chosen over Scenario 3 because of the better features and because, although Polyform Products Company did not say it was necessary, the company would prefer to purchase new extruders rather than retrofit VFDs onto their current equipment.

9) Recommendations

The project team recommends Scenario 1 for the reasons stated above. If this scenario is not feasible or cost-effective upon further communication with the vendors, the team recommends contacting some of the other vendors mentioned in this report. No matter what, the solution must have some sort of dough chunker/conveyer into the extruder, nitrogen generator, an extruder, cutting equipment, a check weighing system, and wrapping equipment.

1) Get in contact with vendors.
    a. Negotiate final pricing and logistics of integration
    b. Discuss expansion into Phase 2 and Phase 3.
    c. Conduct further testing for deformation, functionality, etc. if deemed necessary.
2) Contract vendors to customize features if applicable and integrate the various components of the new line.
3) Draft a new production schedule around the new equipment with a strong focus on downtime reduction.
4) Assemble new line and train employees.

10) References

1. Thomas Register, 2004, Thomas Pub. Co., 2003
2. Drozda, Thomas, and Charles Wick. *Tool and Manufacturing Engineers Handbook: A Reference Book for Manufacturing Engineers, Managers, and Technicians*. Society of Manufacturing Engineers, 1987.
3. "Packaging Trade Show Chicago 2018." *My Industry | PACK EXPO International*, www.packexpointernational.com/.
4. "Chicago, Illinois Local Minimum Wage for 2018, 2019." *Federal and State Minimum Wage Rates for 2018*, www.minimum-wage.org/illinois/chicago-minimum-wage.

Appendix A: Hopper and Auger Specifications

Table 21: Dimensions and Quantity of the Current Augers

Dimensions (Inches)	Quantity of Extruders with this Size Auger
25”L X 5.5” Round	5
31”L X 5.5” Round	5
21”L X 5.5” Round	1
27”L X 5.5” Round	1

Table 22: Dimensions and Quantity of the Current Hoppers

Dimensions (Inches)	Quantity	Capacity (lbs)
14”L X 10”W X 12”H	9	40
10”L X 9.5”W X 11”H	2	25
Cone: 24.5” Diameter X 27”H	1	60

Appendix B: Current Motor Specifications

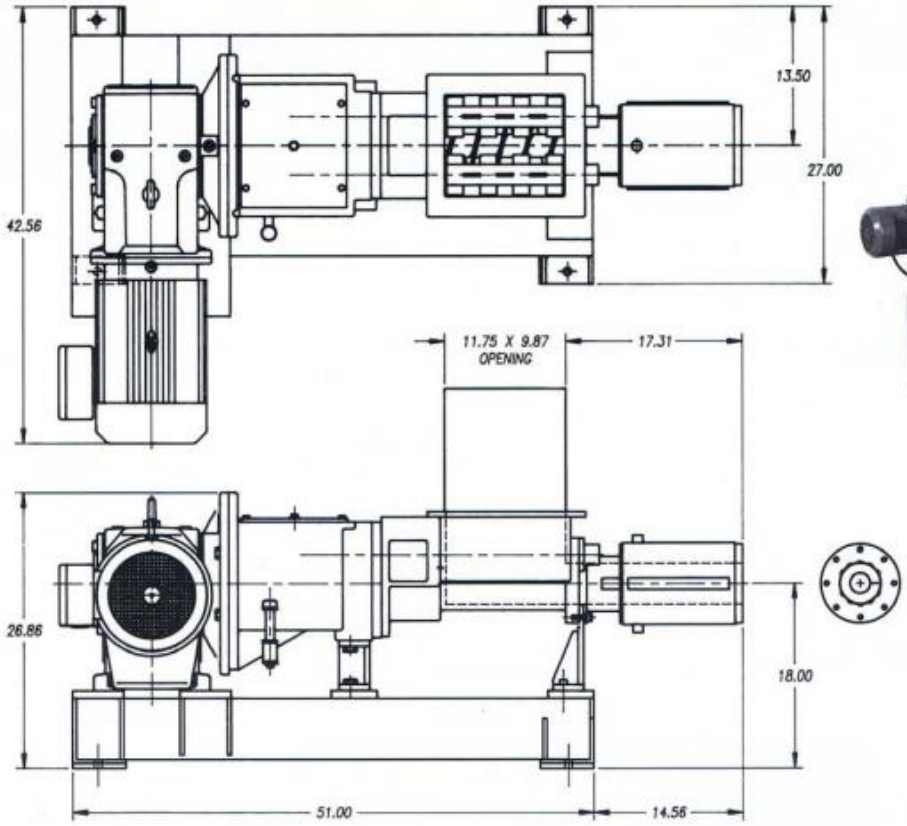
Table 23: Current Extruder Motor Information

	E194A	E194B
Number of Phases	3	3
Speed at Rated Load (RPM)	1745	1745
Voltage (Volts)	208	208
Horsepower Output (HP)	5.0	5.0
Frame Designation	184T	184T
Duty Cycle	Continuous	Continuous
Full Load Amperage (Amps)	15.0-13.6/6.8	14.6-13.7/6.85
Service Factor Maximum Amperage (Amps)	16.7/8.35	16.7/8.35
Maximum Ambient Temperature (°C)	40	40
Usable Amperage (Amps)	16.2	16.2

Appendix C: Potential Machinery from Vendors Including Specifications

Attached are a few brochures from Bonnot, Valtara, Rice Lake Weighing Systems which detail the equipment that are likely candidates to be a part of the project team's solution.

FORMING EXTRUDERS WITH TWIN PACKERS



Counter-rotating shafts in hopper section

This popular, multi-purpose type of extruder is available in four-inch size for pilot plant operations and up to 16" for volume production. Choose from a wide selection of auger and barrel configurations. Cooling and heating of barrel and auger is optional. Interchangeable dies provide a broad range of shapes and sizes. Install with optional rotary-type fly knife or guillotine cutter.

Bonnot Extruder sizes are identified by auger diameter.

Drives

The following are available:

- AC constant speed
- AC inverter
- Mechanical variable speed
- DC

You Get Complete Customized Service, Too!

Free Lab Testing – Our laboratory test facilities are offered to demonstrate the processing characteristics of our equipment using your material. These machines are basic duplications of those offered for sale. You will have the assurance in advance that our equipment will handle your product efficiently and profitably. Testing is absolutely confidential.

Technical Assistance in Selection – Tell us what materials you want to extrude and your special production requirements. Our technicians then advise you on the most efficient processing operation and the Bonnot equipment best suited to do the job. We'll perform a trial run using a sample of your product (minimum capacity is five lbs.).

Rent or Lease Test Equipment – If you wish to test our equipment in your own plant, we have laboratory and pilot plant extruder models available that duplicate the machines we offer for sale. This will enable you to see how our equipment will fit into your operation before you buy.

Field Engineering Service – Our engineers will assist you in setting up your installation. They will show you how Bonnot customized equipment can be incorporated into your present processing operation to improve your production efficiency and reduce your costs.

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BONNOT
THE BONNOT COMPANY
1520 Corporate Woods Parkway
Uniontown, OH 44685
Phone: (330) 896-6544
FAX: (330) 896-0822

Litho in U.S.A.

SleekWrapper Inverted

SERVO DRIVEN HORIZONTAL FLOW WRAPPER

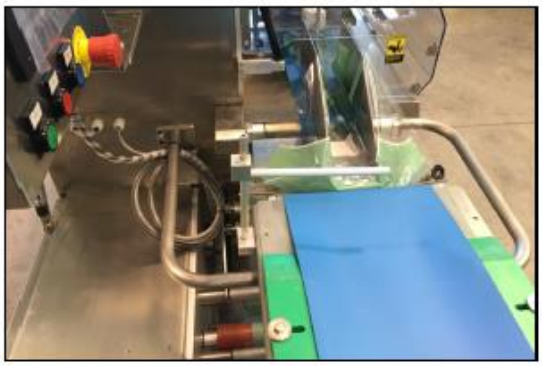
The high performance SleekWrapper Inverted servo driven horizontal flow wrapping machine designed with reliability, simplicity and serviceability.

The SleekWrapper Inverted flow pack machine uses 5 servo motors that create quick and easy changeover and adjustment, reduces product and film waste during production and offers low maintenance costs. Servo drives assures precise positioning, smooth acceleration – deceleration.

Ideal for soft or sticky products, multipacks, and other products that are difficult to push with the lug chain design found on conventional bottom seal flow wrappers. The film is fed from below the product. Hard to handle products are securely carried on top of the packaging film from the former through the cutting head.

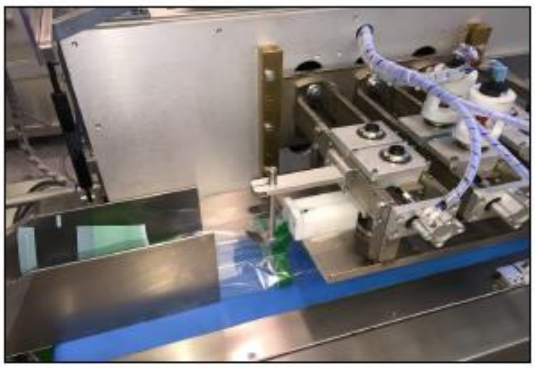
LEADINGEDGE

The SleekWrapper family of horizontal flow wrappers is designed for ease of use, reliability, and flexibility. Available in several models, the servo-driven SleekWrapper fits every budget and production requirement.



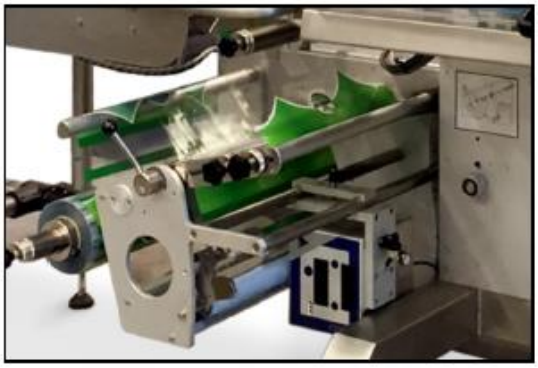
EASY CHANGE-OVER

Product change-over is very simple with belted infeed or dual lug position infeed conveyor and adjustable forming former.



TOP SEAL

Hard to handle products are securely carried on top of the packaging film from the former through the cutting head.



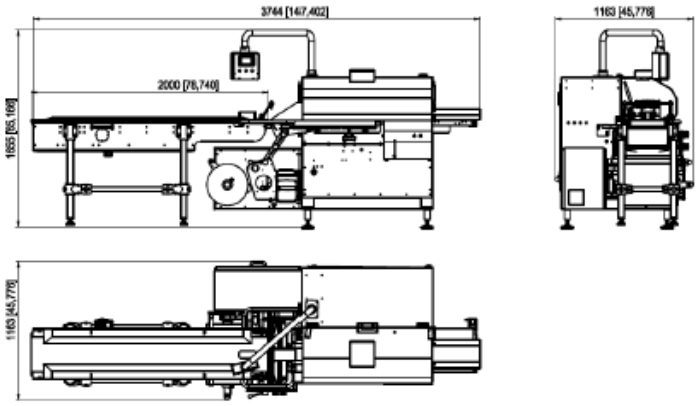
VARIETY OF FILM TYPES

The SleekWrapper runs a wide variety of materials including polypropylene, microperf, multilayer laminated, co-extruded, foil films, and more.

CONSTRUCTION

Built with quality components, the SleekWrapper comes standard with stainless steel construction and servo drives.

SleekWrapper Inverted



Features

- Stainless steel frame construction
- Full servo, driven by 5 servo motors
- Belt driven
- Belted or Lugged Infeed conveyor with snap-in pushers for fast changeovers
- Right hand configuration (left to right)
- Cantilevered self cantering film holder
- Color touch screen HMI and Mitsubishi PLC
- Pre-programmable controls for up to 120 recipes
- HMI Integrated temperature control
- Automatic opening of hot finwheels during stoppages to reduce film waste
- Rotary seal jaws, Long Dwell available as an option
- Automatic synchronization of crimper after jams
- Optional No Product / No Bag
- Optional No Gap / No Seal for misplaced products
- Optional photo cell for bag registration

Package Length

- Up to 24" (620 mm)

Maximum Package Height

- Up to 4.7" (120 mm).

  Subject to web width

Max film roll diameter

- 13" (350 mm) 3" (80 mm) Core

Electrical & Air

240V 1 Phase, 15A. And 90 PSI

*All max dimensions are dependent upon machine configuration

Specifications subject to change without notice

VALTARA™

Quality construction & state-of-the-art technology at reasonable prices

1018

Motoweigh, Conveyor Scale or Checkweigher Application Specifications

RICE LAKE WEIGHING SYSTEMS

Dealer Company Name: _____ Sales Person: _____

Rice Lake Customer Number: _____ Email: _____

Phone: _____ Address: _____

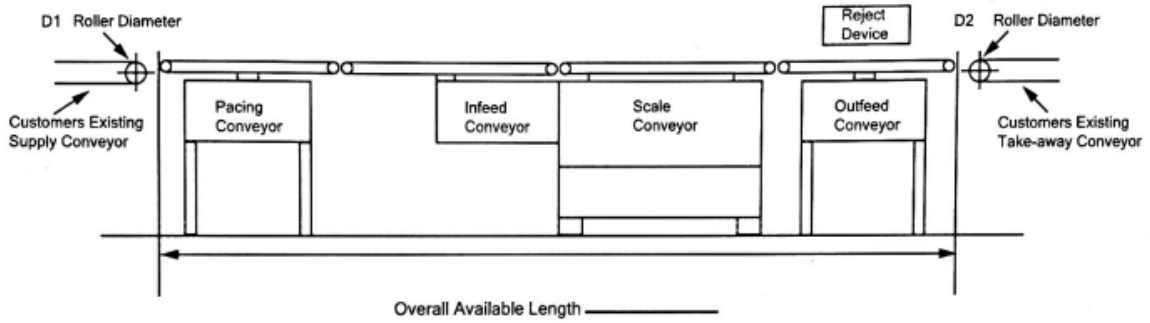
City: _____ State: _____ Zip: _____

PRODUCT SPECIFICATIONS (factory installs are required)

System Components: ☑ Pacing Conveyor ☑ Infeed Conveyor ☑ Scale Conveyor ☑ Outfeed Conveyor

Preferred Material: ☐ Stainless Steel Food Grade ☑ Stainless Steel Industrial ☑ Aluminum

Preferred Measurement: ☐ Inches ☐ Millimeters **and** ☐ Grams ☑ Ounces ☐ Pounds ☐ kg



Contents: ☐ Liquid ☑ Solid

Controlled Spacing: ☑ Yes ☐ No

Air Flow: ☐ Yes ☐ No

Working Environment: Temperature _____ ° F/C Humidity _____ %

Installation Location: ☐ Ground Floor ☐ 2nd Floor ☐ Mezzanine

Conveyor Directions

****Reference Figure 1 to answer the below questions.*

Operator Stands: ☐ North Side **or** ☑ South Side

Conveyor Moves: ☑ West to East **or** ☐ East to West

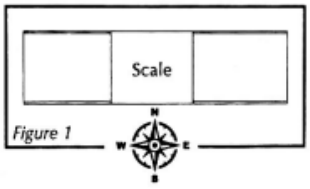


Figure 1

Existing Line Height: _____ open

Existing Belt Width: _____ open

Conveyor Line Speed: Min. 9 ft/min Fixed _____ ft/min Max. 20 ft/min

Existing Roller Diameter: _____ D1 _____ D2

List Container Type and Contents	A= Length	B= Width	C= Height	Minimum product spacing trailing to	Speed Packs /Min	Product Weight	+/_ Accuracy

PROPOSED EQUIPMENT

Given the technical data reported on the previous page, PFM Packaging Machinery Corp. respectfully proposes its wrapper model Falcon BB as per the following standard specs integrated with the features listed on the following pages.

Confirmation of the present proposal is in any case subject to testing of both products and wrapping material

PFM FALCON BB
STANDARD MACHINE CONSTRUCTION

Machine depicted with some optional features, please refer to quotation for actual options included

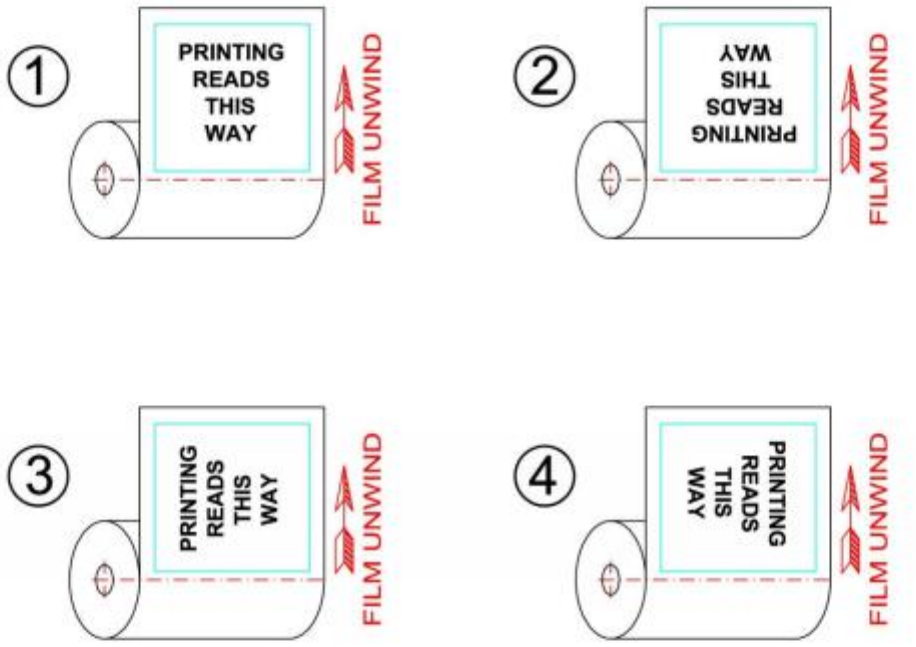
1. Machine engineered and manufactured in compliance with the latest international ergonomic standards for both operators and maintenance personnel. All the controls are readily available at the operator's fingertip; the electrical cabinet is in a frontal position to facilitate the access and the mechanical area is oversized to guarantee easy access and operations
2. Main frame and electrical cabinet in mild steel, matte white, rough textured finish painted for long term rust protection and increased overall equipment durability
3. All parts in contact with the product are either 304 stainless steel or food grade plastic
4. Color Touch Screen to control the main machine functions, such as:
   - Bag Length settings/Dwell
   - Speed of packaging
   - Film Advance
   - Additional client cams
   - Axis Homing
   - Multilanguage controls
   - Product Set Up
   - Product Memory
   - Print Registration settings
   - Diagnostic Center
   - Programming Parameters
   - Temperature Settings
   - Run/Jog
5. 3 axis servo system complete with:
   - 3 Kollmorgen brushless servo motors (to drive the infeed, the finwheels and the crimperhead independently)
   - CMZ Motion Controller/PLC to synchronize the three axis and manage all the machine functions
   - No mechanical dwell box for the crimper assembly. The desired amount of dwell is achieved by profiling the servo motor. This allows for a more accurate selection of the amount of dwell needed for each product and eliminates the maintenance required on a traditional mechanical dwell boxes. All dwell parameters are stored in the HMI in the recipes for each product.
6. No Product No Bag and Misplaced Product Detection features (activation of such features is subject to approval by PFM's Engineering Dept. pending the characteristics of the products, the packaging materials and the speeds of the application) - Available as an option
7. Mechanical speeds up to 200 ppm in a 2 up jaw configuration (maximum cut off at 200ppm is 6")
8. 6.6ft (2mt) long infeed conveyor with 304 stainless steel decking, featuring "easy removable" plastic pushers for fast changeover and easy maintenance. Spacing between pushers as required by the specific application.
9. The standard machine can be equipped with either a fully adjustable former
10. One film roll holder with self-centering cones, spring activated brake system and side lay adjustment (2nd reel holder available as an option)
11. Film calander with fully adjustable approach roller section for smooth film delivery to the fin wheels
12. Max Reel dimensions:
    - Width: 23.6" (600mm)
    - External dia.: 13.7" (350mm)

- Internal dia.: 3" (76mm)

13. Three pairs of fin wheels:
    - 1st set to pull the wrapping material
    - 2nd set to produce the longitudinal seal
    - 3rd set to fold the wrapping material
14. One Up end seal, cast rotary jaw (bolt on jaws available as an option)
    - Jaw width: 9.8" (250mm)
    - Jaw diameter: standard up to 5.9" (150mm)
      (Optional 6.7" (170 mm)
    - Max product clearance: standard up to 3.9" (100 mm)
      (Optional 4.5" with 170 mm diam. Jaws)
    - Seal face: standard 0.5 (12.5 mm) per side of the bag with conventional longitudinal sealing pattern (transverse sealing pattern as well as custom seal width, with or without hang holes, are available as options)
15. Machine cycle stop with crimper in open position to prevent film from melting
16. Mechanical clutch system on the crimperhead to release the drive and stop the machine in case a solid object gets between the jaws
17. 36" (914mm.) powered discharge conveyor, useful width is 10" (250mm.)
18. Product flow left to right from the view point of the operator station (mirror image machine available as an option)
19. The machine is supplied with adjustable feet (swivel locking casters available as an option)
20. One Start/Stop/Emergency Stop control (on operator side)
21. Interlocked safety switches on all doors and guards that can be opened without tools
22. Machine supplied with an air monitoring system which will stop the machine and alert the operator on the display
23. Machine footprint (approx.): 11.5' long x 4' wide x 2' high top of electrical cabinet)
24. Working height 36" +/- 1" (925mm +/- 25mm, machine equipped with feet)
25. Standard weight: 2,200 Lbs.
26. Supply voltage: 230V, three phases, 60 Hz, 30 Amps
27. Control circuit power: 24 VDC
28. Air requirements: non lubricated, compressed air @ 80psi
29. Machine manufactured in compliance with the following standards; OSHA, UL508A and CSA Z432-04
30. The machine will be shipped with one hard copy of both the Operators and Parts Manual and one electronic copy on CD Rom of both manuals
30. All manuals, schematics, correspondence, and in general all documents are in English only. (Other languages can be quoted upon request)

PFM Standard Components List		
Component	*PFM Equivalent Standard*	*Optional (surcharge applies)*
DC Motors	Omnidrive or Torquemaster	N/A
DC Jack Motors	SIR	N/A
AC Jack Motors	Seipee	N/A
AC Motors	GEC or Seipee	Baldor, Lafert , Emerson
Servo Motors	Kollmorgen AKM Series	Allen Bradley MPL/MPF Series
Encoders	Contrex or Eltra	Allen Bradley or Sick
DC Drives	KB Electronics	N/A
AC Drives	Schneider Electric - Altivar 12 & 32	Allen Bradley PowerFlex 4, 40 & 70
Servo Drives	CMZ or Kollmorgen Servostar S400 Series	Allen Bradley Kinetics 6000 Series with Safe-Off
Motion Controller	CMZ	N/A
PLC	CMZ or Siemens S7-200 or S7-300	Allen Bradley MicroLogix, CompactLogix or ControlLogix
HMI	CMZ or Hakko Electronics V600, V700 & V800 Series	Allen Bradley Panelview Plus 700, 1000, 1250
PC	Dell	HP
Cameras	Basler Scout	Cognex
Electrical Controls (contactors, circuit breakers, relays, DC Power Supplies)	Schneider Electric	Allen Bradley
Safety Guard Switches	Telemecanique or Allen Bradley Trojan 5	Allen Bradley Ferroguard or Schmersal
Safety Relay	Allen Bradley MSR 127T	Allen Bradley MSR 138DP
Push Buttons	Schneider Electric 22.5mm Series	Allen Bradley 800H & 800T Series (22.5mm & 30.5mm)
Photoelectric & Proximity Sensors	Sick, Schneider Electric or Wrenglor	Allen Bradley, Keyence or Banner
Temperature Controllers	Azbil	N/A
Solid State Relays	Schneider Electric	Allen Bradley
Gear Boxes	Bonfiglioli or Motovario	Emerson
Bearings	KML or SKF	AMI, INA or Notchy
Pneumatic Controls	Festo	SMC
Belts	Ammeral	Habasit or Siegling
Timing Belts	Brecoflex	N/A

FILM ROLL UNWIND CHART



SEALANT LAYER INSIDE, PRINTED OUTSIDE

BAG TYPE	RECOMMENDED UNWIND(S)
PILLOW PACK	1 - 4
GUSSET PACK	1 - 2
HOLE PUNCH	1 - 2

NOTE: PFM PACKAGING MACHINERY CORPORATION IS NOT LEGALLY RESPONSIBLE FOR EXPENSES RESULTING FROM INCORRECT FILM SPECIFICATIONS AND ORDERS. SEAL SPECIFICATION TO BE CONFIRMED AFTER ORDER ENGINEERING REVIEW.

PRICES

PFM Falcon BB Servo as previously described
Complete with the following:

1	Adjustable Former	
2	2up Crimper Assembly, 250mm wide jaws,	
3	Transverse seal pattern	
4	Automatic 4 servo axis shuttle feeder – this feeding system is used to handle delicate and sticky product that doesn't allow to be backlogged.	
5	Upgrade to AB servo system, including Panelview HMI, CompactLogix PLC and MPL servo motors	
	Total Price Ex-Works Newmarket ON, Canada	**$195,800.00**

OPTIONS:

1	2nd self centering reel holder	US$2,500.00
2	Left hand version (product flow right to left)	US$5,500.00

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2535 W. Broadway, Phoenix, AZ 85041
P.O. Box 8760, Phoenix, AZ 85066
602-243-3951 • 800-373-7763
602-243-0435 fax
www.swscale.com

Polyform Products Company
1901 Estes Ave
Elk Grove Village, IL 60007

Attn: Eric Sandoval

Dear Eric,

Please find the details and quote for an A&D Engineering Checkweigher and Reject System. Based upon our understanding of your functional requirements, we are confident that the proposed system will be a tremendous asset in your quality assurance procedures. These are complete turnkey solutions; all hardware, software, startup and training items are included in this quote.

Image shown may not be identical to the system described in this proposal.

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602-243-0435 fax
www.swscale.com

System Configuration

AD-4961-2KD-2035 Checkweigher – 2,000 gram Capacity

A&D "EZI Check" Intelligent Checkweigher Water & Dust proof
(IP-65) SUS 304 2000g Capacity
Resolution: 0.01g / 0.1g
Max speed 120m/min or 320PPM
Accuracy & PPM (pieces per minute depends on accuracy requirements)
Infeed + Weigh Belt - 708mm (L) X 200mm (W) - 27.8 in (L) X 7.9 in (W)
*(See drawing below)
Front or rear mounted 7" Touch Panel LCD
Real time data capture straight to USB memory
1000 Product ID's with images (via USB) & descriptive codes
Built-in statistical functions, pdf report & graph generator
AC 110-240V with Serial, Ethernet & Modbus I/O
Three user admin levels for product editing
Direct drive DC motors - no drive belts - easy to clean and simple to use

AD-1981-2057 Dual Flipper Rejector

Up to 120 Pieces Per Minute - 575mm (L) X 200mm (W) - 22.6 in (L) X 7.9 in (W) *(See drawing below)

AD-4961-01 Display Stand

AD-4961-02 Tower Light

3 Zone Comparator Indicator Light Tower – Green, Yellow, Red

AD-4961-11 Upper Breeze Break

AD-4961-2035-MNT Maintenance Kit

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602-243-0435 fax
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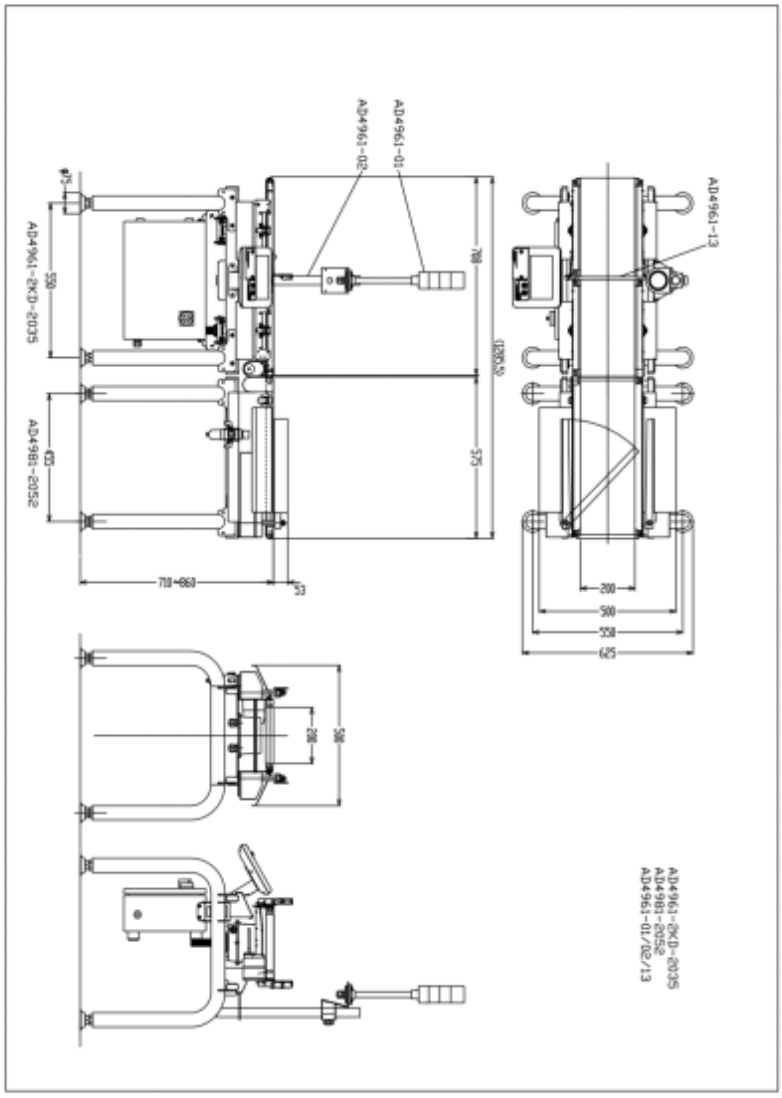
System Drawings



***2,000 Gram Checkweigher & Dual Flipper Rejector (measurements in mm)**

(Display Stand and Tower Light installed)

DELIVERING CONFIDENCE WITH EVERY MEASURE

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P.O. Box 8760, Phoenix, AZ 85066
602-243-3951 • 800-373-7763
602-243-0435 fax
www.swscale.com

Customer Responsibilities:

- Spacing is to be provided by client/ (pitch is measured from leading edge of one packaging to leading edge of the next package.) Proper spacing requires 1.5 times the length of the package.
- Utilities to be provided and accessible
- Product cannot be allowed to backup in reject stations or accumulate on conveyors
- Customer is responsible for delivery to and takeway of product from A&D equipment
- Top heavy or topple prone products require special attention and may require customers to provide modifications to their existing setup or conveyance
- Samples of all possible variations of products prior to quotation if possible
- A detailed timeline for proposed install and scheduled access to the line for installation
- Any required transition pieces between A&D supplied equipment and customer equipment to be supplied by customer.

GOOD OPERATION PROCEDURES WOULD SUGGEST:

1. All machinery to be uncrated prior to the arrival of A&D technician.
2. The machinery should be in the line or in close proximity to the installation site.
3. Utilities should be available, connected, but not turned on.
4. Customer's maintenance and operating personnel should be available to assist and receive proper instruction at the time of the technical representative's visit.
5. Most cases indicate that one machine can be serviced or installed in one day, although exceptions do exist.

Accuracy and Sensitivity:

Accuracy and sensitivity statements are estimates based on experience, machine capabilities, and operator knowledge. All sample testing is done in a laboratory setting and may not take into account environmental factors. If customers product deviates from questionnaire provided prior to sale or environmental factors are present the accuracy and sensitivities will not be repeatable and may fall below customers expectation.

AC Power Requirements:

- **Voltage:** 120VAC, 20A, Steady state voltage +- 10% variation on nominal.
- **Voltage Interruption:** Interruptions must be <3mS with at least 1 second between interruptions
- **Voltage Dip:** Voltage dips cannot exceed 20% of peak for more than one cycle with at least 1 second between dips

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602-243-0435 fax
www.swscale.com

Training Operation Orientation	
Length	4 hours (up to 8 people)
Instructor	Field Engineer
Description	Orientation at time of training. Learn basics of machine start up, shut down, log-in, and how to set-up and train parts.
Cost	Included
Advantages	Quick, convenient, basic knowledge of system.

Once you have had time to review this quotation, I would like to speak with you to discuss any questions you may have. Thank you very much!

Best Regards,

Charles Kreuzer
Sales Engineer – Industrial Systems
Southwestern Scale Company, Inc.

SOUTHWESTERN SCALE COMPANY INC

SALES • SERVICE • RENTALS • MANUFACTURING SINCE 1948

DELIVERING CONFIDENCE WITH EVERY MEASURE

Quote

#8087

03/29/2019

Bill To

Polyform Products Company
1901 Estes Ave
Elk Grove Village IL 60007

Ship To

Polyform Products Company
1901 Estes Ave
Elk Grove Village IL 60007

Customer #	Terms	Sales Rep	Quote Expiration Date	Shipping Method
655824	PREPAID	KREUZER, CHARLES	04/28/2019	

Quote Details

A&D Checkweigher System

LEAD TIME 2 - 4 Weeks ARO (as of 3/29/2019)

Qty	Units	Description	Rate	Amount
1	Ea	AD-4961-2KD-2035 Checkweigher – 2,000 gram Capacity A&D "EZI Check" Intelligent Checkweigher Water & Dust proof (IP-65) SUS 304 2000g Capacity Resolution: 0.01g / 0.1g - Max speed 120m/min or 320PPM Accuracy & PPM (pieces per minute depends on accuracy requirements) Infeed + Weigh Belt - 708mm(L) X 200mm(W) - 27.8 in(L) X 7.9 in(W) Front or rear mounted 7" Touch Panel LCD Real time data capture straight to USB memory 1000 Product ID's with images (via USB) & descriptive codes Built-in statistical functions, pdf report & graph generator AC 110-240V with Serial, Ethernet & Modbus I/O Three user admin levels for product editing Direct drive DC motors - no drive belts - easy to clean and simple to use AD-1981-2057 Dual Flipper Rejector Up to 120 Pieces Per Minute - 575mm(L) X 200mm(W) - 22.6in(L) X 7.9in(W) AD-4961-01 Display Stand AD-4961-02 Tower Light 3 Zone Comparator Indicator Light Tower – Green, Yellow, Red AD-4961-11 Upper Breeze Break AD-4961-2035-MNT Maintenance Kit Includes: One Day On-Site Setup, Testing and Training and Shipping to Elk Grove Village, IL.		$38,470.00

Subtotal	$38,470.00
Tax (0%)	$0.00
Total	$38,470.00

CUSTOMER PURCHASE ORDER NO _____

QUOTE ACCEPTED BY _____

PO Box 8760 Phoenix AZ 85066 | 602.243.3951 | CKreuzer@swscale.com

Barrington Packaging Systems Group, Inc.

Integrating Packaging Equipment and Materials

National Headquarters Office: 847.382.8063 835 Barrington Point, Barrington, IL 60010

Proposal

March 26, 2019

Proposal #032619.4

University of Illinois
Urbana, IL 61801

ATTN: Eric Sandoval (630) 782-4756

Hello Eric -

This proposal is for a BPS-320DX Servo Flow Wrapper. The BPS-320DX is a reliable, value-priced wrapper priced at or below the price of many used machines. Its design and machine speed are ideal for wrapping your product.

The BPS-320D is covered by a two-year warranty covering parts and labor for a full two-year period.

Model: BPS-320DX Flow Wrapper

Horizontal Form Fill Seal Packaging Machine

Features and Benefits of Equipment:

- Rotary jaw seal, top over hard and laminate film sealing
- Bag length, Product counter, and Speed controlled on HMI Panel
- Eye film registration
- H style package
- Adjustable Former (Product may require box former)
- On-screen adjustments cutting knife speed
- Digital HMI Panel, PID Temperature controllers
- CE International Electrical, Pneumatic and Mechanical Components
- 220 VAC / 50, 60 Hz / 1 Phase
- Most economical and best valued unit on the market.
- Stainless steel case and contact parts.
- Compact foot print, easy open frame to work on and clean.

Technical Specifications:

- Sealing Method: Pillow type sealing ("H" sealing)
- Max Film Web Width: 90-360mm / 3.54 – 14.17 inches
- Bag Width: 35 to 160 mm / 1.377 to 6.29 inches
- Bag Length*: 115-280mm / 4.527 -11.02 inches
  *Note - Modification to infeed conveyer required for package lengths exceeding 12".
- Bag Height: 5-50mm / 0.196 – 1.968 inches
- Packing Speed: 40 – 180 ppm
- Voltage: 220V, 1 phase, 50/60 HZ, 2.75Kw,
- Machine Dimensions: 7360 x 1132 x 1549mm / 290 x 46 x 61 inches
- Machine Weight: 850KG / 1874 lbs.
- Single Former: Adjustable for product range listed

Pricing:

BPS-320DX Flow Wrapper	$29,900.00
Indexing Conveyer	42,000.00
Sorting Unit (Conveyer)	16,900.00
Stainless Steel Case ($4,980 value)	No Charge
Registered Wrap ($2,780 value)	No Charge
No Product - No Film $3,040 value)	No Charge
Batch Counter ($990 value)	No Charge
Two-year warranty – parts and labor	No Charge
System Total:	**$88,800.00**
ADDITIONAL CHARGES:	
Installation & Training (Est. 3 days)	$3,600.00
Estimated Local Delivery and Handling	900.00
Estimated Total:	**$93,300.00**
Options:	
Date Code Printer	$3,090.00
Thermal Printer	5,900.00
Extended Product Height	3,300.00
No Gap/No Seal	2,990.00
Hole Punch Jaws	1,900.00
Dual Spindle	17,900.00
Chrome Jaws	900.00
Gas Flushing	1,990.00
Label Applicator	16,900.00
Card Feeder	16,900.00
Case Taper (Manual Adjustment)	4,490.00
Random Case Taper (Automatic Adjustment)	5,990.00
Packing Turntable	3,450.00
Metal Detector	15,900.00
Check Weigher	16,900.00
Metal Detector/Check Weigher Combo Unit	27,900.00
Pallet Stretch Wrappers	TBD
Recommended - 1-day service for production observation	1,200.00

TERMS

Payment Terms: 60 % Down with PO and signed agreement, 40% due immediately prior to delivery.
Shipping: FOB Manufacturing Plant.
Quote valid for 30 days.

Remarks

System speeds, if quoted, are estimates. However, final filled bag speed depends upon the condition of the product prior to the introduction to the equipment, product characteristics, packaging material, final bag sizes, fill target weights, and overall operator skill. Addition of an in-line metal detector, printers, labelers, and other accessories may result in slower speeds if these accessories are not rated to meet the speed of the BPSG system. BPSG cannot accept responsibility for the performance of product feeding or conveyer equipment not purchased through BPSG.

Pictures of equipment, if supplied, are for reference purposes only, are supplied solely to provide a general idea of the type of equipment that our quotes represent, and thus might not exactly represent equipment delivered. BPSG considers each system or piece of equipment supplied as a custom order and as such, reserves the right to make such modifications, as we believe necessary at the time of manufacture to deliver safe and functional equipment.

On occasion, Barrington Packaging Systems Group may generate pictures, videos, or other materials that references your company, product, or packaging during product testing. By signing below, you are authorizing our use of this material for our marketing purposes.

BPSG reserves the right to review and modify this proposal if changes to these specifications are submitted by purchaser or are determined necessary after product and/or film testing.

Changes to specifications may affect price and delivery

STARTUP AND INTERFACING POLICY

BPSG will provide a factory trained service technician or technicians for startup of the quoted equipment as noted under BPSG Standard Startup. Service & Training Rates (In force at the time of startup). The customer is to supply such skilled and casual labor as may be required to complete the work.

Startup includes changes or adjustments required under sustained production conditions during the startup period and initial training of customers, operators and/or maintenance personnel. Basic Initial Training involves: threading the film and how to start and stop the machine. BPSG recommends that you consider additional training for your personnel. The BPSG Service Technician will provide additional training beyond completion of the startup chargeable at our standard service rates and subject to availability.

Customer is required to provide actual product and packaging material when called for by the BPSG Technician for machine set-up and adjustment. If product and/or packaging material are not available, have not been submitted for prior approval when requested, or if product and/or packaging material have been changed, additional days of startup may be required. Such days will be chargeable at our standard service rates and are subject to availability.

BPSG equipment uses electrical and mechanical components supplied by many vendors. Although BPSG does considerable testing prior to shipment, there is always a possibility of a component failing due to shipment damage or early failure. BPSG warranties all parts and the service time (labor) to replace any failed component as outlined in item 6. WARRANTY and item 14. GUARANTEE.

Modifications or adjustments may need to be performed for application or site-specific reasons. Although BPSG will make every effort to perform the startup in the least amount of time possible we make no guarantee, expressed or implied, on the exact time required.

BPSG shall no way be liable for any losses, costs, forfeitures, damages, loss of profits' liabilities of the purchaser to its customers or third parsons, and all other consequential damages, whether or not resulting from or contributed to by the default or negligence of BPSG, its agents, employees, and subcontractors which might be claimed as a result of a service rendered.

NOTE: The following preparations are not part of this agreement and are to be performed and completed by the customer prior to the arrival of the BPSG Service Technician.

a. Receive, inspect, and unpack the equipment.

b. If the equipment is received in damaged condition, promptly file a claim with the carrier and notify BPSG per the BPSG Terms and Conditions of Sale.

c. Position the equipment in its intended location making certain that the machine is located on substantial footings and is properly leveled. Degrease and clean the equipment.

d. Install necessary services such as power, air and water. BPSG service technicians are not state approved qualified electricians and will not connect the wires between the customer's power and the BPSG bagger. Electrical connections and compressed air should be installed by a state approved qualified technician.

e. Have necessary packaging material and product available to make a production run.

f. Have at least one machine operator and/or maintenance person available for instruction during startup and test production run. BPSG service technicians will provide field level training during the startup as possible. However, their main focus is to make sure the equipment supplied is operational and to work on any application or cite specific Issues that may need to be resolved. If the customer requires additional training, they may request additional days after the startup period is compete and the machine is accepted as operational at prevailing rates and subject to availability.

g. Have upstream and downstream equipment in place and operational.

BPSG is not responsible for delays caused by the above preparations being incomplete at the time of arrival of its service technician. The customer will be billed according to the BPSG Standard Startup. Service & Training Rates for such delays.

STANDARD START-UP SERVICE, AND TRAINING RATES

- Startup/Service Travel (weekday) - $150.00lhour (8-hour minimum)
- Startup/Service Travel (Saturday) - $225.00/hour (8-hour minimum)
- Start-Up/Service Travel (Sunday): $300.00/hour (8-hour minimum).
- Overtime (over 8 hours less than 10 hrs.) - 1.5 times that day's rate
- Overtime (over 10 hrs.), 2 times that day's rate
- Commercial travel (air fare, car rental. taxi. bus, etc.) - Actual cost
- Charge for use of personal car - $0.55 per mile
- Lodging expenses (hotel/motel) - Actual cost
- Serviceman's per diem (covers meals & incidental expenses) - $60.00/day